BOOK OF PROCEEDINGS

FOR THE

39TH ANNUAL NATIONAL CONFERENCE

OF

FISHERIES SOCIETY OF NIGERIA (FISON) "ABUJA 2024"

HELD AT

National University Commission (NUC) and Raw Materials and Research and Development Council (RMRDC), FCT, Abuja, Nigeria.

28TH OCTOBER-1ST NOVEMBER 2024

FISON 2024 SPONSORS

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Prof. E. K. Ajani, *Ffs*

Dr. O. R. Oguntade, *Ffs*

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MANUSCRIPT REVIEWERS' ACKNOWLEDGEMENT

1. Prof. E.K. Ajani, *Ffs – University of Ibadan*
2. Dr Ebinimi J. Ansa, *Ffs – African Regional Aquaculture Centre (ARAC) of the Nigerian Institute for Oceanography and Marine Research (NIOMR), Rivers*
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The Conference Editor Report - 39th Annual Conference of the Fisheries Society of Nigeria

Date: 28th October to 1st November 2025 Location: National Universities Commission, Aja Nwachukwu House, Maitama District, Raw Material Research and Development Council (RMRDC), 17 Aguiyi Ironsi Street, Maitama District, Garki, Abuja.

The Esteemed Members of the Fisheries Society of Nigeria (FISON) and Distinguished Participants of the 39th Annual Conference, as we reflect upon the enriching experience of the 39th Annual FISON Conference held in Abuja, Nigeria from October 28 to November 1, 2024, it is with a deep sense of gratitude and admiration that I pen this editorial report.

The 39th Annual Conference of the Fisheries Society of Nigeria has been a monumental event, drawing experts, researchers, and enthusiasts from across the country. The conference was a platform for sharing groundbreaking research, discussing crucial issues, and fostering collaborations within the fisheries community. Our gathering brought together a diverse and dedicated group of professionals, researchers, and practitioners committed to advancing the field of fisheries and aquaculture in Nigeria and beyond.

First and foremost, I wish to extend heartfelt thanks to the members of the conference editorial team. Your unwavering support, dedication, and passion have been instrumental in bringing this conference to fruition. The countless hours spent reviewing manuscripts, organizing sessions, and ensuring the smooth running of the event have not gone unnoticed. Your collective efforts have not only enriched the quality of this conference but have also set a high standard for future gatherings. Your hard work and meticulous attention to detail have been invaluable, ensuring that this event was executed seamlessly

This year, we received an impressive 248 manuscripts from researchers across the country. Each submission was a testament to the vibrant and dynamic nature of our field. However, maintaining the high standards of peer review that we uphold, only 184 manuscripts were able to survive the rigour of our review process. This selection process, though challenging, ensures that the research presented at our conference is of the highest quality and relevance. This highlights the critical need for stringent quality control and adherence to high research standards. Manuscripts that did not meet the criteria were returned with detailed feedback for improvement.

While appreciating the effort of contributors, there is a need for substantial improvement in the quality of research carried out by members and the manuscripts submitted. This conference exposed a concerning trend of declining research standards, which must be addressed to maintain the credibility and impact of our work. It is important to acknowledge the need for continuous improvement in the quality of research and standards of manuscripts produced by our members. The peer review process revealed several areas where enhancement is necessary, including clarity in research objectives, robustness of methodology, and thoroughness in data analysis.

To address these challenges and elevate the standards of research within our association, I propose the following strategies:

1. Workshops and Training: Organize regular workshops and training sessions focusing on research methodology, data analysis, and academic writing. These sessions can provide members with the necessary skills to enhance the quality of their research outputs.
2. Mentorship Programmes: Establish mentorship programmes that pair early-career researchers with experienced mentors. This initiative can provide guidance and support, helping new

researchers navigate the complexities of high-quality research and publication.

3. Collaborative Research Projects: Encourage collaborative research projects that bring together researchers with diverse expertise. Such collaborations can lead to more comprehensive and robust studies, benefitting from the strengths of multiple researchers.
4. Peer Review Training: Offer training programs for peer reviewers to ensure a consistent and rigorous review process. Well-trained reviewers can provide constructive feedback that helps authors improve their manuscripts before submission.
5. Incentives for Quality Research: Introduce awards and recognition for outstanding research and high-quality manuscripts. Recognizing and rewarding excellence can motivate members to strive for higher standards in their work.

The payment of token to conference sectional reviewers for their efforts proved to be a significant motivator, encouraging thorough and timely reviews. Ensuring the timely production of the proceeding was a major achievement and a practice that must be continued in future conferences. The streamlined process demonstrated that with adequate planning and execution, timely dissemination of research findings is achievable. However, one notable shortfall from this conference was the failure to migrate the best manuscripts to the association's journal as promised. This was largely due to the failure of sessional chairpersons to select the best manuscripts from each session as suggested. Doing so now may lead to delays in the release of the proceeding. It is essential to address this in future conferences to uphold our commitment to showcasing top-tier research.

The 38th Annual FISON Conference provided valuable insights and lessons that will guide our future endeavours. Key takeaways include:

1. Emphasize the importance of timely manuscript submission to ensure a smooth review process and timely production of the proceedings.
2. Reinforce adherence to high-quality standards in research and manuscript preparation.
3. Ensure professionalism in manuscript handling and communication with authors and reviewers.
4. Implement best practices from this conference, such as early planning, regular check-ins with sessional chairpersons, and clear communication of expectations.
5. The importance of interdisciplinary collaboration, the need for continuous professional development, and the value of fostering a supportive and inclusive research community.

The 39th Annual Conference of the Fisheries Society of Nigeria has been an enlightening and productive event, thanks to the collective efforts of all involved. As we reflect on the successes and challenges, we remain committed to continual improvement, upholding high standards of research, and fostering a vibrant and collaborative community.

In conclusion, as we move forward, let us build upon the successes of this conference and strive to address the areas of improvement identified. Together, we can enhance the quality of research within our association and contribute to the advancement of fisheries and aquaculture. Once again, I extend my deepest gratitude to all who contributed to making this conference a resounding success. Your dedication and passion are the driving forces behind our collective achievements.

Professor E. K. Ajani
Conference Editorial Chairman

COMMUNIQUE OF THE 39TH ANNUAL CONFERENCE OF THE FISHERIES SOCIETY OF NIGERIA (FISON) HELD AT NATIONAL UNIVERSITY COMMISSION (NUC) AND RAW MATERIALS RESEARCH AND DEVELOPMENT COUNCIL (RMRDC) FEDERAL CAPITAL TERRITORY, ABUJA FROM 28TH OCTOBER - 1ST NOVEMBER, 2024

1.0 INTRODUCTION

The 39th Annual Conference of the Fisheries Society of Nigeria (FISON) was successfully convened in Abuja from 28th October to 1st November 2024. Under the theme "Unlocking the Investment Potential of Nigeria's Blue Economy: Advancing the Fisheries and Aquaculture Sector for Sustainable Development," the conference attracted over 300 participants, including government officials, fisheries professionals, fish farmers, research institutions, private sector operators, and students of fisheries.

The event commenced with pre-conference training workshops on 28 October 2024, focusing on essential topics such as "Using R Innovative Research Outcomes in Fisheries Science and Policy Development" and "Strategies and Methodologies for Writing in High-Impact Journals."

The official opening ceremony was held on 29th October 2024, with His Excellency Alhaji Isiaka Adegboyega Oyetola, CON, Minister of Marine and Blue Economy, declaring the conference open on behalf of His Excellency President Bola Ahmed Tinubu, GCFR.

2.0 HIGHLIGHTS OF THE CONFERENCE

During the conference, several key points were addressed:

- **Commitment to Fish Production:** The Minister of Marine and Blue Economy reiterated the ministry's dedication to achieving self-sufficiency in fish production and enhancing Nigeria's role as a significant exporter of fish and fisheries products.
- **Transition to a New Ministry:** The successful transition of the fisheries department to the Ministry of Marine and Blue Economy has resulted in notable progress, including increased local feed production and reduced reliance on fish imports.
- **Public-Private Partnerships:** Ongoing collaborations between the public and private sectors were highlighted as key strategies to boost investments in the fisheries sector.
- **Fisheries Management Initiatives:** The ministry is currently implementing initiatives aimed at effective fisheries management, investment in aquaculture development, enhancement of post-harvest infrastructure, promotion of innovation, and encouragement of multi-stakeholder collaborations.
- **Sustainable Development Goals:** The FISON National President emphasized the critical role of fisheries and aquaculture in contributing to the United Nations' sustainable development goals.
- Fisheries Institute of Nigeria Charter Bill: The National President also called for the Minister's assistance in realizing the Fisheries Institute of Nigeria Charter bill, which has already passed through the National Assembly twice.
- **Collective Action for Sustainable Development:** Participants emphasized the need for collective action among stakeholders to address the challenges facing the fisheries and aquaculture sectors and to promote sustainable development and economic transformation.
- **Commendation for FISON's Efforts:** Mrs. Didi Esther Walson-Jack, OON, the Federation's Head

of Service, commended FISON for its contributions to research, capacity building, and the preservation of fish diversity, wishing all participants fruitful deliberations.

- **Keynote Address:** Dr. Mohammed Seisay from the African Union – Inter-African Bureau for Animal Resources (AU-IBAR) delivered a keynote address on the potential of Nigeria's blue economy, underlining the investment opportunities within Africa's marine and freshwater ecosystems.
- **Challenges and Opportunities:** Discussions highlighted that despite the sector's potential, it faces challenges such as institutional constraints, climate change, and environmental variability, which hinder socio-economic contributions.
- **Governance Enhancements:** Since 2010, the African Union has made strategic decisions to enhance governance in fisheries and aquaculture through coordinated policy frameworks for equitable socio-economic development.
- **Alignment with National Policies:** The AU supports Nigeria in aligning its national policies with continental frameworks to facilitate investments and development in the blue economy, emphasizing sustainable use, conservation of aquatic resources, gender considerations, climate resilience, and private sector investment mechanisms.
- **Sustainable Coastal and Marine Tourism:** Efforts to create a master plan for sustainable coastal and marine tourism were mentioned. The plan aims to minimize environmental impacts while fostering fisheries investment.
- **Transboundary Cooperation:** Emphasizing the importance of marine spatial planning was also identified as a crucial aspect of the sustainable development of fisheries resources.
- Addressing Challenges: Recognition of the myriad challenges hindering the growth and contribution of fish farmers to Nigeria's economy necessitates collective action from all participants.
- **Innovation and Investment:** There are urgent calls for innovation and increased investment in aquaculture to harness Nigeria's aquatic resources effectively while ensuring environmental conservation.
- **Stakeholder Collaboration:** Acknowledgment of the need for collaboration among various stakeholders to address the fisheries sector's challenges and enhance productivity.
- Role of Biotechnology: Highlighting the necessity for stakeholders to engage in discussions on the role of biotechnology in creating a sustainable aquaculture environment, with a focus on food security.
- **Commitment to Sustainable Practices:** Consensus among Nigerian fish farmers and policymakers on their commitment to sustainable practices while recognizing their substantial challenges, and calls were made for targeted interventions. Proposal for strategic interventions includes:
  - Improved access to education and resources for fish farmers.
  - Development of infrastructure to support the sector.
  - Establish fish broodstock banks and diversify fish species.
  - Establishment of quality fish feed plants.
  - Implement supportive government policies addressing climate change and land tenure issues in the fisheries sector.
- FISON Fellowship Award: The conference witnessed the conferment of fellowship awards on 19 professional members of FISON, an honourary fellowship on His Excellency President Bola Ahmed Tinubu, GCFR, and several other awards to dignitaries.

3.0 CONCLUSION

The conference successfully provided a platform for diverse stakeholders to unite, share knowledge, and collaborate on the pathways to a sustainable fisheries and aquaculture sector in Nigeria. The FISON community remains committed to advancing the industry's interests and contributing to the broader objectives of national development and food security.

We appreciate all participants, speakers, and sponsors for their contributions to the 39th Annual

Conference's success and look forward to continued collaboration in advancing Nigeria's fisheries and aquaculture sector.

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For further information, please contact: www.fison.org.ng

ADDRESS OF THE NATIONAL PRESIDENT DR EBINIMI JOSEPH ANSA (Ffs) AT THE 39TH ANNUAL GENERAL MEETING AND CONFERENCE AND THE 20TH FELLOWSHIP INVESTITURE AND AWARDS CEREMONY OF THE FISHERIES SOCIETY OF NIGERIA (FISON) HELD AT THE NATIONAL UNIVERSITIES COMMISSION (NUC), MAITAMA, ABUJA ON 29TH OCTOBER 2024

His Excellency, The President of the Federal Republic of Nigeria and Commander in Chief of the Armed Forces, President Bola Ahmed Tinubu GCFR
His Excellency, The Honourable Minister, Federal Ministry of Marine and Blue Economy, Alhaji Adegboyega Isiaka Oyetola CON
His Excellency, The Honourable Minister of the Federal Capital Territory, Barrister Nyesom Ezenwo Wike CON
The Honourable Minister, Federal Ministry of Agriculture and Food Security, Senator Abubakar Kyari CON
The Honourable Minister of State, Federal Ministry of Agriculture and Food Security, Senator (Dr) Aliyu Sabi Abdullahi CON
The Senators and Honourable Members of the House of Representatives of the National Assembly
The Head of the Civil Service of the Federal Republic of Nigeria, Mrs. Didi Esther Walson-Jack OON, mni
The Permanent Secretary, Federal Ministry of Marine and Blue Economy, all other Permanent Secretaries here present
Executive Secretaries & Director-Generals of Commissions and Councils here present
The Vice Chancellor, University of Abuja and other Vice Chancellors
Executive Directors of the Research Institutions here present
Rectors and Provosts, of our Fisheries Colleges and Polytechnic
Federal and State Directors of Fisheries
Board of Trustees of FISON
All Past Presidents of FISON
Members of the National Executive Council of FISON
Chairman/Former Chairmen Council of Fellows and all Fellows
Presidents and Captains of Fisheries Industries and Associations
Our great Fishers and Fish Farmers
Distinguished Members of FISON
Distinguished Students
Distinguished Guests,
Gentlemen of the Press
Ladies and Gentlemen,

It is with great pleasure and gratitude to God Almighty that I welcome you all to the 39th Annual Conference and General Meeting as well as the 20th Fellowship Investiture and Awards Ceremony of the Fisheries Society of Nigeria, ABUJA 2024. The conference theme "UNLOCKING THE INVESTMENT POTENTIAL OF NIGERIA'S BLUE ECONOMY: ADVANCING THE FISHERIES AND AQUACULTURE SECTORS FOR SUSTAINABLE DEVELOPMENT" aligns with the global trend in seeking ways of improving the economies of both coastal and inland states and represents a defining moment for our society and our country Nigeria. Our discussions, deliberations, and resolutions over the coming days will play a crucial role in shaping the future of Nigeria's blue economy, particularly our fisheries and aquaculture sectors, which are integral to the United Nation's sustainable development goals.

Your Excellency Sir, permit me to give a brief introduction about FISON

FISHERIES SOCIETY OF NIGERIA (FISON) was established in 1976 and has served as the apex professional body for the Nigerian fisheries Sector. FISON holds a position of authority and leadership, and carries out many functions, which are to:

1. Promote professional and practitioner development of stakeholders in aquaculture, capture fisheries, post-harvest management, fisheries research and development in Nigeria.
2. Create a forum for the productive interaction of individuals and corporate organizations involved in Fisheries and Aquaculture value chains.
3. Collaborate with organizations with related interests in Nigeria and beyond to improve the development of the Fisheries Sector.
4. Support capacity-building initiatives for stakeholders in the Fisheries sector.
5. Collate, publish, and disseminate information for the sustainable development of the Fisheries and Aquaculture Sectors.
6. Host annual conferences, workshops, and seminars across the 36 states of Nigeria and the FCT for the benefits of our members for knowledge sharing, capacity building, networking, collaboration, community and sectoral engagement, showcasing innovation and technology, provide policy direction and advocacy, professional development and recognition.

FISON now has about 5,000 professional and corporate members. Our corporate membership cuts across the capture fisheries and aquaculture subsectors, comprising the trawling companies, fish input dealers, fish farmers, and fish processors, and allied industries.

Our national formations include:

- The Board of Trustees
- The National Executive Council
- The Forum of National Presidents (in view)
- The Council of Fellows
- The Congress
- The State Chapter Formations
- The National Association of Fisheries Students

Your Excellencies, Ladies and gentlemen, today we are gathered here to witness the opening of the 5-day conference and the Fellowship Investiture Awards of the Fisheries Society of Nigeria, and to unlock the vast potentials of Nigeria's aquatic ecosystems and showcase investment opportunities that will transform our fisheries and aquaculture sectors into dynamic engines of economic growth, fish protein availability, and job creation. But to achieve this, we must collectively address several critical issues. Permit me, Sir to highlight these issues one after the other:

1. Establishing the Fisheries Institute of Nigeria (FIN) Bill

A key priority of FISON is the urgent need for the formal establishment of the Fisheries Institute of Nigeria (FIN). As we all know, professionalizing the fisheries and aquaculture sectors will not only enhance capacity but will ensure that we operate within globally accepted standards. Therefore, I use this platform to call on the Honourable Minister of Marine and Blue Economy to sponsor the FIN Bill as an Executive Bill to be presented to the National Assembly.

The FIN Bill is crucial because it will:

- Provide a structured framework for capacity building, certification, and professional development.
- Promote knowledge transfer and the adoption of best practices in fisheries management, aquaculture operations, and marine resource sustainability.

· Ensure a cohesive national strategy that aligns with international fisheries and aquaculture regulations, making Nigeria competitive both regionally and internationally.

We look forward to the support of His Excellency, Mr. President and all stakeholders in ensuring the successful passage of this bill. We are willing to work with the Honourable Minister and his formidable team to provide the documentation and framework for the establishment of the Fisheries Institute of Nigeria which will further help to advance the blue economy in Nigeria.

2. Enhancing Investment in Fisheries and Aquaculture Infrastructure

To unlock the full potential of the blue economy, we must tackle the challenges of underdeveloped infrastructure. This includes investing in energy and water conserving technologies in fish farms, developing cold chain logistics using clean and renewable energy, developing novel technologies into our farming systems such as Integrated Multi-trophic Aquaculture (IMTA), investing in and developing fish vaccines to prevent fish disease outbreaks, investing in alternative fish feed ingredients for fish feed formulation such as insect larvae to replace 50 to 80% of fishmeal in feed formulas, investing in local fish meal production using undersized farmed tilapia and clupeids, and investing in fish processing. Without the right infrastructure, we cannot effectively harness the potential of our aquatic resources or ensure the sustainable development of our fisheries.

We must prioritize the establishment of public-private partnerships (PPP) that will bring in the much-needed capital to upgrade our fisheries and aquaculture infrastructure. Through collaboration with investors, government agencies, and international partners, we can build a more resilient, efficient, and profitable sector.

3. Strengthening Research and Development

In the era of climate change and global economic shifts, research and development (R&D) are key to advancing Nigeria's fisheries and aquaculture sectors. FISON is committed to fostering innovation through research that will improve fish farming practices, increase yields, and ensure the sustainability of our marine resources.

We call for more investment in research institutions, academic institutions, and the private sector to support advancements in aquaculture genetics, fish health management, and feed production. It is only through continuous innovation that we can remain competitive and meet the increasing demand for fish and seafood products. FISON wants to see more collaborations among the research institutions, academia [universities and fisheries colleges] and the private sector; for increased need driven research that will foster innovation, creation of jobs, promote gender mainstreaming, diversify fish protein sources for the populace and enhance sectoral growth. The fisheries research institutions [Nigerian Institute for Oceanography and Marine Research (NIOMR), National Institute for Freshwater Fisheries Research (NIFFR), and other aquaculture research centres across the country should be properly funded and equipped. Personnel should be well trained and this can be achieved in collaboration with the Federal Department of Fisheries and Aquaculture (FDFA) being linked with several local and international organizations like CGIAR, JICA, IFPRI, FAO, FISH4ACP, WTO, FCWC, AU-IBAR for training and capacity building of officers, also strengthening of institutions, formulating and implementing policies that direct the path towards the development of a sustainable fisheries and aquaculture sector in Nigeria. Presently, Nigeria is the leader in African Catfish production with data suggesting that we have hit the 1 million tonnes per annum production figure. The population of Nigeria is still in dire need for more fish protein and depending majorly on catfish and imports has not met that need. Your Excellency, Nigeria is placed with diverse fin and shellfish species in our marine and inland waters and the aquaculture potential of many of these diverse fish species have been documented. A push is therefore required to bring this to limelight and unlock the potentials for the benefit of Nigerians and to boost our shared economy. Some of the indigenous aquaculture fish species we want to see on our plates include the fin fishes: Oreochromis niloticus, Heterotis niloticus, Citharinus citharus, Synodontis batensoda, Gymnarchus niloticus, Lates niloticus, Chrysichthys nigrodigitatus, Liza grandisquamis and the shellfishes – Crassostrea gasar, Senilia senilis, Macrobrachium vollenhovenii, M. Macrobrachion, M. felicinum, and Penaeus notialis. We also desire that fish production will go beyond being rudimentary to having a full value chain investment structure with a broad diversity for fishpreneurs with a lot more choices for consumers. All these can be achieved if we have the will to promote and enhance research, innovation and entrepreneurship. In line with this therefore we call on the Honourable Minister FMMBE, Your Excellency Sir, to call for validation and launch of the National Fisheries and Aquaculture Policy of Nigeria 2024 – 2028. In FISON, we are passionate about this policy document, our members served in the committee that reviewed the draft of the national policy. We pray for the launch and successful implementation of the policy, so that the lift fisheries can bring as a low hanging fruit in the blue economy would begin to be enjoyed by Nigerians in the next couple of months.

4. Promoting Sustainable Fishing Practices

The future of Nigeria's fisheries sector depends on how well we manage our aquatic ecosystems. Overfishing, illegal, unreported, and unregulated (IUU) fishing, and the destruction of marine habitats continue to threaten our blue economy. We must adopt policies and practices that promote the sustainable use of our aquatic resources.

FISON, in collaboration with government agencies and environmental organizations, will continue to champion sustainable fishing practices. This includes advocating for enforcement of regulations to prevent IUU fishing, supporting WTO's agreement on fisheries subsidies, promoting eco-friendly aquaculture systems, and encouraging the conservation of biodiversity within our water bodies. Our members are also involved in the restoration of lost mangrove habitats which is championed by HYPREP and presently led by a FISON Fellow. We believe that such activities will sustain the biodiversity of the blue economy and could form the basis for blue tourism and other job creating ventures in our aquatic environment.

5. Capacity Building and Youth Empowerment

Finally, for Nigeria to fully harness the potential of its blue economy, we must focus on capacity building and the empowerment of our youth. In the light of this, FISON Fellows, Professional, Associate and Corporate members, have been involved in fisheries education, women, men, and youth empowerment programmes. FISON has inducted many Fisheries graduates as Graduate Members of our noble society. The fisheries and aquaculture sectors offer significant opportunities for job creation, especially for young Nigerians. Through targeted training programs, access to finance, and mentorship, we can equip our youth with the skills they need to succeed in this field.

FISON is committed to partnering with vocational institutions, research institutions and the universities, financial organizations, and development agencies to create pathways for young Nigerians to participate meaningfully in the fisheries and aquaculture industries.

6. Establishing a Research Council for repositioning of the Fisheries and Blue Economy Research Institutions

Considering the growing importance of sustainable fisheries and the expanding blue economy, it is imperative to establish a Council for Fisheries and Blue Economy Research to oversee, guide, and harmonize research efforts across all fisheries and blue economy research institutes under the Federal

Ministry of Marine and Blue Economy. This strategic move will help realign research priorities to the national agenda of economic diversification and sustainability in the blue economy which are in line with the UNSDGs 1, 2,14, etc. The Council when established will be involved in coordinating our research institutes, supporting the Ministry with research-based data for policy formulation, provide guidance and source funds for research institutes to carry out need-driven research for sustainable aquatic resource productivity, facilitate partnerships with national, regional and international research organizations and others, enhance human capital development in fisheries science and the blue economy, monitor and evaluate research activities through well established mechanisms and aligning with the Ministry's objectives.

Fellowship and Investiture Awards

Today, we are here to honour and celebrate some of the most distinguished and outstanding members of FISON, who have been conferred with the prestigious fellowship of the society. The fellowship of FISON is the highest honour that the society can bestow on its members, in recognition of their significant contributions to the advancement of fisheries science and practice in Nigeria and beyond. The fellowship of FISON is not only a mark of excellence and distinction, but also a responsibility and a commitment to uphold the values and objectives of the society, and to mentor and inspire the next generation of fisheries professionals.

The fellows of FISON are selected through a rigorous and transparent process, based on their academic qualifications, professional experience, publications, awards, and leadership roles in the fisheries sector. Our Fellows are expected to be role models and ambassadors of the society, and to actively participate in the activities and programmes of the society. The fellows of FISON are also entitled to use the title Ffs after their names, and to wear the distinctive badge of the society. I encourage all Fellows to proudly wear their badge always!

I would like to congratulate all the fellows of FISON, who are being invested today, for their remarkable achievements and contributions to the fisheries sector. You have made us proud, and we are honoured to have you as our fellows. You have set a high standard of excellence and professionalism, and we hope that you will continue to uphold it and to share your knowledge and experience with others. You are the pride and the hope of the Fisheries Sector, and we look forward to your continued support and collaboration.

I would also like to thank the Board of Trustees, the National Executive Council, the Chairman and Members of the Council of Fellows, Chairman and Members of the Local Organizing Committee, and the Chairman and Members of the Fellowship Awards and Investiture Committee, for their diligent and dedicated work in organizing this conference and investiture ceremony. I would also like to appreciate the presence and support of our distinguished Chairman of Ceremony, the immediate past President of the Fisheries Society of Nigeria, who is the Rector of the Federal Polytechnic, Ekowe, Bayelsa State, Dr Lukman Adegoke Agbabiaka Ffs for accepting to Chair this occasion. My profound gratitude also goes to His Excellency Alhaji Adegboyega Isiaka Oyetola, CON, the serving and first Honourable Minister of the Federal Ministry of Marine and Blue Economy, for his support of the activities of the Fisheries Society of Nigeria and for advancing the Fisheries and Aquaculture Sector through sponsoring need driven policies, and human capital development across the sector. We appreciate all our distinguished guests here present, who graciously accepted our invitation and are here to celebrate with us. I would also like to acknowledge the representation and support of our Special Guest of Honour, the Commander in Chief of the Armed Forces and President of Nigeria, His Excellency, President Bola Ahmed Tinubu GCFR for taking a giant stride in declaring a state of emergency on food security and further matching his words with action and creating the Federal Ministry of Marine and Blue Economy and against all odds, he moved the Federal Department of Fisheries and Aquaculture to the Federal Ministry of Marine and Blue Economy. Today, we are glad to have the rare honour and privilege of witnessing the conferment of the Honourary Fellow of the Fisheries Society of Nigeria on our dear President, for his creativity, innovation and bold leadership in repositioning the fisheries and aquaculture sector in the blue economy and for creating policies to support our artisanal and industrial fishers, fish farmers, processors, for the sustainable and increased production of fish in Nigeria. Our hope indeed is renewed that "Fish for All" is achievable!

We hope that with the conferment of the Fellowship Awards and Merit Awards, all our Awardees will strive to do more for the development of the Fisheries Sector. Being a coastal State with 853 km coastline, with numerous water bodies that cut across marine, brackish water and freshwater ecosystems, we have a lot to benefit if we continue to develop our God-given fisheries resources. Investments in the blue economy without deliberate consideration of the aquatic resources of which Fisheries is a conspicuous component will not be sustainable.

Finally, I would like to thank our very distinguished guests, the Honourable Ministers and our Special Guest of Honour, President Bola Ahmed Tinubu GCFR for gracing this occasion despite their very busy schedules. I would like to thank all our sponsors, partners, well wishers and members of FISON, for joining us in this celebration of excellence and achievement. I hope that you will enjoy the rest of the programme, and that you will leave this ceremony with a renewed sense of enthusiasm and passion for Fisheries. Thank you, and God bless you all.

Long live FISON!
Long live Marine and Blue Economy!
Long live the Federal Republic of Nigeria!

Dr. Ebinimi J. Ansa Ffs
National President, Fisheries Society of Nigeria (FISON)

GUEST OF HONOUR SPEECH AT THE 39TH FISON ANNUAL CONFERENCE: 'ABUJA 2024' DELIVERED BY THE HONOURABLE MINISTER OF MARINE AND BLUE ECONOMY ADEGBOYEGA OYETOLA (CON)

PROTOCOL

It is a profound honour to be here today, representing the President of the Federal Republic of Nigeria, at the 39th Annual Conference of the Fisheries Society of Nigeria (FISON), themed "Unlocking the Investment Potential of Nigeria's Blue Economy: Advancing the Fisheries and Aquaculture Sector for Sustainable Development."

Firstly, I would like to acknowledge FISON, an apex non-profit professional organization dedicated to promoting fisheries and aquaculture management, research, and development in Nigeria. FISON has done incredible work towards the advancement of fisheries and aquaculture and as such the Federal Ministry of Marine and Blue Economy is very proud to be associated with this body. I would also like to extend my appreciation to all stakeholders present here today, from within and outside Nigeria, for their commitment to the growth of Nigeria's blue economy. Your dedication to the sector is evident in your presence in this auspicious event.

The theme of this year's conference is particularly significant as it aligns with the Mr President's vision for sustainable economic diversification highlighted in his Renewed Hope Agenda and his creation of the Federal Ministry of Marine and Blue Economy. This resolve has been reinforced by the recent transfer of the Department of Fisheries and Aquaculture to the Federal Ministry of Marine and Blue Economy. This development is significant, as it places all issues related to fisheries administration and related activities under the direct supervision of this Ministry.

The establishment of the Federal Ministry of Marine and Blue Economy marks the beginning of a new era for the fisheries and aquaculture subsector. In alignment with Mr. President's vision for the subsector, The Ministry is committed to achieving self-sufficiency in fish production and positioning Nigeria as a major exporter of fish and fisheries products. The Ministry is also embarking on various initiatives tailored towards strengthening fisheries management, boosting investment in fisheries and aquaculture development, improving post-harvest infrastructure, promoting innovation, leveraging technology, and fostering multi-stakeholder collaboration.

Fisheries and Aquaculture is central to the broader vision to grow Nigeria's Blue Economy Sector. The Ministry's strategic focus is to upscale fish production in a sustainable manner, tapping into the full spectrum of our marine resources. This sub-sector holds the potential to unlock untapped resources, increasing blue food production, blue job opportunities, and drive sustainable development across our coastal and inland waters. This will, in turn, provide long-term prosperity and security for future generations, among other goals.

In the past nine months following the transfer of the Department of Fisheries and Aquaculture to the Ministry, we have made significant progress. We have increased fish production while reducing importation, engaged stakeholders to identify the needs and recommendations for the growth of the sub-sector, leveraged on public-private partnerships (PPP) to increase investment in the subsector, in the process of establishing fish harbours and reviving of desolate terminals, studied best practices from countries like Morocco and collaborated with international organizations such as FAO under the FAO-

Fish4ACP program. Programs such as FAO-Fish4ACP focuses on promoting the sustainable development of Nigeria's fisheries and aquaculture sector, with particular attention to the economic, social, and environmental sustainability of catfish value chains.

Furthermore, Nigeria was recertified to export shrimp to the U.S., EU, and other markets following the U.S. inspection team's recertification of our Turtle Excluder Device (TED) usage. Additionally, the Residue Monitoring and Control Plan for aquaculture shrimp was approved, allowing Nigeria to export cultured shrimp to the EU, USA, and other international market. We have collaborated closely with AU-IBAR in formulating Nigeria's National Blue Economy Strategy, where fisheries and aquaculture play a central role. Strategies, governance frameworks, and implementation plans have been developed alongside stakeholders in the sector. The Federal Government has also affirmed the transfer of NIOMR and other related entities to the Ministry, and Mr. President has approved Nigeria's candidacy in the upcoming election to the IMO Council.

In the coming days, the fisheries and aquaculture policy will be validated in collaboration with IFPRI and WorldFish. The Ministry is also in the process of automating all fisheries operations to enhance service delivery and streamline processes. The Ministry is working on improving linkages between the FDFA and NIOMR and also Federal, state and local governments particularly in the artisanal fisheries and aquaculture sub-sectors. Additionally, we are working towards increasing the participation of women and youth in the subsector, planning to conduct stock assessments to ensure that decision-making and fisheries management are based on accurate data.

On behalf of Mr. President, I would like to extend his warm regards and commendations to FISON once again for taking the initiative of organizing a conference that brings together several stakeholders in fisheries and aquaculture. This event serves as a vital platform for stakeholders to collaborate, exchange ideas, and chart a course toward the sustainable management of Nigeria's vast aquatic resources. The blue economy presents limitless opportunities, and it is through initiatives like this that we can deliberate on, and effectively harness, these opportunities to benefit not only the economy but also our environment and communities.

As we embark on this journey together, I urge all participants to engage meaningfully in the discussions that will take place during the conference. Let us work collectively to develop innovative strategies that will advance the fisheries and aquaculture sub-sector, ensuring that they contribute meaningfully to the broader objectives of sustainable development, economic growth, and national prosperity.
Finally, it is with great pleasure that I declare this conference open, and I wish you all fruitful deliberations and outcomes that will shape the future of our fisheries and blue economy sectors.
Thank you, and God bless the Federal Republic of Nigeria!

Adegboyega Oyetola
Honourable Minister
Federal Ministry of Marine and Blue Economy

GOODWILL MESSAGE BY THE HEAD OF THE CIVIL SERVICE OF THE FEDERATION MRS. DIDI ESTHER WALSON-JACK, OON, mni AT THE OPENING CEREMONY OF THE 39TH ANNUAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) AT NATIONAL UNIVERSITIES COMMISSION HEADQUARTERS ABUJA ON OCTOBER 29, 2024

Protocol

It is a privilege to join you today at this significant gathering—the 39th Annual Conference of the Fisheries Society of Nigeria—celebrating another year of achievements, progress, and the dedication of our country's fisheries and aquaculture professionals. I commend FISON for its commitment to excellence, innovation, and sustainable practices in a sector that holds the promise of both economic growth and food security for Nigeria.

Today, as we honor and invest new fellows, and recognize individuals with merit awards, we pay tribute not only to their outstanding contributions but also to the crucial role of every member of FISON in advancing Nigeria's fisheries industry. Through each of you, our nation is moving closer to its vision of self-sufficiency, job creation, and environmental stewardship—a testament to the power of collaboration and resilience.

Your commitment to sustainable fisheries aligns deeply with our national objectives, especially in the face of current environmental and economic challenges. By enhancing the productivity of our fisheries, promoting research, and building capacity, you are laying the groundwork for a future that balances the needs of today with the preservation of resources for generations to come.

To all the fellows being invested and the merit awardees, I extend my heartfelt congratulations. Your achievements inspire us all to pursue excellence and innovation, creating a ripple effect that reaches far beyond our shores. May you continue to lead by example, strengthening this sector, and upholding the principles that make your work so vital to our nation's progress.

Thank you, and I wish the Fisheries Society of Nigeria a successful and impactful conference.

Mrs. Didi Esther Walson-Jack OON, mni
Head of the Civil Service of the Federation
29th October 2024

identified policy objectives on sustainable use and conservation of aquatics, gender dimensions, climate change, resilience, and private sector financial and investment mechanisms.

To unlock Nigeria's investment potential, it must seize existing opportunities and implement necessary measures to overcome critical challenges. The ongoing AU-IBAR support to Nigerian to embrace blue economy growth also creates the prospects for Nigeria to tap into the inherent opportunities through sustainably harnessing the potential locked in the vast marine and freshwater ecosystems that would significantly advance investments and overall socio-economic development of the country, including food security, livelihoods, GDP, etc. The support to Nigeria to develop a master plan for sustainable coastal and marine tourism, mining, oil, and gas exploration to minimize the impact of these industries on aquatic biodiversity and aquatic environment has laid the foundations for healthy ecosystems and created the pathway for investment in the fisheries and aquaculture sector. Implementing national and transboundary marine spatial planning, marine protected areas, promoting PPP in the sector, issues of capacity building and protection of blue economy resources, etc., would contribute to securing the place of fisheries and aquaculture in the overall blue growth.

"UNLOCKING THE INVESTMENT POTENTIAL OF NIGERIA's BLUE ECONOMY: ADVANCING THE FISHERIES AND AQUACULTURE SECTOR FOR SUSTAINABLE DEVELOPMENT (A KEYNOTE ADDRESS BY DR. MOHAMMED SEISAY)

GENERAL OUTLOOK

Africa has inherent potential and opportunities locked in the marine and freshwater ecosystems that the continent has jurisdiction over. These marine and freshwater ecosystems are endowed with highly biodiverse resources, including fishery resources of high commercial interest that can support large-scale investments in fishing and processing industries, among other things.

Aquatic ecosystems are critical to blue transformation, expanding aquatic food systems and increasing their contribution to nutritious and affordable healthy diets. Presently, the sector contributes immensely to food and nutrition security, livelihoods, income, and GDP and is a social safety net for most Africans. However, challenges continue to undermine the full realization of the potential contribution to the continent's socio-economic transformation. These challenges are institutional and external, including climate change and environmental variability.

AFRICAN UNION RESPONSES

The African Union took major decisions and made extensive declarations at various high-level summits on unlocking and unleashing the full potential of the fisheries and aquaculture sector. These include a significant decision in 2010 at the first Conference of African Ministers in Fisheries and Aquaculture (CAMFA) to establish a coordination mechanism and formulate a continental policy framework for fisheries and aquaculture in Africa to enhance coordination and coherence in the sector's governance. The Policy Framework and reform strategy were therefore developed that identified key policy arenas to support AU member states to create realistic and coherent policies that establish a conducive and enabling environment for the fisheries and aquaculture sector to create equitable, social, and economic development in Africa.

HOW DO WE REPOSITION THE FISHERIES AND AQUACULTURE SECTOR AS THE CONTINENT EMBRACES BLUE GROWTH? And UNLOCK THE INVESTMENT POTENTIAL OF NIGERIA'S BLUE ECONOMY?

To adequately respond to this question, I seek your permission to elaborate on the provisions of the African Blue Economy Strategy. The Sustainable Blue Economy Conference was held in Nairobi, Kenya, in November 2018. The Strategy has a Vision for an inclusive and sustainable blue economy that significantly contributes to Africa's transformation and growth. The Strategy identified five clustered thematic areas that unravel opportunities and complexities in tapping the potential in the ocean, seas, and freshwater resources for the nation's sustainable blue economy development, not least in Africa.

Notably, the African Blue Economy Strategy identified strategic actions for unlocking the potential and advancing fisheries and aquaculture in the context of Africa's blue economy for all African member states.

The African Union's support for Nigeria has enabled this country to align the national policy instrument to the Pan-African policy framework and reform strategy, which would create the environment for investment and power socio-economic development on the continent. The PFRS

UNLOCKING THE INVESTMENT POTENTIAL OF NIGERIA'S BLUE ECONOMY: ADVANCING THE FISHERIES AND AQUACULTURE SECTOR FOR SUSTAINABLE DEVELOPMENT

A KEYNOTE SPEECH PRESENTED BY PROF. ANTHONY NLEWADIM, FFS, DURING THE 39TH ANNUAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) AT IDRIS ABDULKADIR AUDITORIUM, NATIONAL UNIVERSITIES COMMISSION (NUC), ABUJA.

Protocol

INTRODUCTION:

It is a great privilege to serve as a speaker today at this special meeting of the Fisheries Society of Nigeria (FISON), our apex Professional Society in the Fisheries Subsector. I have had the opportunity to serve as the Assistant National Secretary and National Secretary. Before then, I joined the Nigerian Institute for Oceanography and Marine Research (NIOMR) as a young research officer deployed to Rivers State. As I occasionally crisscrossed the waters, I asked myself how the “Fisheries Experts” could make meaningful efforts to maximize the opportunities that abound in the massive water bodies. As of then, the Fisheries and Aquaculture subsector was under the Federal Ministry of Agriculture and Rural Development (FMARD) before it was renamed the Federal Ministry of Agriculture and Food Security.

There is always a reason for everything; sometimes, we find it difficult to understand why some things appear the way they appear. On 6th March 2019, I presented the 39th Inaugural Lecture of Michael Okpara University of Agriculture, Umudike, titled Fishes and Fisheries: The Mysteries in the Waters. Today, 29th November 2024, I find myself as one of the Speakers at the 39th Annual Conference of the Fisheries Society of Nigeria, trying to unlock the investment potentials of the Nigerian blue economy.

Following the carving out of the Ministry of Marine and Blue Economy, the Fisheries and Aquaculture subsector has now found itself swimming in what we used to regard as an “ocean of plenty waters” where it is competing with such strong agencies like the Nigerian Maritime Administration and Safety Agency (NIMASA), Nigerian Shippers' Council (NSC); Nigerian Ports Authority (NPA) and National Inland Waterways Authority (NIWA). This, therefore, calls for more dreams, inspirations, and even discerning spirits on how the Fisheries and Aquaculture subsector will survive and be sustained.

Origin and Conceptualization of Blue Economy

The term “Blue Economy” was first introduced by Professor Gunter Pauli in 1994 as an economic philosophy reflecting business models for the future (Pauli, 2010). The concept gained prominence during the 1410 + 20 Summit 2012, introduced by the United Nations Environment Programme (UNEP) as an application of green economy principles to the ocean realm. The blue economy promotes economic growth, social inclusion, and livelihood preservation while ensuring environmental sustainability. It aims to decouple socio-economic development from ecological degradation and optimize the benefits derived from marine resources. The Blue Economy Concept was conceived as an alternative economic model for sustainable development, acknowledging nations' dependence on oceans.(UNECA 2016). It reflects a modern view that emphasizes sustainability, social justice, and intergenerational equality as guiding principles for further development.

Blue Economy is a term in economics that refers to the exploitation, preservation, and regeneration of the marine environment. It is an economic sector that seeks to conserve marine and freshwater environments while using them sustainably to develop economic growth and produce resources such as food, energy, and food. It also aims to reduce marine pollution and protect marine biodiversity, without which the blue economy may not be sustainable.

The Oceans are not only a source of jobs and wealth; the blue economy contributes to climate initiation by developing renewable energies in the high seas and decarbonizing maritime transport. The blue economy contributes to harmonizing human well-being, social equity, and environmental sustainability. This is against the old business-as-usual model where nations develop their ocean economics only through the exploitation of maritime and marine resources through shipping, commercial fishing, oil, and gas, as well as mineral development without paying adequate attention to the effect of such activities on the future health or productivity of the same resources and ocean ecosystem in which they exist. The blue economy concept provides a more holistic vision that embraces economic growth when it is sustainable and does not damage other sectors, like a green economy.

The Blue Economy in Nigeria comprises activities such as fisheries, aquaculture, shipping, coastal tourism, and offshore energy. With over 850 kilometers of coastline, an Exclusive Economic Zone (EEZ) of 923,768 square kilometers, and numerous rivers and lakes, Nigeria is well-positioned to harness the potential of its aquatic resources. However, the country's Blue Economy appears underdeveloped despite this natural endowment. Challenges such as inadequate infrastructure, poor regulatory frameworks, and environmental degradation have hindered its growth. Addressing these issues is critical to unlocking the full potential of Nigeria's Blue Economy.

UNLOCKING A SUSTAINABLE BLUE ECONOMY IN NIGERIA

The Blue Economy in Nigeria, also known as the Ocean Economy, is a term used to describe the economic activities associated with oceans and seas. The World Bank defined it as the sustainable use of ocean resources to benefit economics, livelihood, and the ocean ecosystem. According to the World Bank, the blue economy globally is worth more than $1.5 trillion annually. It provides over 30 million jobs and supplies over 3 billion people with vital protein resources. Nigeria's blue economy encompasses all economic activities related to the ocean, seas, and coast. It has significant potential for sustainable country development with its extensive coastline and rich marine resources. Nigeria can drive economic growth, create employment, and improve livelihoods by using its enormous marine resources sustainably. One of the key pillars of achieving an efficient blue economy in Nigeria is the sustainable exploitation of fisheries and aquaculture. Nigeria has a rich and diverse range of fish species, providing a valuable source of protein and income for millions of the populace.

However, unsustainable fishing practices such as overfishing and illegal, unreported, and unregulated (IUU) fishing threaten the sustainability of fish stocks and the livelihood of fishing communities. To address these challenges, Nigeria should implement effective fisheries management strategies, promoteSustainable aquaculture practices and combat IUU fishing through vigorous enforcement and international collaborations.

Generally, the blue economy is seen to encompass various aspects, as indicated by Yusuff & Ibidapo-Obe (2024), many of which are economically relevant to the Nigerian economy, as shown in the Table.

A Table showing the v arious aspects of Blue Economy.

Extraction of non-living resources	Harvesting of living resources	Commerce and trade in and around the ocean	Ecosystem protection and Management
• Seabed/deep seabed mining	• Fisheries	• Shipping (marine transportation)	• Surveillance and maritime security
• Oil and gas	• Aquaculture	• Ship building and repair	• Habitat protection/restoration
• Water (desalinization)	• Marine biotechnology	• Marine construction/ Port infrastructure e.g. jetties	• Blue carbon
• Dredging	• Recreational fishing	• Marine and coastal tourism/defense	• Hazard protection
• Energy/renewables (tidal/wave energy, coastal/offshore wind)	• Seafood processing	• Marine services (Maritime insurance, consulting, mapping, etc)	• Waste treatment and disposal
		• Marine education, research and development	• Ecological /ecosystem research

Source: Voyer *et al*., 2018

Advancing Fisheries and Aquaculture Sector in Nigeria

According to WorldFish (2023), Nigeria produces approximately 1.2 million metric tons of fish annually, but per capita fish consumption remains low at 11.3 kg per year, well below the global average of 21 kg. This gap reflects ongoing challenges in increasing local production to meet the needs of Nigeria's growing population, which now appears to be over 223 million. Records have shown that Nigeria's fisheries and aquaculture sectors contribute about 2% to the national GDP. However, despite this progress, local fish production is insufficient to meet demand, leading to fish imports that account for about 45% of total fish consumption, costing the nation about $1 billion annually.

Generally, fish farming significantly contributes to Nigeria's economy by providing income and employment opportunities. Nigeria, a maritime state with 9 out of her 36 states having a bank in the Atlantic Ocean, has a rich fishing environment, particularly in the littoral states of Nigeria that include Lagos, Ogun, Ondo, Delta, Bayelsa, Rivers, Akwa Ibom, and Cross River State in the southern part of the country. The fisheries subsector of Nigeria's economy is, therefore, an essential tool for rural development through its provision of income, high-quality protein, and socio-economic development in fishing communities in Nigeria.Traditional Fishing Practices, deeply rooted in local customs and knowledge, have historically supported sustainable fishing. However, these practices now confront challenges from overfishing, environmental degradation, and climate change impacts.

These issues threaten the long-term sustainability of the fish stocks and the well-being of fishing communities. In response to these challenges, there is a growing emphasis on adopting best practices and innovative approaches within Nigeria's fisheries sector for sustainable development.

This paradigm shift involves integrating modern technologies, promoting sustainable fishing methods, and enhancing conservation efforts. By embracing these innovations, Nigeria aims to improve fisheries management, increase productivity, and mitigate environmental impacts.

Addressing issues such as overfishing, pollution, and infrastructure deficits will not only protect marine ecosystems but also ensure continued economic benefits for fishing communities and contribute to national food security goals. By prioritizing sustainability, Nigeria can preserve its rich marine biodiversity and ensure the well-being of its coastal populations for generations.

Best Practices in Nigeria Fisheries

Implementing sustainable fishing methods and practices is crucial in advancing and maintaining Nigeria's fish populations. The use of selective gear by the fisherfolk will assist in minimizing the catch of juvenile fish. This practice helps to ensure that fish populations remain healthy and robust. Additionally, using “fish aggregating” devices (FADs) can minimize the environmental impact of fishing. The implementation of seasonal closures can also help to protect fish stocks. These measures give fish populations time to reproduce and replenish. The capacity of the fisherfolk could be built in this direction, which is geared towards the importance of sustainable practices. At the same time, training programs can expose them to effective “eco-friendly” methods.

Use of Technology in Tracking Fish Populations

Technology plays a vital role in modern fisheries management. Satellite tracking and GPS systems help to monitor fish movement and population. These tools provide accurate fish stock level data, enabling better management decisions. Electronic logbooks and reporting systems streamline data collection for fishermen. This technology reduces the administrative burden and improves data accuracy. Soner and underwater drones can assess fish population and their habitats. These devices also help to identify overfished areas and protect critical habitats. Mobile apps can also assist fishermen in reporting catches and observing regulations. Real-time data collection ensures that authorities have up-to-date information on fish stocks.

Government Regulations and enforcement for preserving fish stocks.

Government regulations are essential for sustainable fisheries management. Laws should set clear limits on the quota of fish that can be caught. The enforcement of laws could be in the following areas:

a. The allocation of fish quotas to prevent overfishing and ensure long-term fish stock health. Marine protected areas (MPAs) must be established to conserve vital ecosystems. MPAs provide “safe havens” where the fish population can recover and thrive.
b. Effective enforcement of regulations is critical to their success.
c. Patrol boats and Surveillance systems can detect illegal fishing activities. To deter noncompliance, penalties for violations should be strict.
d. Collaboration between government agencies and local communities enhances enforcement efforts. Community involvement ensures that regulations are respected and followed.
e. Regulations should also address the use of harmful fishing practices. Banning destructive methods like dynamite fishing protects marine environments.
f. Promoting the use of sustainable gear and techniques to support conservation efforts. Providing incentives for compliance can encourage fishermen to adopt sustainable practices.
g. Financial support for sustainable fishing initiatives can drive positive changes.
h. Research and data collection are crucial for informed policymaking. Ongoing studies on fish populations and ecosystems can also help refine regulations.
i. Stakeholder engagement is essential for developing effective policies geared towards advancing fisheries and the aquaculture sector for sustainable development involving the fisherfolk, scientists, and conservationists to ensure that regulations are practical-oriented and beneficial too.

j. There will also be the need for better Vessel Monitoring Systems (VMS) and reasonable enforcement of port states' measures.

ADDITIONAL MEASURES TO UNLOCK THE FISHERIES AND AQUACULTURE COMPONENT OF THE BLUE ECONOMY

A. CAPACITY BUILDING:

I am particularly concerned here about the ability of the fisheries sector workforce in the Ministry of Marine and Blue Economy, Universities, Research Institutes, Fisheries Colleges, and the Private sector. This fosters a sense of ownership and empowerment so that community partners gain greater control over their future development. It does this by developing and strengthening the skills, instincts, abilities, processes, and resources organizations and communities need to survive, adapt, and thrive in a fast-changing world.

I may not want anyone to accuse me of probably lamenting over the challenges of my noble fisheries and aquaculture profession as they battle to swim in the newly created Ministry of Marine and Blue Economy. After my lamentation, I pray for the systematic development and careful succession of Fisheries and Aquaculture professionals in the Department of Fisheries and Aquaculture. It is uncomfortable to have a situation where the senior ones continue to retire as Deputy Directors recently without attaining the position of Director. This calls for a strategic approach to capacity building for the staff concerned.

B. BOOSTING THE RECREATION AND TOURISM INDUSTRY through Large scale Aquarium Business.

One aspect of fisheries and aquaculture neglected in Nigeria is recreation and tourism. Unfortunately, while other parts of the world have gone far in fishing, Nigeria has yet to effectively utilize this venture to boost the Nigerian Gross Domestic Product (GDP). The time to unlock has now come. Nigeria can only make better progress in this economic aspect if the leaders can embrace long-term investments. This has been tried successfully in many parts of the world and has given.This has given rise to tourist attractions like the Underwater World at Sentosa Island, Singapore, and the Churaumi Aquarium in Okinawa, Japan, just to mention a few.

C. INCORPORATING THE FISHERFOLK INTO THE SECURITY NETWORK OF COMMUNITIES

The issue of integrating the local artisanal fisherfolk to serve as security informants, as is the case in many nations of the world, has been discussed for a very long time. There cannot be any successful security surveillance in the waters without adequately recognizing the roles of these critical and less recognized key players. When one talks of community policing on land, that of the seas is necessary to minimize illegal fishing, oil theft, and even infiltration of Nigerian waters by illegal foreign nationals. Policies should be put in place to equip these fisherfolk, which I see as co-managers, with GPS-equipped mobile phones and transponders to facilitate this approach. This would significantly improve their information network and assist the government security agencies.

I can still remember that this was one of the resolutions made during a two-day consultative meeting of the Honorable Minister of Agriculture and Rural Development (HMA) with key fisheries stakeholders on repositioning the fisheries subsector organized by Department of Fisheries and Aquaculture of the Federal Ministry of Agriculture and Rural Development from 25th to 26th of February, 2014 under the leadership of Dr. Akinwumi Adesina (who is presently the President of African Development Bank). Still, one cannot tell how far this was followed to a conclusive end. One of the objectives of that workshop was to facilitate stakeholders' shared vision of placing the fisheries sector on a path to sustainability, productivity, and profitability, with the requisite commitment of sustaining the momentum of the Growth Enhancement Scheme (GES), Fisheries and Aquaculture Value Chain (FAVC) development program within what was then called the Agricultural Transformation Agenda (ATA). These programs that probably appear forgotten may still play key roles at this time when the nation is making better efforts to unlock the blue economy. This has become necessary, particularly now that so much restiveness, militancy, and piracy have posed many challenges for the Fisheries subsector.

D. ASSENTING TO THE BILL ON THE FISHERIES INSTITUTE OF NIGERIA AND CHARTER

The studies of Oceanography, Marine Ecology, Fisheries, Aquaculture, and Climate Change have recently become very topical due to many events worldwide. These are professional areas that must be protected. There have been a lot of catastrophes all over the world, particularly in the Americas and Asia. Unfortunately, no one bothers to ask questions about the Nigerian territories. We must not wait until disasters overwhelm us.

These have become more paramount now that we have the Ministry of Marine and Blue Economy. There should be a better understanding of all aspects of economic generating. The various fishing settlements all over the country deserve protection as many of them are being sacked from where they are because of climate change. Many fish farms are also facing major environmental challenges. More technology must be activated to support the “artisanal fisherfolk' as the fisheries resources of our waters cannot be harnessed effectively without their contributions, and this should form part of the “unlocking of the blue economy.” At present, no one has asked many questions on the reasons for all the Boat mishaps we have been experiencing in the River Niger, particularly in Niger State, where our citizens are perishing on a regular basis as they navigate the waters. These are all part of the objectives for the Fisheries Institute of Nigeria proposal. The assenting of that bill by our dear President will attract more attention to this all-important sector of the Nigerian economy. The focus should not only be on licensing fish quotas for import in the newly created Ministry. Therefore, I join in appealing for the revalidation and assenting of the bill passed by the 9th National Assembly, as that will assist the profession in retaining the best brains in the areas involved. That will form part of the climax to unlock the Blue Economy, as there are many mysteries in the waters to exploit.

SOME CHALLENGES FACED BY THE FISHING INDUSTRY IN NIGERIA

The Nigerian Fishing Industry faces multifaceted challenges that threaten its sustainability and productivity. The non-enforcement of most regulatory frameworks tends to deplete fish stocks, disrupt marine ecosystems, and jeopardize the livelihood of fishing communities.

Pollution, including industrial discharge and improper waste disposal, further degrades aquatic habitats and poses health risks to marine life and consumer products. Additionally, the lack of essential infrastructure such as cold storage facilities, efficient transportation network and market access limits the sector's potential for growth and profitability. The adoption of sustainable fishing practices is crucial to safeguarding Nigeria's marine resources for future generations.

Sustainable practices aim to conserve fish populations, protect biodiversity, and maintain the ecological balance of marine ecosystems. Initiatives such as establishing marine protected areas, implementing fishing quotas, and promoting responsible fishing techniques are essential steps towards achieving sustainability. These measures ensure the resilience of fish stocks, support the economic stability of fishing communities, and enhance food security nationwide. While Nigerian fisheries face significant challenges, proactive measures and collaborative efforts are crucial to securing a sustainable future.

GENERAL RECOMMENDATIONS

By harnessing the potential of the blue economy, Nigeria can achieve inclusive economic growth, sustainable development, and environmental stability. Advancing the Nigerian fisheries, aquaculture, and ornamental fish sector requires a multifaceted approach to ensure sustainable development. Focused and strategic efforts must be geared towards some time-bound goals—short-term, medium-term, and long-term goals.

Short-term goals (2024-2025)

- Improve infrastructure: Upgrade fishing ports, landing sites, and markets.
- Enhance regulation: Strengthen enforcement of fishing laws and regulations.
- Increase funding: Allocate more resources to the sector
- Promote aquaculture: Encourage investment in fish farming.
- Develop value chain: Support processing, packaging, and export.

Medium-term goals (2025-2030)

- Research and development: Invest in fisheries research and aquaculture technology.
- Capacity building: Train fishermen, farmers, and processors.
- Market development: Expand domestic and international markets.
- Environmental sustainability: Implement eco-friendly practices.
- Private sector engagement: Encourage investment and public-private partnerships.

Long-term goals (2030-2040)

- Industry transformation: Shift from subsistence to commercial fishing and aquaculture.
- Job creation: Generate employment opportunities through massive ecotourism.
- Food security: Increase protein availability.
- Export-oriented growth: Boost foreign exchange earnings.
- Climate resilience: Develop adaptive strategies.

Key stakeholders such as the Federal and state governments, the private sector (investors), academia and research (Universities, Colleges, and Research institutions), Fisheries cooperatives, and international organizations (e.g., FAO) must be involved. Policy reviews and development, including the National Fisheries and Aquaculture Policy review, strengthening of regulatory frameworks, and increased funding are also needed. Partnerships must be geared to promote public-private partnerships and enhance regional and international cooperation.

It must be understood that there are some challenges with the opportunities presented by the blue economy, growing demand for seafood, untapped aquaculture and ornamental fish potential, great job creation, export market expansion, and sustainable development. These include:
- Climate change
- Overfishing
- Inadequate infrastructure
- Limited funding
- Regulatory inefficienciesBy addressing challenges and leveraging opportunities, Nigeria can unlock the potential of its fisheries and aquaculture sector, contributing to sustainable development and improved livelihoods.

CONCLUSION

Nigeria's blue economy has vast opportunities and challenges, particularly in the fisheries and aquaculture sectors. Nigeria's extensive coastline and abundant marine resources offer significant potential for economic growth, job creation, and environmental sustainability. However, inadequate infrastructure, weak regulatory frameworks, and ecological degradation hinder progress. This speech emphasizes the need for sustainable exploitation of marine resources to ensure long-term benefits. Overfishing, illegal and unregulated fishing, and environmental damage threaten fish stocks and the livelihoods of fishing communities. The government must implement robust fisheries management strategies, promote sustainable aquaculture practices, and collaborate internationally to combat these issues. The key strategies for unlocking the blue economy's potential include adopting modern technologies like satellite tracking and electronic logbooks to monitor fish populations and enforce regulations. Additionally, community involvement and government enforcement are crucial for the success of conservation and anti-illegal fishing efforts.

Capacity building within the workforce, investment in infrastructure, and a shift toward sustainable fishing practices are essential. Incorporating fishing communities into security networks can enhance surveillance and reduce illegal activities in Nigeria's waters. By fostering collaboration among stakeholders— government, private sector, research institutions, and international organizations—Nigeria can tap into the blue economy's vast potential, ensuring economic growth while preserving marine ecosystems for future generations. There must be a clear vision for the future of Nigeria's blue economy, involving short-term, medium-term, and long-term goals, ranging from infrastructure improvement to climate resilience and export-oriented growth. By addressing the challenges and leveraging the opportunities, Nigeria can unlock the full potential of its fisheries and aquaculture sectors, driving sustainable development and improving livelihoods across the country.

REFERENCES

FAO (2023). FISH4ACP Catfish Sector Initiative (2023): Focuses on enhancing the resilience and efficiency of Nigeria's catfish sector.

FAO (2024). The State of World Fisheries and Aquaculture 2024 – Blue Transformation in Action. Rome. pp. 264. https://doi.org/10.4060/cd0683en

Kabo, P.D.; Zarmal, D.U.; Jusemya, B.A. and Dikwahal, S.H. (2024). The Role of Fisheries Resources in National Development: A Review Article. International letter of Natural Science, July 2024.

Nlewadim, A. A. (2019). Fisheries and Fisheries: the mysteries in the waters. 39th Inaugural Lecture presented on 6th March 2029 at Michael Okpara University of Agriculture, Umudike, Abia State. pp.44.

Pauli, G. A. (2010). The Blue Economy: 10 Years, 100 Innovations, 100 million Jobs

The Blue Economy Series. Paradigm Publications. 308pp.UNECA (2016) United Nations. Economic Commission for Africa (2016-03) Economic Report on Africa: Greening Africa's Industrialization. Addis Ababa. © N.ECA. https://hdl.handle.net/10855/23017"

Voyer, M., Quirk, G., Mcllgorm, A. & Azmi, K. (2018). Shades of blue: What do competing interpretations of the blue economy mean for ocean governance? Journal of Environmental Policy and Planning, 20(5): 595-616.

WorldFish (2023). Nigeria Country Profile (2023): Provides statistics on fish production, consumption, and the challenges Nigeria's fisheries sector faces.

Yusuff, K. O. & Ibidapo-Obe, E. O. (2024). Blue Economy in Nigeria: Focus Areas, Potentials And Challenges. International Journal of Women in Technical Education and Employment, 5(1): 161 – 169.

BIOTECHNOLOGY AND BLUE ECONOMY

LEAD PAPER DELIVERED BY PROF. OLUFEAGBA S. OLABODE AT THE 39TH ANNUAL NATIONAL CONFERENCE AND GENERAL MEETING OF FISHERIES SOCIETY OF NIGERIA HELD AT NATIONAL UNIVERSITY COMMISSION, ABUJA ON 28TH OCTOBER TO 1ST NOVEMBER, 2024.

Introduction

The United Nation first introduced the word "blue economy" at a conference in 2012. The word "blue" is the shade of the sea and of the ocean and that defines the world of biotechnology. The blue economy has been projected as the next great economic frontier especially where the bio-resources are exploited sustainably.

Blue economy is a term that refers to the different range of economic activities that are carried out in lakes, rivers, ocean and seas. According to Algattan (2024), blue economy can be divided into six major areas

i Marine Biotechnology which involves the application of science and technology to marine resources, extracting new products and services.

ii Marine Aquaculture which involves the cultivation of shell fish and fish in controlled marine environments for commercial use.

iii Ocean Renewable Energy which involves harnessing energy from ocean waves, tides and currents to produce power

iv Maritime Security which involves protecting sea lanes and maritime territories from piracy and smuggling

v Costal and Cruise Tourism which involves developing sustainable tourism that leverages marine and costal environment

vi Seabed Mining which involves extracting minerals and resources from the ocean floor in an environmentally responsible manner.

According to Smithers Group (2015), global market for marine biotechnology can possibly reach $4.8 billion by 2020, rising to $6.4 billion by 2025. In Nigeria, the nation is lagging behind in the application of biotechnology for the exploitation of the myriads of resources in both the marine and coastal water bodies. The recent creation of the ministry of blue economy has a great potential in unleashing great revenue and prosperity on Nigeria.

The different sectors are a revelation of the vast opportunities and potential of resources that are available for exploitation. Resources available for exploitation and human use include but not limited to fishing, transportation, renewable energy, mariculture, telecommunication e.t.c

Nigerian economy heavily depends on crude oil and any crash in the oil market will result in a decline in GDP. Therefore, there is a need to look for alternative economic pathways for national and economic sustainability. Blue economy is a lush alternative with great potential to replace major chunk of oil revenue or diversification in revenue generation.

Water Resources Profile of Nigeria

Nigeria has significant water resources estimated at 215 billion m3 of surface water (river, lakes, and reservoirs) and 87 billion m3 of ground water resources. The costal and marine environment cover about 853 km and fresh water is made up of two (2) major river systems and several inland water that

takes their sources from four (4) hydrological basins (North central plateau, western highlands, eastern highlands and the uri plateau). There is a huge opportunity in the development of blue economy from both the rivers and the oceans.
There are possibilities of several applications of science and technological advancements to explore the ocean of their abundant resources.

According to Uddim and Mohammed (2019), the marine and fresh water could be exploited with biotechnology tools to yield far beyond the current level of exploitation. The areas of possible biotechnological exploitation include but not limited to marine biotechnology, sea renewable energy, offshore wind energy, marine and seabed mining, deep water oil and gas, maritime safety and surveillance, marine unconventional products and services and even marine research and development.

1. Opportunities in feed production

eed takes about 70% of cost of production on fisheries and is strongly competing with human protein need. The abundant unconventional fishery products in rivers and oceans (mussel, squid, oyster) seaweeds, micro algae are huge source of animal protein for feed formulation (Fig 1)

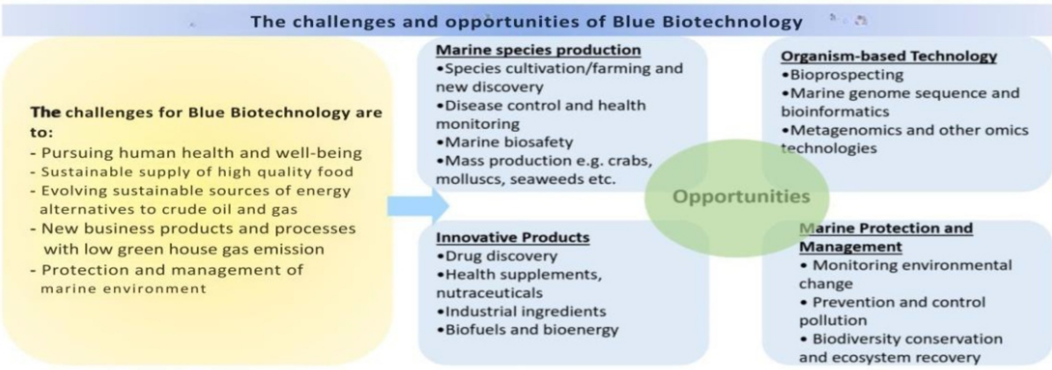

Figure 1: The grand challenges and evolving opportunities of blue biotechnology (Adapted from Uddin and Islam, 2019).

2. Opportunities in renewable energy

This is the most innovative marine renewable energy for electricity provision. Several countries have invested in this. The offshore line of Nigeria is a potential location of wind driven tidal powered electricity for clean and cheap generation.

Nigeria and many countries of the world can have energy security and additional greenhouse gas emission reduction when energy production is directed at the vast ocean current (Fig 2). Production of energy from tides and waves, wind turbines situated offshore could be a cheaper and cleaner replacement for energy requirement and security.

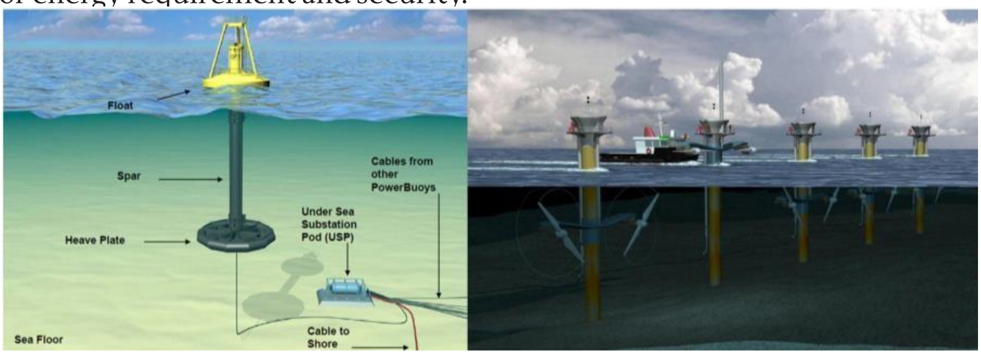

Figure 2: Tidal power generation (Adapted from Uddin and Islam, 2019).

3. Opportunities in biotechnology

Biotechnology is a highly science driven industry sector that uses living organisms and their derivatives to produce products. In the blue biotechnology and blue economy, molecules and substances from water origin are primary targets. One of the uses and application of biotechnology in the blue economy is the culture of fish (mariculture and aquaculture). Principal area of possible application of biotechnology is in the introduction of growth promoter gene which could increase growth significantly and reduce drastically cost of production and duration.

Heppell et al (1998) highlighted that, DNA vaccines are harmless, modest and proficient to be utilized as a part of aquaculture industry for disease control. The use of monoclonal antibiotics and DNA probes for diagnostic strategies for pathogens is also a veritable opportunity (Fig. 3). Application of biotechnology tools in stock assessment, genetic variation studies etc. Several molecular tools; mitochondrial DNA (mtDNA), Nuclear DNA (nDNA), DNA chips (micro arrays), (marine natural products), micro satellite DNA markers are useful for fish identification and management. (Olsen et al 2000, Komoroske et al, 2017).

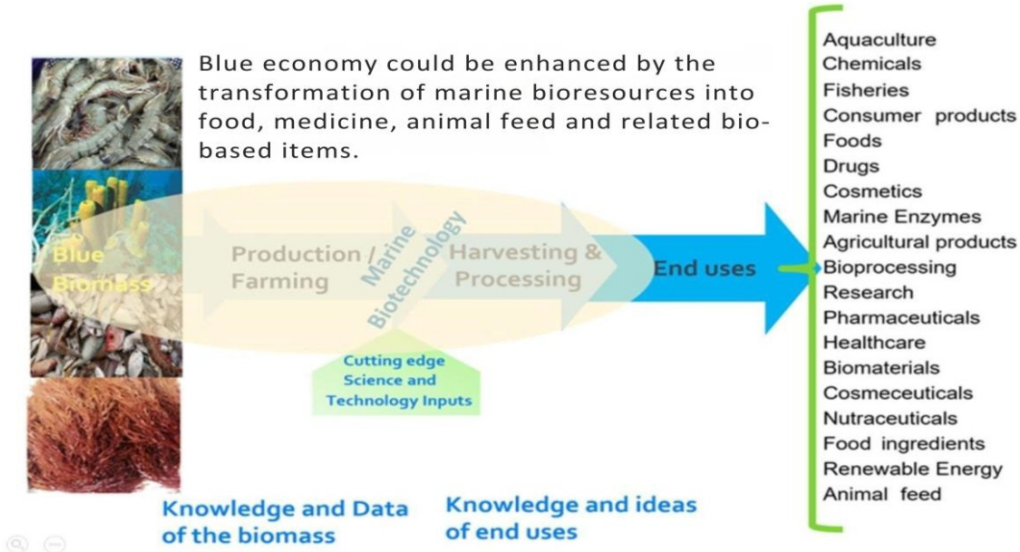

Figure 3: Transformation of Blue biomass into industry or process sectors (Adapted from Uddin and Islam, 2019).

4. Opportunities in pharmaceutical

Bioresources from marine and fresh water like modern chemical compounds, enzymes, drugs etc. are new and highly precious resources that has high impact in the life of people. According to Uddin and Mohammed (2019), example of these new areas includes bioprocessing, ecological remediation etc. According to Ebel and Joseph (2015), marine fish, sponges, molluscs and bacteria are the main sources of bioactive compounds that shows various anti-tumour, anti-inflammatory, analgesia, immunomodulation allergy and anti-viral properties.

As of march 2018, the US FDA has approved seven marine derived drugs for clinical use and another 22 were at different stages of clinical trials (Mayer, 2018).

Other areas of growing business are nutraceutical products like pre-biotic, minerals, fibres, omega-3 etc (Fig 4).

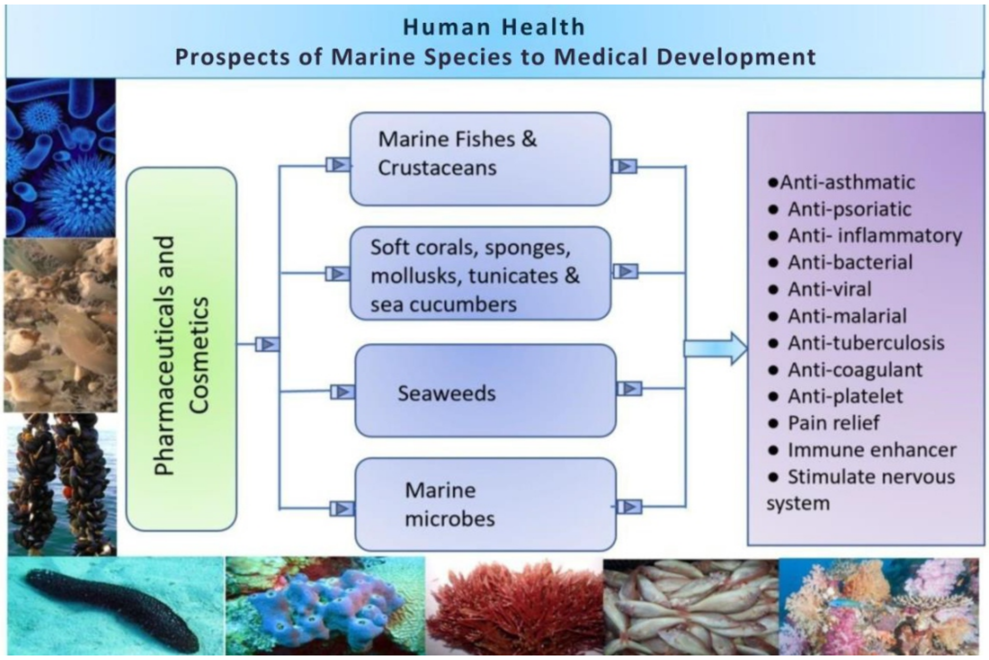

Figure 4: Prospects of marine bioresources to clinical development (Adapted from Uddin and Islam, 2019).

The production of marine fish species will extend the utilization of species that are cultured. New methods of breeding and application of genetics (triploidization, tetraploid induction and interploidy induction) will all lead to increase fish yield. Other areas where the blue economy will enhance fish biomass and yield are (i) increasing culture of biomass from marine resources (ii) increase in controlled culture of both marine and fresh water fish species. Blue economy will eventually lead to market expansion and product innovation.

International Business Relations and Activities

According to Uddin and Islam (2019) despite the huge possibilities in blue economy, challenges with respect to its exploration exist. This includes ocean acidification. This can only be handled by joint activity at a global level, otherwise the potential will mostly be a mirage.

The United Nation specifies blue economy to include range of activities related to oceans, seas and coastal areas. This is principally to promote economic growth, social inclusion and preserve livelihoods. In 2015, all United Nations member states adopted a development policy of sustainable development goals (SDG). The 17 global goals provide a global blue print for peace and prosperity of people and the planet and set to be achieved by 2030. Goal 13 labelled life below water, concerns conservation and sustainable use of the oceans, seas and marine resources for sustainable development and demands. The oceans and seas are key sources of food, energy and minerals.

Nigeria's' establishment of a full-fledged ministry of marine and blue economy in 2023 demonstrates the realization of the potential inherent in the ocean resources, the global and local surge in deep sea exploration. The ministry set a target of establishing at least five (5) new fish processing plants by 2025.

1: Marine unconventional fisheries items, their present status and recommended extraction practices

Important Unconventional fishery items	Exploitable species in marine waters	Current usage pattern and harvest technique	Recommended extraction practices	Reference
Seaweeds	*Caulerpa racemosa, Hypneapannosa Enteromorpha* spp. *GelidiellatenuissimaGelidiumpusillum Sargassum* spp	Extraction from nature use as vegetables, salad, main ingredients for soup, export items. Mostly collected from beach by hand.	Extraction from nature within sustainable limit. Culture practices should be introduced for exploitation	Zemke-White and Ohno, 1999
Mangrove horseshoe crab	*Carcinoscorpius rotundicauda*)	No extraction is reported	Extraction from natural source within sustainable limit	Vestbo *et al*. 2018
Lobstar	*Panulirusornatus* Panuliruspolyphagus *Panulirus*versicolor	Mainly collected from deep seas and rocky beach in the southeastern coast. Mostly sale at local market as fresh or frozen some time exported. Dry specimens also sold as souvenirs. Usually harvested by bottom set gillnets, trawl nets and by diving.	Extraction from natural source within sustainable limit. Culture practices should be introduced for exploitation	Ahmed *et al*. 2007
Sepia	*Sepia haraonis Sepia intermis*	In recent years, these species are heavily exploited. Became a delicacy for their thick and tender flesh, mainly consumed by tribal people and tourists. Usually caught by light lures, traps, push nets, purse seins and hook and line.	Extraction from nature within sustainable limit.	Siddiqui *et al*. 2007
Octopus	*Octopus Macropus* Octopus rugosus	The octopus fishery also became important for local consumption by the coastal people as well as export industries. This fishery has high demand in the south-east Asian countries, usually harvested in the sub-tidal habitats by trawl and spear, and on the intertidal reefs and rocky shore by hand or spear.	Extraction from nature within sustainable limit.	Siddiqui *et al.* 2007
Loligo	*Loliolus Hardwicke, Photololigo duvaucelii*	Recent years fishers involved in this fishery and became a profit-oriented fishery. The species is marketed as fresh, frozen, dried or processed into cleaned mantle (whole hoods, rings). Captured by fishing techniques using light attraction.	Extraction from natural source within sustainable limit	Siddiqui *et al*. 2007
Oysters	*Crassostrea ariakensis, Crassostrea gigas, Crassostrea gryphoides*	Meat of oyster use as food, mainly by tribal people.	Extraction from natural source with sustainable limit. Culture practices should be introduced for exploitation	Siddiqui *et al*. 2007
	Crassostrea virginica			
Edible Jellyfish	*CepheacepheaCatostylusmosaicusCrambionemastigophora Crambionella orsisi Lobonema smithii RhizostomapulmoRhopilemahispidumNeopilema nomurai*	No extraction practice is reported for jellyfish industry. Its future looks promising due to the abundance of these jellyfish Processed jellyfish, as a delicacy, have potential Japanese market.	Extraction from natural source	
Turtle	*Lepidochelys olivacea* Chelonia mydas Eretmochelys imbricate Caretta Liposcelis Dermochelys coriacea	Local people indiscriminately porch turtle eggs for sale and consumption. Turtle meat consume by tribal population.	Sea turtle farming (Green turtle can be a promising ocean-based economic activity	Sarker *et al.* 2018

(Adapted from Uddin and Islam, 2019)

In conclusion, government should urgently understudy the potential of fisheries and fisheries products in the ocean as very little is known about their ecological status, potential harvest and utilization. According to Uddin et al, (2019), allowing commercial exploitation will require detailed knowledge of the abundance of the target species. For example, Size at sexual maturity is needed to know to set size limits to protect immature species, Identification of the areas where these species occur is needed to close fishing in some areas to protect a proportion of the population, to protect the habitat, Identification of the unit stock is needed to protect a proportion of each stock to ensure that individual stocks are not over fished and over protected. The Federal Ministry of Blue Economy should actively develop a marine fisheries management plan to sustainable management marine conventional and unconventional fisheries. Development of a legal framework covering all unconventional fishery items is important before commercial exploitation these species start. The Government should actively promote sustainable exploitation and conservation of unconventional fisheries through providing training, awareness building and market development. With the vast ocean water available, Nigeria has the potential to massively exploit the resources in them for the well being of the nation.

REFERENCES

Alqattan, E.A. M (2024): The Kuwaiti blue economy and its potential obstacles. Heliyon 10 e30975 Ebel, E.R.A., and Jaspars, M. (2015) Report of the 9th European Conference on Marine Natural Products. Marine Drugs. Dec; 13(12): 7150–7249.

Heppell, J., Wu, T., Lorenzen, N., Ellis, A.E., Efler, S.M., Armstrong, N. K., Schorr, J., and Davis, H. L. (1998) Development of DNA vaccines for aquaculture. In Gal, YL., and Halvorson, HO. (Eds.), New development in marine biotechnology. New York: Plenum Press. http://marinepharmacology.midwestern.edu/clinPipeline.htm (accessed 13 June 2018)

Komoroske, L.M, Jensen, M.P., Stewart, K.R., Shamblin, B.M., and Dutton, P.H. (2017) Advances in the Application of Genetics in Marine Turtle Biology and Conservation. Front. Mar. Sci. 4:156. doi:10.3389/fmars.2017.00156. 12

Mayer, A.S.M. (2018) Marine Pharmaceuticals: The Clinical Pipeline, Midwestern University, Available at: http://marinepharmacology.midwestern.edu/clinPipeline.htm

Olsen, J.B., Bentzen, P., Banks, M.A., Shaklee, J.B., and Young, S. (2000) Microsatellites reveal population identity of individual pink salmon to allow supportive breeding of a population at risk of extinction. Transaction of the American Fisheries Society 129:232-242.

Smithers Group (2015) The Future of Marine Biotechnology for Industrial Applications to 2025. Available at: http://www. smithersrapra.com/products/market-reports/biomaterials/thefuture-of-marine-biotechnology-for-industrial.

Uddin, Sheikh Aftab and Islam, Mohammad Mahmudul (2019) "Blue Biotechnology, Renewable Energy, Unconventional Resources and Products as Emerging Frontiers at Sea," Journal of Ocean and Coastal Economics: Vol. 6: Iss. 2.

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AQUATIC POLLUTION AND MANAGEMENT (APM)

ASSESSMENT OF WATER QUALITY AND HEAVY METALS IN WATER, FISHES AND SEDIMENTS OF KIRI RESERVOIR, ADAMAWA STATE, NIGERIA.

[*1]Edward, A., [1]P. M. Ziga, [1]N. Adamu, [2]V. R. Ndeham, [2]l. Bitrus And [3]A. Ishaku
[1]Department of Fisheries and Aquaculture, Adamawa State University, Mubi, P. M. B 25, Mubi, Adamawa State, Nigeria.
[2]Department of Fisheries, Federal Polytechnic Mubi, P. M.B 35, Mubi, Adamawa State, Nigeria.
[3]Department of Fisheries and Aquaculture, Federal University, Gashua, P. M. B 1005, Gashua, Yobe State, Nigeria.
[*]Corresponding Author:
edward230@adsu.edu.ng, +2348032488029, 0000 0003 0086 7272

ABSTRACT
Assessment of Water Quality and Heavy Metals in Water, Fishes and Sediments of Kiri Reservoir, Adamawa State was conducted for the period of eight months from January to August, 2024. Data were collected from three different Sites monthly in triplicate. Some water quality parameters were measured at the sites while others were analysed in the laboratory. Heavy metals were determined using Atomic Absorption Spectrophotometer. Water quality parameters showed some slight but were within recommended levels for tropical fisheries. Chromium and Cadmium were below detection levels. Copper, Nickel and Lead were slightly above the recommended permissible limits. All heavy metals investigated were in measurable amount in sediments. Cadmium, Chromium and Lead in Sediments were beyond permissible level. Heavy metals in fish revealed that Copper, Nickel and Lead were present in fish. The maximum value of Copper in fish did not exceed the allowable limit of 3.0 mg/kg. The maximum values of nickel were within the recommended limits of 0.5-0.9 mg/kg. The maximum values of Lead exceeded the maximum limit of 0.2 mg/kg. Therefore, Kiri Reservoir can be suitable for the survival and growth of fish although slightly contaminated.

KEYWORDS:
Water quality, Heavy metals, Sediments, Reservoir.

INTRODUCTION

Water quality is defined as the suitability of water for the survival and growth of fish and is governed by many variables (APHA 2017) . Concerns about water quality are directly related to its production and therefore water quality parameters are of greatest concern to fish farming and are important to consider in fish culture (David et al 2015). Water is a critical factor in the life of all aquatic species. In aquaculture, any characteristic of water that affects the survival, reproduction, growth, or management of fish or other aquatic creatures in any way is a water quality variable. One of the major environmental issues of our time is the growing demand of water quality conditions suitable for aquatic organisms like fish APHA (2017). Heavy metal contamination in aquatic environments has continued to attract global attention, this is due to their abundance, wide range of sources and bioaccumulation sediments (Ekpechi, and Okori, 2022). It has been found to react with some organic substances under certain conditions to convert them into even more toxic metal-organic complex pollutants. According to Edward (2020) heavy metals cannot be degraded, they are deposited, assimilated or incorporated in water sediment and aquatic animals. Kiri reservoir is the main source of water for irrigation, fishing, domestic and industrial purposes in that area, Agricultural activity like farming takes place in Kiri and environ in which Fertilizers, Pesticides and herbicides are extensively used to increase yield and also to control pests, diseases, weeds and other plant pathogens, also other domestic wastes can generated flows into the reservoir and may contaminate the water with a variety of contaminants especially heavy metals. With changing environmental conditions under increasing anthropogenic activities which might affect the nature of Kiri Reservoir and might also leads to drastic changes in it biological productivity, hence the need for this research.

MATERIALS AND METHODS

Study Area

The research was carried out in Kiri reservoir. Kiri reservoir is located on floodplain of lower Gongola River basin, about 25km upstream of its confluence with River Benue at Numan Zemba, (2016). The research was conducted for the period of eight months, January to August, 2024.

Water quality parameters

Temperature, pH, Electrical conductivity, and Transparency were measured directly on water samples at the sampling stations using mercury bulb thermometer, pH meter, conductivity meter as recommended by ((APHA 2017)). The total dissolved solid was determined as described by (WHO, 2022). Determination of heavy metals in the water samples were determined as described by the American- Public Health Association (APHA 2017). Water samples were digested and determination of Copper, Zinc Lead, Cadmium and Iron were made directly on each final solution using Atomic Absorption Spectroscopy (AAS) (VGP 210.

Fish, water and sediment sampling, digestion and heavy metal determination

Fish species *Clarias gariepinus*, Oreochromise niloticus and Aucchenoglanis occidentalis, water and sediments were collected from the study area from January to August, 2024 forth nightly in triplicate. Samples were digested with tri-acid mixture of sample and were placed on a hot plate at 100°C temperature. The sample was allowed to cool and then filtered through whatmann 41 filter papers. Determination of Heavy metal like Cd, Cu, Ni, Pb and Z were made directly on each final solution using a Buck Scientific 200A model, Atomic Absorption Spectrophotometer (AAS) and the values obtained was expressed in milligram per kilogram (mg/kg) (APHA 2005). Data obtained in this study was analyzed using one way Analysis of Variance (ANOVA). LSD± was used to separate means at $P>0.05$ level of confidence.

RESULTS AND DISCUSSION

The mean variation of water quality parameter is presented on Table 1. The result of the study showed some slight variation in water quality parameters between sampling sites and months of sampling. The slight variation in some of the parameters could be attributed to the flow variability and changes in water shed condition. This agrees with the observation by (Edward et al, 2016) who reported that the high variability of water quality may be due to impact of many factors such as rainfall, surface run-off from farms, tributaries and catchments activities during the wet and dry season periods. The result of the heavy metals in water, fish and Sediment is presented on Table 2. The results of the analysis of heavy metals in water showed some variations in this study. Cadmium and chromium were beyond detection level in water samples. The non-detection of these heavy metals may be due to the inability of the metals to dissolve in water and got deposited to the bottom in the sediments as observed in this study and this is because water sediment are metal reservoirs trapping all the heavy metals that escape detection in water. Research has revealed that nearly all metal content in aquatic environment resides in water sediment (Edward, 2020)). This could be attributed to the variations in natural and anthropogenic activities at the sampling sites. The result of heavy metal in fish showed a significant variability in the accumulation from the sampling months which principally depended on the bioavailable of metal concentration in their aquatic habitats (Edokpayi et al, 2016). The accumulation of heavy metals in fish species were found to be influenced by several factors like temperature, pH of water, conductivity, rainfall, hardness, salinity and also by biotic community interaction. The variation in metal concentration in the fish might be due to different sources of metal pollution, intensive human activities and discharge of municipal waste. Generally, heavy metal concentrations in the tissue of freshwater fish vary considerably among different studies (Nkinda et al, 2021), possibly due to differences in metal concentrations and chemical characteristics of water. Cadmium and Chromium were below detection level in fish organs.

Table 1: Mean Water Quality Parameters of Kiri Reservoir

Months	TEMP	Ph	EC	TRAN	DO	BOD	AMM	ALK	PO_4	NO_3
JAN	22.13±0.87	7.58±0.38	85.81±9.92	19.79±2.00	8.26±0.25	3.47±0.32	0.05±0.03	88.37±5.01	3.19±0.37	4.39±0.42
FEB	21.05±0.85	7.74±0.37	84.53±9.82	17.00±2.30	7.88±0.26	3.78±0.38	0.06±0.07	81.85±5.01	2.41±0.67	3.46±0.42
MAR	26.14±0.83	7.55±0.34	80.15±9.92	16.71±2.07	8.47±0.25	3.47±0.32	0.04±0.03	97.75±5.01	2.65±0.37	2.83±0.42
APR	26.77±0.85	7.41±0.37	80.32±9.82	17.61±2.00	7.53±0.29	3.52±0.39	0.05±0.03	97.17±5.01	2.53±0.37	3.61±0.42
MAY	27.87±0.83	7.01±0.38	111.47±9.90	24.65±2.00	7.07±0.27	2.86±0.34	0.07±0.03	92.19±5.01	1.62±0.27	1.97±0.42
JUN	27.75±0.85	7.46±0.37	105.34±9.92	25.72±2.08	6.76±0.25	3.10±0.32	0.08±0.09	79.89±5.21	2.96±0.37	2.54±0.47
JUL	27.93±0.85	7.79±0.77	93.90±9.92	30.72±2.00	7.79±0.15	3.73±0.31	0.08±0.02	85.22±5.04	2.83±0.47	2.63±0.42
AUG	28.43±0.89	7.72±0.32	75.48±9.94	32.61±2.00	5.68±0.25	4.14±0.36	0.09±0.03	110.33±5.01	2.06±0.36	4.05±0.43
MEAN	26.01±0.89	7.53±0.32	89.63±9.94	23.10±2.00	7.43±0.25	3.51±0.36	0.07±0.03	91.60±0.03	2.53±0.36	3.19±0.43

Pb-Lead, Cu-Copper, Cd- Cadmium, Ni-Nickel, Cr-Chromium.

Table 2: Mean Heavy Metals in water, Fish and Sediment of Kiri Reservoir

	Water			Fish				Sediment			
Month	Pb	Cu	Ni	Pb	Cu	Ni	Cr	Cd	Pb	Cu	Ni
JAN	0.02±0.71	0.27±0.66	0.04±0.05	0.04±0.10	0.44±0.13	0.04±0.02	0.56±2.82	0.86±0.29	0.62±0.28	18.45±0.51	9.80±0.63
FEB	0.03±0.21	0.33±0.06	0.04±0.09	0.41±0.10	0.62±0.13	0.07±0.02	0.56±2.78	0.81±0.24	0.93±0.24	17.87±0.36	9.71±0.65
MAR	0.03±0.11	0.12±0.07	0.03±0.01	0.22±0.10	0.67±0.13	0.07±0.02	0.50±2.98	1.03±0.26	0.58±0.22	17.50±0.54	9.94±0.68
APR	0.02±0.61	0.11±0.06	0.04±0.29	0.25±0.10	0.58±0.13	0.08±0.02	0.49±2.76	0.78±0.23	0.51±0.24	17.91±0.51	10.31±0.65
MAY	0.04±0.11	0.27±0.09	0.04±0.07	0.05±0.10	0.61±0.13	0.09±0.02	0.06±2.70	2.96±0.94	0.62±0.28	19.05±0.58	9.51±0.65
JUN	0.03±0.31	0.26±0.06	0.05±0.09	0.24±0.10	0.55±0.13	0.08±0.02	0.07±2.77	1.11±0.24	0.93±0.24	18.01±0.16	10.27±0.63
JUL	0.04±0.11	0.20±0.05	0.06±0.79	0.09±0.10	0.73±0.13	0.08±0.02	0.59±2.74	0.93±0.27	0.58±0.22	19.74±0.56	7.90±0.64
AUG	0.05±0.19	0.19±0.16	0.03±0.09	0.07±0.10	0.46±0.13	0.07±0.02	0.87±2.71	0.71±0.24	0.51±0.24	19.43±0.56	8.35±0.61
MEAN	0.03±0.19	0.22±0.16	0.04±0.09	0.17±0.10	0.58±0.13	0.07±0.02	0.46±2.71	1.15±0.24	0.66±0.24	130.96±0.56	9.47±0.61

Pb-Lead, Cu-Copper, Cd- Cadmium, Ni-Nickel, Cr-Chromium.

All the heavy metals investigated were present in sediments. Unlike in water and fish. The reason why all these heavy metals were found in sediments may be due to the inability of these metals to dissolve in water and got deposited to the bottom in the sediments. Sediments are metal reservoirs trapping all the heavy metals that escaped detection in water. Research has revealed that nearly all metals content in aquatic environment resides in water sediments (Ekpechi, and Okori, 2022). The result of the heavy metal in sediments in this study showed some variability of metal levels. This variation could be attributed to variation in environmental content of different sampling months as well as the diversity of the different activities taking place around the study area.

CONCLUSION

In conclusion therefore, a slight variation in Water quality parameters between sampling months was observed. Not all the heavy metals investigated were in measurable amount in water, Chromium and Cadmium were below detection levels. Copper, Nickel and Lead were slightly above the recommended permissible limits. All heavy metals investigated were in measurable amount in Sediments. Cadmium, Chromium and Lead in Sediments were beyond permissible level. Heavy metals in Fish investigated revealed that Copper, Nickel and Lead were present in Fish. The maximum value of Copper in Fish did not exceed the allowable limit. Therefore, Kiri Reservoir can be suitable for the survival and growth of fish although slightly contaminated. Assessment of water quality parameters and heavy metals in water, sediments and fish should be done regularly to ascertain the healthy state of Kiri reservoir.

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REFERENCES

APHA (2017). Standard Methods for the Examination of water and waste water.17thEdn. Washington, D.C. 35-41.

Ayeku, P.O., Adakole, J.A. and Balarabe, M.I. (2015). Spiked Sediments Toxicity of Cd, Pb, Cr, Zn, Mn and Fe on Chironomus riparius. Proceeding of 30th FISON Annual Conference, Delta State. 80-84.

David, D L., Edward, A., Addass, P. A and Jesse, C. (2010). Some Aspect of water quality and the biology of Clarias gariepinus in Vimtim Stream, Mubi Adamawa State. World Journal of Fish and Marine Sciences. 2(2):129-133

Ekpechi, D. and Okori, B. (2022). Seasonal variation of heavy metals in sediments, water, shiny nose fish, shrimp and periwinkle in esukEkpoEyo Beach Akpaiyo, South East, Nigeria. Journal of environmental treatments techniques. 10(4): 264- 283.

Edokpayi, J., Odiyo, J., Popoola, E. and Msagati, T. (2017). Evaluation of temporary seasonal variation of heavy metals and their potential ecological risk in Nzhelele River, South Africa. Journal of open Chemistry 15(1).

Edward, A., Abubakar, A.K. and Ladu, B.M.B (2016). Evaluation of heavy metals concentrations in water and sediments from Upper Benue River, Yola, Adamawa State, Nigeria. Proceeding of the 31st Annual Conference of Fisheries Society of Nigeria (FISON) held on 30th Oct-4th Nov at Umaru Musa Yar'adua University, Katsina, Nigeria. 109-110.

Edward, A. (2020). Seasonal variability of heavy metal concentration in water and sediments from Upper River Benue Yola,Adamawa, State. Journal of Environmental Science, Toxicology and food technology. 14(2):01-04

Nkinda, M., Rwiza, m., Ijumba, J., Njau, K. (2021). Heavy metal risk assessment of water and sediments collected from selected river tributaries of the Mara Rivers in Tanzania.

World Health Organization (WHO) (2022). Guidelines for drinking water quality. 4th edition world incorporating the first and second Addenda.

Zemba, A. A. Adebayo, A. A. and Ba, A. M. (2016). Analysis of Environmental and Economic Effects of Kiri Dam, Adamawa State, Nigeria. Global Journal of Human-Social Science: 16(1): 1-7.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

EFFECTS OF PHYSICOCHEMICAL PARAMETERS ON PHYTOPLANKTON DIVERSITY AND ABUNDANCE IN BLATAVA RESERVOIR, MARARABA HONG LOCAL GOVERNMENT OF ADAMAWA STATE.

[1]Apollos T. G, [1]A. Edward, [1]S. D Duwal, [1]P.M Ziga, [2]V.R Ndeham And [1] M. M Kutte
[1]Department of Fisheries and Aquaculture Adamawa State University Mubi.
[2]Department of Fisheries Federal Polytechnic, Mubi

Corresponding Author:
garba573@adsu.edu.ng, +2347035582187

ABSTRACT
Study was carried out to determine the phytoplankton compositions in relation to physicochemical parameters of Blatava Reservoir in Mararaba Hong. Water samples were collected from the reservoir for six (6) weeks and standard method was used for the analysis of the physicochemical parameters. Results obtained show that there is variations in some of the physicochemical parameters. The mean temperature value of 17.00±670C, pH of 5.20±21, Turbidity of 12.23±49cm, Conductivity 784.94±0.00µs/cm and Dissolved Oxygen value of 6.31±23mg/L was obtained respectively. While element such as; Ammonium, Nitrogen, Phosphorus, Silicon, Calcium, Copper Zinc and Cobalt were found to be 12.18mg/L, 384.51±00mg/L, 17.49±68mg/L, 4.75±34mg/L 1.13mg/L 0.00±00mg/L, 7.45mg/L, and 63.52±25mg/L respectively. A total of 13 species belonging to four divisions were discovered during the study period. Bacillariophyta were found to have the highest number of species with 6 species resulted to (70.13%) followed by Chlorophyta with 3 species which resulted to (17.53%), Cyanobacteria with 3 species and a total of (10.39%) and Dinoflagelate with 1 species and a total of (1.95%). Results from the research shows that, physicochemical parameters have effects on the distribution and diversity of phytoplankton species of the pond, though there is no harsh effect on the biotic community because no record of any toxic species found in the reservoir.

Keywords: Physicochemical Parameter, Phytoplankton, Bladava Reservour and Hong.

INTRODUCTION

Phytoplankton is microscopic aquatic plants, occurring as unicellular, colonials or filamentous forms without any resistance to current and free floating or suspended in the open water. Phytoplankton is vital and important organisms which act as producer to the primary food supply in any aquatic ecosystem. Hassan et al.(1995). They are the initial biological components for which energy is transferred to higher organisms through food chain (Tiwari and Chauhan, 2006; Saifullah et al., 2014). Almost all species of phytoplankton move at the mercy of water current for transport to areas that are suitable for their survival and growth. Physical and chemical properties of water play a significant role in determining the distribution of phytoplankton species. Thus phytoplankton varies widely in physical and chemical requirements for population growth (Rani et al., 2012). The physicochemical parameters are the major factors that control the dynamics and structure of the phytoplankton of an aquatic system (Hulyal and Kaliwal, 2009).

Changes in physicochemical parameters of ecosystems have a substantial impact on the species that live within them. The interplay of physicochemical parameters and biological properties of water obtained lead to the production of phytoplankton, while their assemblage, composition, distribution, diversity and abundance are also structured by these factors (Jaji, 2007). Phytoplankton are possibly the most important group of organisms on earth generating most of the oxygen and also produce vegetative matter required at various links in a food chain (Jyothi et al., 2015). They form good indicators of water quality as they have rapid turn-over time and are sensitive indicators of environmental stresses (Agale et al., 2013). Phytoplankton communities are affected by physicochemical parameters, making them valuable tool in monitoring programs. Phytoplankton survey thus helps to find out the trophic status and the organic pollution in ecosystem (Ramchandra and Solanki, 2007). They are highly sensitive to even slight fluctuations in water quality, maximum phytoplankton abundance is obtained when the physicochemical parameters are at optimum level; even slight disruption result in disequilibrium of community structure and absence of some species from the system (Fonge et al., 2012). As a result, species composition of phytoplankton community is an efficient bio-indicator for water quality (Celekli and Kukuiluglu, 2006). This study served as a baseline for further studies in the study site and attempts to provide a survey of phytoplankton distribution and abundance in relationship to the physicochemical parameters in Blatava Dam.

MATERIALS AND METHODS

The study was carried out in Blatava Dam to determine the effect of Physicochemical Parameters on phytoplankton distribution and abundance. Water Samples were collected bi-weekly for the period of three months. Collection was done in the morning (7:00am). Plankton net was used to collect the phytoplankton samples by stroking from depth of about 30cm vertically upward and at the water surface and horizontally. Collected samples were carefully poured into plankton bottle, fixed with 2ml of ethanol. The samples were allowed to settle and the supernatant was then decanted. After decanting, concentrated plankton were analyzed. A dropping pipette was used to place the concentrated plankton on a slide and covered with cover slip and viewed under microscope. Phytoplanktons were determined in triplicate using quantitative analysis and identified according to the method described by Jeje and Fernando, (1986).

For the Physiochemical parameters, temperature was taken directly at the study area (in-situ) using mercury bulb thermometer. The bulb was placed in water and the reading taken after two minutes, to achieve the equilibrium as describe by Ali et al., (2000). pH of the water body was determined at the study area using pH meter. Sechi disc was used to determine the transparency of the water body as described by Stirring (1985). Dissolved Oxygen (DO) was determined with (DO) meter. Electric Conductivity (EC) of the water body was determined, using conductivity meter as described by Ali et al., (2000). Water samples were collected from the study area using sample bottles and then transported to the Chemistry laboratory, for analysis of the following elements Ammonia (NH_4), Nitrogen (N), Phosphorus (P), Silicon (Si), Calcium (Ca), Cupper (Cu), Zinc (Zn) and Cobalt (Co), using Atomic Absorption Spectrometer as described by Radojevic and Bashkin (1999)

Data obtained were analyzed using simple descriptive statistics and Analysis of Variance (ANOVA) to determine the level of significant of the values.

RESULTS

Phytoplankton

A total of 13 different species of Phytoplankton were recorded and complied systematically placing the species into 4 divisions as shown in Table 1.

Table 1.
Table 1 : Abundance of Phytoplankton

Division	Class	Order
Bacillariophyta	Bacillariophyceae	Naviculales
	Coscinodiscophyceae	Thalassiosirales
Chlorophyta	Zygnematophyceae	Zygnematales
	Trebouxiophyceae	Chlorellales
Cyanopyta	Cynophyceae	Oscillatoriales
	Cyanophyceae	Chroccocales
Dinoflagellate	Chroccocales	

Physicochemical parameters
The result for physicochemical parameters recorded during the course of the research is shown in Table 2. The highest temperature was recorded in August with the value of 20.10±0.460C. The pH of the study area showed no remarkable variation. Turbidity was high with the average value of 12.50±0.52 cm throughout the period of the study. Dissolved Oxygen (DO) values for the period under study showed no much variation with mean value of 6.30±0.42mg/L. The ammonium concentration increases in June with 4.23±0.22mg/L.

Table 2: Physicochemical Parame ters of Blatava Reservoir

Months		**Physicochemical**	**Parameters**			
	Temp (^{0}C)	pH	Turbidity (cm)	Conductivity (µS/cm)	DO (mg/L)	NH_4 (mg/L)
June	23.02±0.32c	6.2±0.21	12.60±0.22	786.52±0.21	6.25±0.12	4.23±0.22
July	21.00±0.56^b	5.2±0.24^b	12.40±0.34	785.57±0.24	6.34±0.22	2.25±0.32
August	20.10±0.46	5.2±0.56^b	12.10±0.52	784.60±0.27	6.33±0.42	2.00±0.52
Mn	17.67	5.2	12.5	785.94	6.30	3.48
V	2.89	1	0.01	0.25	0.001	0.13
SD	1.70	1	0.1	0.5	0.03	0.36

Mean in the same row with the same superscript do not differed significantly P≤ (0.05)
Key: Temp (Temperature), pH (Potencial of Hydrogen), Turb (Turbidity), EC (Conductivity), DO (Dissolved Oxygen), NH4 (Ammonium), Mn (Mean), V (variance), SD (Standard Deviation).

Elementals

The concentration of trace element in the reservoir is shown in Table 3. All the trace elements were present except Silicon. The variation in the concentration of the trace elements was not remarkable during the course of the research.

Table 3: Abundant Elements

Month	Elements						
	N	P	Si	Ca	Cu	Zn	Co
June	4.61±0.34[b]	63.52±0.23[a]	0.00±0.00[a]	384.15±0.45[a]	7.42±0.23[a]	12.15±0.10[a]	1.12±0.11[a]
July	4.64±0.23[b]	63.55±0.12[a]	0.00±0.00[a]	384.17±0.11[a]	7.44±0.45[a]	12.19±0.12[a]	1.13±0.12[a]
August	5.00±0.10[a]	63.50±0.45[a]	0.00±0.00[a]	385.20±0.42[a]	7.48±0.23[a]	12.20±0.24[a]	1.13±0.32[a]
Mn	4.75	63.52	0.00	384.51	7.45	12.18	1.13
V	0.03	0.04	0.00	0.24	0.01	0.01	0.03
SD	0.17	0.02	0.00	0.49	0.03	0.02	0.05

Mean in the same row with the same superscript do not differed significantly P≤ (0.05)
Key: N (Nitrogen), P (Phosphorus), Si (Silicon), Ca (Calcium), Cu (Copper), Co (Cobalt), Mn (Mean), V (Variance), SD (Stanrdard Deviation).

DISCUSSION

Physicochemical parameters of Blatava reservoir varies base on the parameters taken within the period of the study. Among the parameters recorded, temperature, recorded the highest value in June with 23.02. While, the highest pH value of 6.22 was also recorded in June. All the pH values recorded during the course of the research are within the range of 6.5 to 8.0 for all warm water fishes. These values agree with the work of Avoaja, (2005) which discovered that the range of pH between 6.27 to 8.68 is conducive for aquatic life. Conductivity has the highest value of 785.60, in June. While DO (Dissolved Oxygen) has the highest value of 6.33 in August. Table 1, this findings agreed with the work of Abubakr et al., (2015). In his study on Preliminary survey of fish diversity in the Hadeja Nguru Wetlands and found out that most value of tropical waters have high dissolved oxygen during the inflow of rain water to the reservoir.

The elements found in Blatava reservoir shows that Nitrogen is high during the month of August with the highest value of 5.00mg/l. This finding agreed with the work of Funge et al., (2012). In his study on Phytoplankton diversity and abundance in Ndop wetland plain of Cameroon. Phosphorus has the highest value of 63.55 in the month of July. The reservoir has no silicon during the course of the study. The highest value of Calcium was recorded in August with the value of 385.20mg/l. Table 2. The values of calcium were low during the course of the study because calcium supports many structures of aquatic animals such as tissues of fish and shells of mollusk according to Jeje and Fernando (1986). The abundance of phytoplankton observed during the course of the study shows that; Bacillariophyta has six different species, with (Actinocy clusingens, Actinocy clusellipticus, Morenensis, Dendriculopsis praedimorta, Bogorovia praepalacea, Diploneisbombus, Stephanodiscus sp., followed by Chlorophyta and Cyanobacteria with three species each which include: Spirogyra spp., Tetraeron trigonium, Oocystisso litart . Cyanobacteria and Gloeocapsa spp., Oscilltoria spp., Merismopedia sp respectively. Dinoflagelate has only one specie i.e Ceratium hirundinella.

CONCLUSION

The study revealed that some physicochemical parameters and mineral element have influence on the distribution and diversity of phytoplankton species of the reservoir. Also increase in this trace element will have no significant effect on the biotic community. No trace of any toxic species in the reservoir. The division Bacillariophyta which was found to be dominant in the reservoir indicates that they need elements such as Nitrogen and Phosphorus to multiply very easy.

RECOMMENDATION

Water quality and phytoplankton abundance of Blatava reservoir can be improve by monitoring the pollution status of the reservoir regularly.

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REFERENCES

Abubakar .M.M, Kutama. A.S. and SulaimanI.M, (2015). Preliminary survey of fish diversity in the Hadeja Nguru Wetlands. International Journal of Biological Science 2(1) 23-29

Avoja D.A (2005) The Ecology and fish fauna of Elgon East Africa. Animal Research International

Ali W., Afsheen.Z, Zarina .A, and Beena. N (2000) Effect of salinazation and alkalinazation on seed germination and early seedling growth of leguminous species. Journal of plant Science 6(1) 1- 11

Chauhan Shakti (2006) Evaluation of dynamic elastic polypropylene composites. Journal of Applied Science (102) 2 1706-1711

Fonge B. Ambo M.G. and Oben M (2012) Phytoplankton diversity and abundance in Ndop wetland plain Cameroon. Journal of Environmental Science and Technology 6(6)

Rani .K., Rana. R, and Datt. S. (2012) Review on latest overview of proteases. International journal of Current Life Science 2, 12-18

Jaji. M. Bamgbose .O., Arowolo .T., and Odukoya .O., (2007) Water Quality Assessment of Ogun River South West Nigeria Environmental monitoring and Assessment 133, 447-482

Jeje and Fernando (1986) Zooplankton assemblage of Oyun Reservoir, Offa Nigeria Revista de Biologia Tropica 57(4)

Radojevic M. and Bashkin V.N (1999). Practical Environmental Analysis first edition. The royal society of chemistry Uk. 466

Ramachandra T. Solaki M. (2007). Ecological assessment of lentic water bodies of Bangalore. Somatic scholar.

Stirring (1985). Effect of stirring on cellulose graft copolymerization V. influence of reaction parameters. Journal of applied polymer Science 30(10) 4175-4186

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

ACUTE TOXICITY AND PROXIMATE COMPOSITION OF *Datura innoxia* STEM ON *Clarias gariepinus* JUVENILES

[1]Isiyaku, M. S., [2] R.M. Iorhiin, [1]B.I., Usman, [1]V.F. Akinjogunla, [1]S. A. Mohammed, [1]Z.R Mudi, and [1] F.B. Abubakar

[1]Department of Fisheries and Aquaculture, Bayero University, Kano, Nigeria.
[2]Department of Fisheries and Aquaculture, University of Calabar, Calabar, Nigeria

Correspondence Author:
imsani.faq@buk.edu.ng, 08035337548, 0000-0002-9377-0586

ABSTRACT
This study was carried out to determine the toxicity, phytochemical and proximate composition of Datura innoxia stem to Clarias gariepinus. The range – finding test was conducted twice in order to get reliable values that could be used for the definitive test. The toxicant (Datura innoxia stem) was introduced at varying concentrations of 300mg, 330mg, 360mg, 390mg and 420mg in the first range- finding test, however, in the definitive test, the toxicant was introduced at varying concentrations of 320mg, 330mg, 340mg, 350mg and 360mg of Datura innoxia stem per litre of water (mg/l). From the definitive test, the Median Lethal Concentration of Datura innoxia stem powder to Clarias gariepinus was found to be 334.370 mg/l. The result also shows that proximate composition were within acceptable limits. The water quality data were analyzed by subjecting them to one way Analysis of Variance (ANOVA).Thus, the study indicates that Datura innoxia stem is toxic to Clarias gariepinus juveniles.

Keywords:
Bioassy, lethal concentration, mortality

INTRODUCTION

The reduction in water quality cannot be ruled out as a major contributing factor to declining aquatic productivity and fish catches. The increase in the use and application of pesticides poisonous plants in agriculture in Nigeria today, which contributes greatly to aquatic pollution and hence reduction in water quality is mainly due to the increase in agricultural activities. Fish are one of the most widely distributed organisms in an aquatic environment and being susceptible to environmental contamination may reflect the extent of the biological effects of environmental pollution in waters (Ramesh et al., 2009). Fish are widely used to evaluate the health of aquatic ecosystems, and biochemical changes observed in fish serve as biomarkers of environmental pollution (Cavas and Ergene-Gözükara, 2005). Datura innoxia is a highly toxic plant that belongs to the Solanaceae family. It contains a range of active compounds, such as hyoscyamine, scopolamine, and atropine, which are known to have hallucinogenic and toxic effects (Prado et al., 2009). Understanding the impact of Datura innoxia on fish species is important for managing and protecting aquatic ecosystems and the organisms that rely on them. Datura innoxia is a multipurpose plant widely available in the tropics, the leaves, seeds, stem, fruits and roots have economic importance for industrial and medicinal uses. In Nigeria, despite the widespread use in demarcation, garden and medicinal purposes, their toxicity and effectiveness of the Datura innoxia stem to aquatic organisms, particularly fish, have not receive much attention. Mortality or bioassay experiments in general present the most preferred way to evaluate the ecological influence of toxic compounds as their effects on fish and ecological risks cannot be determined by chemical analysis (Baser et al., 2003).

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Fish Hatchery Laboratory of the Department of Fisheries and Aquaculture, Bayero University, Kano, Nigeria.

Experimental fish

One hundred and Eighty (180) of C. gariepinus (mean weight, 19.56 ± 0.7g and 31.07±1.23g juveniles were used for the study, fish were purchased from a reputable fish farm from Kano, Kano State.

Source and Preparation of Datura innoxia

Fresh samples of D. innoxia plant were collected from Ankpa Local Government Area of Kogi State. The sample were separated into different part with special emphasis on the stems. The sample were air dry at constant weight under Laboratory condition and ground into fine powder in a clean laboratory mortar. The resultant powder were sieve (0.2mm) and store in air tight wide mouth bottle for analysis. 500g of each stored sample was dissolved in 2 litres each of distilled water at room temperature (27 ± 0.30C) for 24 hours. The settled aqueous portion was then decanted and filtered through a Whitman filter paper using a vacuum pump. The filtrates were freeze dried and stored in a refrigerator (100C) for use.

Experimental Design

Completely randomized design was used for the experiment. A total of eighteen (18) plastics tanks of (60cmx40cmx40cm) capacity were used. The plastic tanks were washed thoroughly and then filled with 20 litres of water. All plastic tanks were labelled. Fish were weighed and distributed at the rate of 10 fish per tank. A total of one hundred and eighty (180) of C. gariepinus juveniles were randomly stocked into the tanks at a stocking rate of 10 fish per tank in triplicates.

Proximate analysis of Datura innoxia stem

The moisture content, ash content, crude protein, ether extract and crude fibre of the experimental Datura innoxia stem were determined using AOAC (2005) techniques in the Department of Animal Science, Bayero University Kano.

Range and Definitive Test

Preliminary 96 hours range finding test was conducted separately for C. gariepinus s juvenile following static bioassay to determine the toxic range of Datura innoxia stem to C. gariepinus juveniles as described by Parrish (1985). For the range finding test 300mg, 330mg, 360mg, 390mg and 420mg Datura innoxia stem per litre of water were used and 320mg, 330mg, 340mg, 350mg and 360mg of Datura innoxia stem per litre of water (mg/l) were used for definitive test. Ten C. gariepinus juveniles were separately weighed with a sensitive electronic weighing scale (mettler Toledo FB602) and stocked each into the 18 tanks filled with 20 litres of tap water. The response of the fish to slight stimuli was used as an index of toxicity while non-response of the fish to atrazine powder estimated to be lethal to 50% of the test organism after 96 hour of exposure.

Statistical Analysis

Data were analysed using Minitab 16 for summary of statistics in water quality parameter. The mean lethal concentration (LC50) for 96 hours was computed using probit analysis (Finney, 1971).

RESULTS AND DISCUSSION

The mortality of Clarias gariepinus juvenile after 96-hours exposed to different concentration of Datura innoxia stem during the acute test is presented in Table 1.

Table 1: Mortality of Clarias gariepinus juveniles exposed to Datura innoxia stem over the 96 hr period

Treatments/ Concentration (mg/L)	Log Concentration	Number Stocked	Mortality 12 hrs	24 hrs	48 hrs	72 hrs	96 hrs	Total	%	Probit
T0 (Control)	0	30	0	0	0	0	0	0	0	0
T1 (320)	2.51	30	0	0	3	3	2	8	26.67	4.39
T2 (330)	2.52	30	0	3	5	3	2	13	43.33	4.82
T3 (340)	2.53	30	3	4	5	3	3	18	60	5.25
T4 (350)	2.54	30	6	5	5	2	4	22	73.33	5.61
T5 (360)	2.56	30	9	7	4	3	3	26	86.67	6.13

It was observed that the mortality recorded in this investigation increased with increase in the concentration of Datura innoxia stem. The first death was noticed 178 minutes after the introduction of toxicant in the bowl with the highest concentration in mercuric chloride (360mg/l). This is in conformity with Ayuba et al. (2007) who reported the first death in 30 minutes after introduction of toxicant to Clarias gariepinus in acute concentration of different parts of Datura innoxia. Olaifa et al (2004) reported the first death three hours after the introduction of toxicant in the exposure of Clarias gariepinus to lethal and sub lethal concentration of copper. Datta and Kaviraj (2002), Fafioye et al. (2004) and Okomoda et al. (2010) recorded the first death 36 hours after the exposure to acute toxicity treatment of Clarias gariepinus with synthetic pyrethyroid Deltamethrin, Raphia vinifera extracts and formalin respectively. Guedenon et al. (2011) recorded the first death after 30 hours while treating Clarias gariepinus with 120mg/l of cadmium sulphate. The duration of resistance of Clarias gariepinus in the present study appeared to be lowest compared to those in the aforementioned studies. Though Clarias gariepinus has proved to be very resistant to various toxicants. The LC50 found in this investigation is 334.37mg/l (Fig 1) similar to that of Isiyaku et al., (2022) when Oreochromis niloticus was exposed to acute concentration of tamarindus indica seed husk.

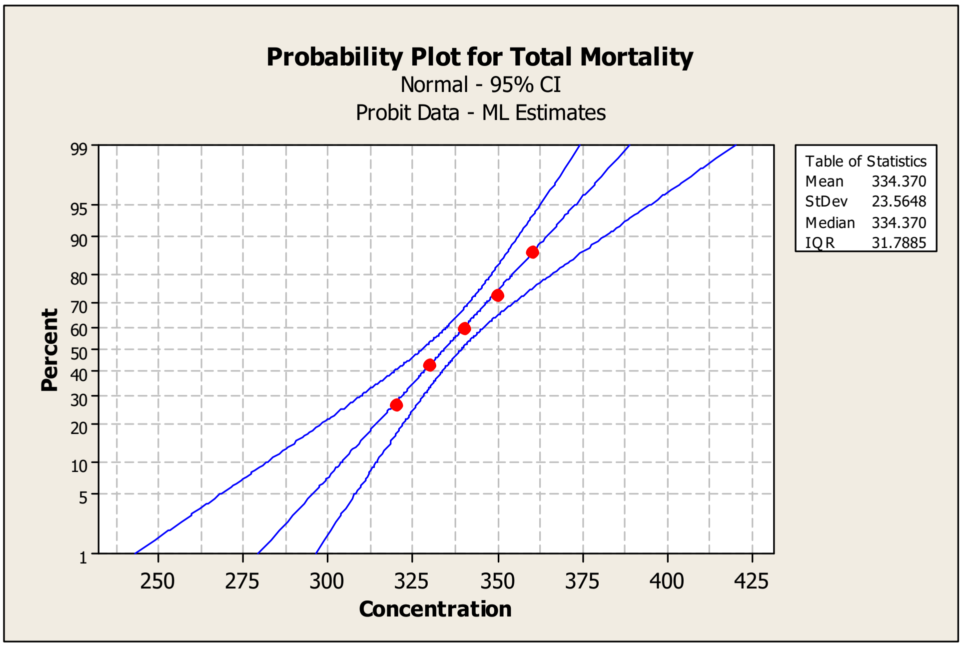


Figure 1: Linear relationship between mean probit mortality and log concentration of *Clarias gariepinus* exposed to various concentrations of *Datura innoxia* stem for 96 hrs.

Isiyaku et al. (2015), recorded 0.22mg/l as LC50 in an acute mercury toxicity treatment to Oreochromis niloticus. The median lethal concentration in this study was the highest recorded compared to those reported by previous workers. The chemical product being the same; the difference in the results could be attributable to the variety in the species used. However, the LC50 found in the study was by far lower than those reported with Clarias gariepinus by Ayuba and Ofojikwu (2002), Ezike and Ufodike (2008), Lawson et al. (2011) and Guedenon et al. (2011) who reported (204.17mg/l) for Dutura innoxia, (334mg/l) for petrol, (129mg/l) for Lindane (Gamma-Hexachloro-cyclohexane) and (46.11mg/l) for cadmium sulphate. The difference might be due to not only to the various substances and compound used in the experiment but also the distinct environmental conditions.
The Proximate Composition of Clarias gariepinus of Datura innoxia stem is presented in Table 2

Table 2: Proximate Composition of *D. innoxia* stem

Parameters	Concentration (%DM)
Crude Protein	34.87
Moisture	15.12
Ash	20.01
Ether Extract	8.32
Crude Fibre	29.73
Nitrogen Free Extract	21.52

According to the NRC (1993), crude protein of less than 20% indicates low protein content of that feed stuff. These crude protein results are however comparable with the result of some tropical plant seeds analysed by Ezeagu et al. (2000), who reported that Diospyno mespiliformis and Entandrophrgma angolense had crude protein contents of 3.46 and 12.34%, respectively. The moisture content which measures the amount of water in the plant also varied with the root having the lowest (3.5%) moisture content while the stem had the highest of 15%. The seed, pod and leaf had 10.00, 8.50 and 7.5% moisture contents respectively. Significant difference ($P < 0.05$) was observed in the moisture contents of the plant parts. According to NRC (1993), moisture content of 5 - 20% (DM) is regarded as high. This indicates that the moisture content of the leaf, seed, stem and pod were high. The result of this investigation is comparable with those obtained by Ezeagu (2000) for Gliricidia sepium 6.77%, Albizu zygia 7.8%, Doneillia ogea 9.86% and D. mespiliformis 8.99% but at variance with those obtained for Lophira lanceolata seed (2.78%) as reported by Lohlum et al. (2010). The crude lipid and ash content followed the same pattern as reported by Ayuba et al. (2007).

CONCLUSION AND RECOMMENDATION

The results obtained from acute toxicity studies shows that Datura innoxia stem is toxic to fish, and that the toxic response in the fish was dose and duration dependent. However, the combination of this method improves the understanding of the biological risk on aquatic life arising from heavy metal contamination. Therefore, the consumption of Datura innoxia stem contaminated fish may pose serious health risks to fish consumers. It can be conclusively deduced from this study that fish has the tendency to bioaccumulate heavy metals in a polluted environment. Hence, the indiscriminate consumption of fish from a polluted water body should be discouraged.

REFERENCES

AOAC (Association of Official Analytical Chemists), (2005). Official methods of Analysis of the AOAC. W. Hortwitz (ed.), 13 edn. Washington: D.C., AOAC, 858p

Ayuba V.O. and Ofojekwu P.C. (2002). Acute toxicity of the root extracts of Jimsons Weed Datura innoxia to the African catfish Clarias gariepinus, Journals of Aquatic Sciences. 17(2): 131-133.

Ayuba, V.O. and Ofojekwu, P.C. (2007). Effects of sub-lethal concentration of Datura innoxia haematological indices of African catfish, Clarias gariepinus. Journal Aquatic Sciences. 20 (2): 113-116.

Baser, K. H. C., Demici, B., Dekebo, A. and Dagne, E., (2003). Essential oils of some Boswellia SPP., Myrrh and Opopamax. Flarour and Fragrance Journal, 18, 153-156. DOI: 10.1002/ffj.1166.

Cavas, T. and Ergene-Gözükara, S. (2005). Micronucleus test in fish cells, a bioassay for in situ monitoring of genotoxic pollution in the marine environment. Environmental and Molecular Mutagenesis, 46: 64-70.

Datta, M. and Kaviraj, A. (2002) Acute Toxicity of Synthetic Pyrethroid Deltamethrin to Freshwater Catfish Clarias gariepinus, Bulletin. Environment Toxicology. 70: 296-29.

Ezeagu, I.E., Metges, C.C., Proll, J., Petzke, K. J. and Akinsoyinu, A. O. (2000). Chemical composition and nutritive value of some wild gathered tropical plants seeds. International Journal of Food Science and Nutrition 45:127-134

Ezike. C. and Ufodike. E.B.C (2008). Acute toxicity of petrol to the African catfish Clarias gariepinus. Annals of research in Nigeria. 6:1-4.

Fafioye, O. O., Adebisi, S. O. and Fagade, A. A. (2004). Toxicity of Parkia biglobosa and Raphia vinifera extracts on Clarias gariepinus juveniles. African Journal of Biotechnology. 3 (11):137−142.

Finney, D.J. (1971). Statistical methods in biological assay, 2nd Ed. Hafner Pub.Co. New York. N.Y. Cambridge University Press, London, England. 68p

Guedenon P., Edorh P.A., Hounkpatin A. S.Y., Alimba C. G, Ogunkanmi A. and Boko M. (2011) Acute Toxicity of Mercury (HgCl2) to African Catfish, Clarias gariepinus International Journal of Biology Chemistry and Science. 5(6): 2497-2501

Isiyaku, M. S., Laurat, H. T and Maimunatu, A. (2022). Histopathology of gills and liver tissues of the freshwater fish Oreochromis niloticus (Linnaeus 1758) exposed to Tamarindus indica seed husk powder. 37th Annual conference of the Fisheries Society of Nigeria. Held on 30th October to 4th November, 2022 at the Federal College of Education, Yola, Adamawa State.

Isiyaku, M. S., P.A. Annune and L.O. Tiamiyu (2015). Acute Toxicity and Histopathological Changes in Liver and Gill Epithelium of African Catfish (Clarias gariepinus) exposed to Mercuric Chloride. Journal of Aquatic Sciences. 30(2): 329-336.

Lawson E.O., Ndimele P.E., Jimoh A.A., Whenu O.O. (2011). Acute Toxicity of Lindane (Gamma Hexachloro Cyclohexane) to African Catfish (Clarias gariepinus), International Journal of Animal Veterinary Advances. 3(2):63-68.

Okomoda, J, Ayuba VO, Omeji, S. (2010). Heamatological Changes of Clarias gariepinus (Burchell, 1822), fingerlings exposed to Acute Toxicity of Formalin. Production Agriculture Technology. 6:100-109.

Olaifa F.E. Olaifa A. K. and Onwude T.E. (2004).Lethal and sub-lethal effects of copper to the African catfish (Clarias gariepinus) Juveniles, African Journal of Biomedical Research. 8: 65 -70.

Parrish, P.R. (1985). Acute toxicity test. In: M and Petrocelli S.R. (Eds.). Fundamentals of Aquatic Toxicity. Rand G Hemisphere, Publishing Corporation. Washington, DC.

Prado, R., Rioboo, C., Herrero, C. and Cid, A. (2009). The Herbicide Paraquat Induces Alterations in the Elemental and Biochemical Composition of non-target Micro-algal species. Chemosphere, 76: 1440-1444. DOI: 10.1016/j.chemosphere.2009 .06.003.

Ramesh M., Srinivasan R. and Saravanan M. (2009). Effect of Atrazine (herbicide) on blood parameters of common carp Cyprinus carpio. African Journal of Environmental Science and Technology. 3(12):453–458.

DETERMINATION OF HEAVY METALS IN SELECTED FISH SAMPLES OBTAINED FROM KAINJI LAKE NEW BUSSA NIGER STATE

[1]Adekola A. A, [1] Y. Birnin Yauri [2]A.I. Tsafe, [2] I.M. Magami,[3]U.Z. Sa'id

[1]Chemistry unit Central service laboratory, National Institute for Fresh Water Fisheries Research, PMB 6006, New Bussa, Niger state, Nigeria
[2]Department of pure and applied chemistry, Usmanu Danfodiyo University PMB 2346, Sokoto, Nigeria
[3]National research institute for chemical technology, PMB 1052, Zaria, Kaduna State, Nigeria

Corresponding author:
adekolaakeem4@gmail.com, +2348057331454

ABSTRACT
The prevalence of anthropogenic activities and local mining of solid minerals around the kainji dam necessitated the need to study the level of bioaccumulation of heavy metals in fishes located within the Kainji dam. Two species of fishes namely Oreochromis niloticus and Synodontis schall obtained at a distance of 50m, 100m and 150m from Kanji dam were investigated for heavy metals. The control sample was obtained from Yangba River along Wawa road in New Bussa, Niger State. Concentration of six (6) heavy metals namely; Copper, Manganese, Chromium, Zinc, Lead and Cadmium was determined using atomic absorption spectroscopy. The result showed that the concentrations of these metals are higher at 50m and 100m away from the dam site respectively. The maximum concentration of this heavy metal in Oreochromis niloticus and Synodontis schall were observed at sampling point closer to the dam and decreases as the distance away from the dam increases. From the result analysed, the mean concentration of manganese ranges from 2.153-7.820mg/Kg and 2.822-3.569mg/Kg, copper ranges from 3.240-5.330mg/Kg and 4.279-7.057mg/Kg, and chromium ranges from 1.557-3.010mg/Kg and 0.698-4.650mg/Kg, zinc ranges from 1.650-5.188mg/Kg and 4.385-5.097mg/Kg, lead ranges from 0.738-1.365mg/Kg and 1.689-2.354mg/Kg while cadmium ranges from 0.481-1.440mg/Kg and 1.132-2.013mg/Kg respectively. None of the heavy metals investigated was above the maximum permissible level set by the world health organization (WHO)

Keywords:
Water, bioaccumulation, anthropogenic, pollution

INTRODUCTION

Generally, the riverine ecosystem is a repository of a wide variety of plants and animals including green germ plasms; supplier of one of the best and relatively cheap forms of protein in the form of fish and a plethora of other benefits both economic and aesthetic (Singh et al 2001). Economic benefits of rivers include being a source of water for drinking, irrigation, industrial processes, means of transportation etc. However, deforestation and catchment areas leading to increased silt load in rivers, increased abstraction of river water for irrigation, industrial and domestic purposes and pollution arising from the discharge of industrial and domestic effluents have resulted in the deterioration of water quality of world rivers (Singh et al).

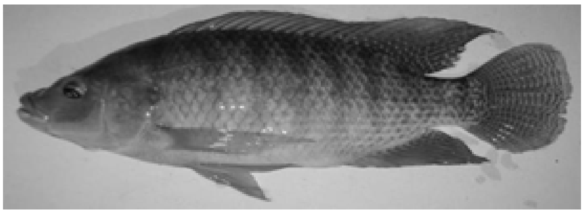
Pollution is the introduction into the environment of substances or effects that are potentially harmful and interfere with man's use of his environment or interfere with species or habitats (Porteus, 1996). Pollution can be material (smoke, chemicals etc.) or non-material (noise, light, radiation etc. means of transportation etc. means of transportation etc. However, deforestation and catchment areas leading to increased silt deforestation and catchment areas leading to increased silt (Agarwal, 2002). River pollution is the presence of any foreign substance (organic, inorganic radiological, biological) in the riverine ecosystem which tend to degrade the quality of the ecosystem so as to constitute a hazard to biota or impairs the usefulness of water (Agarwal, 2002). Fish production from inland water resources (rivers, lakes and streams) is under threat from pollution, habitat alteration and degradation, changes in river flows and over-exploitation (Gupta, 2006). When pollutants like heavy metals enter rivers, they change the water quality, bind to sediments and accumulate in aquatic biota, causing anaemia, disturbance of physiological functions and mortalities of fish (Biney et al., 1994, Jenneth et al., 1980). This reduces production and income from fish and aquatic organisms. . According to Dougherty (2000), fish consumption is a major route of chemical exposure to man and heavy metal pollutants are potentially harmful to man when contaminated fish and water are consumed.

The main aim of this study is to investigate the concentrations of zinc, copper, cadmium, chromium, manganese and lead in two fish species name (Oreochromis niloticus and Synodontis schall) obtained from Kainji Lake.

The objectives are to:

a) To determine the concentration of the above metals in the fish samples using Atomic Absorption Spectrophotometry.

b) To access the heavy metals pollution status of the fish sample obtained from kainji lake by comparison with National and International standard.



Oreochromis niloticus

Synodontis Schall

Picture of the fishes investigated.

MATERIALS AND METHODS
METHODS:
SAMPLING AND PRESERVATION

Name	Formula	%Purity	Grade	Manufacturer
Calcium carbonate	$CaCO_3$	99%	AR	BDH Chemical
Cadmium chloride	$Cd(NO_3)_2$	99%	AR	BDH Chemical
Copper(ii) nitrate	$Cu(NO_3)_2$	98.5%	AR	May & Beaker
Lead Nitrate	$Pb(NO_3)_2$	99%	AR	BDH Chemical
Zinc oxide	ZnO	99%	AR	BDH Chemical
Con, Hydrochloric acid	HCl	99%	AR	Philipharrison
Con. Nitric acid	HNO_3	38%	AR	Philipharrison
Con. Sulphuric acid	H_2SO_4	70%	AR	May & Beaker
Potassium dihydrogen phosphate	KH_2PO_4	98%	AR	BDH Chemical
Anhydrous zinc Sulphate	$ZnSO_4$	95%	AR	BDH Chemical
Oven	MEMMERT			Memmert United Kingdom
Analytical balance	W11400179			Kern, Germany
Atomic Assumption Spectrometer	Pye-unicam 969			Unicam, UK
Digestion block	TECATOR 1015			Tecator, Germany
Fume cupboard	NS			NS

Three samples each of sub adult sizes (115-180g body weight) of fish species namely Oreochromis niloticus and Synodontis schall were collected. This size range was to avoid different states of reproductive physiology. The use of older fish species was avoided as Dusek et al (2005) reported that older predator fish species living in moderately and heavy polluted sites show negligible statistical differences.

Fish samples was collected with cast net from Kainji lake at 150 metres,100 meters, and 50 meters to the dam site which serve as the sampling point. As shown in figure 1 below. The control sample were collected from Yangba river along Wawa road and each of the fish species were collected at each sampling point making a total of eight fish samples. A canoe was used as sampling craft and at each point the canoe was stopped for samples to be collected.

The samples were wrapped with polythene bags and stored in an iced plastic box and subsequently transported to the laboratory of Sokoto Energy Research Centre where it was stored in a deep freezer.

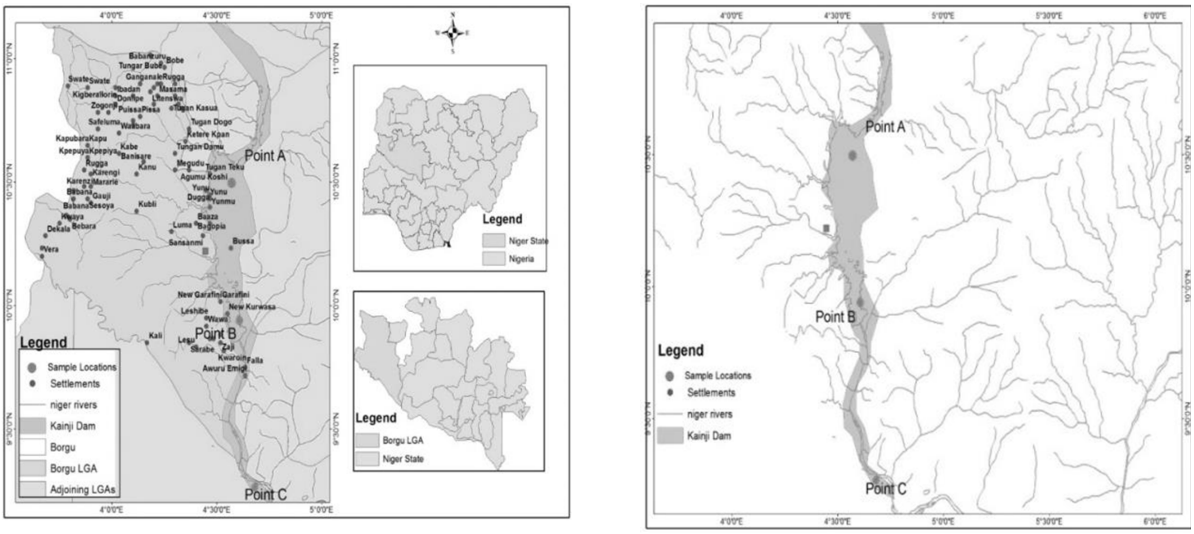


FIGURE 1: Sampling location at Kainji dam, New Bussa, Niger State

DIGESTION OF FISH SAMPLES FOR HEAVY METAL ANALYSIS

Fish sample were digested as described by Olaifa et al (2004) as follows: 5g of fresh fish muscle was weighed and placed in beaker. 10ml of freshly prepared concentrated HNO3/H2O2 (1:1) solution was added and the beaker was covered with watch glass for initial reaction to subside. The beaker was placed on water bath and boiled at a temperature not exceeding 1600C for 2 hours to reduce the volume to 3-4mls. It was cooled and transferred to 50ml volumetric flask and made up to volume with distilled water for the metal analysis.

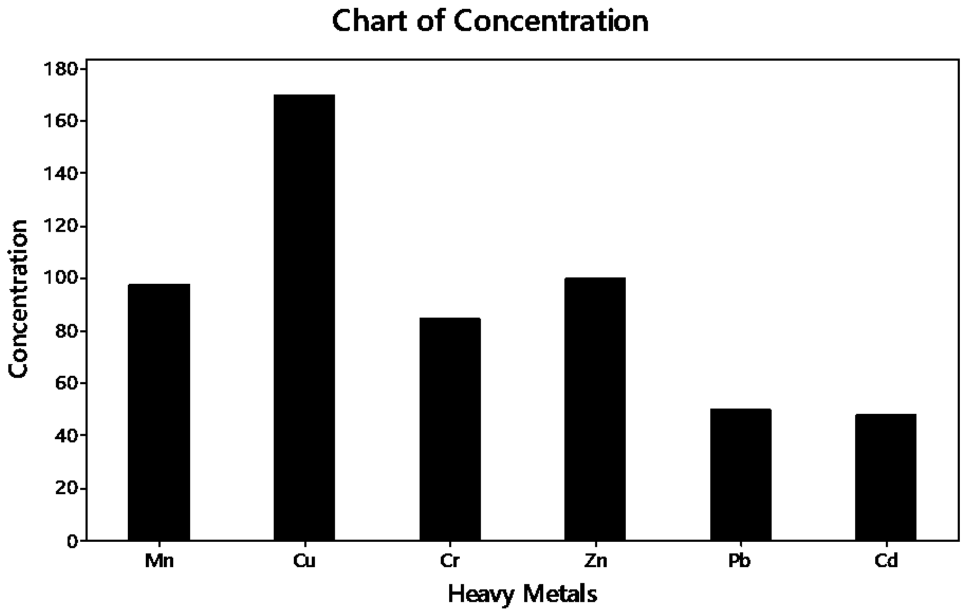
RESULTS

The concentration of heavy metals in Oreochromis niloticus (mg/kg)

Distance	Mn	Cu	Cr	Zn	Pb	Cd
50m	4.5900±2.29	6.6660±0.6140	3.0100±3.810	1.8530±1.6720	1.0805±0.000252	1.0150±1.1550
100m	6.50±4.520	6.026±1.31	4.650±1.960	4.253±0.687	1.0805±0.000252	0.481±0.577
150m	2.15300±0.385	4.249±0.842	3.0400±0.751	5.188±0.295	1.365±1.528	1.8130±0.5770
Control	3.567±1.7310	3.240±1.410	1.5570±0.9440	4.3850±0.3780	2.354±0.579	2.130±1.000

Concentration of heavy metals in Synodontis schall (mg/kg).

Distance	Mn	Cu	Cr	Zn	Pb	Cd
50m	3.3330±0.8650	7.0570±0.8030	0.6980±0.5660	1.7390±0.3090	0.7380±0.5520	1.440±1.730
100m	7.28±4.30	6.456±5.990	4.454±0.837	1.650±0.760	1.0805±0.000252	1.127±1.000
150m	2.5430±1.214	7.590±2.270	3.0950±2.8	4.928±1.445	1.366±0.577	1.9020±0.5770
Control	2.8220±0.2070	5.330±1330	3.0100±2.090	5.0970±1.2000	1.6870±1.527	1.1326±0.00173



Concentration of Heavy Metals at each sample location

DISCUSSION

In sample 1, at the control point copper has the highest concentration and cadmium has the least likewise for sample 2 at the control point also in both species of the fish. In Sample copper have the highest concentration and cadmium has the least concentration in sample 2. This is in line with the work of Mansour and sidkey,(2003), who reported a cadmium concentration of 1.1002 - 1.1342±0.000143 000143 in Synodontis schall while working on heavy metal contamination on fish in Wadi elrayan wetland region of Egypt..

For sample 3 taken at 50 km from the dam site representing Oreochromis niloticus, the concentration of chromium was the highest and cadmium the lowest. This is in contrast to the work done by Adakole 1995, who reported a value of 0.39mg/g for chromium, which is the least concentration of heavy metals and chromium was reported to have the least concentration i.e. 0.39mg/g, from my investigation the concentration of chromium was the highest ;the variation of the result can be attributed to the presence of mining activities closer to the vicinity of the sampling area.

For sample 4 taken at 50km from the dam site representing Synodontis schall species of the fish, the concentrations of copper was the highest and lead the lowest. This in line with research work of baeyenis et al, 2005 who reported a value of 8.700-3.00mg/kg for zinc and 7.825-6.520mg/kg for copper. He discovered that the high concentration of copper and zinc can lead to decrease in concentration of cadmium.

For sample 5 representing sampling point 100km away from the dam site, the species of fish caught was Oreochromis niloticus. This result obtained is in agreement with the work of bayens et al who analyse manganese, copper, chromium, zinc, and lead in Oreochromis niloticus. The metal with least concentration was found to be cadmium.

Sample 7. The result obtain is in agreement with the result reported by baaeyens et al 2005 after studying the presence of heavy metals in Niwar lake, the result for chromium was 4.787-3.300 while lead was 3.0298-0.0321

For sample 8 representing point at 150km from the dam site and the species of fish caught was Synodontis schall. This equally agrees with the work of Binnig and Baird, 2003 who reported a value of 9.78mg/kg for copper and 2.195mg/kg for lead.

CONCLUSION

Going by this result it could be inferred that the concentration of Heavy metals in the studied fish sample were within their acceptable limit set by World Health Organization (WHO), and National Agency for Food Administration and Control (NAFDAC). More intensive sampling of other fish species could be carried out to determine the possibility of their been use as a bio-monitor so as to further widen the scope of this research.

REFERENCES

Abdul Kashan, M.D and Singh, B.R (2012) Heavy metal contamination of soil and vegetation in the vicinity of
industries in Bangladesh water, a, and soil pollution 115: 347-361

Adakole, J.A (2013) the effect of pollution on a stretch of River Kubanni, Zaria. M.Sc.
Thesis.Dept. of Biological Science, Ahmadu Bello University. Zaria, Nigeria.

Agarwal, S.K (2010) Pollution Management, vol. 2-Water Pollution A.P.H publishing corporation New Delhi p37-45

Aizawa, H (2012): Metabolic Maps of pesticides, vol. 2, Academic Press, San Diego, California, USA, P 19

Albaiges, J. (2012): Persistent Organic Pollutants in the Mediterranean Sea, Hdb. Env, Chem. Vol. 5, Part K: DOI 10.1007=b107145, Springer-Verlag, Berlin, Monitoring of pesticides in the Environment P. 351.

Albro, and PW, Fish Bein L, (2010). Absorption of aliphatic hydrocarbons by rats, Biochem Biophys Aca, 219, 437-446

Ali, U., Syed, J and Malik, R. (2012); “Organochlorine Pesticides (OCPs) in South Asian Region: a Review,” Science of the Total Environment, 476-477: 705-717

ASSESSMENT OF WATER QUALITY PARAMETERS AND AQUATIC INSECTS OF DUTSIN-MA RESERVIOR, KATSINA STATE

Abubakar, I.*, A.B. Dauda, H.U. Yunusa, and M.A. Sadauki

Department of Fisheries and Aquaculture, Federal University Dutsin-ma, Katsina, Nigeria

Corresponding author:
iabubakar21@fudutsinma.edu.ng, +234-9074628336

ABSTRACT
This research was conducted to assess the water quality parameters and aquatic insects of Dutsin-Ma reservoir with a view to investigate the pollution status of the water body. pH, turbidity, dissolved oxygen and total dissolved solids in Dutsin-ma reservoir were examined twice a day, every week for eight weeks. Sampling of aquatic insects of Dutsin-ma reservoir was done with sampling nets and hand picking in three stations once in a week for eight weeks. A total number of 96 individuals representing 6 species were recorded. Majority of the insect fauna found in this study are typically found in similar water bodies in the tropics. However, the observed insect community structure revealed relatively low taxa richness with a dominance of pollution-resistant species which suggests a moderately polluted condition of the water body. The correlation analysis showed a poor relationship between the examined water quality parameters and the insects. This study established that the use of aquatic insect communities as bio-indicator for rapid assessment of water quality in Dutsin-Ma reservoir may be more reliable beyond only physico-chemical parameters.

Keywords:
Abundance, aquatic insect, bio-indicator; diversity, physicochemical variables, richness.

INTRODUCTION

Nigeria is blessed with an enormous area of freshwater and brackish water ecosystems that extend from the coast into the arid zone (Essien-Ibok and Isemin, 2020). A body of water does not necessarily have to be still or enclosed; rivers, streams, canals, and other geographical features where water flows from one point to another are also termed bodies of water; the majority of these features are naturally occurring, but some are man-made. Water qualities include all physical, chemical and biological properties that influence the beneficial use of water (Jenyo-Oni et al., 2010). The economy of the aquatic biotype depends on water which is the fish habitat (Agbabiaka, 2014). Some water quality parameters including pH, alkalinity, and hardness could have so much influence on the most other variables in the water bodies.

Aquatic insects are recognized worldwide as bio-indicator organism in the aquatic environment (Yakubu et al., 2000). Most importantly, aquatic insects are very good indicators of water quality since they have various environmental disturbance tolerance levels (Arimoro and Ikomi 2008). Some are very vulnerable and sensitive to pollution, while others can live and proliferate in disturbed and extremely polluted waters (Heap et al., 2013). Among benthic macro invertebrates, aquatic insects are one of the most common groups of organisms used to assess the health status of aquatic ecosystems (Jenyo-Oni et al., 2010). Some aquatic insects respond to specific changes in water conditions and have become indicators of river health condition to aquatic ecologists. The presence and absence of some particular aquatic insect indicate the degree of pollution, though the specific causative physicochemical pollutant may be identified by physicochemical methods (Gupta and Paliwal, 2010). Since diversity and abundance of aquatic insects provides an indication of the overall health of the water body. Identifying the diversity and community composition of aquatic insects in Dutsin-Ma reservoir might help to ascertain the health status of the reservoir. This study therefore examined the water quality parameters and aquatic insect diversity of Dutsin-ma reservoir, with the aim of investigating the overall health status of the water body.

MATERIALS AND METHODS

Study Area

The study area, Dutsin-Ma reservoir is an earth-fill structure completed in 1974 on the coordinates 12°1 '11" N (latitude) and 7°20'21" E (longitude) in Dutsin-Ma LGA of Katsina State. The dam has a perimeter of 5.05 km and covered an area of 1.10 square kilometers (Figure 1) (Dauda et al., 2021). Dutsin-Ma town experience wet/rainy season and dry season. The rainy season last from June to September with annual rain fall range of 1500-1800mm (Dasuki et al., 2014). The reservoir was constructed primarily for domestic water supply in 1974. It is only fed during the rainy season by three main sources: korama from the west side, Darawa -korama from the Eastern side, Hadari -korama and surface run off from the surrounding catchment areas during the rainy season. It drained through the main control overflow structure towards Dantsido and through uncontrolled channel by the west axis. The reservoir has only one landing site where all catches are landed (Dauda et al., 2021).

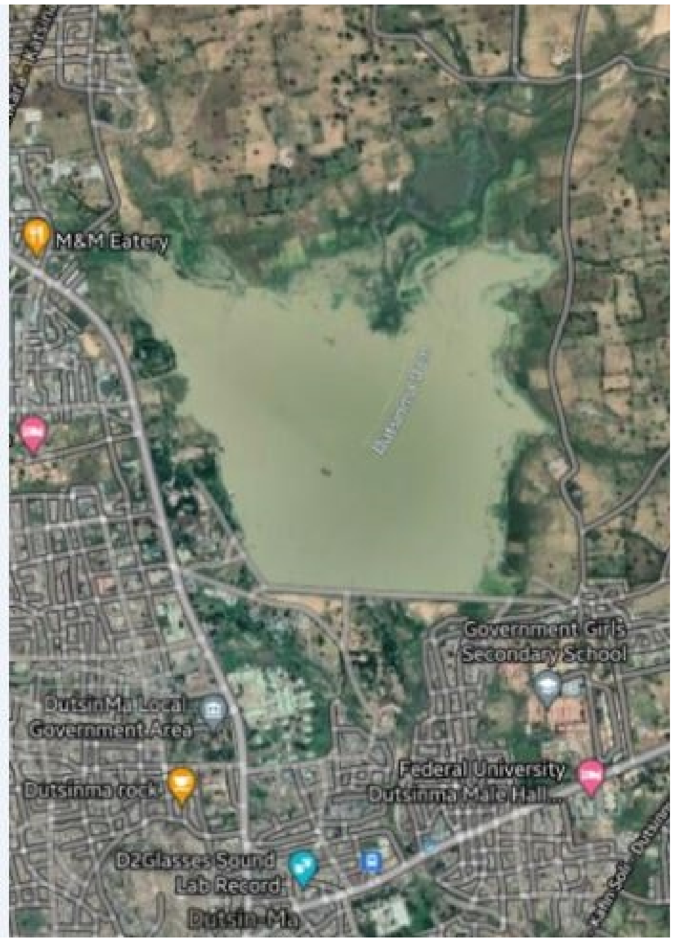


Figure 1: Satellite image of Dutsin-Ma Reservoir Katsina State
Source: Dauda et al. (2021)

Sampling Procedure for physico chemical parameters and duration

Water samples were collected twice every day from each of the three selected stations (upstream (A), middle area (B) and downstream (C)) in the reservoirs between 800 and 1000 hours and 1630 and 1730 hours, once a week for a period of 2 months (August to September 2023). The water samples were analysed in the field for the selected water quality parameters including; temperature, pH, dissolved oxygen, turbidity, ammonia and alkalinity as described by Dauda and Akinwole (2014), with all the procedure in line with the standard methods (APHA, 2012).

Sampling of insects

Aquatic insects were sampled nine times from August to September 2023. The samples were collected along the reservoir. The reservoir was divided into three parts: which were upper, middle and lower reservoir. The specimens were collected by sampling nets (1mm mesh size), and hand-picking technique. Samples were placed in white trays for sorting and screening of the aquatic insects. The aquatic insects were handpicked from the tray. Any non-aquatic insects caught were immediately returned to the reservoir (Adu et al., 2016). The content of each sample (net) was transferred into properly labeled plastic containers and taken back to the laboratory for analysis. In the laboratory, aquatic insects were sorted on a Petri dish and identified to the family level using taxonomic keys (De Moor et al., 2003) and a pictorial guide (Umar et al., 2013). Large aquatic insects were sorted by the naked eye whereas the sorting of the smaller ones was done under a dissecting microscope. All the sorted samples were kept in properly labeled vessels.

Data analysis

Data collected were presented using mean and standard deviation for the water quality parameters, and frequency and percentages for the aquatic insect. Pearson correlation was used to test the interdependence between the water quality parameters and aquatic insects. All analysis was done using IBM SPSS version 23.

RESULTS AND DISCUSSION

All the physicochemical parameters during the study period showed no significant difference ($P<0.05$) among the stations except dissolved oxygen (DO) which was significantly lower in station A (5.38±.0.51 mgL-1) compared to the two other station (Table 1). According to Sadauki et al. (2022) damming of water to create reservoirs is one of the ways of making more water available for the needs of man as the water is stored and made available all the time. Nonetheless, water is only able to be of maximum advantage if it is of optimum quality. All the water quality parameters in this study were within the recommended level for tropical water bodies except Ammonia that is high (Dauda and Akinwole, 2014). While other parameters were similar, DO was higher in stations B and C, however the least DO observed in station A was higher than the recommended minimum of 5 mg/L as optimum DO for surface waters (Yakubu and Ugwumba, 2009). The result of this research is in line with Sadauki et al., (2022) who reported 6.70mg/L as the highest value of DO and 6.90mg/L as the least in Zobe reservoir in the same Dutsin-Ma Local government area.

Table 1: Physicochemical parameters of water in Dutsin-Ma Reservoir

Parameters	Station A	Station B	Station C
Temperature ^{0}C	26.66±0.60^a	26.38±0.69^a	26.57±0.38^a
Turbidity mg/L	0.00±0.00^a	0.00±0.00^a	0.63±0.63^a
Dissolved oxygen mg/L	5.38±.0.51^b	5.66±0.36^a	5.66±0.36^a
pH	7.03±0.12^a	6.98±0.09^a	6.96±0.07^a
Ammonia mg/L	2.26±0.47^a	2.58±0.56^a	2.42±0.44^a
Alkalinity mg/L	25.85±1.61^a	27.50±1.89^a	26.30±1.83^a

Different letters as superscripts across the rows indicate significant difference at $P<0.05$

During the study, six species of aquatic insects were identified in the reservoir as presented in (Table 2), namely; water beetle, water scorpion, beetles' larvae, dragon flies, damsel flies and may flies in all the stations. Whereas damsel flies dominated all the three stations (Table 2). Correlation analysis showed that dissolved oxygen had a significant negative correlation with NH3, and temperature also had significant negative correlation with pH, DO and Alkalinity. Temperature showed a significant positive correlation with beetles' larvae (Table 3).

Table 2: Distribution of aquatic insects in Dutsin-Ma reservoir

Insect	**A**		**B**		**C**	
	Frequency	**%**	**Frequency**	**%**	**Frequency**	**%**
Water beetle	8	13.12	10	16.40	2	5.72
Water scorpion	10	16.39	8	13.11	3	8.57
Beetles' larvae	9	14.75	11	18.03	2	5.71
Dragon flies	12	19.67	12	19.67	9	25.71
Damsel flies	14	22.95	12	19.67	12	34.28
May flies	8	13.11	8	13.11	7	20
Total	61	100	61	100	35	100

Damsel flies was found to be the most diverse and abundant in the stream. Several factors are known to influence the distribution of aquatic macro invertebrates, but the important factors likely to affect the diversity and abundance in an aquatic ecosystem, are water temperature, water velocity, nutrient availability, etc. The six species of aquatic insects recorded in this study was low compared with 13 taxa reported by Popoola and Otalekor (2011) in Awba reservoir, Ibadan and 19 taxa reported by Edegbene et al. (2015) in River Chanchaga, Niger State, Nigeria. However, it was similar to the works of Onyenwe et al. (2018) who reported 7 taxa in the Anya River in Umudike South East, Nigeria. The species richness was similar in all the station but abundance was least in station C. The similarity in richness might be influenced by the similarity in the water quality parameters among the stations, while the least abundance at the downstream might be associated with accumulated pollutants and velocity of water at the downstream, which is expected to be different from that of up and middle stream. There is weak correlation between the water quality parameters and the aquatic insects. Many studies have reported low correlation between insects and physico-chemical parameters and this has been attributed to wide range of adaptability of insects to changing environments (Amusan and Balogun, 2018). According to Jenyo-Oni et al. (2010), while phyisco-chemical parameters reflect immediate change in the water quality, bio-indicators such as macro-invertebrates and aquatic insect reflect long time effect of pollutants.

Table 3: Interdependence among the water quality parameters and the aquatic insects in Dutsin-ma reservoir

	Temp	**pH**	**DO**	**Turb**	**NH_3**	**Alk**	**W.btl**	**W.sc**	**B.lar**	**Dr fly**	**Dam fly**	**May fly**
Temp	1											
pH	-0.426**	1										
DO	-0.548**	0.354*	1									
Turb	-0.039	0.019	0.085	1								
NH_3	0.235	0.086	-0.484**	-0.140	1							
Alk	-0.466**	0.247	0.502**	0.88	-0.035	1						
W. btl	0.025	-0.040	-0.431	0.0	-0.037	-0.27	1					
W.sc	-0.005	-0.347	0.019	0.00	0.105	-0.205	0.025	1				
B.lar	0.506*	-0.126	-0.261	0.00	-0.165	-0.294	-0.057	0.138	1			
Dr fly	0.184	-0.065	-0243	0.00	-0.467	-0.279	0.072	0.075	0.502*	1		
Dam fly	0.024	0.238	-0.073	0.00	0.024	0.074	0.413	0.053	-0.066	-0.083	1	
May fly	-0.270	-0.205	-0.294	-0.279	0.074	0.290	0.227	0.305	-0.050	0.147	0.278	1

*indicate significant different at P<0.05 **indicate significant difference at P<0.01

Keys: Temp-Temperature, DO-Dissolved oxygen, Turb-Turbidity, NH3 -Ammonia, Alk-Alkalinity, W.btl-Water beetle, W.sc- Water scorpion, B. lar- Beetle larvae, Dr fly-Dragon fly, Dam fly- Damsel fly, May fly- May fly

CONCLUSION

The study established that the water quality parameters are similar among the stations except the dissolved oxygen. There is low richness and diversity of the aquatic insect with damsel fly as the dominance species in the water body. The water body can be said to be under slight pollutional stress considering the high concentration of the ammonia and pollution-tolerant characteristics of most of the aquatic insects found in the water body. Therefore, the use of aquatic insect as a bioindicators in surface waters is recommended.

REFERENCES

Adu B.W., Kemabonta, K.A. and Ogbogu, S.S. (2016) Monitoring of environmental disturbance using abundance and distribution of red-vein and dark-vein species of genus Trithemis (Odonata: Libellulidae). Zoologist 14:31-36

Agbabiaka.L.A. (2014). Aquaculture and pond management in Tropics. Revised edition: 91-99 pp

Amusan B. and Balogun I. (2019). Assessment of the aquatic insect assemblage and water quality of a tropical stream in Southwestern Nigeria. Journal of Entomology and Zoology Studies; 7 (1): 1199, 1205.

APHA (2012). Standard Methods for the Examination of Water and Waste Water. 22nd Edition, American Public Health Association, American Water Works Association, Water Environment Federation, Washington DC.

Arimoro, F.O. and Ikomi, R.B. (2008). Response of Macroinvertebrate Communities to Abattoir Wastes and Other Anthropogenic Activities in a Municipal Stream in the Niger Delta, Nigeria. Environmentalist, 28, 85-98. http://dx.doi.org/10.1007/s10669-007-9033-8

Dasuki A., Dauda A.B., Oshoke J.O., Tiri G.D. And Bichi A.H. (2014): A Survey Of Artisanal Fisheries of Makera Zone of Zobe Reservoir, Katsina State. In: Proceedings, 29th Annual Conference of Fisheries Society of Nigeria (Fison), held between 24th – 29th November 2014 at Royal Choice Inn Ltd, Gondo Aluor Road, Old GRA, Lobi Quarters, Makurdi, Benue State Nigeria, pp 2-5.

Dauda, A.B., Dogo, M.T. and Abdulkareem H.O. (2021). Socio-economic status of fisherfolks and fishing activities in Dutsin-Ma reservoir, Katsina State, Nigeria. In: Akinrotimi O.A. (edited), Book of Proceedings 36th Annual conference of the Fisheries Society of Nigeria, Garden City 2021, held between 24th and 29th October 2021 at Ebitimi Banigo Auditorium, University of Port Harcourt, Choba Rivers State, pp 706 – 712.

Dauda A. B. and Akinwole A. O. (2014) Interrelationships among water quality parameters in recirculating aquaculture system. Nigerian Journal of Rural Extension and Development, 8(4): 20-25.

Edegbene, A. O., Arimoro, F. O., Odoh, O. and Ogidiaka, E. (2015). Effect of anthropogenicity on the composition and diversity of aquatic insects of a municipal river in North Central Nigeria. Biosciences Research in Today's World, 1(1): 55 - 66.

De Moor, I. J., Day, J. A., and De Moor, F. C. (2003). Guides to the freshwaterinvertebrates of Southern Africa, vol. 7. In Insecta 1 (Ephemeroptera, Odonataand Plecoptera) TT, (p. 300). Pretoria: Water Research Commission.

Essien-Ibok, M. and Isemin, N.L. (2020). Fish species diversity, abundance and distribution in the major water bodies in Akwa Ibom state, Nigeria. Biodiversity Int J. 4(1):42-48. DOI: 10.15406/bij.2020.04.

Gupta, M., and Paliwal, A. (2010). Role of aquatic insects of water quality in related to physico-chemical parameters in Yamuna River at district Firozabad (UP). Advanced Biomedical Research, 1(1), 71-74.

Heap, L.A., Goh, C.C., Kassahn, K.S., and Scott, E.K. (2013) Cerebellar output in zebrafish: an analysis of spatial patterns and topography in eurydendroid cell projections. Frontiers in neural circuits, 7:53. DOI:10.23818/limn.25.33

Jenyo-Oni, A., Akinwole, A. O. and Dauda, A. B. (2010). Benthic Macroinvertebrates and Physico Chemical Quality of Reservoirs in University of Ibadan, Fish Farm. Ibadan Journal of Agricultural Research, 6, 19-26.

Onyenwe, E.A., Emeka D. and Nnyama, G.I. (2016). Preliminary Assessment of Aquatic Insects Biodiversity and Water quality Parameters of Anya River, Umudike, South East, Nigeria: Animal Research International 15(2): 3041 - 3047.

Popoola, K. O. and Otalekor. (2011). Analysis of aquatic insects' communities of Awba Reservoir and its physico-chemical properties. Research Journal of Environmental and Earth Sciences, 3(4): 422 - 428.

Sadauki, M.A., Bichi, A.H., Dauda, A.B., Geidam, M.B. (2022). Assessment of Water Quality Parameters of Zobe and Ajiwa Reservoirs, Katsina State, Nigeria. African Scientist 23(1) 9-18

Umar, D. M., Harding, J. S., and Winterbourn, M. J. (2013). Freshwater invertebrates of the Mambilla Plateau, Nigeria, (p. 88). New Zealand: Photographic Guide School of Biological Sciences University of Canterbury

Yakubu A.S. and Ugwumba A.A. (2009). A study on macroinvertebrates fauna of lower Ogun River at Ishasi, Ogun State, South west Nigeria. Jounal of zoologist 7:65-74

Yakubu, A.F., Sikoki, F.D. Abowei-JFN and Harts, S.A. (2000). A Comparative study of Phytoplankton Communities of some rivers, Creeks and Burrow pits in the Niger Delta Area, Journal of applied science environment and management.

ACUTE TOXICITY OF AQUEOUS BARK EXTRACT OF DESERT DATE *(Balanite aegyptiaca)* ON JUVENILES OF *Clarias gariepinus* (Burchell 1822)

[1]Ebenezer, S., [1] A.N. Olanrewaju, and [2] L.N. Wanas

[1]Department of Fisheries Technology, Federal College of Freshwater Fisheries Technology, Baga, P.M.B 1060 Maiduguri, Borno State
[2]Department of Fisheries, University of Maiduguri, Maiduguri, Borno State

Corresponding Author:
Samuelebenezer021@gmail.com +2349037696614

ABSTRACT

A 96hr lethal concentration static toxicity bioassay was carried out to examine acute toxicity (LC50) of aqueous bark extracts of Balanite aegyptiaca on juvenile Clarias gariepinus. The phytochemical composition of the stem bark of Balanites aegyptiaca was also identified. Twenty-five fish in two replicates were exposed to piscicide plant extract at 0.0 (control), 0.40, 0.80, 1.2, and 1.6 g/L-1. The phytochemical screening of the aqueous bark extract of Balanites aegyptiaca revealed Alkaloid, Saponins, Carbohydrate and Glycosides as its active ingredients. Fish exposed to the aqueous extracts except the control showed symptoms of toxicity including erratic movement, lethargies, moribund, air gulping, loss of sensitivity and gasping for air before death. These responses were much frequent and faster at the highest concentration (1.6g/L). The 96h LC50 value for C. griepinus in this study was 0.9215g/L-1. The study concluded that the application of aqueous bark extract of Balanite aegyptiaca causes lethal toxic effects on juveniles C. gariepinus. Hence, indiscriminate use of the plant for fishing should be discouraged and regulated to protect fish biodiversity loss in nattural water bodies.

Keywords:
Piscicide, Toxic, Freshwater fish, Claridae, Proximate, Balanite aegyptiaca, Aduwa.

INTRODUCTION

The use of plant extract as poisons for hunting and fishing is common among fishermen in Nigeria. Fish poisons from plants are also known as piscicides or ichthyotoxins. Several plant species are known to possess bioactive compounds that are toxic to fish. However, the effect of plant extract is dependent on the types and sizes of fish species. This implies that different fishes of different sizes are either tolerant or susceptible to a particular fish poison (Agbor et al., 2014). Synthetic chemicals have been the major piscicides in the control of pests and undesirable fish species in aquaculture, but these chemicals have harmful effects on non-targeted fish species (Kumar et al., 2010), thus cause serious environmental hazards (Adesina et al., 2013). In the last few decades, efforts have been made to replace the non-biodegradable chemical piscicides with biodegradable plant extracts (Suely et al., 2015).

Piscicidal plants have been widely used by traditional fishermen all over the world as a means of catching fish. Some of these plants are non-selective in destruction, thereby, interfering with ecological balance of the immediate environment. Piscicides are phytochemical substances that are poisonous to fish since it contains different active ingredients such as Alkaloid, Micotine, tannis, saponins, pipanne, resin, amide, ricin, glycoside, carbazole, curcin, coumanin, parkine, resoranol and cardol (Fafioye and

Adewande et al., 2009.) However, Alkaloids are toxic to fish at high concentration and wear off within short time (Adewumi, 1990). In Nigeria, fresh leaves of Adenia cissampeloides has been found to be toxic to fish which when processed and applied into dammed portions of rivers or streams that has large numbers of fishes, within fifteen minutes, both small ad big fishes are found floating dead (Morah, 1986). Extracts of many plants including Deris elliptica, D. trifoliate, Balanites aegyptiaca, Tephrosia candida, T. vogelii, and Parkia folicoides (Mohotti and Epa, 2016) contain biodegradable phytochemicals which have traditionally been used in aquaculture in different parts of the world (Epa, 2016). Power et al. (2008) reported that introduction of macerated plant material into rivers, streams or shallow ponds stupefy fish for easy collection.

Fish is one of the cheapest and direct sources of protein and micronutrients for many people all over the world. Today, more than one billion people rely on fish as a source of animal protein. Fish accounts for about 30% of the total protein intake for people in Asia, 10% in Latin America, 20% in Africa and 55% in Nigeria (Anyanwu et al., 2011). Olaosebikan and Raji (2013) stated that the family clariidae represents freshwater catfishes and comprises of three genera which include gymnallabes, heterobranchus and clarias with fourteen species found in Nigeria. The African catfish (Clarias gariepinus) is a popular economic freshwater food fish in Nigeria. Owing to this reason, some fishermen adopt obnoxious fish method of using piscicides for collecting this important fish species. Meanwhile, synthetic organic compounds are identified with problems of environmental resistance, pest resurgence and detrimental effects on non-target organisms because of their non-degradability. The effects of piscicide on food chain biodiversity can also lead to total eradication of certain species or caused them into extinction. Therefore, there is need to create awareness to the fisher folks on the dangers of using chemical substance as a fishing methods of catching fish on the ecosystem. Thus, this study was design to explore the acute toxicity of aqueous bark extract of Balanite aegyptiaca on juveniles of Clarias gariepinus.

MATERIALS AND METHODS

The research was conducted at the Teaching and Research Fish Farm of the Department of Fisheries, University of Maiduguri, Nigeria. Maiduguri is located on Latitude 11°05'N and Longitude 13°05'East, and characterized by hot, dry and wet, and harmattan seasons. One hundred juveniles of Clarias gariepinus was obtained from the outdoor pond, Fish Hatchery Complex of Fisheries Department, University of Maiduguri, Borno State. Ten aquaria (50cm x 25cm x 30cm) were prepared outdoor for the experiment. The tanks were supplied with 10litres of de-chlorinated tap water and 5 fingerlings were introduced into each tanks of different treatments in replicates. The fish was acclimatized in glass tanks for at least five (5) days prior to the commencement of the study.

The stem bark sample of Balanites aegyptiaca was collected within the University of Maiduguri campus area. The collected sample was shade-dried for 4 days, pulverized with pestle and mortar, and sieved into fine powder (0.2mm). The powdered sample was then wrapped into nylon bag and stored at room temperature for further analysis. Sample (30g) were taken to the phytochemical laboratory in Faculty of Pharmacy, University of Maiduguri for qualitative analysis. The dried stem bark powder was soaked for the period of 48hrs, filtered using 0.1mm sieve, and the filtrate was use as the aqueous extracts. The phytochemical screening of Balanite aegyptiaca for Alkaloids, Flavonoids, Saponin, Tannins, Carbohydrates, Glycosides was cconducted following the methods adopted by Fasola (2000). Balanite aegyptiaca extract powder was used during the Toxicity tests on Clarias gariepinus for only acute toxicity of the plant extract. Pilot study was carried out to determine the minimum (0.04g) concentration that did not produce death and the maximum concentration (0.16g) that produced 100% death. Four different acute concentrations were prepared in duplicate. The acute lethal concentrations used are 0.40g, 0.80g, 1.2g, 1.6g, and 0.00g/L (control). The 96-hour LC50 (lethal concentration) was determined through probit analysis method for acute toxicity test as

recommended by Yadav and Singh, (2001). Mortality and behaviours of the fish were recorded daily. Dead fish was immediately removed from each test tank to avoid pollution in the tanks. After the test, fish are exposed to various concentration of the bark extract. The behavioural responses and the mortality rate of the fish was observed and recorded at the interval of 24, 48, 72 and 96 hours. The fish in the control tank was monitored and it serves as a reference to the behavioral response observed in those exposed to the different concentration of the extract.
Statistical analyses by Excel (2016) software were performed. Data were analyzed by one-way analysis of variance (ANOVA) and level of significance was determined at P<0.05. Lethal concentration (LC50) was calculated logarithmically.

RESULTS AND DISCUSSION

Phytochemical Screening of Stem Bark of the Balanites aegyptiaca

Phytochemical screening of stem bark of the Balanites aegyptiaca in this study revealed the presence of alkaloid, saponins, glycosides, anthraquinones and carbohydrates while flavoid and tannin are absent (Table 1). This study agreed with Emad et al. (2012), who reported that phytochemical screening of Balanites aegyptiaca bark contain the presence of alkaloid, saponin, glycoside, carbohydrate, with tannin and flavonoid absent. The quantitative estimate of the above primary metabolites showed the various phytochemical constituents present in the plant extract. The absence of steroid is an indication that the bark of this plant cannot be used to boost reproductive performance in fish as observed by Samulelsson et al. (1991). Similar report has been documented in Azadirachta indica by Akinwande et al. (2007). The findings of this study also agree with the report of Samulelsson et al. (1991).

Table 1. Qualitative estimation of phytochemical screening of the bark of *Balanites aegyptiaca*

Phytochemicals	Observation
Alkaloid	++
Saponin	+++
Glycoside	++
Carbohydrate	++
Flavonoid	---
Tannin	---
Steriod	NA

Keys: Highly present +++, Moderate ++, Absent --, Not Available N/A

Physicochemical Parameters of the Experimental Setup for 96 Hours

The physicochemical parameters of the experimental setup at different concentration levels are as shown in table 2. The physicochemical parameters examined were pH, Dissolved oxygen and temperature levels. pH (6.10 – 6.38), dissolved oxygen (4.10 – 6.05mg/L), and temperature ranged from 26.68 to 26.82 oC (Table 2).

Table 2. Physicochemical parameter of the experimental setup for 96 Hours

Concentration (g/L)	pH	Dissolve Oxygen	Temperature 0^{c}
0.00	6.38^{a}	6.05^{ab}	26.9^{a}
0.40	6.30^{b}	5.45b	26.8^{a}
0.80	6.30^{b}	5.03^{a}	26.8^{a}
1.20	6.15^{c}	4.06^{a}	26.81^{a}
1.60	6.10^{c}	4.10^{a}	26.80^{a}
SEM	0.06	0.04	0.02

Mean on the same columns with different superscripts are statistically different (P<0.05), SEM ……

Behavioral Responses of Clarias gariepinus Juvenile Exposed to different Concentration of Balanites aegyptiaca

The mean behavioural responses, induction and recovery times of Clarias gariepinus juvenile during exposure to aqueous stem bark extract of Balanites aegyptiaca is as shown in table 3. Similar result was reported by Adeogun (2011), who reported that gasping for breath and rapid opercula movement may be due to the effect of the saponins foam which can coat fish gill epithelia. This observation is in agreement with the report of Adeogun (2011) who revealed presence of saponins in Raphia hookeri. The authors indicate that this causes hyperventilation, rapid opercula movement, and mortality in mud-cattish. The observation also concurs with the report of Roy et al. (1990) that saponins are highly toxic to fish because of their damaging effect on the respiratory epithelia. The resulting irritation and impairment of the respiratory epithelia will reduce the opacity of fish gill epithelia for diffusion of oxygen across the membrane.

According to Adeogun (2011), the continuous exposure of such fish to Saponins-rich pollutants as found in this study show asphyxiation, alternate swimming on the lateral side, and rapid and erratic swimming behavior. All of these are the effects resulting from the discomfort that the exposed test organisms are experiencing. The different behavioral responses of the fish can also affect the nervous coordination (Adeogun 2011).

Table 3. Behavioral responses of *Clarias gariepinus* **juvenile exposed to different concentration of** *Balanites aegyptiaca*

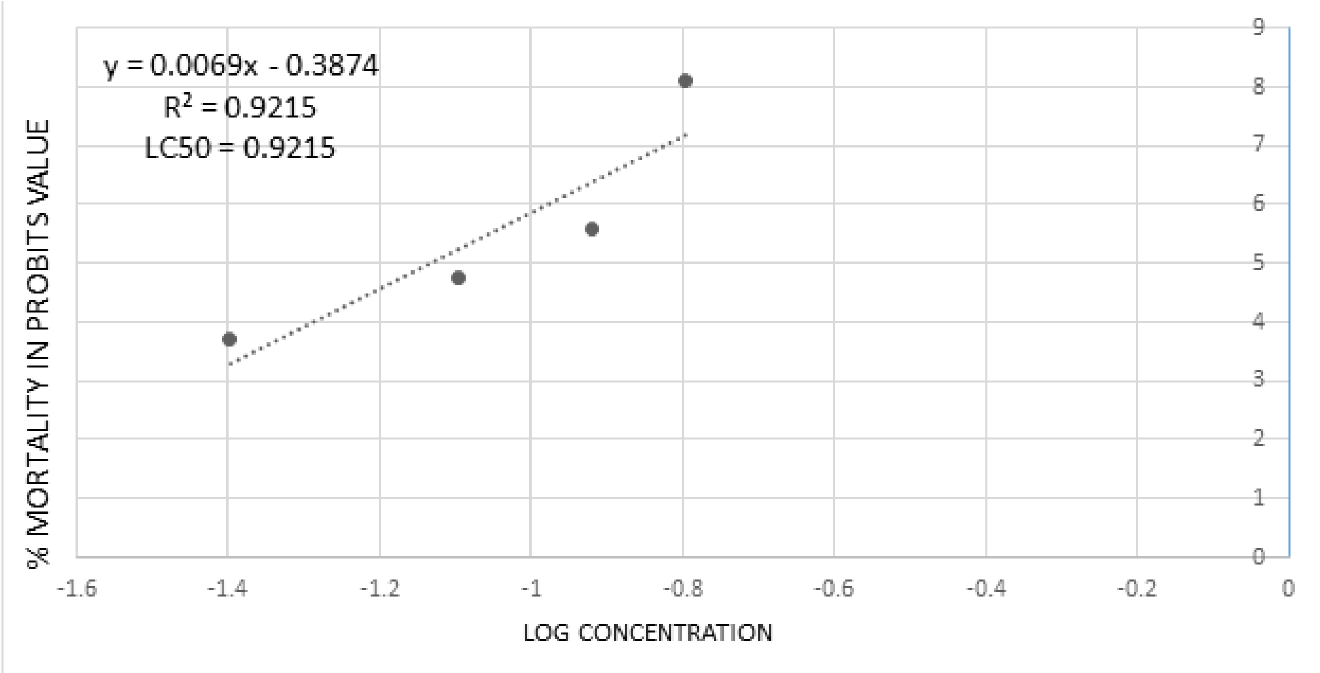
Concentration (g/L)	24hrs	48hrs	72hrs	96hrs
0.00	Normal swimming	Normal swimming	Normal swimming	Normal swimming
0.40	Rapid opercula movement	Jumping up with head up	Lethargic Swimming	Lethargic movement
0.80	Rapid opercula movement	Erratic Swimming	-	Gasping for air
1.20	Jumping out of the container	Rapid opercula movement	Gasping for breath	Gasping for air
1.60	Swim away from the point of extract	Erratic Swimming with head up	Death recorded	-

Percentage mortality of C. gariepinus juvenile exposed to different concentration of Balanites aegyptiaca

Mortality occurred in all the experimental tanks except in the 0.00g/L tank which had 0% mortality rate (Table 4). The first fish mortality was observed in 24 hrs in tanks containing 0.4g/L with mortality value of 1 (10% mortality rate). Concentration of 0.8g/L had 40% mortality rate, which was recorded from the 48hrs, 72hrs, and 96 hrs respectively with a corresponding mortality value of 1, 2, and 1 fishes. A total of 8 fish was observed at the concentration of 1.2g/L, which was resulted from the mortality value of 2 fish at 24hrs, 48hrs (3), 72hrs (3) and 96hrs (0). At 1.2g/L, mortalities were recorded at the 24hrs (4), and 48hrs (6) only, while no mortality was recorded in 72 and 96 hrs respectively. The highest percentage mortality of 100 was recorded in 1.6g/L while the lowest (0%) was recorded in the control set-up.

Table 4. Percentage mortality of *Clarias gariepinus* juvenile exposed to different concentration of *Balanites aegyptiaca*

Concentration (g/L)	Log Concentration	24hrs	48hrs	72hrs	96hrs	% Mortality	Probits
0.00	0	0	0	0	0	0	0
0.40	-0.397940009	1	0	0	0	10	3.72
0.80	-0.096910013	0	1	2	0	40	4.75
1.2	0.079181246	2	3	2	1	80	5.84
1.6	0.204119983	4	6	0	0	100	8.09



CONCLUSION

The study has shown that the aqueous extract of Balanites aegyptiaca stem bark was toxic to juveniles' African catfish (Clarias gariepinus) in 96-hr with LC50 value of 0.9215g/L. The phytochemical screening of the Balanites aegyptiaca stem bark aqueous extract revealed that it contained Alkaloid, Saponins, Carbohydrate and Glycosides as the active ingredients that give the plant its potency. Therefore, the use of the stem bark extract of Balanites aegyptiaca as a means of catching fish could lead to contamination and disruption of an ecological system, thus posing great threat to fish and other non-target organisms.

REFERENCES

Adeogun, A. O. (2011). Haematological profile of the African Clarrid catfish (Clarias gariepinus) exposed to methanolic extract of Raphia hookeri. Tropical Veterinarian, pp. 27-43. https://doi.org/10.1155/2014/615908

Adesina, B. T., Omitoyin, B. O., Ajani, E. K. and Adesina, O. A. (2013). Acute-lethal toxicity (LC50) of Moringa oleifera (Lam.) fresh root bark extract on Oreochromis niloticus juveniles under renewal toxicity exposure. International Journal of Applied Agriculture and Apiculture Research, 1&2:182-188. https://doi.org/10.1016/j.toxlet.2009.06.589

Adewumi, C. O. (1990). Plant Molluscicides. Potential of Aridan, Tetrapleura telraptera for schistosomiasis control in Nigeria. Environment, 102: 21-33. https://doi.org/10.1016/0048-9697(91)90306-Y

Agbor, R. B. and Okoi, E. P. (2014). The early life toxicity of Godogbo (Adenia cissampeloides) stem against catfish juveniles. Researcher, 6(9): 17-19. https://doi.org/10.9734/arrb/2017/38114

Akinwande, A. A. and Sogbesan O. A. (2007). Piscicidal potential of mesocarp of Neem plant (Azadirachyta indica). Fruit on fry of Heteroclarias Pp 533-536. https://doi.org/10.9734/jeai/2020/v42i930607

Anyanwu, D. C., Udedibie, A. B. I., Osuigwe, D. I. and Ogwo, V. O. (2011). Haematological responses of hybrid of Heterobranchus bidorsalis x Clarias gariepinus fed dietary levels of Carica papaya leaf meal. World Rural Observation, 3(1): 9-12. https://doi.org/10.4314/joafss.v5i2.46739.

Emad, M., Abdallah, A., Ben H.,, Khalifa S. A., (2012) Antimicrobial, antioxidant and phytochemical investigation of Balanites aegyptiaca (L.) Del. edible fruit from Sudan. African Journal of Biotechnology. 11(52): 11535- 11542. https://doi.org/10.5897/ajb12.1102

Fafioye, O. O. and Adebisi, A.A (2001). Growth of the Nile Tilapia, Oreochmis niloticus (Trewavas) exposed to sub-lethal concentrations of aqueous extracts of Raphia vinifera and Parkia biglobosa. Journal of Applied Sciences: 115-119pp. https://doi.org/10.4314/biokem.v17i2.32599

Kumar, A., Prasad, M., Mishra, D., Srivastav, S. K. and Srivastav, A. K. (2010). Toxicity of aqueous extract of Euphorbia tirucalli latex on catfish, Heteropneustes fossilis. Ecotoxicology and environmental safety, 73: 1671-1673. https://doi.org/10.1016/j.ecoenv.2010.08.003

Mohotti, C. R. W. C. and Epa, U. P. K. (2016). Toxicity of aqueous extract of white hoary pea, Tephrosia candida (Papilionoideae) on Nile tilapia, Oreochromis niloticus (Cichlidae) fingerlings. Sri Lanka Journal of Aquatic Sciences, 21(2):105-112. https://doi.org/10.4038/sljas.v21i2.7506

Suely, A., Zabed, H., Ahmed, A. B. A., Mohamad, J., Nasiruddin, M., Sahu, J. N. et al. (2015). Toxicological and haematological effect of Terminalia arjuna bark extract on a freshwater catfish, Heteropneustes fossilis. Fish Physiology and Biochemistry, 1: 1-15. https://doi.org/10.1007/s10695-015-0149-3

Yadav, R. P., Lata, K. and Singh, A. (2009). Toxicity of alcoholic leaf extracts of Lantana indica plant: effect on haematological and physiological parameters in non-target fish, Heteropneustes fossilis. International Journal of Fisheries and Aquatic Sciences, 2(1): 13-17.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

THE EFFECTS OF RIVER DUMPING ON WATER QUALITY AND FISH BIODIVERSITY: A GLOBAL CONCERN

*Igbani, F., J. Ofate and L. Himalayas

Department of Fisheries and Aquaculture, Faculty of Agriculture and Life Sciences, Federal University Wukari, KM 200 Katsina-Ala Road, PMB 1020 Wukari, Taraba State, Nigeria.

+23486003973, 0000-0002-0043-5667.

ABSTRACT
The menace of river dumping pollution starts with anthropogenic activities of individual household, industrialization and waste management in the ecosystem. The objectives of the review were on the effects of river dumping on water quality and on fish biodiversity. Several literatures were reviewed on the effects of river dumping on water quality and fish biodiversity. Researchers critically administered questionnaires and collected water quality parameters to analyze the level of effects by river dumping thus: Human contributions to water pollution are enormous, such as dumping of solid wastes, industrial wastes, and domestic wastes. Water pollution is a major concern to the world; river dumping has compromised the quality of consumable fish and aquatic organisms as well as the water purity of the aquatic environment; continuing this practice of river dumping would be a serious threat to the aquatic ecosystems components and it will be responsible for water quality depletion, deterioration and destruction of aquatic biodiversity. Additionally, policymakers should focus on developing appropriate rules and regulations suitable for a country and its citizens. Finally, enforcement of laws in a proper way is required to reduce the severity of pollution in freshwater ecosystems which are the most affected by river dumping pollutions.

KEYWORDS:
Aquatic Pollution, River Dumping, Biodiversity, Drums of Death, Pollutants, Water Quality

INTRODUCTION

Rivers, the lifeblood of our planet, are facing an unprecedented threat. The indiscriminate dumping of waste into these waterways is not only harming the environment but also jeopardizing human health. This review highlights the alarming effects of river dumping on water quality and fish biodiversity, justifying the need for immediate action. The consequences of river dumping are too severe to ignore. It is imperative that we take immediate action to: "protect human health (to prevent waterborne diseases and cancer-causing pollutants)"; "preserve biodiversity (to safeguard aquatic species and ecosystems)"; "support economic growth (to maintain: fisheries, tourism, and recreational industries)" and "ensure environmental sustainability (to preserve water quality for future generations)".

Water is a universal solvent that gives ample important merits to human existence, survival, and continuity (Akankali and Onyeche, 2012). Anthropogenic activities are a result of man-made inclinations toward the ecosystem at large leading to increased pollution of water all over the world. These pollutants can be either organic or inorganic (Akram et al., 2018). Anthropogenic activities including wastewater disposal have nearly doubled inputs into the global cycle. Manmade activities have the potential to make an impact on the water quality of an aquatic ecosystem, depending on the water body; disturbance of the aquatic ecosystem may lead to changes in the biological, chemical, and physical composition of the water (Arora et al., 2018).

Waste dumping in Africa is becoming an increasingly insurmountable burden, with many of the natural habitats and bodies of water becoming severely polluted. Lake Victoria, for instance, which is one of the great African lakes and one of the largest fresh-water lakes in the world, adjoining Kenya, Uganda and Tanzania, is suffering from the effects of waste (Treaster, 2011). It is polluted with raw sewage, and has muddied from the erosion of soil from nearby hills which are losing trees and shrubs to people in search of firewood. Like Lake Chad in West Africa, and a few other lakes around the world, it has also been shrinking. In addition, parts of Lake Victoria are also clogged with hyacinths and algae that have been thinning out the fish populations (Treaster, 2011).

EFFECTS OF RIVER DUMPING ON WATER QUALITY

Water quality is a general term used to describe the characteristics (physical, chemical, and biological) of water resources. It plays an important role in determining aquatic ecosystems and public health (He et al., 2020; Uddin et al., 2022). It is a concern across the world due to the widespread release of pollutants into freshwater ecosystems (Zanoni et al., 2022). It plays a vital role in maintaining the ecological integrity of the river ecosystem (Viswanathan et al., 2015). As an important indicator of river health, water quality deterioration is a challenge to humanity (Zanoni et al. 2022) and is a critical challenge faced by many countries in Africa (Nkwanda et al., 2021; Biswas et al., 2019; Borett et al, .2019) and other regions (Tiyasha., 2020).

Igejongbo et al. (2018) researched on the impact of municipal waste on the hydrochemistry of Epe Lagoon, they reported mean dissolved oxygen value, 7.17±0.67 mg/l; all the three sampling sites Ejirin had the highest dissolved oxygen mean value, 7.35±0.15 mg/l and Agbowa-Ikosi had the lowest mean value, 7.07±0.87 mg/l. They stressed that the mean dissolved oxygen value of 7.17±0.67 mg/l which is just slightly below recommendation of 8-10 mg/l (FEPA. 1991).

Mean Values of the Physicochemical Parameters of the Epe Lagoon (August, 2014 - July 2016)

	DO	Temp	pH	Salinity	Turbidity	Nitrate	Alkalinity	Phosphate	Conductivity	BOD
Epe	7.09	27.07	6.97	0.04	57.31	1.33	56.21	7.72	77.69	1.60
Ejirin	7.35	27.36	7.03	0.08	57.94	1.30	59.00	7.38	75.85	2.09
Agbowa	7.07	26.95	6.95	0.10	58.86	1.31	59.80	7.45	86.08	1.76
Mean	7.17	27.13	6.98	0.13	58.04	1.31	58.34	7.52	79.87	1.82
SEM	0.129	0.107	0.071	0.00	0.95733	0.029	0.797	0.122	1.592	0.120
Unit	ppm	^{0}C		ppt	uhoms/cm	ppm	ppm	ppm	ppm	ppm

Source: Field Survey (August, 2014 - July, 2015; Igejongbo et al., 2018).

Deteriorating water quality is stalling economic growth and exacerbating poverty in many countries. The explanation is that, when biological oxygen demand-the indicator that measures the organic pollution found in water-exceeds a certain threshold, the growth in the Gross Domestic Product (GDP) of the regions within the associated water basins falls by a third. Urbanization, population growth, unsuitability, untenable land use and industrialization are the main sources of the pollutants that lead to water pollution. These sources lead to the increase of gas emissions, wastes and excessive use of water. Thereafter, these actions result in eutrophication, population loss, lethal substances and acidification. In this regard, the effects of river dumping on water quality and biodiversity by heavy metals, chemicals and other pollutants on the health and quality of fish. Urban rivers play an important role in supporting economic and social development (Feisal et al., 2023; Larsen et al., 2016).

Waste dumping in Africa is becoming an increasingly insurmountable burden, with many of the natural habitats and bodies of water becoming severely polluted. Lake Victoria, for instance, which is one of the great African lakes and one of the largest fresh-water lakes in the world, adjoining Kenya, Uganda and Tanzania, is suffering from the effects of waste (Treaster, 2011). It is polluted with raw sewage, and has muddied from the erosion of soil from nearby hills which are losing trees and shrubs to people in search of firewood. Like Lake Chad in West Africa, and a few other lakes around the world, it has also been shrinking. In addition, parts of Lake Victoria are also clogged with hyacinths and algae that have been thinning out the fish populations.

A considerable problem caused by tourism in Africa is that while some hotels have their own water treatment systems, most of the smaller hotels and restaurants use the natural waterways to dispose of their waste. In addition, tourists generate more solid wastes than locals; with hotels, restaurants, shops, diving and adventure trip organizers all using large amounts of products that come in personal single-use plastic packaging (Quaade, 2018). Tourism development in Malawi is now also being affected by sewage and solid waste disposal. The Mangochi District Council of Malawi, for instance, does not have a sewage disposal system outside the town area, so holiday resorts have had to construct their own sewage and solid waste disposal systems. The UN says that more than 80% of the world's sewage finds its way into seas and rivers untreated. Constructing these disposal systems is costly and often unaffordable for the smaller hotels, meaning that this waste often ends up in the surrounding bodies of water, polluting the waterways and posing health hazards to humans and wildlife (Ngochera et al., 2018). Waste in Malawi is also harming the prospects of further tourism, with poor ecological conditions becoming a detractor to any future potential tourists and industrial waste (SDNP. 2006). Tourism, however, remains the single largest driver of waste dumping into Lake Malawi. Many tourist sites around the lake act as locations for people to be able to interact with nature, which has resulted in numerous businesses arising to support the tourism activities, while providing employment to people from various different backgrounds and professions. Tourists visit Lake Malawi from all over the country, and from other countries, to explore the waters, and to taste the multitude of fish species that reside in the waters. In the process, however, there is a considerable amount of waste produced. Many lodges, hotels, and restaurants, for instance, deposit garbage and human waste into the lake; while many residents from the surrounding villages, such as those employed in the thriving tourism industry, dump food residues, defecate, wash, and bath in the lake. Tourists, too, dump large amounts of plastics and food items that they use into and around the lake (Tsuro, 2021).

Europe attracts some of the highest numbers of tourists, however many resorts have poor waste management records: some cases include waste dumping into the Mediterranean Sea where Turkey, Spain, Italy, and France were reported to dump 144, 126, 90, and 66 tons per day, respectively (WWF, 2018). Aside from the major increase in safety to public health and the environment due to these improvements in water quality, they have also generated considerable economic benefits, with the UK sea side tourism industry now being worth £3.6 billion each year, and supporting 210,000 jobs in England and Wales alone (Tsuro, 2021).

THE “DRUMS OF DEATH” AND THE “DUMP-TOWN”

According to UNESCO (2003), the types of pollutants plaguing marine ecosystems includes sedimentation, agricultural run offs, thermal and light energy, sewage, solid wastes, chemicals, metals, radioactive substances, oil and biological materials. Thus, this finding in the Lagos lagoons conforms to the UNESCO assertions. The dominant solid wastes recorded in most of the dump sites surveyed were plastics which include nylons (polyethylene bags), containers, packaging materials and other plastic products. The dominance of plastics can be attributed to the frequency of use because of their low cost and their non-biodegradable nature. This corroborates the findings of (Ajao, 1996; UNEP, 2006) which noted widespread pollution of the Lagos lagoon. Polyethylene products can lead to suffocation of aquatic animals which mistakenly swims into them and when swallowed may result is blockages of tracts and eventually death. Nubi et al., (2008) in their study, reported that most of the wastes found in these dumps are persistent (non-biodegradable) in the environment, and continuously leach heavy metal into the water body. The presence of the solid waste dumps is an indication of unregulated anthropogenic activities in such areas and suggests a general lack of proper waste management service and control. Therefore the use of these open coastal spaces is preferred for its convenience as suggested (Sankoh et al., 2013).

In 1988, a huge toxic waste was dumped in a farming town in southeast Nigeria's restive oil-producing Delta region, as by a community leader. The community leader, Collins Edema, president of the National Association of Itsekiri Graduates, said the waste was dangerous to both agricultural produce and aquatic life. It was dumped in Koko, a town in the Warri north local government district of Delta state, Mr. Thankgod Seibi, a special assistant to the state's governor on community development (Odogwu and Taiwo, 2017). The waste was brought in from a foreign country into Nigeria and dumped at Koko. The state government has not done anything about it yet, he said. Mr. Seibi did not give details of the foreign country. They were called “the drums of death”. Over 3,500 tons of hazardous waste, packaged in innocent-looking barrels, and shipped to an obscure village in Delta State, causing mayhem, igniting national outrage and eliciting global concern. That was in June, 1988; when Nigeria had no comprehensive environmental laws; when we responded to ecological crisis on an ad hoc basis (Odogwu and Taiwo, 2017). An Italian trickster, Gianfranco Rafaelli, claimed he was shipping residual chemicals and raw materials for a proposed fertilizer manufacturing company to Nigeria. He deceived Nigerian authorities and passed through with his toxic shipment. The killer cargo got to Koko Port "in the present Warri North Local Government Area" from Lagos and finally landed in the backyards of Mr. Sunday Nana, a grandson of the legendary founder of the town, Chief Nana Olomu, (both of whom are now late). As Nana innocently accepted the cargo for safe keep on his land, he unwittingly embraced the Grim Reaper's cauldron of afflictions. Influenza, fever, and death followed. The rest is now a well-rehashed history (Odogwu and Taiwo, 2017).

EFFECTS OF RIVER DUMPING ON FISH BIODIVERSITY

Pollution is one of the biggest threats to biodiversity and the environment in the world. Solid wastes are often everyday by-products of households, commercial, and institutional entities, and include waste such as garbage, sludge from wastewater and water supply treatment plants, as well as other discarded materials from industrial operations. Moreover, heavy metals disrupt aquatic ecosystems such as aquatic fauna and aquatic flora. Heavy metals are the major sources of water pollution and it has been observed that heavy metals causes high damage in fish health that ultimately affects human health. These pollutants have also affected the diversity of fish and have created a major imbalance in aquaculture. Therefore, heavy metal toxicity has impacted the health and quality of fish and consuming them can affect the nervous system and damage sensitive organisms. The prevalence of pollutants and heavy metals has caused a major impact on the health and diversity of fish. Water is among the most important aspects associated with regular activities and the survival of living creatures. Hence, business organizations can focus on improving their waste releasing practices and incorporate sustainability approaches to improve the nature of waste and reduce harmful waste. Adopting these practice help to improve the quality of water by reducing pollution and also improve fish quality and health. Destruction of biodiversity, water pollution depletes aquatic ecosystems and triggers unbridled proliferation of phytoplankton in lakes' eutrophication (Javed and Usmani, 2019).

Abiodun (2021) researched on the implications of dumping human waste into Lagos Rivers, he observed that dumping human waste in Lagos rivers has negative impacts on human lives, as it results in spreading bacterial and viral diseases; it has negative health consequences for people who depend on the river as a source of food; it also increased rate of low birth weight as a result of women exposed to waste pollutants, and high rate of mortality with sectional average mean of 3.25. He stressed that careless dumping of refuse in waters is detrimental to both human and animals including aquatic life (Ezechi et al., 2017).

The Opinion of the Respondents on the Effect of Dumping Human Waste in Lagos Rivers on the Environment

	Mean*	Stdev.	Decision To accept ≥2.5
Reduced food production	3.64	0.63	Accepted
Deteriorate water quality which stalls economic growth,	3.50	0.55	Accepted
Generates gas which is explosive and contributes to the greenhouse effect.	3.71	0.57	Accepted
Attraction of vermin	3.63	0.31	Accepted
Overall Means and Standard Deviation	**3.62**	**0.52**	

1= strongly disagree, 2= disagree, 3= agree, 4= strongly agree; Source: Research Data computation (2021); Abiodun, 2021.

Aragaw and Giovanini (2022) researched on pollution potential of dumping sites on surface water quality in Ethiopia, using leachate and comprehensive pollution indices. They reported that dumping sites posed a considerable risk of pollution to adjacent water resources. They stressed that the overall Leachate Pollutions Index (LPI) ranged from 23.34 to 27.35, which is higher than the discharge standard LPI of 5.69, indicating that dumping sites can threaten the surrounding water resources and human health as well as aquatic lives.

Bashir et al. (2020) researched on the concerns and Threats of contamination on aquatic ecosystems. They opined that the discharge of various pollutants into aquatic environments is the outcome of countless anthropogenic activities, threatening the heath of the living beings and damaging the quality of the environment by rendering water bodies unsuitable (Abowei and Sikoki., 2005; Ekubo and Abowei., 2011). They stressed that the degradation of aquatic ecosystems is largely due to human activities as well as increased urbanization and industrialization are greatly responsible for water pollution.

Sonone et al. (2020) have opinionated about the effects of heavy metals and other pollutants on aquaculture which showcases that power plants, biochemical wastes, agricultural activities, electronic wastes, volcanic eruptions and others are the core sources of the heavy metals that affects the aquatic environment and the health of the fishes. Metal bioavailability and metal accumulation leads to habitat loss of the fishes and that creates a poor aquatic environment which eventually negatively affects the health of the fishes (Madhav et al., 2020).

Tsuro (2021) researched on the impacts of waste dumping in Lake Malawi. He observed that waste dumping reduces the number of tourist visitors to the Lake. He stressed that waste dumping affects the Inhabitants well-being, aquatic species abundance and diversity, and the Lake water quality. He stressed that for the lake not to lose it economic potentials: food supply, source of income, entertainment, foreign earnings, job opportunity, enhancing sport, home for game and wildlife species and other cultural activities, such as swimming, therefore, proper waste management systems should be ensured for a healthy aquatic ecosystem.

Abdullah et al. (2022) researched on microplastics pollution in the Surma River in Bangladesh: A threat to fish diversity and freshwater ecosystem. They reported that the presence of microplastics affects water quality, freshwater ecosystem and fish diversity due to inadvertent plastic dumping. They also opined that the massive dumping of microplastics has also compromised the quality of consumable fish and aquatic organisms as well as the water purity of the freshwater ecosystem. They stress that, there is an urgent need to raise awareness among the common people regarding the fate and consequences of plastic pollution.

Manalo and Hemavathy (2023) researched on the effects of water pollution on the quality of fish. They opined that water pollution disrupts the growth of the fishes and decreases the quality of them.

They noted that the percentage of fish population decreases as well as the percentage of fish decline also increases due to water contamination. They observed that these contaminants are formed through different activities, including domestic waste, industrial and agricultural waste and stated that heavy metals are the major sources of water pollution and it has been observed that heavy metals cause high damage in fish health that ultimately affects human health. Hence, these pollutants have also affected the diversity of fish and have created a major imbalance in aquaculture. They recommended that companies and business organizations should focus on improving their waste releasing practices and incorporate sustainability approaches to improve the nature of waste and reduce harmful waste by adopting best waste management practices which will help to improve the quality of water by reducing pollution and also improve fish quality and health.

CONCLUSION

River dumping starts from human behaviour with their generated wastes and poor waste management; due to urbanization, a lot of community dustbins were replaced by living structures-population blast and the alternative dumping sites are the aquatic ecosystems, such as rivers, streams, lakes and lagoons. Most people dump their wastes into gutters for the rains to flush into rivers and the seas by extension. The degradation of aquatic ecosystems is largely due to human activities, increased urbanization, industrialization and agriculture are greatly responsible for water pollution. This review has provided useful data on the effects of river dumping on water quality and aquatic biodiversity in the aquatic ecosystems. Human contributions to water pollution are enormous, such as dumping of solid wastes, industrial wastes, and domestic wastes. Water pollution is a major concern to the world; river dumping has compromised the quality of consumable fish and aquatic organisms as well as the water purity of the aquatic environment; continuing this practice of river dumping would be a serious threat to the aquatic ecosystem's components and it will be responsible for water quality depletion, deterioration and destruction of aquatic biodiversity.

RECOMMENDATIONS

Environmental education is very important to reduce the pollution of aquatic ecosystems. Regulatory bodies should spring into action to control the dumping of refuse along the river course, so as to prevent the extinction of aquatic life in the aquatic ecosystems. Individuals should separate their wastes into soft/solid/plastic or biodegradables (decomposing wastes) and non-biodegradables (and not decomposing wastes) in their homes and the industries/companies (should treat their sewage before discharging into the aquatic ecosystems). Open defecation should be discouraged by humans to maintain adequate water quality and healthy potable water for livestock and man.

REFERENCES

Abdullah, A.H., Chowdhury, G., Adikari, D., Jahan, I, Andrawina Y. O., Hossain, M.A., Schneider, P. And Iqbal, M.M. (2022). Microplastics Pollution in the Surma River in Bangladesh: A Threat to Fish Diversity and Freshwater Ecosystems. Water, 14, 3263. https://doi.org/10.3390/w14203263.

Abiodun, S. (2021). Implications of Dumping Human Waste in Lagos Rivers. International Journal of Research Publication and Reviews, Journal homepage: www.ijrpr.com ISSN 2582-7421, Vol (2) Issue (7) (2021): 1350-1356.

Abowei, J. F. N. and Sikoki, F. D. (2005). Water pollution management and control. Double Trust, Port Harcourt.

Ajao, EA (1996). Review of the state of pollution of the Lagos lagoon. Nigeria Institute for Oceanography and Marine Research (NIOMR) Technical Paper No. 106.

Akankali, J.A. and Onyeche, L.A. (2012). Determination of some environmental parameters of Anwai -stream, Niger-Delta,Nigeria.

Akram, R., Turan, V., Hammad, H. M., Ahmad, S., Hussain, S., Hasnain, A. and Nasim, W. (2018). Fate of organic and inorganic pollutants in paddy soils. In: Environmental pollution of paddy soils (pp. 197-214). Springer, Cham.

Arora, N. K., Fatima, T., Mishra, I., Verma, M., Mishra, J. and Mishra, V. (2018). Environmental sustainability: challenges and viable solutions. Environmental Sustainability, 1(4): 309-340.

Aragaw, T. T., Giovanni, V. and Mentore, V. (2022). Pollution Potential of dumping sites on Surface water quality in Ethiopia using leachate and Comprehensive pollution indices. Environ Monit Assess, 194:545. Https://choi.org/10.1007/510661-022-10217-2.

Bashir, I., Lone, F. A., Bhat, R. A., Mir, S. A., Dar, Z. A., and Dar, S. A. (2020). Concern and Threats of Contamination on Aquatic Ecosystems. Springer nature, https://doi.org/10.1007/978-3-036-35691-0-1,1-26.

Ezechi, E.H., Nwabuko, C. G., Enyinnaya, O. C. and Babington, C. J. (2017). Municipal solid waste management in Aba, Nigeria: Challenge and prospects. Environ Eng Res, 22, 231-236.

FEPA. (1991). Guidelines and Standard for Environmental Pollution Control. Federal Environmental Protection – Agency, 27, 20.

Ekubo, A. J. and Abowei, J. F. N. (2011). Aspects of aquatic pollution in Nigeria. Res J Environ Earth Sci 3:673–693.

Igejongbo, T. F., Adeparusi, E. O. and Dada, A. A. (2018). Impact Of Municipal Waste On The Hydrochemistry Of Epe Lagoon, South Western, Nigeria, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 18, Issue 1, 2018. PRINT ISSN 2284-7995, E-ISSN 2285-3952.

Javed, M. and Usmani, N., (2019). An overview of the adverse effects of heavy metal contamination on fish health. Proceedings of the National Academy of Sciences, India Section B: Biological Sciences, 89, pp.389-403.

Madhav, S., Ahamad, A., Singh, A.K., Kushawaha, J., Chauhan, J.S., Sharma, S. and Singh, P., (2020). Water pollutants: sources and impact on the environment and human health. Sensors in Water Pollutants Monitoring: Role of Material, pp.43-62.

Manalo, J. V. I. and Hemavathy, R. V. (2023). Effect of water pollution on the quality of fish. Journal of Survey in Fisheries Sciences, 10(15), 6029-6035.

Nubi, OA, Ajao, EA, Nubi, AT (2008). Pollution assessment of the impact of coastal activities on Lagos Lagoon, Nigeria Science World Journal 3(2): 83-88.

Sankoh, P. F., Yan, X and Tran, Q. (2013). Environmental and Health Impact of Solid Waste Disposal in Developing Cities: A Case Study of Granville Brook Dumpsite, Freetown, Sierra Leone. JEP 4: 665-670

Sonone, S.S., Jadhav, S., Sankhla, M.S. and Kumar, R., (2020). Water contamination by heavy metals and their toxic effect on aquaculture and human health through food Chain. Lett. Appl. NanoBioScience, 10(2), pp.2148-2166.

Tsuro, L. (2021). The Impacts of Waste dumping in Lake Malawi. Development Southern Africa. https://doi.org/10.1080/0346835X-2021.1919058, 1-16.

UNEP (2006). Marine And Coastal ecosystems And Human Well-Being Synthesis: A synthesis report based on the findings of the Millennium Ecosystem Assessment.

UNESCO (2003). The integrated strategic design plan for the coastal observations module of the Global Ocean-ographic Observing System. IOC/INF-1183.GOOS Report 125.

CONCENTRATIONS OF HEAVY METALS IN *Liza grandisquamis* FROM CREEKS RECEIVING INDUSTRIAL EFFLUENTS IN THE UPPERBONNY ESTUARY, NIGER DELTA

[1]Davids, C. B. D., [2]I. K. E, Ekweozor and [2]E. R. Daka

[1]Department of Agriculture, Ahoada West Local Government Area, Rivers State, Nigeria
[2]Department of Animal and Environmental Biology, Rivers State University, Port Harcourt, Nigeria

Corresponding author:
davids.caleb@gmail.com, +2348033150464

ABSTRACT
The level of heavy metals was determined in mullet (Liza grandisquamis) in four stations, three of which are in the creeks receiving effluents from the National Fertiliser Company of Nigeria (NAFCON), Port Harcourt Refining Company (PHRC) and Trans Amadi Abattoir, while the fourth station (Control) was located at Kalio/Abam axis of Okrika. Fish samples were collected monthly for a period of one year. Copper (Cu), Cadmium (Cd), Chromium (Cr), Nickel (Ni) and Lead (Pb) were examined in flesh(tissue), liver and gills of Liza grandisquamis. The trend of concentration observed was Ni>Cu>Pb>Cd>Cr. Concentrations of heavy metals were highest in the liver than in the gills and flesh, indicating a concentration trend of Liver>Gills>Tissue. Cu, Cd, Cr, Ni and Pb were found in mullet organs from the Control station. However, the levels in the organs of L. grandisquamis in all stations studied were generally within regulatory acceptable limits.

Keywords:
Industrial effluents, Mullet, Heavy metals, liver, gills

INTRODUCTION

The upper bonny estuary in the Okrika area of Rivers State is a regular receiver of domestic and industrial waste disposals The bioaccumulation of chemicals from industrial and domestic wastes by the biota is an important and interesting study, as concentration levels determine the toxicity to the organisms. There is an increasingly need to assess the contaminant levels in fish as indicators of health and wellbeing of both the fish and their consumers, including humans (Daka, 2005). Mugilidae are amongst the prevalent fish species in Okrika creeks. Likely bioaccumulation of these heavy metals in mullet has raised serious concerns, especially, being a fish of high consumption amongst the locals and the attendant health challenges it might cause. The need for this study is timely

MATERIALS AND METHOD

Three estuarine creeks in the upper Bonny Estuary studied have impact of anthropogenic influences from National Fertilizer Company of Nigeria (NAFCON), Port Harcourt refinery Company (PHRC) and other companies in the Trans-Amadi Area, including the Abbatoir. Twelve (12) sampling points were established for the study. Three (3) sampling points within each station (NAFCON, Refinery, Azuabie and Control). Samples were collected monthly for a period of twelve months, covering wet and dry seasons.
Liza grandisquamis were collected from fishermen operating in each of the study stations. Fish samples collected were properly labelled in a storage polythene bags and preserved in ice packed cooler and

taken to the laboratory for analysis. Three replicates of flesh, gills and liver were examined for each sampling point. Each replicate is composited from ten (10) individual fish species to obtain enough material for analysis. Fish samples were dissected in the laboratory. The liver, gill and tissue (flesh) were separated and dried in the oven at temperature of 75C. The samples were allowed to cool and then crushed into fine powders using porcelain mortar and pestle, and then digested with acid for the determination of copper, lead, nickel, chromium and cadmium using Unicam 969 Atomic Absorption Spectrometer (AAS).

Fig. 1 Map of the area indicating the sampling stations

RESULTS AND DISCUSSION

Nickel concentrations were generally higher than other heavy metals analysed in Liza grandisquamis with the trend, Ni>Cu>Pb>Cd>Cr. (Figures 2-4). The results also revealed that, there was higher concentration of heavy metals in the liver of the species, than in the gills and flesh tissue, indicating a concentration trend of Liver>Gills>Tissue. (Figures 2-4). This is consistent with the study of heavy metals level (Cd and Cr) in three major carps from River Ravi, Pakistan by Rauf et al (2009), which reported that fish liver appeared to have significantly higher tendency for the accumulation of Cd and Cr. Also, in a study on the concentrations of copper, zinc, cadmium and lead in Rabbitfish (Siganus oramin), in Victoria harbour, Hong Kong, Chan (1995) had reported that, concentrations of copper, zinc and lead in the muscle were found to be the lowest in the muscle as compared with other parts of the body. This observation is not different from this study, where copper, cadmium, chromium, nickel and lead concentrations are lowest in the flesh, than in the gills and liver.

Copper is an essential part of several enzymes, and it is necessary for the synthesis of haemoglobin. The mean concentration range of Cu (Figures2-4) in L. grandisquamis (0.096-0.533mg/kg) analysed was below the FAO recommended guideline of 30 μg/g (FAO, 1983).

The major source of Ni for humans is food and uptake from natural sources, as well as food processing (NAS-NRC, 1975). Increased incidence of cancer of the lung and nasal cavity caused by high intake of Ni has also been reported in workers in Ni smelters. The estimated maximum guideline (USFDA, 1993) for Ni is 70 - 80 μg/g. The concentrations of Ni in all the samples and in all stations (Figures 2-4) were below the stipulated limit. The source of Cd in humans is through food consumption. Severe toxic symptoms resulting from Cd ingestion are reported between 10 to 326 mg (Sivapermal et al, 2007).

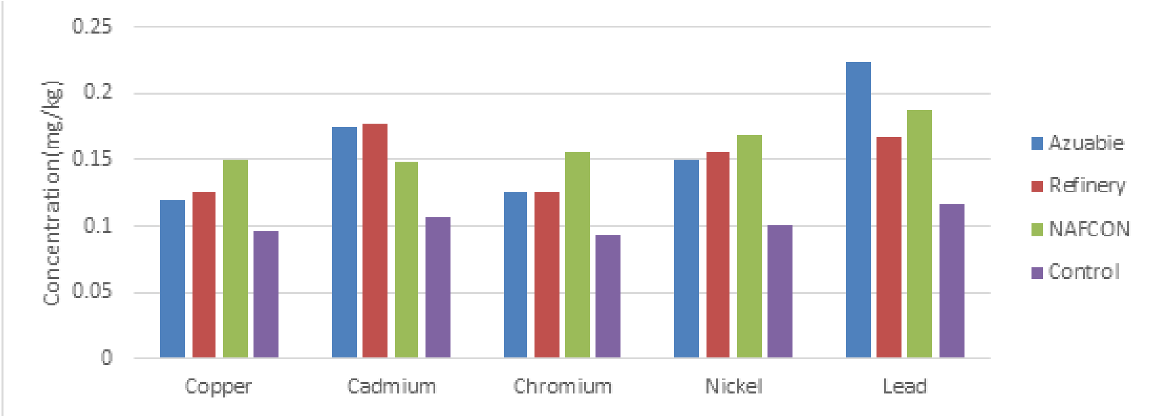


Fig. 2: Concentrations of Heavy Metals in Flesh of Liza grandisquamis

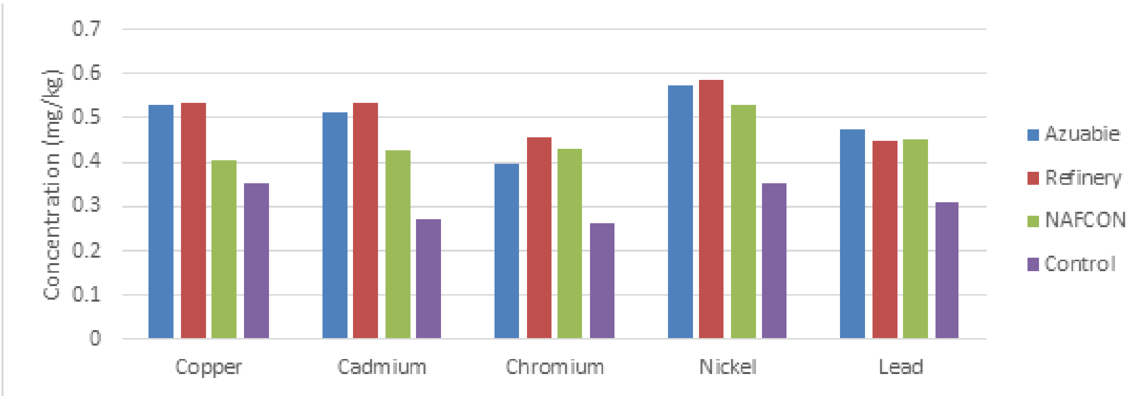


Fig. 3: Concentrations of Heavy Metals in Gills of Liza grandisquamis

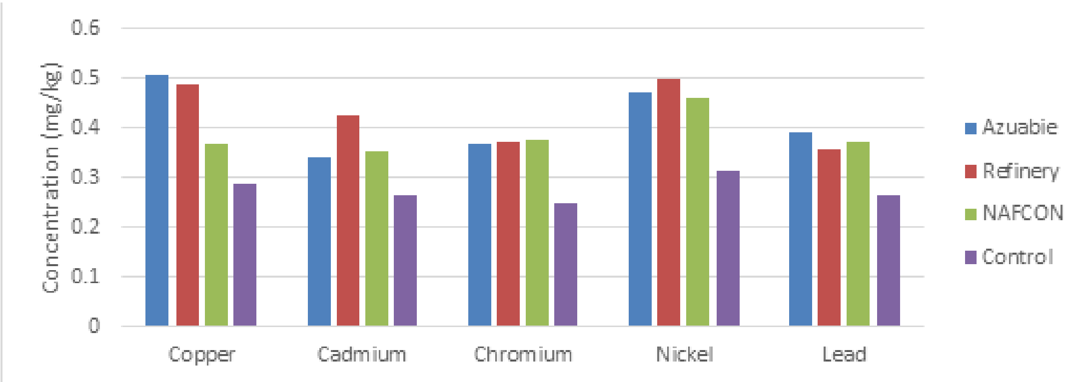


Fig. 4: Concentrations of Heavy Metals in Liver of Liza grandisquamis

Fatal ingestions of Cd, producing shock and acute renal failure, occur from ingestions exceeding 350 mg/g ([NAS-NRC, 1982). In the fish flesh samples, the highest concentration (0.18mg/kg) was recorded in the Refinery station (Figure 2), which fell below the FAO/WHO (2011) limits of 0.3mg/kg. Lead is classified as one of the most toxic heavy metals. The biological effects of sublethel concentrations of lead include delayed embryonic development, suppressed reproduction and inhalation of growth, increased mucous formation, neurological problems, enzyme inhalation and kidney dysfunction (Rompala et al, 1984). The highest concentration of 0.48 mg/kg was observed in the liver of the fish at the Azuabie station (Figure 3). This is above the 0.3mg/kg FAO/WHO (2011) permissible limits. The deficiency of Cr as an essential trace metal results in impaired growth and disturbances in glucose, lipid and protein metabolism (Calabrese, et al, 1985). The lowest detectable concentration of 0.094 mg/kg was measured in the flesh of the fish samples from the Control station

(Figure 2), while the highest concentration of 0.46mg/kg was observed in the liver of the fish samples from the Refinery station. The maximum guideline of 12 - 13 μg/g stipulated by (USFDA, 1993) was however, higher than the concentrations of Cr measured in all the fish samples, hence the samples are safe for human consumption.

CONCLUSION

The results of the study showed that despite the industrial presence, the levels of heavy metals in fish tissues, with few exceptions, are within regulatory limits. However, there were significantly higher values of most metals in the locations receiving industrial inputs compared to the Control, so there is potential for the threshold levels to be breached in the future. Continuous monitoring is therefore recommended.

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REFERENCES

Calabrese E.J, Canada A.T. and Sacco C.(1985) "Trace Elements and Public Health," Annual Review of Public Health, Vol. 6, No. 1, pp. 131-146.

Chan J. (1992). Research and development in sewage and sludge treatment. Waste Man. Environ. 3, 37-42.

Chan K. M. (1995). Concentrations of Copper, Zinc, Cadmium and Lead in Rabbitfish (Siganus oramin) collected in Victoria Harbour, Hong Kong. Marine Pollution Bulletin, 31, 277-280.

Daka. E.R. (2005). Heavy metal concentrations in Littornia saxatilis and Enteromorpha intestinalis from Manx estuaries. Marine Pollution Bulletin, 50 (11), 1452-1456FAO (1983). "Compilation of Legal Limits for Hazardous Substances in Fish and Fishery Products", FAO Fisheries circular NO.464, pp.5-100.

FAO/WHO (2011). Joint FAO/WHO food standards programme. Codex committee on contaminants in foods, fifth session, The Hague, the Netherlands, 21-25 March 2011. Working document for information and use in discussions related to contaminants and toxins in the GSCTFF.

NAS-NRC (National Academy of Sciences-National Re- search Council), "Division of Medical Sciences, Medical and Environmental Effects of Pollutants Nickel," National Academic Press, Washington DC, 1975.

NAS-NRC (National Academy of Sciences-National Research Council), "Drinking Water and Health," National Academic Press, Washington DC, 1982.

Rauf ,A., Javed ,M., and Ubaidullah, M. (2009). Heavy metal levels in three major carps (Catla catla, Labeo rohita and Cirrhina mirigala) from the River Ravi, Pakistan. Pakistan Veternary Journal, 29(1), 24-26

Rompala J.M., Rutosky F.W. and Putnam D.J. (1984). "Concentrations of Environmental Contaminants from Selected Waters in Pennsylvania," US Fish and Wildlife Service. Special Scientific Report, State College, Pennsylvania.

Sivapermal P., Sankar J.V. and Viswanathan P.G.N. (2007). "Heavy Metal Concentrations in Fish, Shellfish and Fish Products from Internal Markets of India visà-vis International Standards. Food Chemistry, 102(3), 612-620.

USFDA, "Food and Drug Administration, Guidance Document for Nickel in Shellfish," DHHS/PHS/FDA/ CFSAN/Office of Seafood, Washington DC, 1993.

USFDA, "Food and Drug Administration, Guidance Document for Chromium in Shellfish," DHHS/PHS/FDA/ CFSAN/Office of Seafood, Washington DC, 1993.

PREVELANCE OF PROTOZOAN PARASITES OF AFRICAN CATFISH *(Clarias gariepinus)* FROM COMMERCIAL FISH FARMS IN EKITI STATE, NIGERIA

[1]Kelau, J. S., [1]A. M. Akinsorotan, [1]J. O. Jimoh, [1]A. A. Fabusoro, [1]A. Adesanoyes, [2]G. O. Oyenakazi, [2]A. O. Issa, and [3]G. E. Anosike

[1]Department of Fisheries and Aquaculture, Federal University Oye Ekiti, P.M.B 373, Oye-Ekiti, Ekiti State, Nigeria.
[2]Department of Aquaculture and Fisheries Management, University of Ibadan, P.M.B 3017, Ibadan, Nigeria.
[3]Department of Aquaculture and Fisheries Management, University of Ibadan, P.M.B 3017, Ibadan, Nigeria.

Corresponding Author:
joel.kelau@fuoye.edu.ng +2347061110926, 0009-0006-4997-8116

ABSTRACT
Protozoa are freshwater fish parasites that affect public health and cause losses to fish. Parasites cause stress, slowed growth rates, weakened immunological responses, and higher mortality rates, which have a substantial negative influence on fish welfare and aquaculture productivity. The study aimed at investigating the prevalence of protozoan parasites in Clarias gariepinus in commercial farms in Ekiti North, South and Central districts. Fish samples were purchased from three commercial fish farms in Ekiti State and were transported to the Fish Biology Laboratory at Federal University Oye-Ekiti. The fish samples were checked with a hand lens for ectoparasites. Fins, skins, and gills were scraped using a swab stick, smeared on a clean glass slide, and checked for external parasites with an OLYMPUS CH binocular microscope. Parasites were identified using keys. Data were analyzed using SPSS version 26.0 statistical package. A total of 191 samples of C. *gariepinus* were obtained, 117 were infected with protozoan parasites. Seven protozoan parasite species (Ich. multifilis, Trichodina sp, Chilodonella sp, Epistylis sp, Ichthyobodo sp, Apiosoma sp, and Heximata sp) were observed on the skin, fins and gills. The most prevalent species is Ich. multifilis in all districts. The overall prevalence of protozoan parasites in sampled fish was 61.26%. The percentage prevalence in the districts shows that Ekiti North had 54.69%, Ekiti South (62.32%) and Ekiti Central (67.24%). Fish parasitism is one of the major problems facing fish production. Hence, water quality management is imperative for sustainable aquaculture and should be advocated to prevent low fish production.

Keywords:
Protozoan, Parasites,
Prevalence species,
Clarias gariepinus.

INTRODUCTION

Fin fish have a high protein content and are rich in lipids, minerals, and vitamins. They have a profound effect on the lives of many people and communities as a major source of easily accessible and fairly priced animal protein (Islam et al., 2023). Compared to other vertebrate groups, fish have the highest species diversity, with 33,600 recognized species (Fish base, 2017). The need for fish as a source of protein unavoidably rises along with the human population. Fish is a great food source, but because they contain pathogenic bacteria and/or their toxins, parasites, and chemical residues, eating them can increase the risk of food poisoning and illnesses (Oso et al., 2017). The majority of fish parasites that are frequently encountered are protozoa, which are the easiest to recognize and control with practice. Protozoa are a huge collection of eukaryotic creatures (Esteban and Fenchel, 2020). Ecto- and endoparasitic protozoans are among the most serious potential risks to fish health among the protozoa (Manbe et al., 2020). According to Manchanayake et al. (2023), these parasites attack fish and severely damage their skin and gill epithelium. Protozoan infections can result in large financial losses in aquaculture. Slower growth rates, ineffective feed conversion, greater death rates, and increased medical costs for illness diagnosis, treatment, and prevention could all contribute to these losses (Ismail et al., 2020). Parasite/protozoan prevalence in several fish species has been the subject of research conducted in impoundment (dams and reservoirs) in Ekiti State, Nigeria (Oso et al.,2017, Olagbemide and Awolabi, 2022). Hence, this study will bridge the gap in protozoan parasite prevalence in Ekiti State commercial fish farms. This study examines the prevalence of protozoan parasites in commercial farms in Ekiti State, Nigeria.

MATERIALS AND METHODS

Study Area

This study was carried out in Ekiti State, Nigeria. Geographically, Ekiti State is situated between latitudes 7° 15 to 8° 5' north of the Equator and longitudes 4° 45' to 5° 45' east of the Greenwich Meridian. Three commercial fish farms were randomly selected, one in each geographical district. The selected farm in Ekiti North district is situated in Ikole-Ekiti, Latitude 7°47'53.76"N and a Longitude of 5°30'52.17"E; Ekiti Central district is situated in Ado-Ekiti, Latitude 7.621111, and the Longitude is 5.221389; and Ekiti South district is situated in Egbe-Ekiti, Latitude 7°35'54.2"N and Longitude 5°36' 27E.

Collection, Identification and Examination of Fish Sample

Live fish samples of C. *gariepinus* (n=191) with an average total length of 16.5-21.5cm were obtained at random from three notable fish farms located in each of the three geographical districts of Ekiti State. They were then brought in plastic containers to the Fish Biology Laboratory of the Department of Fisheries and Aquaculture, Federal University Oye-Ekiti for examination. The fish samples were checked with a hand lens for ectoparasites, and then the fins, skins, and gills were scraped using a swab stick. The scrape was then smeared on a clean glass slide and checked for external parasites with an OLYMPUS CH binocular microscope. The approach outlined by Ekanem et al. (2011) was followed in the independent examination of each fish sample. Keys were used to identify the parasite (Robert, (1978); Poulder et al. (2005)). The sexes of the fish samples were identified by physical observation of the urogenital papillae as described in Lagrue et al., (2011) Prior to the parasitic examination.
Prevalence of infection and the intensity of parasites are estimated using the following equation by Das et al. (2014) as follows:

$$\text{Prevalence of infection} = \frac{\text{Total number of infected fish}}{\text{Total number of fish examined}} \text{ X } 100$$

$$\text{Intensity of Parasite} = \frac{\text{Total No of parasite species in a sample of fish examined}}{\text{No of fish host infected}}$$

Data Analysis

Data were analyzed using SPSS version 26.0 statistical package and T-test. to compare the relationships between factors such as fish sex, weight, total length, and parasitic infection. Significant values were taken at (P < 0.05)

RESULTS AND DISCUSSION

Seven (7) parasite species were encountered during the study period as shown in Table 1. Out of the 191 samples examined (64 in Ekiti North, 58 in Ekiti South, and 69 in Ekiti Central), 117 were infected with protozoan parasites in their skin, fins and gills. The parasite encountered are Ichyobodo sp, Trichodina sp, Epistylis sp, Ich. Mutifilis sp, Apiosoma sp, Chilodinella sp, Heximata sp. The overall parasites prevalence is (61.26%). The percentage prevalence in the selected farms shows that Ekiti North (54.69%), Ekiti Central (67.24%), Ekiti South (62.32%) (Table 2). The overall protozoan parasites prevalence in this study (61.24%) is higher than (32.9%) as reported by Eyo et al. (2014) in Warri River, (28.57%) in Yola Adamawa State by Idowu et al. (2023), (46.89%) in Makurdi as reported by Omeji et al. (2022), (55.56%) as reported by Olagbemide and Awolabi, (2022) in Ekiti State dams. The mean intensity was higher in Ekiti North (5.43±0.22a) and the lowest was recorded in Ekiti Central (4.10±0.12b). The variations in parasitism rate could be related to biotic and abiotic conditions in the study site (Mohammed et al., 2020). Unfavorable conditions may also influence fish physiology, encouraging parasite infection and invasion (Eyo et al., 2014); contamination of the fish environment may also contribute considerably to fish infestation (Kelly et al., 2010). Fish parasites can be internal or external. Parasitic infections are widely used to measure water quality because parasites increase in quantity and diversity in polluted environments (Omeji et al., 2011).

Table. 1: Parasitic Infection in C. *gariepinus* from commercial fish farm in Ekiti, State.

Zone	Protozoans Parasite	No of fish infected by each parasite	%	Location: Skin	%	Gill	%	Fin	%
EN	*Ichthyobodo sp.*	16	20.78	-	-	16	50.00	-	-
	Trichodina sp.	16	20.78	10	35.71	08	25.00	-	-
	Epistylis sp.	2	2.59	01	3.57	-	-	02	9.09
	Ich.Multifilis sp.	24	31.17	12	42.86	02	6.25	13	59.09
	Apiosoma sp.	11	14.29	02	7.14	03	9.36	06	27.27
	Chilodenella sp.	7	9.09	02	7.14	03	9.36	01	4.55
	Heximata sp.	1	1.29	01	3.57	-	-	-	-
EC	*Ichthyobodo sp.*	12	14.46	-	-	12	33.33	-	-
	Trichodina sp.	15	18.07	11	44.00	06	16.67	-	-
	Ich.Multifilis sp.	28	33.33	11	44.00	08	22.22	13	46.43
	Apiosoma sp.	08	9.64	02	8.00	03	8.33	03	10.71
	Chilodonella sp.	08	9.64	-	-	07	19.44	1	3.57
	Heximata sp.	06	7.23	01	4.00	-	-	05	17.86
	Epistylis sp.	06	7.23	-	-	-	-	06	21.43
ES	*Ich.Multifilis sp.*	23	33.33	11	40.74	2	6.25	10	71.43
	Trichodina sp.	14	20.29	08	29.63	7	21.88	1	7.14
	Ichthyobodo sp.	14	20.29	-	-	14	43.75	-	-
	Chilodonella sp.	10	14.49	05	18.52	06	18.75	-	-
	Apiosoma sp.	08	11.59	03	11.11	03	9.89	3	21.43

EN= Ekiti North, EC=Ekiti Central, ES=Ekiti South, %P = Percentage prevalence

Table.2: Prevalence, Mean Intensity and Abundance of Parasitic Infestation of *C. gariepinus* in Commercial Farms in Ekiti State.

Zone	No of fish Examined	Infected	Total no of parasite	Prevalance (%)	Mean Intensity
EN	64	35	88	54.69	5.45 ± 0.22^{a}
EC	58	39	101	67.24	4.10 ± 0.12^{b}
ES	69	43	120	62.32	4.97 ± 0.16^{c}
Total	191	117	309	61.26	

Mean intensity with different alphabets superscriptions are different significantly at $P < 0.05$.

Ekiti North and South surveyed farms showed that the parasite prevalence is higher in male than female C. *gariepinus* while the female out weights the male. Female of C. *gariepinus* were more infected than the male in Ekiti central. There was no correlation between weight, length and parasite prevalence in this study. However, this is not in conformity to the findings of Olagbemide and Awolabi, (2022) who observed significant correlation of parasite prevalence with the length and weight of fish in Ekiti State dams. This is an indication that procurement of parasite is not by sex, weight or length.

Table.3: Parasite Prevalence in Relations to Fish Sex, Weight and Total Length

Zone	Species	Sex	No of fish infect Ed	% Prevalence	Weight	Length
EN	*C.gariepinus*	Female	20	37.14	76.76 ± 8.67^{a}	54.35 ± 5.09^{a}
		Male	44	62.86	62.98 ± 7.45^{a}	39.70 ± 4.01^{a}
EC	*C.gariepinus*	Female	42	71.79	50.34 ± 5.03^{b}	49.76 ± 5.30^{b}
		Male	16	28.21	93.86 ± 8.97^{b}	51.12 ± 5.76^{b}
ES	*C.gariepinus*	Female	31	46.51	53.44 ± 5.06^{c}	49.67 ± 5.01^{c}
		Male	38	53.49	63.29 ± 7.45^{c}	56.46 ± 5.04^{c}

Mean with different alphabets superscriptions are different significantly at $P < 0.05$.

CONCLUSION

Parasites have an impact on fish health, growth, and survival certain parasites cause extremely hazardous and deadly sickness to the host fish. Ich. multifilis was the most prevalent parasite across all zones. This parasite is known for causing "white spot disease," which can lead to significant morbidity and mortality in fish populations. The skin was the most common site of infestation, followed by the gills and fins, indicating the need for regular monitoring and treatment protocols to manage these infestations effectively. Hence, pollution control, biosecurity and regular examination of the water in culturing receptacles should be prioritized.

REFERENCES

Abba, A. M., Emere, M. C., Appah J., and Omenesa, R. L. (2018). Helminth Parasites of Two Freshwater Fishes (Oreochromis niloticus and Clarias gariepinus) in Jibia Earth Dam, Katsina State, Nigeria. Global Journal of Science Frontier Research, 18(1), pp. 35-41.

Das, B. K., Kar, S. and Kar, D. D. (2014). Studies on prevalence, abundance and intensity of Fish parasites in Monopterus cuchia. Indian Journal of Applied and Pure Biology, 29(1), 25- 33.

Ekanem, A. P., Eyo, V. O., Sampson, A.F. (2011). Parasite of landed fish from Great Kwa River, Calabar. Cross River Nigeria International Journal of Fisheries and Aquaculture. 2011; 3(12): 225-230.

Esteban, G. F., and Fenchel, T. M. (2020). Ecology of protozoa. The Biology of Free-living Phagotrophic Protists: Springer International Publishing, Cham, Switzerland.

Eyo, J. E., Ejere, V. C., Aguzie, O. I., Ivoke, N, Ekeh, F. N, Ezenwaji, N. E. (2014). Parasites fauna of Five Freshwater Fishes in A Nigerian Freshwater Ecosystem. Croatian Journal of Fisheries. 2014; 72:1-16.

Idowu, T. A., James, M., Sajo, Z. M., Adedeji, H. A. and Sogbesan, O. A. (2023). Occurrence Of Parasites In Live Clarias Gariepinus Sold At Jimeta Modern Market, Yola, Adamawa State. FUDMA Journal of Sciences (FJS) ISSN online: 2616-1370 ISSN print: 2645 - 2944 Vol. 7 No. 2, April, 2023, pp 206 - 209 DOI: https://doi.org/10.33003/fjs-2023-0702-1397.

Islam, M. R., Yeasmin, M., Sadia, S., Ali, M. S., Haque, A. R., and Roy, V. C. (2023). Small indigenous fish: A potential source of valuable nutrients in the context of Bangladesh. Hydrobiology, 2(1), 212-234.

Kelly, D. W., Poulin, R, Tompkins, D.M., Townsend, C. R. (2010). Synergistic effects of glyphosate formulation and parasite infections and survival. Journal of Applied Ecology. 2010; 47:498-504

Lagrue, C., Kelly, D. W., Hicks, A. and Poulin, R. (2011). Factors influencing infection patterns of tropically transmitted parasites among a fish community: host diet, host – parasite compatibility. 79:466–485

Manbe, M. Y., Mohammed, A. K., Abdulfatai, I., Muaz, U., and Hussaini, K. (2020). Prevalence of protozoan parasites in some freshwater fishes of Dangana Lake Lapai Niger State Nigeria. aquaculture, 4(6).

Manchanayake, T., Salleh, A., Amal, M. N. A., Yasin, I. S. M., and Zamri-Saad, M. (2023). Pathology and pathogenesis of Vibrio infection in fish: A review. Aquaculture Reports, 28, 101459.

Mohammed, Y. M., Adamu, K. M., Ismail, A., Umar, M. and Kanki, H. (2020). Prevalence of protozoan parasites in some freshwater fishes of Dangana Lake Lapai, Niger State Nigeria. International Journal of Veterinary Sciences and Animal Husbandry 2020; 5(2): 13-16

Olagbemide, P. T, Owolabi, O. D. (2022). Prevalence, intensity and influence of size and seasons on parasites of Oreochromis niloticus in Ekiti State dams, Southwest, Nigeria. Abuad international journal of natural and applied sciences. ISSN: 2955-1021 AIJNAS 2022, Volume 2, Issue 2, pp 123–131 https://doi.org/10.53982/aijnas.2022.0202.010-j Copyright ©2022 https://journals.abuad.edu.ng/index.php/aijnas

Omeji, S., Adadu, M. O. and Kolndadacha, O. D. (2022). Parasitic incidence in cultured and wild Nile tilapia (Oreochromis niloticus) in Makurdi, Benue State, Nigeria. Global Journal of Fisheries Science Volume 4(1), pages 7-16, July 2022 Article Number: 8182EB9F2 ISSN: 2782-750X https://doi.org/10.31248/GJFS2022.036 https://integrityresjournals.org/journal/GJFS.

Omeji, S., Solomon, S. G, Idoga, E. S. (2011). A Comparative Study of the Common Protozoan Parasites of Clarias gariepinus from the Wild and Cultured Environments in Benue State, Nigeria. Journal of Parasitology Research. 2011.

Oso, J. A., Idowu, E. O., Adewumi A. A. and Longe, D. O. (2017). Prevalence of Parasites Infection of Resident Fish Species in a Tropical Reservoir. Asian Journal of Biology 2(3): 1-7, 2017; Article no. AJOB.33229

Poulder, B. D., Curtis, E.W, Yanong, P.E.R. (2005). Common Freshwater Fish Parasites Pictorial Guide. Edis IFAS Extension, University of Florida, 2005. http://edis.ifas.ufl.edu

Robert, R. J. Fish Pathology, Bailliere TindalBooks. London, 1978, 318

EFFECTS OF A 'TRI-PYRETHROID" INSECTICIDE ON THE FINGERLINGS OF *Clarias gariepinus* (BURCHELL, 1822)

Lelei, K. E.*, W. V. Ebikebuna, N. L. Ezamgba and O. S. Nanakumo

Department of Biological Sciences, Faculty of Science, Niger Delta University, Amassoma, Bayelsa State, Nigeria

Correspondence Author:
kariyelelei@gmai.com; +2348055409784; ORCID: 0009-0002-2321-440X

ABSTRACT
This study assessed the acute toxicity of a commonly sold 'tri-pyrethroid' insecticide on Clarias gariepinus fingerlings. One hundred and sixty fingerlings of mean weight and length, 2.620 ± 0.370g and 6.480 ± 0.598cm respectively were procured, acclimatized for seven days and randomly allocated to five exposure concentrations of 0.0045, 0.0085, 0.0110, 0.0125 and 0.015ml/L in triplicates, and a control (0ml/L) for 96hours in the laboratory using Completely Randomized Design. Some physicochemical parameters of the test media were determined. Mortalities per exposure concentration were recorded 24hourly, the 96hr-LC50 of the insecticide was extrapolated using Probit analysis. The gills, muscle, intestines and brain were excised for histopathological examination. The results showed that, the mean values of the physicochemical parameters varied significantly ($P < 0.05$) and were concentration dependent. The histopathology of the tissues reflected concentration- dependent degenerations and alterations. Fish mortality reduced with time, mortalities were 6.67, 10.0, 56.67, 30.0 and 63.33% in the 0.0045, 0.0085, 0.0110, 0.0125 and 0.015ml/L concentrations respectively, indicating concentration-dependent effect. The lethal concentration (96hr-LC50) of the toxicant was 0.0128ml/L which implied that, the tri-pyrethroid insecticide was highly toxic, will pose great risk to fish and aquatic productivity by extension if present in aquatic ecosystems. These findings underscore the importance of understanding the toxicological effects of such insecticides on non-target species, so as to develop effective environmental management strategies to mitigate their ecological risks.

Keywords:
Tri-pyrethroid, Clarias gariepinus, lethal concentration, histopathology.

INTRODUCTION

Pyrethroid pesticides, a type of synthetic organic insecticide derived from pyrethrins, an insecticidal chemical present in natural pyrethrum in the flowers of Chrysanthemum cinerariaefolium (Evan and Evans, 2009) are amongst the important classes of pesticides mostly used in the control of pest populations and domestic insects (Ayaz and Kumar, 2023). They are the only type of pesticides that may be applied on insecticide-treated nets (ITNs) and are the cheapest pesticides for controlling malaria vectors (Van den Berg et al., 2021), recommended and present in all WHO-prequalified types of ITNs (WHO, 2020; Lissenden et al., 2021), used in the production of long-lasting insecticidal nets (LLINs). Pyrethroids are neurotoxic, they target the voltage-gated sodium channel's receptor site-specifically of insects (Valmorbida et al., 2022), cause change in the membrane potential resulting in abnormal state of hyper-excitability in the nerve cells, these alterations in insects have sub-lethal incapacitating 'knockdown' effects, and kill exposed insects by binding to sodium channels resulting in excitatory paralysis (Davies et al., 2007). There are over twenty pyrethroids widely used in insecticide formulations; some are combined to reduce insect resistance and improve the effectiveness of formulations. The wide use of pyrethroids pesticides especially for insects control, threatens the health of the aquatic organisms as they end up in aquatic ecosystems through spray drifts, run-offs and discharges (Bashir et al., 2020; Galadima et al., 2021), with their resultant toxic effects on the environment and non-target organisms amongst which are fish. With the recent influx of assorted 'labeled and unlabeled', 'powder and liquid' insecticide formulations into markets in Bayelsa State, there was need to assess the toxic effects of one these 'labeled', 'liquid,' locally produced insecticide formulations (a type II pyrethroid classed as moderately hazardous) using *Clarias gariepinus* fingerlings.

MATERIALS AND METHOD

Test Organisms

Two hundred and forty fingerlings of C. *gariepinus* of mean weight and length, 2.620 ± 0.370g and 6.480 ± 0.598cm respectively were procured from a fish farm in Akenfa, Yenegoa, Bayelsa State. These were acclimatized for seven days, kept in holding in plastic tanks of 50L capacity in the laboratory of the Department of Biological Sciences, Niger Delta University, Bayelsa State using borehole water (Reish and Oshida, 1987). They were fed twice daily with Coppen® feed (0.8-1.2mm) at 5% body weight twice daily during the holding period with change of media to prevent stress and fouling of the water. The fingerlings were monitored for mortality and behavioural changes to allow for stabilization before exposure. There was no mortality during the holding period.

Toxicant

The toxicant used in this study was a commonly sold and used 'tri-pyrethroid' insecticide with the assigned name 'B' (to protect the 'trademark'). The insecticide is locally produced in the State and was procured from a market in Yenegoa metropolis, Bayelsa State, Nigeria. This 'tri-pyrethroid' insecticide-'B' (thus, named) was a mixture of three pyrethroids: Deltatmethrin (0.5%), Cypermethrin (0.2%) and Cyhalothrin (0.4%).

Range Finding Test

This was done to determine the threshold concentrations (concentrations at which minimum responses will be elicited from the exposed fish) of the 'tri-pyrethroid' insecticide- 'B'. The concentrations of 0.0045, 0.0085, 0.0110, 0.0125 and 0.015ml/L respectively were determined as the acute toxicity exposure concentrations after 0.025, 0.05, 0.10 and 0.20ml/L respectively adapted after Yidi et al. (2021) and Mohammad et al. (2022) resulted in one hundred percent (100%) mortality within three hours of exposure.

Experimental Design

A static renewal toxicity test with five exposure concentrations of 0.0045, 0.0085, 0.0110, 0.0125 and 0.015ml/L, and a control (0ml/L) made up to 15L with borehole water of acceptable quality in the 50L plastic tanks was carried out for 96hours (during which the fish were not fed to reduce fouling). The experiment consisted of one hundred and sixty (160) fingerlings of C. *gariepinus* randomly allocated to the five exposure concentrations in triplicates, and control using Completely Randomized Design.

Physicochemical Parameters of Test Media (Water)

The dissolved oxygen (DO), temperature, total dissolved solids (TDS), pH, electrical conductivity (EC) and salinity were determined to ascertain the suitability of the water for fish survival (Boyd, 2015) before and after exposure. These were measured in-situ using Hanna HI 9828 pH/ORP/EC/DO water analyzing device.

Toxicity Testing

This was based on the determination of the mean values of the evaluated physicochemical parameters of the exposure media and the control, assessment of the mortalities of the fish in the exposure concentrations and control with time, determination of the lethal concentration (96hr LC50; the concentration at which 50% of the test population will die), and histopathological examinations of the excised gills, muscle, intestines and brain of the exposed fish against the control.

Histological Analysis

Sections of the muscles, gills, intestines and brain of C. *gariepinus* were prepared by dehydration, clearing, impregnating, embedding then microtomed and stained with Haematoxyline and Eosin. Prepared slides were then viewed under the microscope and microphotography was done using Olympus CX31 binocular microscope at x100 and x400 magnification.

Mortalities

During the 96-hr exposure period, observations were made and records taken of the mortalities in the exposure concentrations every 24hrs and the percentage mortalities deduced with respect to time. Probit Plot of mortality was used to determine the median/lethal concentration (96hr LC50) of the toxicant.

Statistical Analysis

Data obtained were analyzed for means ± standard deviation. One-way Analysis of Variance (ANOVA) was used to compare the differences in the means at $P < 0.05$ and the post hoc test utilized Duncan's Multiple Range Test using SPSS® version 2.1.0 software.

RESULTS AND DISCUSSION

The results of the mean values determined for the physicochemical parameters of the test media (Table 1) showed that, there were significant differences ($P<0.05$) with respect to concentrations with obvious differences in the mean values of the TDS, EC and salinity.

Table 1: Result Showing the Mean ± Standard Deviation of the Physicochemical Parameters of the Test Media of the Different Exposure Concentrations of a the Tri -Pyrethroid Insecticide –'B'

Exposure Concentrations (ml/L)	Temperature	pH	DO (mg/L)	TDS (mg/L)	EC (µS/cm)	Salinity (mg/L)
0	26.90±0.10^{a}	6.95±0.04^{cd}	4.73±0.09^{ab}	119.30±3.33^{d}	253.00±5.23^{d}	151.50±11.37^{d}
0.0045	27.85±0.05^{b}	6.83±0.10^{ab}	5.37±0.25^{ab}	110.50±8.50^{bc}	221.50±17.50^{bc}	141.76±11.20^{b}
0.0085	27.95±0.05^{bc}	6.59±0.08^{a}	5.31±0.70^{ab}	104.00±3.00^{b}	209.00±5.00^{b}	133.76±3.20^{ab}
0.0110	27.95±0.05^{bc}	6.92±0.03^{c}	4.94±0.04^{a}	92.00±1.00^{a}	183.50±1.50^{a}	117.44±0.96^{a}
0.0125	28.00±0.00^{c}	6.79±0.12^{bc}	5.62±0.30^{b}	124.50±2.50^{d}	249.00±5.00^{c}	159.36±3.20^{cd}
0.0150	28.10±0.00^{d}	7.09±0.01^{d}	5.68±0.17^{b}	115.50±11.50^{cd}	231.00±22.00b^{c}	147.84±14.80^{cd}
WHO (2008)	<40	6.5–8.5	> 4	500	70	<600
USEPA (2011)	-	6.5–8.5	-	500	-	-

Key: Means with the same superscripts were not statistically different at $P<0.05$; DO =Dissolved Oxygen; pH = Potential Hydrogen; EC = Electrical Conductivity; TDS = Total Dissolved Solids; WHO = World Health Organization; USEPA = United States Environmental Protection Agency

The differences in the values of the TDS, EC and salinity among the exposure concentrations were attributable to increased physiological activities in the fish in response to increased stress due to the toxicant/concentrations. The DO and EC levels were observed to be higher than the WHO (2008) and USEPA (2011) guidelines for water thus, fish. These values indicated increased presence of solutes in the test media which implied increased physiological activities and stress in the fish since they were not being fed. The parameters determined were affected by the toxicant and the variations were concentration-dependent which had negative implications on the fish physiology. These findings had similar patterns with the reports of Yidi et al. (2021), who worked on the effects of Deltamethrin on Chanas argus and

Hossain et al. (2022), who worked on the effects of Chlorpyrifos on Oreochromis niloticus.
For the mortality, there were 32, 9, 6 and 4 dead fish at the 24th, 48th, 72nd, and 96th hour. The exposure concentrations of 0.0045, 0.0085, 0.011, 0.0125 and 0.015ml/L had 6.67, 10.0, 56.67, 30.0 and 63.33% mortality respectively while the control had one (Fig. 1). These indicated that, mortality reduced with time (attributed to the sequestration of the insecticide) but increased with increase in concentration, thus, mortality was concentration-dependent.

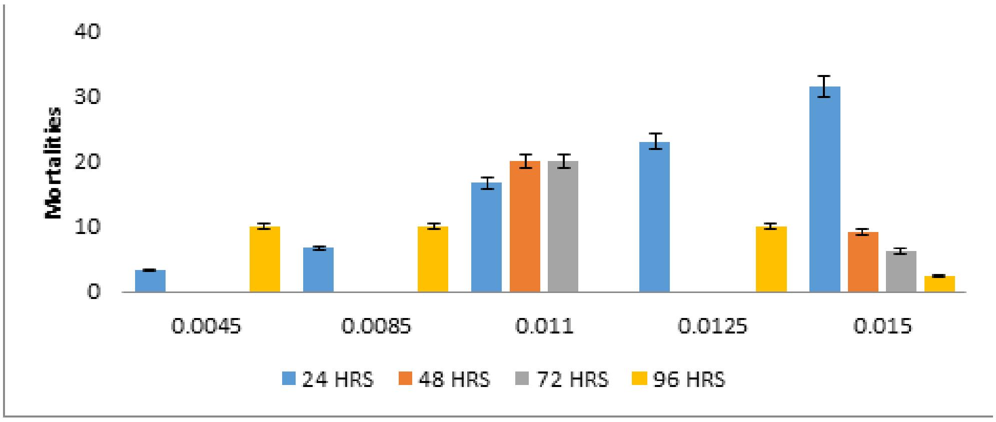
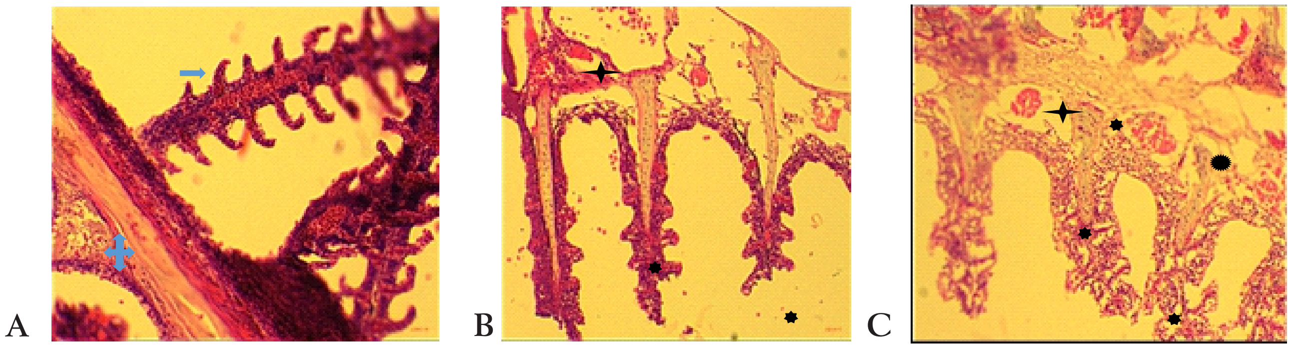


Fig. 1: Mortalities of *Clarias gariepinus* fingerlings in the Different Exposure Concentrations of the Tri-Pyrethroid Insecticide – 'B' with time.

The lethal concentration (96hr LC50) of the insecticide was extrapolated to be 0.0128ml/L which implied that, this tri-pyrethroid insecticide was highly toxic. Prudencio et al. (2023), investigated the acute toxicity of increasing concentrations of the insecticides- Pyrinex Quick 212 EC (Deltamethrin 12g L−1and Chlorpyrifos 200g L−1) and Pyro FTE 472 EC (Cypermethrin 72 gL−1and Chlorpyrifos 400g L−1) on C. gariepinus with emphasis on liver histopathological effects for 96hr. The values of the reported 96hr LC50 were 0.004 and 0.012μL L−1 for Pyrinex and Pyro respectively, indicating very high toxicity to C. gariepinus juveniles. These values were similar to the findings of this study for the tri-pyrethroid (cypermethrin, cyhalothrin and deltamethrin) implicated in the toxicity of this insecticide as reflected in the mortalities observed. This value was lower than the 1.94 g/L 96hr-LC50 determined by Yidi et al. (2021), for Deltamethrin insecticide, which implied that, deltamethrin alone was less toxic than the tri-pyrethroid, attributable to the synergy between Deltatmethrin, Cypermethrin and Cyhalothrin.

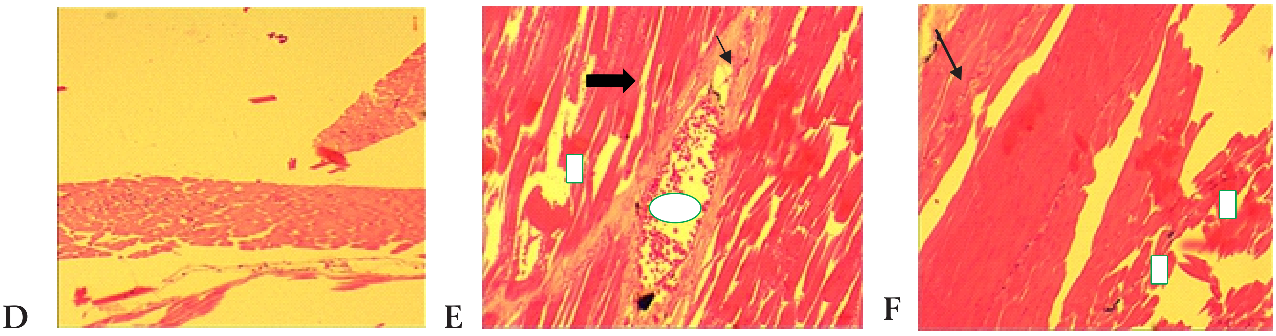
Histology of the Gills, Muscles, Intestines and Brain

Microscopic examinations of the prepared slides showed histopathological changes in the muscles, gills, intestines and brain of C. *gariepinus* from the exposure concentrations when compared with the control (Plates A - L). The changes increased with increase in the concentration of the toxicant that is, the alterations were concentration-dependent.
The gills from the control had the gill filaments arranged in parallel rows, the gill archs were intact with the secondary branchial lamellae evenly spaced (Plate A). The sections of gill tissues from the exposure concentrations showed diffusion of muscous cell, damaged gill filaments and rakers (shortening of and eroded secondary lamellar), acute necrosis of epithelial cells (Plates B and C).



A= Control (0ml/L); B= 0.0045ml/L; C= 0.0150ml/L : Intact gill archs : Intact Gill filament/rakers = Necrosis and Lesions of epithelial cells :Damaged gill filaments/rakers (shortening of and eroded secondary lamellar); :Congestion of secondary gill lamella; : Diffusion of mucous cell

Normal muscles of fish are smooth (non-skeletal and nucleated), striated (skeletal), musculature has myotomes which slope in nature. These were observed in the fish tissues from the control (Plate D). The muscle tissues from the exposure concentrations showed slight thickening or atrophy of the tissues with increased sloping, necrosis, vacuoles and splitting of muscle fibers. The vacuoles and degenerated muscles increased with the concentration of the toxicant (Plates E and F).

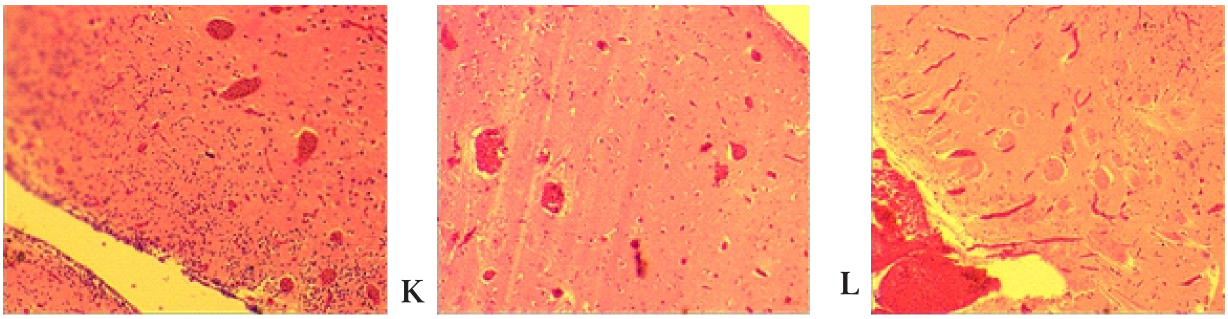


D= Control (0ml/L); E = 0.0045ml/L; F= 0.0150ml/L; = Necrosis; = Sloping/Degeneration of muscle fiber; = Splitting of muscle; = Vacuole

The small intestine has large circular folds called plicae circular ( )that has the mucosa ( ) and the villi ( ) which are finger-like projections of simple columnar epithelium and goblet cells ( ). These were intact in the control (Plate G). The villi increase the internal surface area of the intestinal walls which allows for more intestinal wall area to be available for absorption, to aid in digestion and absorption of food nutrients. These tissues were damaged in the exposed fish (Plates H and I) which increased with concentration when compared with the control. Tissue alterations included erosion of the villi, clumped/atrophied in the villi, shrinkage and deadening of the goblet cells (darker colour), lesions in the mucosa which may result in intestinal dysfunction. These observations were in line with the study of Wu et al. (2022), who studied Deltamethrin disruption of the intestinal health of Crucian Carp. The intestinal tract is essential in controlling nutrient digestion and absorption while functioning as a barrier to prevent foreign antigens and pathogens from entering the mucosal tissues. The integrity of the goblet cells and their secretions-mucins play vital role as intestinal barrier in maintaining intestinal homeostasis. Goblet cells defects can allow bacteria to make contact with the epithelial cells, thereby, triggering excessive immune response in fish and various intestinal infections (Johansson and Hansson, 2014; Birchenough et al., 2015; Yang and Yu, 2021), a threat to fish health and well-being.

G= Control (0ml/L); H = 0.0045ml/L; I= 0.0150ml/L; Control had normal plicae circular showing mucosa and villi with the goblets. = Lesions in the mucosa; = Shrinkage and deadening of the goblet cells; = Erosion of villi; → = Clumped/atrophied in the villi.

The sectioned brain showed that, there was reduced mass and evident separation within and between tissues in the grey matter (lighter shade) and white matter (darker shade), with slight clumping and necrosis which was obvious in the tissues of fish from the exposure concentrations (Plates K and L) which were different from the control (Plate J).



J= Control (0ml/L); K = 0.0045ml/L; L= 0.0150ml/L; → = Slight clumping and necrosis; = Reduced mass and separation of tissues.

The low proclivity of pyrethroid pesticides to accumulate in organisms (Ayaz and Kumar, 2023), their quick photo-biodegradation (Agnieszka et al., 2018), and efficiency (Li et al., 2017) have resulted in their abuse with predictable resultant effects. In insects, type II pyrethroid insecticides cause 'choreoathetosis syndrome' (Gupta and Crissman, 2013). Paul and Simonin (2006), reported that, pyrethroids were 10–1000 times more toxic to aquatic animals than to mammals and birds due to their lower ability to degrade pyrethroid pesticides. Fish lack hydrolase, hence, cannot detoxify synthetic pyrethroid pesticides hydrolytically as efficiently as mammals (Yang et al., 2016). Several studies have shown that, pyrethroid pesticides are hazardous to fish in reproductive and early development phases (Farag et al., 2021). Uptake of pyrethroids in fish may be due to the lipophilic and hydrophilic properties (Clasen et al., 2018) and the ease of entry into fish through the gills, skin, during feeding, and their transport to tissues through blood circulation thereby, resulting in the toxic effects. Deltamethrin, cypermethrin, and lambda-cyhalothrin have been shown to cause histopathological abnormalities in tissues such as, fish gills, liver and muscles (Ogueji et al., 2019; Yang et al., 2020) which were comparable to the effects of Chlorpyrifos on *Oreochromis niloticus* (Hossain et al., 2022) as were observed in the degeneration and alterations in the excised gills, muscles, intestines and brain in this study. These histological changes can impair behaviour, respiratory function, nutrition and development, swimming performance and balance. These can have significant implications on the survival, health, well-being and even reproductive successes of the fish when exposed to such insecticides in aquatic ecosystems.

CONCLUSION

Following the environmentally relevant concentrations of the tri-pyrethroid-'B' in this study, the findings have clearly shown histopathological alterations that are detrimental to C. gariepinus. It is highly toxic to fish and aquatic vertebrates by extension evident in the mortalities; with negative impacts on physicochemical parameters of water and aquatic productivity by implication. Understanding of the toxicological effects of such insecticides on non-target species is important, so as to develop effective environmental management strategies to mitigate their ecological risks.

REFERENCES

Agnieszka Chrustek, Iga Hoły ´nska-Iwan, Inga Dziembowska, Joanna Bogusiewicz, Marcin Wróblewski, Anna Cwynar and Dorota Olszewska-Słonina (2018). Current Research on the Safety of Pyrethroids Used as Insecticide. Medicina, 54: 61. doi:10.3390/medicina54040061

Ayaz, Ahamada and Jitendra Kumar (2023). Pyrethroid pesticides: An overview on classification, toxicological assessment and monitoring. Journal of Hazardous Materials Advances, 10: 100284.

Bashir, I., Lone, F.A., Bhat, R.A., Mir, S.A., Dar, Z.A. and Dar, S.A. (2020). Concerns and threats of contamination on aquatic ecosystems. In: Bioremediation and Biotechnology. Springer, Cham. Pp. 1–26.

Birchenough, G.M., Johansson, M.E., Gustafsson, J.K., Bergstrom, J.H. and Hansson, G.C. (2015). New developments in goblet cell mucus secretion and function. Mucosal Immunol., 8(4):712–719. doi:10.1038/ mi.2015.32 5.

Boyd, C. E. (2015). Water Quality: An Introduction. 2nd Edition. Springer International Publishing. New York, 374p. doi 10.1007/978-3-319-17446-4

Clasen, B., Loro, V.L., Murussi, C.R., Tiecher, T.L., Moraes, B., Zanella, R. (2018). Bioaccumulation and oxidative stress caused by pesticides in Cyprinus carpio reared in a rice-fish system. Sci. Total Environ., 626: 737–743.

Davies, T.G.E., Field, L.M., Usherwood, P.N.R. and Williamson, M.S. (2007). DDT, Pyrethrins, Pyrethroid pesticides and insect sodium channels. IUBMB Life, 59 (3):151–162

Evans, W.C. and Evans, D. (2009). Pesticides of natural origin. Trease Evans' Pharmacogn., 533– 536. doi:10.1016/b978-0-7020-2933.

Farag, M.R., Alagawany, M., Bilal, R.M., Gewida, A.G., Dhama, K., Abdel-Latif, H.M. and Naiel, M.A. (2021). An overview on the potential hazards of pyrethroid insecticides in fish with special emphasis on Cypermethrin toxicity. Animals, 11 (7): 1880

Galadima, M., Singh, S., Pawar, A., Khasnabis, S., Dhanjal, D.S., Anil, A.G. and Singh, J. (2021). Toxicity, microbial degradation and analytical detection of Pyrethroid pesticides: A Review. Environ. Adv., 5: 100105.

Gupta, R.C. and Crissman, J.W. (2013). Agricultural chemicals. In: Haschek and Rousseaux's Handbook of Toxicologic Pathology. Academic Press. Pp. 1349–1372.

Hossain, M. A., Lipi Sutradhar, Tumpa Rani Sarker, Shuva Saha and Mohammed Mahbub Iqba (2022). Toxic effects of Chlorpyrifos on the growth, hematology, and different organs histopathology of Nile tilapia, Oreochromis niloticus. Saudi Journal of Biological Sciences, 29: 103316

Li, Z. H., Velisek, J., Grabic, R. and Machova, J. (2017). Effects of Pyrethroid and Oxadiazine Pesticides on Common Carp (Cyprinus carpio L.) Hematology and Plasma Biochemistry. Environmental Toxicology and Pharmacology, 52:159-165.

Lissenden, N., Armistead, J.S., Gleave, K., Irish, S.R., Martin, J.L., Messenger, L.A., Lees, R.S. (2021). Developing consensus standard operating procedures (SOPs) to evaluate new types of insecticide-treated nets. Insects, 13 (1): 7.

Mohammad Amzad Hossain, Lipi Sutradhar, Tumpa Rani Sarker, Shuva Saha, Mohammed Mahbub Iqbal (2022). Toxic effects of Chlorpyrifos on the growth, hematology, and different organs histopathology of Nile tilapia, Oreochromis niloticus Saudi Journal of Biological Sciences, 29: 103316.

https://doi.org/10.1016/j.sjbs.2022.103316

Ogueji, E. O., Jumaine, E. O. and Auta, J. (2019). Histopathological changes in the gill and muscle of Clarias gariepinus (Burchell, 1822) exposed to sub-lethal concentrations of Cypermethrin. Bulletin of the National Research Centre, 43(1): 1-8.

Paul, E.A., Simonin, H.A. (2006). Toxicity of three mosquito insecticides to Crayfish. Bull. Environ. Contam. Toxicol., 76: 614–621.

Prudencio Agbohessi, Laurence Olowo, Bodelaire Degila, Gisèle Houedjissi, Ibrahim Imorou Toko, Syaghalirwa N. M. Mandiki and Patrick Kestemont (2023). Comparative assessment of acute toxicity and histological changes in liver of African Catfish, Clarias gariepinus exposed to Cotton insecticides. Journal of Environmental Science and Health, Part B, 58 (1): 31-44

Reish, D.J. and P.S. Oshida (1987): Manual of Methods in Aquatic Environment Research. Part 10. Short-term Static Bioassay. Food and Agriculture Organization Fisheries Technical Paper (247):62.

USEPA (2011). USEPA Regional Screening Level (RSL) Summary Table. November 2011. Available at http://www.epa.gov/regshwmd/risk/human/indexht m.

Valmorbida, I., Hohenstein, J.D., Coates, B.S., Bevilaqua, J.G., Menger, J., Hodgson, E.W. and O'Neal, M. E. (2022). Association of voltage-gated sodium channel mutations with field- evolved pyrethroid resistant phenotypes in Soybean Aphid and genetic markers for their detection. Sci. Rep., 12 (1): 1–14.

Van den Berg, H., da Silva Bezerra, H.S., Al-Eryani, S., Chanda, E., Nagpal, B.N., Knox, T. B. and Yadav, R.S. (2021). Recent trends in global insecticide use for disease vector control and potential implications for resistance management. Sci. Rep., 11 (1): 1–12.

World Health Organization (2008). Guideline for drinking water quality. Health Criteria and other supporting information. 3rd Edition, Geneva.

WHO (2020). Prequalified vector control products. WHO—Prequalification of medical products (IVDs, medicines, vaccines and immunization devices, vector control). https://extranet.who.int/pqweb/vector-control-products/prequalified product-list.

Wu, H., J. Gao, M. Xie, J. Wu , R. Song, X. Yuan, Y. Wu and Dongsheng Ou (2022). Chronic exposure to Deltamethrin disrupts intestinal health and intestinal microbiota in juvenile Crucian carp. Ecotoxicology and Environmental Safety 241 (2022) 113732

Yang, C., Lim, W. and Song, G. (2020). Mediation of oxidative stress toxicity induced by Pyrethroid pesticides in fish. Comp. Biochem. Physiol. C Toxicol. Pharmacol., 234: 108758.

Yang, Y., Ye, X., He, B. and Liu, J. (2016). Cadmium potentiates toxicity of Cypermethrin in Zebrafish. Environ. Toxicol. Chem., 35 (2): 435–445.

Yang, S. and Min Yu (2021). Role of Goblet Cells in Intestinal Barrier and Mucosal Immunity. Journal Inflammation Research, 14: 3171–3183

Yidi Kong, Min Li, Xiaofeng Shan, Guiqin Wang and Guanghong Han (2021). Effects of Deltamethrin Sub-acute exposure in Snakehead fish, Channa argus: Biochemicals, antioxidants and immune responses. Ecotoxicology and Environmental Safety, 209: 111821.

PRELIMINARY ASSESSTMENT OF HEAVY METALS IN WATER, FRESH AND DRIED *Clarias gariepinus* (BURCHELL, 1822) FROM LAKE ALAU DOWN STREAM, MAIDUGURI, NIGERIA

[*1]Garba, A. I., [1]A. Abdullahi, [1]Y. A. Musa, [2] L. A. Ahmed And[2]B. M. Abatcha
[1,2]Department of Fisheries Technology, Federal College of Freshwater Fisheries Technology, Baga, Maiduguri, Borno State Nigeria, P. M. B. 1060Maiduguri.
[2]Gombe State University. Gombe Nigeria.
*Corresponding author:
abdullahiidigarba112212@gmail.com,
+2348036022028, 0009-0003-0743-0281

ABSTRACT
Heavy metals are natural components of the aquatic environment, but industrial, agricultural, and mining activities have increased their levels. The concentration of heavy metals in water sources has raised health concerns, particularly for humans. Ngadda River, used for domestic, car washing, irrigation, and fishing, is polluted with heavy metals from wastewater, burnt tires, sewage, and automobile waste. Water and fish samples were collected from four sites along the river in August and September 2022 from river Ngadda, downstream of Lake Alau, Maiduguri. The samples were analyzed for cadmium (Cd), lead (Pb), iron (Fe), and chromium (Cr) using the nitric-perchloric acid digestion method. The results obtained from this study were 0.016-0.352mg/l and 0.013-0.363mg/l in August and September for cadmium (Cd) in water samples, 0.015-0.617 mg/l and 0.038-0.505 mg/l, 0.031-0.655mg/l and 0.044-0.535mg/l in August and September for cadmium (Cd) in fresh and dried fish samples. Lead (Pb) below detection limit and 0.014-0.016mg/l for water samples, 0.280-0.538mg/l and 0.285-1.538mg/l for fresh and dried fish in August and September. Iron (Fe) 0.264-2.429mg/l and 0.273-2.447mg/l for water, 2.569-13.70mg/l and 7.104-14.723mg/l for fresh and dried fish in August and September. Chromium (Cr) 0.004-0.094mg/l and 0.036-0.237mg/l for water samples 0.196-0.680mg/l and 0.126-0.446mg/l for fresh and dried fish, in August and September respectively. The results showed that the concentrations of Cd, Pb, Fe, and Cr in water samples exceeded the WHO/FAO permissible limits. The study concluded that the river is polluted with heavy metals, posing health risks to humans. To mitigate this, laws enforcing the recycling of leather, rubber, and plastics should be enacted to reduce heavy metal contamination in aquatic ecosystems.

Keywords:
Heavy metals concentration, Lake Alau, Anthropogenic activities, African catfish products.

INTRODUCTION
Pollution can be defined as the introduction of contaminants into the natural environment that causes adverse change (Merriam-Webster, 2010). Pollution can take the form of chemical substances or

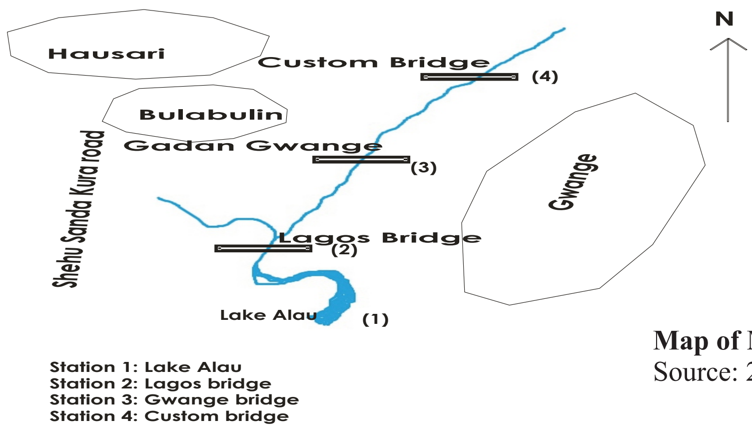
energy, such as heavy metals. In 2015, pollution killed 9 million people in the world (Beil and Carrington, 2017). A Heavy metal is dense that is (usually) toxic at low concentrations. Although the phrase "heavy metal" is common, there is no standard definition assigning metals as heavy metals (Helmenstine, 2018). Heavy metal is defined mainly on the basis of its specific weight. Heavy metal on the basis of periodic table would be referred to as transition elements, rare earth elements, which can be subdivided into lanthanides and actinides, a heterogeneous group including the metal B1, elements that form amphoteric oxides aluminium (Al), gallium (Ga), indium (In), titanium (Ti), tin (Sn), lead (Pb), antimony (Sb) polonium (Po) and the metalloids germanium (Ge), arsenic (As) and tellurium (Te) (Klaus, 2010). Heavy metals are essential components of aquatic environment, usually found in really low concentrations. The many parts of the heavy metals released into the earth discover their way into the freshwater and marine environment as by many ways as input of direct air deposition, climatic, and disintegration due to rainwater. The levels of heavy metals are too high, in the area where domestic activities, mining activities, mechanical and cultivating activities are across the natural areas (Suleiman and Suleiman 2019)

The bioaccumulation of heavy metals widely varies among aquatic organism species, which is mainly due to specific physiological processes, metabolic activities, feeding strategies, and living habits (Baki et al. 2018; Liu et al. 2019). Moreover, some metabolically active organs, such as gills and the liver, generally accumulate high levels of heavy metals (Subotić et al., 2013; Djikanović et al. 2018). Recent development and advancements in the agricultural sector, industrialization, and urbanization have contributed substantially to elevated heavy metal pollution in freshwater and marine environments. Anthropogenic activities such as mining and smelting (Chen et al. 2015), combustion of fossil fuel refining (Muradoglu et al., 2015), discharge and disposal of domestic and municipal wastes (Khan et al., 2016), using pesticides in agricultural sector (Ogunlade and Agbeniyi 2011), sewage irrigation in some countries (Sun et al., 2013), fertilizer and urea application (Atafar et al., 2010), dust (Chen et al., 2011) contribute to spread the levels and concentrations of dangerous heavy metals in the aquatic environments. Different parts of fish such as gills, liver, kidneys and muscles have been widely investigated for heavy metals (Oguzie and Izevbigie, 2009). Fish have been considered as one of the most significant indicators in water systems for the estimation of metal pollution level (Oguzie and Izevbigie, 2009). Therefore, the objective of this project is to determine the concentration of Heavy metals in water, tissues of fresh and dried Clarias gariepinus.

MATERIALS AND METHODS

Study Area

The study site lies between latitude 11o 48' N – 11o 52' and longitude 13o 06'E – 13o 14' at an altitude of 345m above sea level. This area has a long period of dry season and the vegetation is of grassland type with Sudan type of climate. The annual rainfall is light with average value of 864mm (34inches) and the temperature ranges from 22–31°C (Bukar et al., 2016).



Map of Maiduguri showing Ngadda River.
Source: 2019 Research.

Sampling

Water and fish samples were collected monthly from each of the four sampling sites from August to September 2022. Samples were collected along the river with the aid of a canoe. Water samples were collected at the water surface using 350ml HDPE (high density polyethylene) bottles. Water sampling bottles were rinsed with the water before sampling was done at each site. A wide fishing net (drag net) was pushed to the bottom of the river and dragged out. One water and two fish samples were collected from each site monthly during the study period.

A total of 16 fishes belonging to Clarias garipienus were sampled throughout the sampling periods.

Sample preparation

Fish digestion

Nitric-Perchloric acid (HNO3-HClO4) digestion method was carried out as recommended by Association of Analytical Communities (AOAC, 1990). A sample of 1.0 g was taken into a digestion tube and 10 ml of concentrated HNO3 acid was added. The mixture was boiled for 45 minutes to remove all oxidizable matter. After cooling, 5ml of HClO4 was added and the mixture was boiled until a white fume was observed. Then 20 ml of distilled water was added and the mixture was further boiled to release any gas. Finally, the mixture was filtered using filter paper. Each digested sample was diluted and make up to 50ml with distilled water after the digestion, for AAS readings.

Water digestion

Nitric (HNO3) digestion was carried out. 50ml of the water sample was transferred into a beaker and 5ml of HNO3 was added, it was then placed on a hot plate and evaporated for about 20 minutes. After cooling, another 5ml of HNO3was added. The beaker was covered with watch glass and returned to the hot plate. Heating was continued for 20 minutes, and then a small portion of HNO3 was added until the solution appears light colored and clear. The samples were filtered and the volume was adjusted to 100cm3 with distilled water (Radojevic and Bashkin, 1999).

Heavy metal Analysis

The concentrations of Cd, Pb, Fe, and Cr were determined by an Atomic Absorption Spectroscopy (AAS) in the Chemistry Laboratory, National Institute for Freshwater Fisheries Research (NIFFR). AAS determinations are made by furnace AAS when the concentrations are high enough, or by graphite furnace AAS (GFAAS) when the concentrations are low. As long as the same results are above the detection limit both techniques basically give the same result.

Statistical Analysis

All experiments were performed in triplicate. One-way analysis of variance (ANOVA) was utilized to distinguish the mean levels of each of the four heavy metals (Cd, Pb, Fe and Cr). A stepwise multiple comparisons procedure will be used to identify sample means that are significantly different from each other.

RESULTS

Concentrations of heavy metals in fresh fish of August and September

The results showed significant differences in metal concentrations among stations. In August, the highest mean values were recorded for cadmium (0.617mg/L) at station three, lead (0.538mg/L) at station three, iron (13.617mg/L) at station one, and chromium (0.680mg/L) at station one. In September, the highest mean values were recorded for cadmium (0.655mg/L) at station three, lead (0.566mg/L) at station four, iron (13.77mg/L) at station one, and chromium (0.682mg/L) at station one. The results showed that metal concentrations were generally higher in September than in August.

Table 4.1: **Mean concentrations (mg/kg) of Cd, Pb, Fe and Cr from fresh fish samples of August and September**

Stations	Cd	Pb	Fe	Cr
SSA1	0.015±0.003[c]	0.407±0.001[b]	13.70±0.003[a]	0.680±0.010[a]
SSA2	0.177±0.009[b]	0.280±0.006[c]	10.16±0.013[b]	0.298±0.000[b]
SSA3	0.617±0.001[a]	0.538±0.001[a]	2.569±0.001[d]	0.227±0.001c
SSA4	0.019±0.000[c]	0.528±0.001[a]	5.436±0.002[c]	0.196±0.002[d]
SSS1	0.057±0.001[c]	0.435±0.002[c]	13.77±0.009[a]	0.682±1.667[a]
SSS2	0.194±0.002[b]	0.297±0.002[d]	10.34±0.015[b]	0.315±1.453[b]
SSS3	0.655±0.002[a]	0.545±0.003[b]	2.577±0.001[c]	0.234±1.453c
SSS4	0.031±0.001[d]	0.566±0.002[a]	5.463±0.015[d]	0.195±2.646[d]

SSA: Sample station in August, SSS: sample station in September.

Mean value within the column with the same superscript are not significantly different

Concentration of heavy metals in dried fish of August and September

The results showed significant differences in metal concentrations among stations. In August, the highest mean values were recorded for cadmium (0.505mg/L) at station three, lead (1.538mg/L) at station one, iron (14.643mg/L) at station two, and chromium (1.307mg/L) at station four. In September, the highest mean values were recorded for cadmium (0.535mg/L) at station four, lead (1.552mg/L) at station one, iron (14.723mg/L) at station two, and chromium (0.446mg/L) at station one. September generally recorded higher metal concentrations than August.

Table 1: **Mean concentrations (mg/kg) of Cd, Pb, Fe and Cr from dried fish samples of August and September**

Stations	Cd	Pb	Fe	Cr
SSA1	0.038±0.001[c]	1.538±0.001[a]	13.263±0.018[b]	0.435±0.001[b]
SSA2	0.153±0.002[d]	0.315±0.002[c]	14.643±0.015[a]	0.216±0.001[c]
SSA3	0.094±0.002[b]	0.285±0.002[d]	6.917±0.002[d]	0.137±0.017[d]
SSA4	0.505±0.002[a]	0.443±0.001[b]	11.873±0.009[c]	1.307±0.001[a]
SSS1	0.044±0.003[c]	1.552±0.001[c]	13.387±0.026[a]	0.446±0.001[a]
SSS2	0.106±0.004[b]	0.337±0.002[d]	14.723±0.038[b]	0.223±0.001[b]
SSS3	0.106±0.001[a]	0.343±0.020[b]	7.104±0.003[d]	0.126±0.002[c]
SSS4	0.535±0.002[d]	0.474±0.002[a]	12.030±0.015[c]	0.317±0.003[d]

SSA: Sample station in August, SSS: sample station in September.

Mean value within the column with the same superscript are not significantly different

Concentrations of heavy metals in water samples of August and September

In water samples of the first month, the highest mean value was recorded as 0.353±0.002 at station three and the least value of 0.105±0.003 was recorded at station one for cadmium, the means are significantly different from one another. For lead, all the four stations were below detection limit. Iron has the highest value of 2.429±0.003 at station one and with the least value of 0.264±0.003 at station two the means are significantly different from one another. Chromium has the highest mean of 0.094±0.002 at station one and a least value of 0.004±0.002 at station four, the means are not significantly different from one another, while the September, the highest mean value was recorded as 0.363±0.004 at station four and the least value of 0.013±0.002 was recorded at station one for cadmium, the means are significantly different from one another. Lead has the highest mean of 0.016±0.002 at station three and a least value of 0.014±0.002 at station one, the means are not significantly different from one another. Iron has the highest value of 2.447±0.001 at station three and with the least value of 0.273±0.002 at station two, the means are significantly different from one another. Chromium has the highest mean of 0.237±0.015 at station three and a least value of 0.036±0.001 at station one, the means are significantly different from one another.

Table 2: **Mean concentrations (mg/kg) of Cd, Pb, Fe and Cr from water samples of August**

S/N	Cd	Pb	Fe	Cr
SSA1	BDL	BDL	1.813±0.001^{c}	BDL
SSA2	0.183±0.002^{c}	BDL	0.264±0.003^{d}	BDL
SSA3	0.105±0.003^{b}	BDL	2.429±0.002^{a}	0.004±0.001^{b}
SSA4	0.353±0.002^{a}	BDL	1.943±0.002^{b}	0.094±0.002^{a}
SSS1	0.013±0.002^{d}	0.014±0.002^{a}	2.131±0.006^{b}	0.036±0.001^{c}
SSS2	0.027±0.003^{c}	BDL	0.273±0.002^{d}	BDL
SSS3	0.116±0.002^{b}	0.016±0.002^{a}	2.447±0.001^{a}	0.237±0.015^{a}
SSS4	0.363±0.004^{a}	BDL	1.959±0.001^{c}	0.177±0.007^{b}

SSA: Sample station in August, SSS: sample station in September.

Mean value within the column with the same superscript are not significantly different

DISCUSSION

The presence of heavy metals in water and fish higher than a certain concentration especially the well-known set standards can cause a serious health hazard to human beings and other living organisms. Knowing the concentration of heavy metals in fish tissues has become a necessity for knowing how to control nature and combat pollution on the one hand and their suitability for human consumption (Sankhla et al., 2016). Cadmium (Cd) concentrations in fish tissues were found to be below the World Health Organization (WHO) recommended limit of 2.0 mg/kg, but the concentrations in water samples exceeded the permissible limit of 0.003 mg/l. Though the levels were lower in fish, cumulative exposure may still pose a health risk, especially with prolonged consumption.

Lead concentrations in fish tissues were within safe limits, but water samples showed elevated Pb levels. This is likely due to anthropogenic sources, particularly agricultural activities around the river. Lead is harmful, affecting the nervous system, causing anemia, and may lead to other serious health issues.

The concentrations of iron in both fish tissues and water were well below the WHO's recommended upper limit of 43 mg/l, suggesting no significant health risks associated with iron in the studied area.

Several stations showed chromium concentrations exceeding the recommended limit of 0.15 mg/l in fish tissues. The elevated levels are likely due to industrial waste, such as from leather tanning and metallurgy, contaminating the environment.

CONCLUSION

While the concentrations of cadmium, lead, and chromium in fish and water samples pose some potential health risks, especially with chronic exposure, iron concentrations do not appear to be a concern. The study suggests that contamination is mainly due to anthropogenic activities, and careful monitoring and consumption of fish from these water sources are necessary to avoid health hazards.

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REFERENCES

Atafar Z., Mesdaghinia A., Nouri J., Homaee M., Yunesian M., Ahmadimoghaddam M., and Mahvi A.H. (2010). Effect of fertilizer application on soil heavy metal concentration. Environmental Monitoring Assessment 160 (1-4): 83-89. DOI: 10.1007/s10661–008–0659–x

Baki, M. A., Hossain, M. M., Akter, J., Quraishi, S. B., HaqueShojib, M. F., AtiqueUllah, A. K. M., and Khan, M. F. (2018). Concentration of heavy metals in seafood (fishes, shrimp, lobster and crabs) and human health assessment in Saint Mart in Island, Bangladesh. Ecotoxicology and Environmental Safety, 159, 153–163.

Beil, Laura and carrigton, November (2017). https://extranet.who.int/pqweb/vector-control-products/prequalified product-list.

Bukar P. H., Zakari I.Y., Oladipo M.O.A., and Ibeanu I. G.E. (2016). Assessment and distribution of metal pollutants in the sediments of River Ngadda and Alau Dam in Maiduguri, Borno State, Nigeria. American Journal of Communication;4(4).

Carrington, Damian (October 20, 2017). "Global pollution kills 9m a year and threatens 'survival of human societies'". Guardian. Retrieved October 20, 2017.

Chen J., Wang W., Liu H. and Ren L. (2011). Determination of road dust loading and chemical characteristics using resuspension. Environ Monit Assess 184: 1693-1709.

Chen Z.F., Zhao Y., Fan L.D., Xing L.T. and Yang Y.J. (2015). Cadmium (Cd) localization in tissues of cotton (Gossypium hirsutum L.) and its phytoremediation potential for Cd-contaminated soils. Bulletin of Environmental Contamination and Toxicology 95: 784-789. DOI: 10.1007 /s00128–015–1662–x

Djikanović, V., Skorić, S., Spasić, S., Naunovic, Z., and Lenhardt, M. (2018). Ecological risk assessment for different macrophytes and fish species in reservoirs using biota-sediment accumulation factors as a useful tool. Journal of Environmental Pollution, 241, 1167–1174.

FAO/WHO. (2011) Joint FAO/WHO food standards programme CODEX Committee on Contaminants in Foods. Fifth Session, The Hague, The Netherlands, 14-88.

Food and Agriculture Organisation of the United Nations/ World Health Organization (FAO/WHO), (2011) Joint FAO/WHO Food Standards Program, CODEX Committee on contaminants in Foods. CODEX Alimmentarius Commission. pp 1-88.

Khan I., Ghani A., Rehman A.U., Awan S.A., Noreen A. and Khalid I. (2016). Comparative analysis of heavy metal profile of Brassica campestris (L.) and Raphanussativus(L.) irrigated with municipal wastewater of Sargodha city. Journal of Clinical Toxicology 6: 1-4. DOI: 10.4172 /2161-0495.1000307

Liu, Q., Liao, Y., and Shou, L. (2018). Concentration and potential health risk of heavy metals in seafoods collected from Sanmen Bay and its adjacent areas, China. Mar.ine Pollution Bulletin, 131, 356–364.

Liu, Q., Xu, X., Zeng, J., Shi, X., Liao, Y., Du, P., Tang,Y., Huang, W., Chen, Q., and Shou, L. (2019b). Heavy metal concentrations in commercial marine organisms from Xiangshan Bay, China, and the potential health risks. Marine Pollution Bulletin, 141, 215–226.

Muradoglu F, Gundogdu M, Ercisli S, Encu T, Balta F, Jaafar HZE and Zia-Ul-Haq M. (2015). Cadmium toxicity affects chlorophyll a and b content, antioxidant enzyme activities and mineral nutrient accumulation in strawberry. Biology and Resource 48: 1-7. DOI: 10.1186 /S40659–015–0001–3

Ogunlade M.O. and Agbeniyi S.O. (2011). Impact of pesticides use on heavy metals pollution in cocoa soils of Cross-River State, Nigeria. African Journal of Agricultural Resource 6: 3725-3728.

–Pollution Definition from the Merriam-Webster Online Dictionary". Merriam-webster.com. (2010-08-13). Retrieved 2010-08-26.

Sankhla, M. S., Kumari, M., Nandan, M., Kumar, R., and Agrawal, P. (2016). Heavy metals contamination in water and their hazardous effect on human health-a review. International Journal of chemistry and Microbiology and Applied Science, 5(10), 759-766.

Subotić, S., Spasić, S., Višnjić-Jeftić, Ž.,Hegediš, A., KrpoĆetković, J., Mićković, B., Skorić, S., and Lenhardt, M. (2013). Heavy metal and trace element bioaccumulation in target tissues of four edible fish species from the Danube River (Serbia). Ecotoxicology and Environmental Safety, 98, 196–202.

Sulieman H.M.A. and Suliman E.M. (2019). Appraisal of heavy metal levels in some marine organisms gathered from the Vellar and Uppanar estuaries Southeast Coast of Indian Ocean. Journal of Taibah University of Science 13 (1): 338-343. DOI: 10.1080/16583655.2019.1576276

Sun W.H., Jiang YX and Li X. (2013). Research of the evaluation on heavy metal pollution in rice by sewage irrigation. Appl Mech Mater 295- 298: 1594-1599.2 DOI: 10.4028/www.scientific.net/AMM.295–298.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

EFFECTS OF OIL CONTAMINANTS ON FISHERIES IN BAYELSA STATE: A REVIEW

Eli, A. A.

Department of Environmental Management and Toxicology, Faculty of Science, Federal University Otuoke, Bayelsa State, Nigeria.

Correspondence Author:
akayinaboderi@gmail.com; +2348036769665; ORCID: 0009-0002-1521-1102

ABSTRACT
Oil contamination poses significant threat to fisheries in Bayelsa State, Nigeria, impacting aquatic biodiversity, water quality, and the socio-economic welfare of host communities. This paper synthesized recent findings on the effects of oil contamination on fisheries in Bayelsa State, provides crucial insights into the detrimental effects of oil contamination on fisheries. A review of recent literature with focus on the impacts of oil spills and pollutants such as, polycyclic aromatic hydrocarbons (PAHs) and heavy metals on fish populations and aquatic ecosystems helped to assess the threats, effectiveness of various monitoring and management strategies. The findings revealed that, oil spills and pollution have extensive and long-lasting effects on fish populations and aquatic ecosystems. Contaminants accumulate in fish tissues, posing health risks to humans, disrupting ecosystem balance and dependent livelihoods. Effective long-term monitoring programs that integrate biological and chemical analyses are essential for tracking changes in species abundance, and water quality. The paper provides recommendations for research and actions to address these challenges, and offers practical remediation and sustainable management strategies. The study underscored the critical need for adaptive management strategies and sustainable fishing practices to mitigate the impacts of oil contamination. Such strategies are vital for ecosystem recovery and maintaining the viability of local fisheries. Future actions should include the implementation of long-term monitoring programs, the regulation of fishing seasons, the establishment of catch limits, and the creation of marine protected areas. Emphasizing on sustainable fishing practices will help safeguard the future of fisheries in Bayelsa State.

Keywords:
Oil contamination, fisheries, Bayelsa State.

INTRODUCTION

Fisheries in the Niger Delta are highly developed with Bayelsa State as one of key player states within this region. (Izah et al., 2022). Flourizel et al. (2024), reported that, the state has rich marine and freshwater fisheries in the rivers and streams that flow into the Atlantic Ocean due to its extensive coastline. Bayelsa State created in 1996 from Rivers State has evolved to become a center for fishing camps, causing many of its inhabitants to go about their daily lives as fishermen (Olali, 2023). Bayelsa State has a small land area of 10,773sq kilometers (Mienye, 2016). The streams, rivers that transverse the state with Nun River and Forcados River as the major tributaries; and the Atlantic Ocean to the south (Abam and Fubara, 2022) with the mangroves, brackish waters and wetlands are fertile for fisheries with diverse fish species and other aquatic resources for artisanal and industrial fishing activities (Aghughu et al., 2021). Bayelsa State is significant in terms of ecological importance as these water bodies provide diverse ecosystems, important spawning grounds (Nwankwoala and Okujagu, 2021) and habitats for different aquatic species (Andrews et al., 2021).

The indigenous Ijaw people, who form a significant part of the state's population, have traditionally relied on fishing as a primary source of livelihood. This historical dependence on fishing activities, passed down skills and knowledge have shaped the state's cultural and economic landscape (Asanebi, 2018). Riverine settlements in Bayelsa State have a wide range of small-scale fishing techniques that are based on indigenous technology. Some examples of these techniques include the use of set gill nets, purse seine, long lines, nets, hooks, small boats, cast nets, landlines, basket nets, and low-capital gear (Odele et al. 2022).

The Problem

Since the discovery of oil in 1956 in Bayelsa State, oil naturally took center stage in Nigeria and generates more than 85% of the country's export earnings (Wilcox, 2024). The past sixty years have seen unprecedented changes as crude oil production has largely replaced agriculture (Eleke et al., 2019) and other sectors, and exposed Nigeria to the best and worst parts of modern civilization. Oil spills and vandalism of pipelines have become more common, resulting in high levels of oil contamination on land and water (Akpoghelie et al., 2021). This has had devastating impacts on artisanal fishing activities and the dependent families, leading to high levels of poverty as fishing efforts have little or no outcome (Freduah et al., 2017). Large amounts of produce water and other contaminants are often released into the environment during oil exploration and exploitation have worsened the environmental conditions. Run-offs from municipal areas is another source of oil pollution. According to Abam and Fubara (2022), oil products (naptha, paraffin, asphaltenes, hydrocarbons, etc.) in run-offs from roads, parking lots, and industrial areas besides spills get into water drains, rivers, estuaries, and the sea. Polycyclic aromatic hydrocarbons (PAHs) and heavy metals are two groups of compounds that are found in petroleum products that have potentials to cause health problems in marine life (Mehr et al., 2020); their impacts on livelihoods is severe and prolonged, and has led to a state of pollution that can be said to be 'acute' in its destruction of aquatic life, habitat and livelihoods (Akagbue et al., 2024).

Impacts on Ecosystems

Several researchers have studied the effects of oil pollution on soil quality, ecosystems, and agricultural productivity (Gao et al., 2022). Fertile lands have been converted into wastelands due to oil-degraded soils resulting in soil pH changes associated with changes in organic matter, nutrient availability, reduced crop yield and food security (Ekundayo et al., 2001). Dido (2021), examined the use of degreasing agents and surfactants for the rehabilitation of crude oil-contaminated soils along the Qua Iboe River in the Niger Delta and showed improvements in soil quality and crop growth metrics after treatment. Akpan (2022), Isukul et al. (2023) and Ephraim-Emmanuel et al. (2023), examined the devastating effects of the oil industry on marine biodiversity, soil, air, water, and overall ecosystem health in the affected areas, with mortalities and extinction of marine species, natural resource degradation, impacts on human livelihoods, health and well-being. Izah et al. (2022), studied the effects of oil on soil and microbiological features with focus on hydrocarbon-utilizing bacteria, showed higher carbon/nitrogen ratios in more degraded areas, and consequently increased soil infertility and microbial diversity. Usiobaifo et al. (2023), highlighted the negative impacts on social and economic activities, especially artisanal fisheries which is important for many coastal communities. Ephraim-Emmanuel et al. (2023), reported that, artisanal fisheries are severely reduced due to periodic oil spills causing significant reductions in local fisheries productivity and impoverishment among dependent families.

Artisanal fisheries, defined as small-scale fisheries that typically use local boats near shore with traditional fishing techniques, is an important activity that supports livelihoods and local food security (Manhice et al., 2022). Pegg and Zabbey (2013), examined how the oil industry has destroyed traditional livelihoods centered on agriculture and fishing. These have serious consequences on food security and livelihood, as water pollution and loss of fishing areas threaten the survival of artisanal fisheries.

Effects of Oil Contaminants on Fisheries in Bayelsa State

An oil spill is often very destructive, it quickly spreads a film over large areas of the affected water body (Plates 1 and 2) causing death of animals as oil droplets coat them, cut off oxygen supply, and cover the tidal zone (Wilcox, 2024).

Plates 1 and 2: Oil slicks covering water bodies

Spilled oil can be absorbed through the skin or ingested, leading to metabolic harm, physical stress, and death. Oil pollution also has substantial implications on human health (Ordinioha and Sawyer, 2010). One critical effect on fish is the disruption of the reproductive abilities (Okwuosa et al., 2016). Hydrocarbons and heavy metals in the water, for example, might affect hormonal balance and reproduction leading to lower fertility or total reproductive failure. Moreover, pollution of spawning grounds like mangrove forests and river beds might limit surviving fish larvae, as eggs are poisoned with chemical mixtures that may affect their development and viability (Wilcox, 2024). These can move up the food chain to affect not only fish but also predatory birds and mammals and man.

For the local communities in Bayelsa State that depend on fish as their primary source of protein and income, bioaccumulation poses significant health threat (Flourizel et al., 2024). Eating contaminated fish may result in neurological damage, cancer and other long-term effects. Scarcity, furthermore, has had significant economic consequences arising from the declines in fish catches and destruction of marketable fish stock due to contamination that translates into poverty, as well as, food insecurity within the region (Bernardo et al., 2022). Fishing and fisheries in Bayelsa State is a key source of sustenance and livelihood in the local communities, and holds significant cultural value for the people influencing their ways of life (Okwuokenye and Ikoyo-Eweto, 2016). As fish stocks have suffered from overfishing and have been further decimated by pollution, commercial fishermen find it harder to make a living. Other employment options in the region are scarce, such that, poverty and social instability have become more pronounced with time (Elum and Snijder, 2023). Several communities have experienced a cultural loss due to the loss of their traditional fishing grounds, enterprises and the knowledge passed down through generations.

Economic Impacts on Fishing Communities

Many fishing communities around the world struggle against severe economic circumstances that have profound implications for fishermen, local markets, and the broader well-being of their citizens:

ss Loss of Income for Fishermen and decreased seafood availability for local markets

Fishing is the economic backbone of many communities in Bayelsa State. Local fishermen are engaged in artisanal, as well as, commercial fishing with the use of small boats and crafts for coastal water netting to larger trawlers offshore (Isukul et al., 2023). These threaten the fish stocks, as well as, other environmental issues related to overfishing, significantly affecting the capacity of the fisher folks to provide for their welfare. The coastal areas around Bayelsa State have been depleted as a result of excessive fishing, driven by local demand and foreign markets that pay greater rates (Kinds et al., 2021). The environmental degradation due to oil spills and waste discharges have generally pushed the fisheries to a much lower level (Usiobaifo et al., 2023) as reported in some studies by Ibe (2019), Nwankwo (2020) and Akinpelu (2021) amongst others. With damaging effects on fish species, leading to diminishing yields for fishermen, lowered income generation potentials with long-term adverse effects on the ecosystem, which can make it hard for the recovery of fish populations (Bashir et al., 2020). Fluctuations in catch sizes and market prices can make all the difference for those whose livelihoods depend completely on fishing. This loss of income among the individual fishermen does not only have its immediate impacts on their personal welfare but also has general consequences for the local economy and community stability (Elisha and Golden, 2022).

The state of the fish markets in Bayelsa State also reflect on what is available to fishermen living within this region. Fish and other marine resources have traditionally been vital, staple food sources in the subsistence islands, as they provide protein and key nutrients to many inhabitants. However, local markets suffer shortages and price fluctuations as fish stocks are depleted or less accessible due to overfishing and environmental perturbations (Ephraim-Emmanuel et al., 2023). The prices seafoods have thus skyrocketed, disruptng market dynamics and chains of supply, with the risks of financial losses due to reduced revenue while affecting low-income homes where fish makes up a greater part of total protein intake. Odele et al. (2022), stated that, lack of seafoods may lead the consumer to shift towards other alternative protein sources which in turn may influence the cultural dietary behaviours and local culinary traditions. These ripple effects go beyond fishermen to affect many aspects of the local economy that depend on fishing productivity and stability (Tonbra, 2021).

Increased Poverty and Food Insecurity in Fishing Communities

According to Sam et al. (2024), loss of income for fishermen and a reduction in seafood availability imply that, the fishing communities in and around the state are much poorer than would otherwise be expected. The problem of poverty which comes due to not having enough income to take care of basic needs, because fishermen get decreased earnings when catches are landed. Bayelsa State, a region with fishing communities that consume more traditional seafood-based diets than other parts of Nigeria, levels drop in fish catches and low ability to meet nutritional requirements will result in negative health outcomes that can be of particular concern for some sections of the population, such as, children and pregnant women. These can intensify social inequalities and consolidate poverty traps into which many in the fishing communities in Bayelsa State have already been pushed with no other livelihood choices or benefits of any social safety net thus, continuing and increasing the inter-generational poverty trap. This economic fragility can interfere with broader development and increase their susceptibility to major external blows like financial contractions or environmental calamities.

Mitigating Economic Impacts and Promoting Sustainable Fisheries

Addressing the adverse economic impacts of fisheries decline in Bayelsa State necessitate solutions that incorporate sustainable fishery management, strategies for diversifying the economy (aquaculture, eco-tourism and value-added processing initiatives represent potential sources of additional income for fishermen) and community empowerment programs (Krupa and Valcic, 2011). The enforcement of fishing regulations and the formation of marine protected areas in addition to sustainable fisheries management practices are crucial for maintaining fish stock levels while enhancing productivity over time (Brown et al., 2019). The world over, governments and industries have introduced extensive strategies to deal with the challenges of oil contamination which involve regulatory measures, clean-up campaigns (with the use of mechanical or chemical techniques), bioremediation, as well as, community participation (Kobayashi, 2023). To facilitate these clean-ups, government agencies often collaborate with private industry and non-governmental organizations, State and Local Governments, industry representatives and community organizations to help ensure comprehensive and effective response. Community involvement is a critical component of this strategy for dealing with oil contamination (LASEPA, 2020). Governments have also imposed tough regulations to avoid the recurrence of oil contamination cases. These regulations are often established upon international conventions, national legislation, and industrial standards with objectives to ensure that, oil recovered from the extraction site will be safely transported and processed without leading to further environmental pollution (Ampara et al., 2018).

CONCLUSION

There have been significant reductions in fish populations as a result of oil pollution. The challenges of oil contamination on the fisheries necessitates collective action and commitment, spurred by government and industry initiatives. All communities and stakeholders must prioritize ecological considerations within policy agenda. State instruments play crucial roles in enhancing governance and regulatory frameworks, reinforcing their enforcement mechanisms, environmental standards, conducting more frequent audits, and enforcing violations. But to stay engaged, the oil companies are industry actors in environmental management, their best practices should be to forgo investment protection and respond to environmental impacts as a transparency practice. Corporate social responsibility projects in this region should aim to mitigate environmental harm, integrate sustainable development, and assist local communities. Efforts for conservation and sustainable management should be led by the local communities, particularly those belonging to the fisher folk sector and indigenous groups. Community-based organizations can only fight relevantly by being proactive about what affects their interest. The fishing sector's future in Bayelsa State hinges on strong environmental management and sustainable development methods. By dealing with oil pollution in an appropriate way, natural ecosystems may become robust for fish populations, aquatic biodiversity, and secure the livelihoods of fisher folks. Based on the foregoing, there is need for long-term monitoring of fish populations and water quality of important water bodies, sustainable fishing practices should be encouraged in the region; and there should be advocacy for stricter compliance with regulations by the oil companies operating especially in Bayelsa State.

References

Abam, T. K. S. and Fubara, D. M. J. (2022). Analysis of Hydrological Characteristics: A Case Review of the Niger Delta. Journal of Water Resource and Protection, 14(09):611–631. https://doi.org/10.4236/jwarp.2022.149032

Aghughu, A., Sangari, D., Ogah, A. and Alkali, M. (2021). Effect of Oil Spills on Artisanal Fishery in the Niger-Delta, Nigeria. African Scholar Journal of Agriculture and Agricultural Tech (JAAT-1), 22 (1):82–85. https://www.researchgate.net/profile/Peter_Nwilo

Akagbue, B. O., Popoola, T. O., Aminu, M. B., Nenger, J. A. and Babatunde, S. (2024). Negative Health and Environmental Effects of Oil Exploitation in Southern Ijaw, Bayelsa State, Nigeria. European Journal of Environment and Earth Sciences, 5(3): 34–41. https://doi.org/10.24018/ejgeo.2024.5.3.464

Akinpelu, A. O. (2021). The economic impact of oil spills on fisheries in Bayelsa State. Economic and Environmental Studies, 11 (3):33-39

Akpan, E. E. (2022). Environmental Consequences of Oil Spills on Marine Habitats and the Mitigating Measures—The Niger Delta Perspective. Journal of Geoscience and Environment Protection, 10(06):191–203. https://doi.org/10.4236/gep.2022.106012

Akpoghelie, J. O., Ugbuku, U. A. and Esemedafe, U. J. (2021). A Review of Oil Spill Pollution and Air Quality in the Niger Delta: Causes, Effects and Control. Journal of Chemical Society of Nigeria, 46(5): https://doi.org/10.46602/jcsn.v46i5.660

Andrews, N., Bennett, N. J., Billon, P. L., Green, S. J., Cisneros-Montemayor, A. M., Amongin, S., Gray, N. J. and Sumaila, U. R. (2021). Oil, fisheries and coastal communities: A review of impacts on the environment, livelihoods, space and governance. Energy Research & Social Science, 75: 102009. https://doi.org/10.1016/j.erss.2021.102009

Asanebi, D. H. (2018). A Historical Evolution and Development of Amassoma-Seigbein Fishing and Feasting Festival in Central Niger Delta Region of Nigeria. Abraka Humanities Review, 8 (1): 137–158.

Bashir, I., Lone, F. A., Bhat, R. A., Mir, S. A., Dar, Z. A. and Dar, S. A. (2020). Concerns and Threats of Contamination on Aquatic Ecosystems. Springer. Pp. 1–26. https://doi.org/10.1007/978-3-030-35691-0_1

Bernardo, F., Alves, A. and Homem, V. (2022). A review of bioaccumulation of volatile Methyl-Siloxanes in aquatic ecosystems. The Science of the Total Environment, 824: 153821. https://doi.org/10.1016/j.scitotenv.2022.153821

Brown, A. R., Lilley, M., Shutler, J., Lowe, C., Artioli, Y., Torres, R., Berdalet, E. and Tyler, C. R. (2019). Assessing risks and mitigating impacts of harmful algal blooms on mariculture and marine fisheries. Reviews in Aquaculture, 12(3): 1663–1688. https://doi.org/10.1111/raq.12403

Dido, M. S. (2021). Use of close-to-nature surfactants and microbiological degradation for improving the remediation of crude. https://www.researchgate.net/publication/357839825_Use_of_close-to-nature_surfactants_and_microbiological_degradation_for _improving_the_remediation_of_crude_oil_contaminated_soils_in_the_Nigerian_Niger-Delta

Ekundayo, E., Emede, T. and Osayande, D. (2001). Effects of crude oil spillage on growth and yield of maize (Zea mays L.) in soils of midwestern Nigeria. Plant Foods for Human Nutrition, 56(4): 313–324. https://doi.org/10.1023/a:1011806706658

Eleke, P. N., Jibril, M. and Nte, J. M. (2019). A Review of the Effect of Crude Oil Exploration on Agriculture: A Case Study of the Niger Delta Region. Journal of Agricultural Economics, Environment and Social Sciences, 5 (1 & 2): 87–98). http://www.jaeess.com.ng

Elisha, O. D. and Golden, E. I. (2022). Community-Based Intervention in the Control of Artisanal Refining Against the Environment in Niger Delta Region, Nigeria. Asian Journal of Current Research, 21–33. https://doi.org/10.56557/ajocr/2022/v7i37973

Elum, Z. A. and Snijder, M. (2023). Climate change perception and adaptation among farmers in coastal communities of Bayelsa State, Nigeria: A photovoice study. International Journal of Climate Change Strategies and Management, 15(5): 745–767. https://doi.org/10.1108/ijccsm-07-2022-0100

Ephraim-Emmanuel, B. C., Enembe, O. and Best, O. (2022). Risk Perceptions of Environmental and Health Problems Associated with Artisanal Crude Oil Refining in Bayelsa State, Nigeria. Asian Journal of Environment & Ecology, 42–50. https://doi.org/10.9734/ajee/2022/v18i230313

Ephraim-Emmanuel, B. C., Enembe, O. and Ordinioha, B. (2023). Respiratory Health Effects of Pollution Due to Artisanal Crude-Oil Refining in Bayelsa, Nigeria. Annals of Global Health, 89(1). https://doi.org/10.5334/aogh.4247

Flourizel, I., Weapngong, T. G. and Ukwubile, O. M. (2024). A Review on the Effects of Crude Oil Spill on Aquatic Life (Fish) in the Niger Delta, Nigeria. International Journal of Environment and Pollution Research, 12(1): 75–94. https://doi.org/10.37745/ijepr.13/vol12n17594

Freduah, G., Fidelman, P. and Smith, T. F. (2017). The impacts of environmental and socio-economic stressors on small scale fisheries and livelihoods of fishers in Ghana. Applied Geography, 89: 1–11. https://doi.org/10.1016/j.apgeog.2017.09.009

Gao, H., Wu, M., Liu, H., Xu, Y. and Liu, Z. (2022). Effect of petroleum hydrocarbon pollution levels on the soil microecosystem and ecological function. Environmental Pollution, 293: 118511. https://doi.org/10.1016/j.envpol.2021.118511

Nembe, Bayelsa State. AgEcon Search. https://doi.org/10.22004/ag.econ.338408

Izah, S.C., A. O. Aigberua and A. L. Srivastav (2022). Factors influencing the alteration of microbial and heavy metal characteristics of river systems in the Niger Delta Region of Nigeria. Ecological Significance of River Ecosystems: Challenges and Management Strategies (2022): 51-78.

Kinds, A., H, P. L. F., Speelman, S. and Guyader, O. (2021). Challenging the 'Artisanal vs. Industrial' dichotomy in French Atlantic fisheries: An organizational typology of multi-vessel fishing firms. Marine Policy, 134: 104753. https://doi.org/10.1016/j.marpol.2021.104753

Kobayashi, M. (2023). Promoting sustainable fisheries and aquaculture – Enabling policies, innovation and challenges for achieving sustainable blue economies in Ambon, Maluku Province, Indonesia. IOP Conference Series Earth and Environmental Science, 1207(1): 012006. https://doi.org/10.1088/1755-1315/1207/1/012006

Krupa, M. B. and Valcic, B. (2011). Sustainable fisheries: How externalities impact urban fishery management. Journal of Environmental Studies and Sciences, 1(3): 159–168. https://doi.org/10.1007/s13412-011-0023-2

Lagos State Environmental Protection Agency (2020) LASEPA – Executive Team. Lagos State Environmental Protection Agency. https://lasepa.gov.ng/

Manhice, H., Pedersen, J. S. T. and Santos, F. D. (2022). Holes in the Policy Net: An Analysis of Sustainable Food Production in Artisanal Fishing Communities and Policy Challenges to Ensure Long-Term Food Security in Sofala Bank, Mozambique. World Sustainability Series. Pp. 361–380. https://doi.org/10.1007/978-3-030-98617-9_21

Mehr, M. R., Keshavarzi, B., Moore, F., Fooladivanda, S., Sorooshian, A. and Biester, H. (2020). Spatial distribution, environmental risk and sources of heavy metals and polycyclic aromatic hydrocarbons (PAHs) in surface sediments-northwest of Persian Gulf. Continental Shelf Research, 193: 104036. https://doi.org/10.1016/j.csr.2019.104036

Mienye, E. (2016). A Case Study of Six Land Conflicts in Bayelsa State, Nigeria. Journal of Environment and Earth Science, 6 (4).

Nwankwo, D. I. (2020). The impact of oil spills on aquatic ecosystems in Bayelsa State. Journal of Coastal Research, 5 (2): 34-40

Nwankwoala, H. O. and Okujagu, D. (2021). A Review of Wetlands and Coastal Resources of the Niger Delta: Potentials, Challenges and Prospects. Environment & Ecosystem Science, 5(1): 37–46. https://doi.org/10.26480/ees.01.2021.37.46

Odele, M., Idris, N. M., Babalola, A. and Modibbo, M. (2022). Climate change impact and adaptation strategies of farmers and fishermen in Bayelsa State, Nigeria. https://www.ajol.info/index.php/atbu/article/view/243789

Okwuokenye, G. and Ikoyo-Eweto, G. (2016). Farmers' Participation in Homestead Fish Production: Implications for Poverty Alleviation in Bayelsa and Delta States, Nigeria. Journal of Agriculture and Ecology Research International, 6(2): 1–13. https://doi.org/10.9734/jaeri/2016/22717

Okwuosa, O. B., Nwuba, L. A., Chukwuma, A. C., Kalu, J. and Mbano, O. F. (2016). Effects of Oil Spillage on Fish in Nigeria: A Case Study of Niger Delta. https://journals.aphriapub.com/index.php/TMP/article/view/22

Olali, S. T. (2023). The Ijaw in the 21st century: Experiences from the historic past and imperatives for Bayelsa state. ACADEMICIA an International Multidisciplinary Research Journal, 13(3): 62–82. https://doi.org/10.5958/2249-7137.2023.00036.8

Ordinioha, B. and Sawyer, W. (2010). Acute health effects of a crude oil spill in a rural community in Bayelsa State, Nigeria. Nigerian Journal of Medicine, 19(2). https://doi.org/10.4314/njm.v19i2.56500

Pegg, S. and Zabbey, N. (2013). Oil and water: the Bodo spills and the destruction of traditional livelihood structures in the Niger Delta. Community Development Journal, 48(3): 391–405. https://doi.org/10.1093/cdj/bst021

Sam, K., Zabbey, N., Vincent-Akpu, I. F., Komi, G., Onyagbodor, P. O. and Babatunde, B. B. (2024). Socio-economic baseline for oil-impacted communities in Ogoniland: Towards a restoration framework in Niger Delta, Nigeria. Environmental Science and Pollution Research, 31(17): 25671–25687. https://doi.org/10.1007/s11356-024-32805-0

Tonbra, R. O. (2021). Factors that inhibit the Adaptive Capacity of Rural Households to Oil Pollution in the Niger Delta Region, Nigeria. Wilberforce Journal of the Social Sciences, 6(1): 136–158. https://doi.org/10.36108/wjss/1202.60.0170

Usiobaifo, A. H., Chidiebere, A., Olusola, A. S., Dada, A. R. and Ukoje, N. L. (2023). Assessment of the Impact of Flared Gas and Oil Spilled on Human Health and Environmental Degradation: Evidence from the Niger Delta Region, Nigeria. American Journal of Environmental Science and Engineering. https://doi.org/10.11648/j.ajese.20230701.12

Wilcox, G. I. (2024). Effect of Crude Oil Spillage and Constraints Associated with Artisanal Fishing in Oil-Spilled Areas of Bayelsa State. African Journal of Agriculture and Food Science, 7(2): 158–168. https://doi.org/10.52589/ajafs-jbanfg

ASSESSMENT OF MICROBIAL LOADS OF *Clarias gariepinus* JUVENILE EXPOSED TO VARIED CONCENTRATIONS OF DRIED POULTRY DROPPINGS

*1Tope-jegede, O. H., 1 A.A. Fabusoro, 1 B.l. Ogunwuyi., 1 J.b. Olasunkanmi and 1 T.o. Ariyomo.
1Department of Fisheries and Aquaculture, Federal University Oye Ekiti
Corresponding Author:
Oluwatosin.topejegede@fuoye.edu.ng,
+2348034665824, 0009-0001-0450-8982

ABSTRACT
This study assessed and characterized the microbial loads in the gastrointestinal tract of Clarias gariepinus juveniles exposed to varying concentrations of granulated dry poultry droppings (GDPD). A total of 100 juveniles, with a mean weight of 35.5g ± 0.1, were procured and stocked in ten 50-liter tanks (60 × 30 × 23.4 cm). The experiment, conducted over 56 days, consisted of five treatments (T1, T2, T3, T4, T5) in duplicates. T1 served as the control (0 g GDPD), while T2, T3, T4, and T5 contained 3 g, 4 g, 5 g, and 6 g of GDPD per liters, respectively. After the exposure period, microbial analyses of the gastrointestinal tract and spleen revealed significantly higher ($p < 0.05$) total bacterial counts (TBC) and total fungal counts (TFC) in T5 (4.48×10^8 and 5.5×10^4 CFU/ml, respectively) and the lowest counts in T2 (1.56×10^8 and 3.5×10^4 CFU/ml). Among the isolated bacteria, 88.24% were rod-shaped, with Gram-negative bacteria dominating (68.63%). Escherichia coli (31.37%) and Bacillus spp. (19.61%) were the most prevalent isolates. The study recommends using 3 g of GDPD per liters of water in aquaculture to minimize microbial risks to fish and public health.

Keywords:
Aquaculture,
Clarias gariepinus,
Microbial Loads,
Poultry Droppings.

INTRODUCTION

Efforts to alleviate hunger, food insecurity, and various forms of malnutrition have been the subject of extensive research (Xie et al., 2021). Despite recent advancements, many nations, particularly in developing regions like Sub-Saharan Africa, continue to face significant challenges related to food insecurity (Xie et al., 2020). Agriculture, aquaculture, and fisheries are the three major activities that play vital roles in food production. Current knowledge reveals that the global stocks of fish and shellfish, though renewable, possess finite production limits that cannot be exceeded even with optimal management practices. Aquaculture, however, stands out as an effective means of boosting fish production, making it a profitable industry with substantial potential (Troell, 2023).

In aquaculture, water quality is crucial for the health and growth of fish populations. The African catfish (Clarias gariepinus) is popular in aquaculture due to its capacity to withstand a wide range of environmental conditions, thrive in densely stocked conditions, grow rapidly, consume artificial feed, reproduce efficiently, and be easily bred artificially, all of which contribute to its high market value (Tivkaa and Sampson, 2013). Nigeria, the third-largest producer and consumer of C. gariepinus in Africa, benefits significantly from catfish farming, which provides income, employment opportunities, and contributes to the GDP (FAO, 2016). However, the high costs of feeding fish in aquaculture have prompted numerous efforts to reduce production expenses, with one alternative being the use of animal manure as a pond fertilizer.

The application of animal manure in aquaculture has been explored to supplement or replace conventional feed, with various types of manure documented for this purpose (Ahuja et al., 2020). Studies have shown that different animal manures have varying effects on the populations of zooplankton species, which are crucial for fish growth (Minich et al., 2018; Mosha et al., 2016). Despite these findings, there is limited research on the microbiological quality of fish exposed to or fed with poultry droppings, which has significant implications for public health. This study aims to isolate and identify microbial loads in Clarias gariepinus exposed to varying concentrations of dried poultry droppings, addressing the potential risks associated with the use of organic manure in aquaculture.

MATERIALS AND METHODS

The study was conducted at the Fisheries and Aquaculture wet laboratory of the Federal University Oye Ekiti, Ikole Campus. The experiment utilized one hundred juveniles Clarias gariepinus, each with an average weight of 35.5g, procured from a reputable fish farm in Ado Ekiti. These juveniles were transported in 15-liter containers filled with clean, oxygenated water and acclimatized for fourteen days before the experiment commenced. Fresh poultry manure was collected from a poultry farm in Ikole Ekiti, sun-dried to prevent mold growth, and stored in plastic bags at room temperature. The fish samples were stocked in experimental tanks with varying concentrations of granulated dry poultry droppings at rates of 0 g for T1 (control), 3 g for T2, 4 g for T3, 5 g for T4, and 6 g for T5 per litre of water each. Fish were fed commercial diets twice daily while being exposed to the different concentrations of poultry droppings, and the experiment lasted for eight weeks.

Laboratory analysis included the preparation and sterilization of various media, such as Nutrient Agar, Shigella Agar, Eosin Methylene Blue Agar, Manitol Salt Agar, and MacConkey Agar, following standardized methods (Debnath, 2024). The equipment and working tables were sterilized to maintain aseptic conditions. Fish samples were dissected to collect the gastrointestinal tract and spleen, which were then homogenized and subjected to serial dilution. The diluted samples were plated on the respective agar media for microbial isolation, and bacterial and fungal colony counts were conducted post-incubation. Gram staining was performed to differentiate bacterial cells, and various biochemical tests, such as the Citrate Utilization Test, Urease Test, Indole Test, Catalase Test, and Sugar Fermentation Test, were employed for bacterial identification.

Statistical analysis was carried out using one-way analysis of variance (ANOVA), with mean separation performed using Duncan's Multiple Range Test to determine the significance of differences between treatment groups.

RESULTS AND DISCUSSION

Total Bacterial Counts (TBC) and Total Fungi Counts (TFC)

The results of the bacterial and fungal count carried out on the bacterial and fungal isolates from Clarias gariepinus exposed to varying level of dried poultry droppings presents varying concentrations. The total bacterial and fungal count (TBC and TFC) showed consistent fungal abundance across treatments which was significantly different ($p>0.05$), implying microbial dynamics presence. The mean bacterial and fungal count for Treatment 1 (0g) is 3.4 x 107and 2.0 x 104 CFU/ml; Treatment 2 (3g/ltr) is 156.0 x 108and 3.5 x 104 CFU/ml; Treatment 3 (4g/ltr) is 3.38.0 x 108 and 4.5 x 104 CFU/ml; Treatment 4 (5g/ltr) is 4.48 x 108 and 5.5 x 104 CFU/ml, Treatment 5 (6g/ltr) is 5.08 x 108 and 7.5 x 104 CFU/ml. Treatment 5 (6g/ltr) had the highest bacterial and fungal count. This agrees with the work of Omojowo and Omojola (2013), who observed higher microbial load in ponds treated with raw untreated poultry waste. The bacterial and fungal loads isolated from treatment 1 with 0g/ltr of poultry droppings may be attributed to uneaten feed waste which is broken down and serve as substrate for microbes. This assertion is supported by Ogbondeminu (1993).

Table 1: Total Bacterial Count in the gastrointestinal tract of *Clarias gariepinus* exposed to varied concentrations dried poultry droppings

Treatment (g/ltr)	Count (cfu/ml)	Mean
0	3.4×10^{7a}	34.0 ± 1.0^{a}
3	156.0×10^{8a}	156.0 ± 3.0^{a}
4	$3.38.0 \times 10^{8b}$	337.0 ± 17.5^{b}
5	$4.48 \times 10^{8\,bc}$	444.0 ± 43.0^{bc}
6	5.08×10^{8c}	508.0 ± 89.5^{c}

Cfu/ml: Colony forming unit per milliliter
Values in each row having the same superscript are not significantly different (P>0.05).

Table 2: Total Fungi Counts in the gastrointestinal tract of *Clarias gariepinus* exposed to varied concentrations dried poultry droppings

Treatment (g/ltr)	Count (cfu/ml)	Mean
0	2.0×10^{4a}	$2.0 \pm 0.0\ ^{a}$
3	3.5×10^{4ac}	3.5 ± 0.5^{ab}
4	4.5×10^{4bc}	4.5 ± 0.5^{bc}
5	5.5×10^{4c}	5.5 ± 0.5^{c}
6	7.5×10^{4d}	7.5 ± 0.5^{d}

Cfu/ml: Colony forming unit per milliliter
Values in each row having the same superscript are not significantly different (P>0.

Gram staining/biochemical test on bacterial Isolates
Seven (7) bacteria were isolated in all samples with varying frequencies of occurrence, the majority of bacteria exhibited a rod-shaped or bacilli-shaped morphology (93.33%), with a dominance of Gram-negative bacteria (76.67%). In terms of isolated bacteria organisms, the majority of bacteria exhibited a rod-shaped morphology (93.33%), with a dominance of Gram-negative bacteria (76.67%). However, there is high prevalence of gram negative (68.63%) over gram positive bacteria observed. This is in accordance with the work of AlHarbi and Uddin (2010), where the prevalence of gram-negative rods bacterial accounting for 75% of the total isolated strains was reported in catfish cultured in Saudi Arabia. These groups of fish are therefore more susceptible to pathogenic infections (Ampofo and Clerk, 2010). The occurrence of Escherichia coli, Bacillus sp., Salmonella sp., and Staphylococcus saprophyticus and Klebsiella sp. were more abundant in the gastrointestinal tract of Clarias gariepinus exposed to dried poultry droppings especially the one with high concentration of poultry droppings (5g/ltr and 6g/ltr). Some of the bacteria identified have been implicated in causing a wide range of infectious diseases such as ophthalamitis, ear infections, meningitis, wound and food borne infections (Ajani, et al., 2016). In human, when loads are beyond tolerable ranges. S. saprophyticus has been demonstrated to cause urinary tract infections (UTIs) in women, while Salmonella sp. has been reported to cause enteritis and systematic disease (Shinkafi and Ukwaja, 2010). This study has revealed increased occurrence of bacterial and fungal count as the concentration of poultry droppings increase across the treatments. Therefore, there is the need to consciously regulate the application of poultry manure in fish ponds despite its numerous advantages, such that fish health and public health will not be compromised.

CONCLUSION

The study on the microbial loads of Clarias gariepinus juveniles exposed to varying concentrations of dried poultry droppings highlights the intricate relationship between manure concentration and microbial dynamics in fish samples. The results revealed a significantly higher total bacterial and fungal count in the gastrointestinal tract of fish exposed to 6g of dried poultry droppings, with dominant bacterial isolates including Escherichia coli, Bacillus sp., Salmonella sp., Staphylococcus saprophyticus, and Klebsiella sp. This indicates that higher concentrations of poultry manure substantially impact the intestinal microbiota composition, potentially affecting fish health and posing public health risks. Consequently, a cautious approach is recommended when applying poultry droppings to fish ponds, with a suggested safe concentration of 3g/ltr to balance growth benefits and microbial risks. Further research is needed to explore the long-term effects on fish health, pond ecosystems, and the safety of fish products.

REFERENCES

Ahuja, I., Dauksas, E., Remme, J. F., Richardsen, R., and Løes, A. K. (2020). Fish and fish waste-based fertilizers in organic farming–With status in Norway: A review. Waste Management, 115, 95-112.

Al-Harbi, A. H., and Uddin, M. N. (2010). Bacterial populations of African Catfish, Clarias gariepinus (Burchell 1822) cultured in earthen ponds. Journal of Applied Aquaculture, 22(3), 187-193.

Ampofo, J. A., and Clerk, G. C. (2010). Diversity of bacteria contaminants in tissues of fish cultured in organic waste-fertilized ponds: health implications. The Open Fish Science Journal, 3(1).

Das, D., Tiwari, B. N., Singh, R., and Mishra, A. K. (2005). Effect of different types of manures on growth and survival of Indian major carp, Labeo rohita (Hamilton, 1822). Aquaculture Research, 36(11), 1295-1302.

Debnath, A., Roy, K., Debnath, P. P., Haldar, L., Barman, A. K., and Veena, N. (2024). Microbiological Analysis of Dairy Products. In Analytical Methods for Milk and Milk Products (pp. 81-212). Apple Academic Press.

FAO. (2016). The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all. FAO.

Minich, J. J., Zhu, Q., Xu, Z. Z., Amir, A., Ngochera, M., Simwaka, M., ... and Knight, R. (2018). Microbial effects of livestock manure fertilization on freshwater aquaculture ponds rearing tilapia (Oreochromis shiranus) and North African catfish (Clarias gariepinus). Microbiologyopen, 7(6), e00716.

Mosha, S. S., Kang'ombe, J., Jere, W., and Madalla, N. (2016). Effect of organic and inorganic fertilizers on natural food composition and performance of African catfish (Clarias gariepinus) fry produced under artificial propagation. J Aquac Res Dev, 7(8).

Troell, M., Costa-Pierce, B., Stead, S., Cottrell, R. S., Brugere, C., Farmery, A. K., and Barg, U. (2023). Perspectives on aquaculture's contribution to the Sustainable Development Goals for improved human and planetary health. Journal of the World Aquaculture Society, 54(2), 251-342.

Shinkafi, S. A., and Ukwaja, V. C. (2010). Bacteria Associated with Fresh Tilapia Fish (Oreochromis niloticus) Sold at Sokoto Central Market in Sokoto, Nigeria. Nigerian Journal of Basic and Applied Sciences, 18(2).

Tivkaa, J. A., and Sampson, U. N. (2013). Bacterial flora of African catfish (Clarias gariepinus) harvested from ponds in Uyo South-South Nigeria. Journal of Environmental Science, Toxicology and Food Technology, 5(3), 72–76.

Xie, L., Huang, Z., and Chen, J. (2020). Food Insecurity and Its Determinants in Sub-Saharan Africa: A Comprehensive Review. Sustainability, 12(7), 2963.

Xie, L., Wan, G., Huang, Z., Jin, L., and Chen, J. (2021). Addressing Food Insecurity: A Comprehensive Review of Current Efforts and Future Directions. Frontiers in Sustainable Food Systems, 5, 644889.

EFFECT OF AFRICAN OIL BEAN SEED POWDER ON THE HAEMATOLOGICAL PROFILE OF JUVENILES CATFISH

Adene, I. C., O. E. Adaba and O. E. Ajagunna

Department of Fisheries and Aquaculture, Adekunle Ajasin University, Akungba Akoko, Ondo State, Nigeria.

Corresponding Author:
adabaoluwajuwon@gmail.com, +234 814 084 1130

ABSTRACT

African oil bean (Pentaclethra macrophylla) seed contains bioactive compounds such as alkaloids, tannins, and saponins, which may leach into aquatic ecosystems through runoff or direct disposal and these compounds can potentially cause health risk to aquatic organisms. The effect of P. macrophylla seed powder at different concentrations on behavioural and haematological parameters of C. gariepinus juveniles was examined under proper laboratory conditions. The acute toxicity bioassay was conducted for 96 h on juveniles C. gariepinus subjected to six different treatments in triplicates; control (0.0), 0.40 mg/l, 0.50 mg/l, 0.6 mg/l, 0.7 mg/l and 0.8 mg/l) to determine the effect of this potential toxicant on the blood of exposed fish. Behavioural reactions such as loss of reflex, barbel deformation, erratic swimming and air gulping was observed in the fish during exposure. The result for haematogical indices showed a significant increase ($P<0.05$) in PCV (19.49±0.00 - 27.99±0.00 %), RBC (1.00±0.11 -1.40±0.05 x1012cell/μl), MCH (67.38±6.81-88.19±00.40 pg/cell), Hb (6.50±0.11-9.34±0.20 g/dl), MCV (202.09±20.43-264.59±1.21 fl/cell) and decrease in WBC (1.30±0.23-0.60±0.00 x103cell/μl), granulocyte (0.54±0.14-0.15±0.02 cell/μl) and Lymphocyte (0.75±0.08-0.44±0.05 cell/μl) when compared with control. These observations indicate an unusual enlargement of the red blood cell (macrocytosis) of the fish, inhibiting the free movement of oxygen through their blood vessels and decline in the immunity after exposure to P. macrophylla seed powder. It is evident from the result that P. macrophylla seed can cause damage to the health of fish due to bioaccumulation, hence should be avoided at all cost in close proximity to the aquatic environment.

Keywords:
Toxicity, Environment, Haematology, Behaviour, Clarias gariepinus

INTRODUCTION

Catfish (C. gariepinus) is commonly cultured in Nigeria due to its high growth rate, high consumer acceptability and high resistance to poor water quality (Adene et al., 2017). Nutritional value of fish depends on their biochemical composition, which is affected by water pollution (Prado et al., 2009). Catfish is very important to human due to its very high-quality protein as well as the essential amino acids required by the body for growth and maintenance of muscle tissue.

African oil bean (P. macrophylla) is a leguminous tree native to West Africa, and its seeds have been traditionally used for culinary purposes in various forms, such as soups and sauces. It is used in preparation of “Ugba” in Igbo land. The seeds are rich in protein, oil, and essential nutrients, making them an important food resource in many Nigerian communities (Ikegwuonu et al., 2014). Previous studies have suggested that the consumption of untreated or inadequately processed P. macrophylla seeds may lead to adverse health effects in humans, such as vomiting and diarrhoea, due to the presence of toxic compounds and phytochemicals like saponin, terpenoids, anthraquinones and cardiacglycosides (Okwu and Ekeke, 2003). These compounds may leach into aquatic ecosystems through runoff or direct disposal and can potentially accumulate in water bodies leading to environmental contamination and adversely affecting aquatic organisms, including fish.

Haematology is of ecological and physiological interest in helping to understand the relationship of blood characteristics to the environment (Ovuru and Ekweozor, 2004) and so could be useful in diagnosis of many diseases as well as investigation of the extent of damage to blood (Isaac et al., 2013). Hematological parameters, such as red blood cell count (RBC), hemoglobin concentration (Hb), hematocrit (Hct), and white blood cell count (WBC), are essential indicators of fish health and can provide insights into the impact of toxins on their physiological status (Kori-Siakpere et al., 2010).

MATERIALS AND METHODS

Description of Study Area: The experiment was carried out in the Central Laboratory of Fisheries and Aquaculture Department, Faculty of Agriculture, Adekunle Ajasin University Akungba-Akoko, Ondo State.

Experimental Design: Eighteen (18) rectangular plastic tanks of 50 litres capacity were used with each tank filled with 30 litres of unchlorinated water during the experiment. A total of one hundred and eighty (180) apparently healthy C. gariepinus juveniles of 6.5-11cm length, weighing 14.5-18g were purchased at Akure and transported with an open plastic keg to the experimental laboratory. The health status of selected fish was assessed based on the presence or absence of physical appearance (injuries) and other morphological deformities. The fish were certified healthy by assessment and were acclimatized under laboratory conditions for two weeks (14 days) prior to the commencement of the experiment. During the acclimatization period, the fish were fed with coppen commercial feed. Feeding was discontinued 24 h before distribution of fish into six (6) treatments at the rate of Ten (10) fish per tank in triplicate and covered with netting materials to prevent jumping out of the water.

Toxicant Preparation: African Oil bean (P. macrophylla) seed fruits were collected from different locations within Akungba Akoko. The seeds obtained from their pods were spread on a platform and air-dried. The dried seeds were pulverized into fine powder using a mechanical blender and stored in well tight container before use.

Range and Definitive test: Preliminary 24hrs range finding test was conducted to determine the toxicity range of African oil bean seed to be used. Based on the results from the range finding test, a 96hrs definitive test was carried out with six test solution of African oil bean seed powder (0.0, 0.4, 0.5, 0.6, 0.7, and 0.8 mg/L) introduced directly into a set of 18 rectangular plastic tanks, each filled with 30L of unchlorinated water containing batches of ten juvenile C. gariepinus. The behavioural pattern and mortality of the test fish in each tank were monitored and recorded for the first 4hours, 12hours, 24hours, 48hours, 72hours and 96hours. Dead fish was removed immediately with scoop net to avoid contamination due to rotting.

Blood Collection and Analysis: About 3ml of blood was collected into 5ml sample bottle treated with anticoagulant, Ethylene Diamine Tetraacetic Acid (EDTA) from the experimented fish through the vertebral caudal blood vessel with the help of disposable hypodermic syringe and needle of 5ml after 96hrs of exposure and was transferred to refrigerator for subsequent analysis.

Statistical Analysis: The obtained data on fish hematological parameters was subjected to One-way analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS). Significant differences in the means were tested and separated at 5% probability level using Duncan Multiple Range test.

RESULTS AND DISCUSSION

The result for haematogical indices showed significant increase (P<0.05) in PCV, RBC, MCH, Hb, MCV and decrease in WBC, granulocyte, Lymphocyte when compared with the control after exposure of juvenile C. gariepinus to P. macrophylla seed powder as presented in Table 1. The highest PCV (27.99 + 0.00 %) was found in the group with the highest concentration T6 (0.8 mg/l) and least (20.49 ±0.00 %) at T5 (0.7 mg/l), there was significant (P<0.05) increase with increase in concentration. The PCV increase in this study could be traceable to dehydration of the fish when subjected to the toxicant at different concentrations as it agrees with the observation of Riaz-ul-Haq et al. (2018) on the exposure of freshwater fish Labeo rohita to Diafenthiuron and the report of Amaeze et. al., (2020). The trend is also similar to the work of Adene et al., (2017) on acute toxicity of Jatropha curcas seed powder on adult C. gariepinus. The RBC decreased and then increased with increase in concentration of P. macrophylla powder with the highest value (1.40 ± 0.05 x1012cell/μl) in Treatment 6 (0.8 mg/l) while the least value (0.85 ± 0.02 x1012cell/μl) was recorded in T2 (0.4 mg/L). The increase in RBC may be as a result of the blood cell reserve in combination with cell shrinkage which is due to blood osmotic alteration from the activities of the toxicant (Singh and Srivastava, 2010). There was no significant difference (p>0.05) in the value of MCHC activity after 96h of exposure. The MCV value were highest (264.59 ± 1.21 fl/cell) in T2 (0.4 mg/L) while the least value (170.84 ± 2.39 fl/cell) was recorded in T5 (0.7 mg/l). Hemoglobin (Hb) was recorded highest (9.34 ± 0.20 g/dl) in T6 (0.8 mg/l) and least (6.84 ± 0.05 g/dl) in T5 (0.7 mg/l). The increase in Hb can result into a condition in which there is an increase in the capacity of the blood to transport Oxygen carrying tissues. The white blood cell (WBC) has the highest value (1.10 ±0.05 x103cell/μl) at T6 (0.8 mg/l) and lowest (0.60 ±0.00 x103cell/μl) in T3 (0.5 mg/l). The observed decrease in WBC as observed with increased concentration could be responsible for the death of the exposed fish because decrease in WBC result in less resistance to fight the unwanted substance in the environment. The observed changes in WBC are similar to what was observed by Amaeze et al., (2020) when C. gariepinus was exposed to Chlorpyrifos and it could also be a mechanism of resistance to prevalent unwanted change and adaptation to the environment. Lymphocyte is also highest (0.78 ±0.20 cell/μl) in T6 (0.8 mg/l) and least (0.44 ± 0.05 cell/μl) in T3 (0.5 mg/l) and T4 (0.6 mg/l) with significant difference (p<0.05) in all the treatment when compared with the control. Behavioural alterations displayed by C. gariepinus exposed to different concentration of P. macrophylla African oil bean includes; loss of reflex, air gulping, erratic swimming and Barbel deformation which are due to termination of impulse transmission by rapid hydrolysis of the neurotransmitter acetylcholine in numerous cholinergic pathways at the central and peripheral nervous system.

Table 1: Haematological parameters of C. gariepinus exposed to Pentaclethra macrophylla seed powder

Parameters(mg/l)	T1(0.0)	T2(0.4)	T3(0.5)	T4(0.6)	T5(0/7)	T6(0.8)
PCV (%)	19.49 ± 0.00^{a}	22.48 ± 0.01^{b}	21.48 ± 0.01^{ab}	25.49 ± 0.00^{c}	20.49 ± 0.00^{ab}	27.99 ± 00.00^{d}
RBC($x10^{12}$cell/μl)	1.00 ± 0.11^{ab}	0.85 ± 0.02^{a}	0.95 ± 0.02^{a}	1.15 ± 0.02^{bc}	1.20 ± 0.00^{c}	1.40 ± 0.05^{d}
MCHC (g/dl)	33.25 ± 0.10^{a}	33.33 ± 0.00^{a}	33.48 ± 0.00^{a}	33.33 ± 0.00^{a}	33.41 ± 0.85^{a}	33.38 ± 0.55^{a}
MCV (fl/cell)	202.09 ± 20.43^{ab}	264.59 ± 1.21^{c}	226.10 ± 2.25^{b}	221.59 ± 1.96^{b}	170.84 ± 2.39^{a}	201.54 ± 12.44^{ab}
Hb (g/dl)	6.50 ± 0.11^{a}	7.50 ± 0.28^{b}	7.18 ± 0.28^{ab}	8.50 ± 0.28^{c}	6.84 ± 0.86^{ab}	9.34 ± 0.20^{d}
WBC ($x10^{12}$cell/μl)	1.30 ± 0.23^{c}	0.95 ± 0.14^{abc}	0.60 ± 0.00^{a}	0.65 ± 0.08^{a}	0.85 ± 0.02^{ab}	1.10 ± 0.05^{bc}
Granulocytes (cell/μl)	0.54 ± 0.14^{b}	0.35 ± 0.08^{ab}	0.15 ± 0.02^{a}	0.20 ± 0.05^{a}	0.25 ± 0.02^{a}	0.31 ± 0.05^{ab}
Lymphocytes (cell/μl)	0.75 ± 0.08^{b}	0.59 ± 0.05^{ab}	0.44 ± 0.05^{a}	0.44 ± 0.05^{a}	0.59 ± 0.00^{ab}	0.78 ± 0.20^{b}
MCH (pg/cell)	67.38 ± 6.81^{ab}	88.19 ± 0.40^{c}	75.39 ± 0.75^{b}	73.85 ± 0.66^{b}	56.94 ± 0.77^{a}	67.19 ± 4.15^{ab}

Mean values on the same row carrying similar superscripts are not significantly different ($p>0.05$). PCV, Packed cell volume; RBC, red blood cell; MCHC, mean corpuscular hemoglobin concentration; MCV, mean corpuscular volume; Hb, hemoglobin; WBC, white blood cell; MCH, mean corpuscular hemoglobin.

Table 2: Behvioural responses of C. gariepinus exposed to oil bean seed powder, P. macrophylla

	24 hours						48 hours						72 hours						96 hours					
Behaviour	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Colouration	-	-	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+
Air gulping	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+
Barbell deformation	-	-	-	-	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+
Erratic swimming	-	-	-	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+
Loss of reflex	-	-	-	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+

Key – no reaction + reaction (T1= 0.0, T2= 0.4, T3= 0.5, T4=0.6, T5= 0.7, T6= 0.8 mg/L)

CONCLUSION

The sub-lethal concentrations of P. macrophylla powder on juveniles C. gariepinus caused alterations in haematological parameters; Hb, RBC, WBC, PVC, MCH, MVC and MCHC of the fish causing a range of defects and health conditions like anaemia as evidently observed in decreased white blood cells of the fish. Blood is very important in the life of organisms, so the impact of P. macrophylla powder on the blood characteristics posed an adverse damage to the health of the exposed fish. Hence the P. macrophylla seed should be avoided in any area where fish are cultured. The information of this work can be used as a baseline for toxicity of P. macrophylla in an aquatic environment.

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REFERENCES

Adene, I. C., Fagbenro, O. A. and Amoo, I. A. (2017). Acute toxicity of Jatropha curcas (LINNAEUS) seed powder on Adult African Catfish, C. gariepinus (BURCHELL 1822). Biological and Environmental Sciences Journal for the Tropic.14(1) June, 2017.

Adeyemo, O.K. (2005): Haematological and histopathological effects of cassava mill Effluent in Clarias gariepinus. African Journal of Biomedical Research.8: 179-183.

Amaeze, N.H., Komolafe, B.O., Salako, A.F., Akagha, K.K., Briggs, T.D. and Olatinwo, O.O. (2020). Comparative assessment of the acute toxicity, haematological and genotoxic effects of ten commonly used pesticides on the African Catfish, Clarias gariepinus Burchell 1822. Heliyon. 6: e04768. https://doi. org/10.1016/j.heliyon.2020.e04768

Isaac, L. J., Abah, G., Akpan, B. and Ekaette, I. U. (2013). Haematological properties of different breeds and sexes of rabbits (p.24-27). Proceedings of the 18th Annual Conference of Animal Science Association of Nigeria.

Ikegwuonu, F. I., Obioma, N. P., Egbuna, C. and Akpanabiatu, M. I. (2014). Nutrient and anti-nutrient composition of Pentaclethra macrophylla Benth seeds.Food Chemistry, 148, 153-156.

Kori-Siakpere, O., Ekelemu, J. K., Adeyemi, M. B., and Obi-Iyeke, G. E. (2010). Hematological parameters in the African catfish (C. gariepinus) exposed to water soluble fractions of crude oil. Comparative

Clinical Pathology, 19(2), 155-158.
Okwu, D. E., and Ekeke, O. P. (2003). Nutrient and anti-nutrient contents of Aspiliaafricana (Pers.) C. D. Adams.Journal of Applied Sciences and Environmental Management, 7(1), 71-74.
Ovuru, S.S. and Ekweozor, I.K.E. (2004). Hematological Changes Associated with Crude Oil Ingestion in Experimental Rabbits. African Journal of Biotechnology, 3, 346-348.
Prado, R., Rioboo, C., Herrero, C. and Cid, A., (2009). The herbicide paraquat induces alterations in the elemental and biochemical composition of nontarget microalgal species. Chemosphere., 76: 1440-1444.
Riaz-ul-Haq, M., Javeed, R., Iram, S., Rasheed, M.A., Amjad, M. and Iqbal, F., (2018). Effect of Diafenthiuron exposure under short- and long-term experimental conditions on hematology, serum biochemical profile and elemental composition of a non-target organism, Labeorohita. Environmental Toxicology Pharmacol., 62: 40-45.
Singh,N.N. and Srivastava, A.K. (2010). Haematological parameters as bioindicators of insecticide exposure in teleosts.Ecotoxicology, 19 (5) (2010), 838-854.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

TOXICITY OF DETERGENT ON AFRICAN CATFISH *(Clarias gariepinus)*

Olasunkanmi J. B., J O Jimoh, O. H. Tope-Jegede, O. D. Ayandeyi, P. A. Adebowale and J. S. Kelau.

Department of Fisheries and Aquaculture, Federal University Oye Ekiti, P.M.B 373, Oye-Ekiti, Ekiti State, Nigeria.

Corresponding Author.
john.olasunkanmi@fuoye.edu.ng; +2348064281112, 0000-0003-3609-9324

ABSTRACT
Detergent toxicity to catfish Clarias gariepinus was investigated with the objective to measure its impact on the histology of some internal organs. One hundred and twenty Clarias gariepinus juveniles with the average weight of 6.9 ± 0.2 g were randomly distributed into four treatments at ten fish per tank and each treatment was replicated thrice. 0.00g/l (control [T1]), 0.15g/l (Treatment [T2]), 0.30g/l (Treatment [T3]) and 0.45g/l (Treatment [T4]) of detergent was added to each tank and observed for 72 hours. Histology assessments was carried out. The analysis of gill and liver histology revealed anomalies such as hyperplasia, hemorrhaging, fusion of lamellae, and distortion of issues. The study confirmed that Clarias gariepinus exposure to detergent led to gills, liver, intestine and tissue damage. The research underscores the negative effects of detergents to aquatic life and the ecosystem necessitating mitigation strategies.

Keywords:
Detergent, Histology, internal organs

INTRODUCTION

Aquatic creatures such as fish have been reported to have had their habitat prone to contamination by series of human activities such as agriculture, domestic washing among others. Detergent from domestic washing has been identified as one of the contaminants of aquatic environments (Nagtode et al., 2023). Most detergents contain surfactants organic compounds that combine hydrophilic and hydrophobic groups in one molecule (Isyaku and Solomon 2016). Detergents in water negatively impacts water quality parameters, ultimately leading to deterioration in organ health of aquatic animals (Paul et al., 2022). According to El-SiKaily and Shabaka, (2024) physiological changes in fish serve as biomarkers of environmental pollution and are frequently employed to assess the health of aquatic ecosystems. Uncontrolled release and mishandling of chemicals like herbicides, pesticides, and heavy metal-containing detergents in natural waterways negatively affect fish and aquatic life, with potential long-term environmental consequences (Alengebawy et al., 2021). Toxicants provoke hematological responses and tissue damage, particularly in the gills, liver, heart, kidney, and epidermis of animals. This study investigates the effect of detergents on the histology some organs of C. gariepinus.

MATERIALS AND METHODS

Two hundred healthy juveniles of African catfish species, Clarias gariepinus with 6.9 ± 0.2 g weight were procured and their morphometric data taken. Fish were acclimatized for two weeks during which they were fed with dried commercial fish food containing 40% crude protein at 5% of body weight twice daily. Thirty pieces of the fish were then randomly selected for the range finding test to determine the concentration at which 50% was killed (LC50) in 96 hours (Finey, 1982). Definitive test was then carried out in triplicate immediately after in which ten fish per tank were randomly distributed into four different concentrations - 0.00g (control), 0.15g (T2), 0.30g (T3) and 0.45g (T4) of the detergent containing linear alkyl benzenesulfonate were used and observed for 72h. Some of the internal organs were thereafter collected and examined for possible histology change(s) using methods described by Luna, 1968.

RESULTS AND DISCUSSION

Histopathological changes observed in the organs are presented in Plates 1 to 12. A wide range of histological changes were observed in the key organs studied. The lamellae of the gills in treatments 2 and 3 suffered incomplete and complete fusion respectively (Plates 2 and 3) while there was thickening of the epithelium of the filament and degeneration of the chondrocyte in treatment 4 (Plate 4). The liver suffered distortion in its architecture in all treatments (Plates 6 - 8) except for the control (Plate 5) and there was congestion in the liver of treatment 4 (Plate 8) in addition to the distortion. There was no significant change in the intestine of fish in T1 (Plate 9) and T2 (Plate 10) but the fish in T3 (Plate 11) and T4 (Plate 12) suffered both edema and degeneration of lamina propia and submucosa layer respectively.

The result obtained in the present study confirms the findings of Ogundiran et al., (2009) that exposure of C. gariepinus to even low concentrations of soap and detergent effluents is enough to induce various toxicological effects in terms of histological degradations in gill structures while Xia et al. (2021) reported that degeneration of gill cells lead to a loss of cartilage integrity, affecting the structure and function of the gills and potentially causing problems with mobility or respiration as observed in this study. Studies by other workers have also shown that the liver experiences morphological changes under specific hazardous situations (Farrher et al., 2021, Xia et al., 2021, Agbohessi et al., 2023). According to (Gabella, 2019), the degeneration of the lamina propria can compromise the structural integrity of the intestinal wall, affect nutrient absorption, and impair the fish's overall digestive function.

CONCLUSION

The result obtained from this study underscores the harm caused by pollutants such as detergent to physiological processes in fish. The implications of these effects extend beyond individual organisms, affecting entire food webs, nutrient cycling and ecosystem services. This calls for urgent action by the relevant authorities in order to salvage threat imposed by constant and indiscriminate discharge of effluents from homes, commercial centers such as car wash and other anthropogenic sources.

Plate. 1: T1 with normal gill filament, rakers, and no necrosis.

Plate.2: T2 with hyperplasia (C), incomplete (arrow) and complete (arrowhead) fusion of several lamellae complete fusion of several lamellae

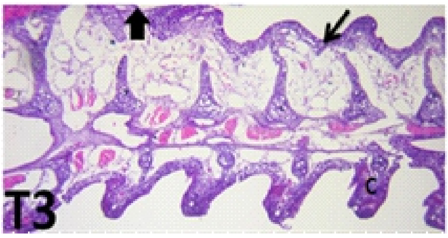


Plate. 3: T3 with hyperplasia (C), incomplete (arrow) and complete (arrowhead) fusion of several lamellae complete fusion of several lamellae

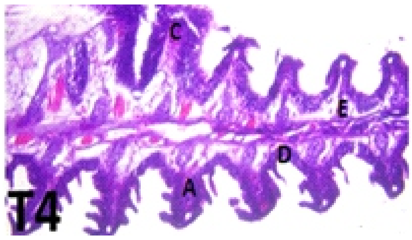


Plate. 4: T4 with hyperplasia (C), hypertrophy (D), thickened epithelium of filament and degeneration of chondrocyte (E)

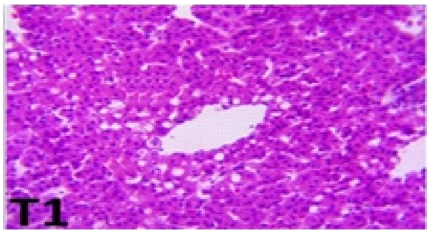


Plate. 5: T1 with normal histo-architecture of liver.

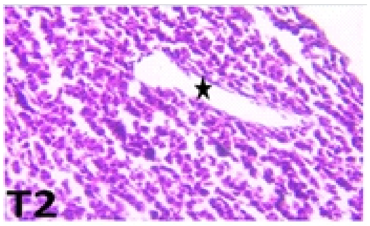


Plate. 6: T2 with distortion in histo-architecture and dilated blood vessel [star]

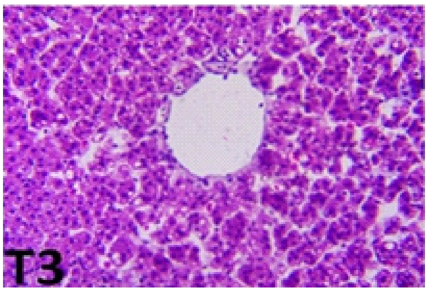


Plate. 7: T3 with mild distortion in liver histoarchitecture.

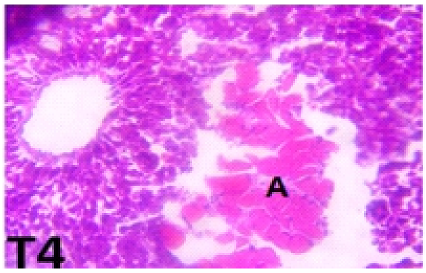


Plate. 8: T4severe distortion in histoarchitecture and congestion (A)

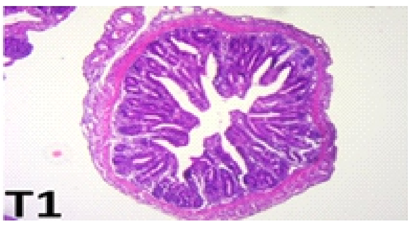


Plate. 9: showing normal histoarchitecture.

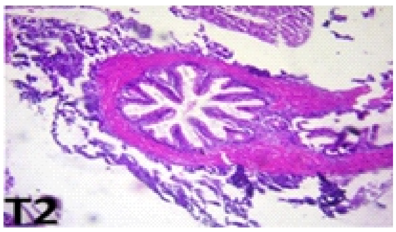


Plate. 10: T2 showing normal histoarchitecture

Plate. 11: T3 with muscularis edema (A) and degeneration of lamina propia [C].)

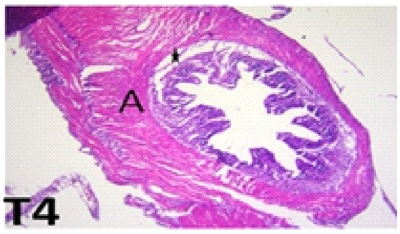


Plate. 12: Intestine with muscularis edema (A) and degeneration of submucosa layer (star)

REFERENCES

Agbohessi, P., Olowo, L., Degila, B., Houedjissi, G., Imorou Toko, I., Mandiki, S. N. M., and Kestemont, P. (2023). Comparative assessment of acute toxicity and histological changes in liver of African catfish Clarias gariepinus exposed to cotton insecticides. Journal of Environmental Science and Health, Part B, 58(1), 31–44. https://doi.org/10.1080/03601234.2023.2168445

Alengebawy A, Abdelkhalek S T, Qureshi, S. R. and Wang, M. Q. (2021) Heavy Metals and Pesticides Toxicity in Agricultural Soil and Plants: Ecological Risks and Human Health Implications. Toxics. 2021 Feb 25:9 (3):42. doi: 10.3390/toxics9030042. PMID: 33668829; PMCID: PMC7996329.

Amany El-SiKaily and Soha Shabaka, (2024) Biomarkers in aquatic systems: Advancements, applications and future directions, Egyptian Journal of Aquatic Research, Volume 50, Issue 2, Pages 169-182, https://doi.org/10.1016/j.ejar.2024.05.002.

Farrher, E., Chiang, C. W., Cho, K. H., Grinberg, F., Buschbeck, R. P., Chen, M. J., and Kuo, L. W. (2021). Spatiotemporal characterisation of ischaemic lesions in transient stroke animal models using diffusion free water elimination and mapping MRI with echo time dependence. Neuroimage, 244, 118605.

Gabella, G. (2019). Lamina propria: The connective tissue of rat urinary bladder mucosa. Neurourology and Urodynamics, 38(8), 2093-2103.Isyaku, B., and Solomon, J. R. (2016). Effects of detergents and the growth of the African catfish (Clarias gariepinus). Tropical Journal of Zoology, 19, 198-204.

Luna, L. G. (1968) Manual of Histologic Staining Methods of the Armed forces Institute of Pathology. Migraw-Hillbulk Co, New York.

Nagtode, V. S., Cardoza, C., Yasin, H. K. A., Mali, S. N., Tambe, S. M., Roy, P., ... and Pratap, A. P. (2023). Green Surfactants (Biosurfactants): A Petroleum-Free Substitute for Sustainability- Comparison, Applications, P. T. Olowo, Market, and Future Prospects. ACS omega, 8 (13), 11674-11699.

Ogundiran, M.A., Fawole, O. O., Adewoy,e S.O and Ayandiran T. A. (2009). Pathologic lesions in the gills of Clarias gariepinus exposed to sublethal concentrations of soap and detergent effluents. Journal of Cell and Animal Biology Vol. 3 (5), pp. 078-082.

Paul, Maxi B., Fahrenson Christoph, Givelet Lucas, Herrmann Tim, Loeschner Katrin, Böhmert Linda, Thünemann, Andreas F., Braeuning Albert, Sieg Holger (2022) Beyond microplastics - investigation on health impacts of submicron and nanoplastic particles after oral uptake in vitro. Microplastics and Nanoplastics 16, Vol. 2: 1. 2662-4966. doi: 10.1186/s43591-022-00036-0

Xia, Q., Wang, Q., Lin, F., and Wang, J. (2021). miR-125a-5p-abundant exosomes derived from mesenchymal stem cells suppress chondrocyte degeneration via targeting E2F2 in traumatic osteoarthritis. Bioengineered, 12(2), 11225-11238.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

ACUTE TOXICITY AND BEHAVIOURAL RESPONSE OF *Clarias gariepinus* JUVENILES to GINGER LEAVES POWDER

[1]TAHIR, L.H. [1], M. ABDULLAHI, AND A.L. SHAIBU
[1]Department of Zoology, School of Life Sciences, Modibbo Adama University of Technology, Yola, Nigeria.
[2]Department of Fisheries and Aquaculture, Kogi State University, Anyigba.

Correspondence Author:
ummeeirfan@gmail.com, +234 803 057 1980

ABSTRACT
This study was carried out to determine the toxicity and behavioral response of Clarias gariepinus to ginger leaves powder. The range-finding test was repeated twice to obtain credible results that could be used in the ultimate test. The toxicant (ginger leaves powder) was introduced at varying concentrations of 10mg, 12mg, 14mg, 16mg, and 18mg in the first range-finding test; however, in the definitive test, the toxicant was introduced at varying concentrations of 7.5mg, 9mg, 10.50mg, 12mg and 13.5mg per litre of water (mg/l). From the definitive test, the Median Lethal Concentration of ginger leaves powder to Clarias gariepinus was found to be 9.25 mg/l. According to the study, juvenile Clarias gariepinus showed rapid opercular movement, skin darkening, lack of reflex, and initially erratic movement. Furthermore, the results show that ginger concentration of upto 9.25mg/l is tolerable to Clarias gariepinus juveniles. The water quality data were evaluated using one way Analysis of Variance (ANOVA). As a result, the study suggests that ginger leaves powder is hazardous to Clarias gariepinus juveniles.

Keywords:
Acute Toxicity, Lethal concentration, behavioural response, Clarias gariepinus

INTRODUCTION

Aquatic ecosystems worldwide are continually exposed to a variety of pollutants, including chemical compounds from agricultural, and domestic sources. These pollutants can have detrimental effects on aquatic organisms, leading to disruptions in the delicate balance of the ecosystems. One such pollutant of concern is ginger leaf, which contains a complex mixture of compounds, including nicotine, alkaloids, and other toxic constituents. The impact of tobacco leaf on aquatic organisms, particularly fish, has become a subject of growing interest due to the potential threat it poses to aquatic biodiversity and ecosystem health (Ballantyne and Mars, 2017).

Ginger (Zingiber officinale) belongs to Zingiberaceae family. The used part of the plant is rhizome. This plant produces an orchid like flower with greenish yellow petals streaked with purple color. Ginger is cultivated in areas characterized by abundant rainfall. Even though it is native to southern Asia, ginger is also cultivated in tropical areas such as Jamaica, China, Nigeria and Haiti and it is an important spice crop in India (Akintobi, et al., 2013).

Ginger, Zingiber officinalis, is a perennial herbaceous plant. Ginger is an important plant with several medicinal, ethno medicinal and nutritional values. The intensification of aquaculture practices has led to an increased use of synthetic chemicals and substances, some of which may have toxic effects on cultured fish and the surrounding aquatic environment. The exploration of plant-based materials, such as ginger leaves, as potential alternatives to synthetic chemicals in aquaculture has gained interest due to their perceived lower toxicity and more environmentally friendly nature. The indiscriminate use of plant-based extracts, including ginger leaf, in aquaculture can have unintended consequences on the health and growth of the cultured fish species. It is essential to investigate the acute toxicity and effects of ginger leaf on *Clarias gariepinus* juveniles to ensure the safe and sustainable use of this potential aquaculture remedy. Fish are frequently utilized as sentinel organisms in ecotoxicological research because they perform a variety of roles in the food chain, collect toxic compounds, and respond to low mutagen quantities (Cavas and Ergene-Gözükara, 2005). As a result, the use of fish biomarkers as indices of the impacts of pollution is increasingly important and can facilitate early diagnosis of aquatic environmental problems (Baser et al., 2003). Acute toxicity experiments help to understand the limiting effects of various substances on organisms (Baser et al., 2003; Svobodova et al., 2003).

MATERIALS AND METHODS

The Experimental Site

The experiment took place in the Fish Hatchery Laboratory of Bayero University's Department of Fisheries and Aquaculture in Kano, Nigeria.

Experimental fish

One hundred and Eighty (180) of C. gariepinus (mean weight, 18.36 ± 0.3g and mean length of 12.42±0.3cm) juveniles used for the study, were purchased from a reputable fish farm in Kano, Kano State.

Source and Preparation of Ginger leaves

Fresh samples of ginger leaves plant were taken from Zango Kataf Local Government Area of Kaduna State. The samples were set to air dry for four days before being pounded into a fine powder in a sterile laboratory mortar and pestle. Material was sieved using a mesh size of 0.2m and stored in air tight wide mouth bottle for analysis. 500g of each stored sample was dissolved in 2 litres each of distilled water at room temperature (27 ± 0.30for 24 hours (Omoregie and Onuogwu, 2015). Afterwards, a vacuum pump was used to decant and filter the settling aqueous component via Whitman filter paper. To prepare them for usage, the filtrates were freeze-dried and kept in a refrigerator at 100°C.

Experimental Design

The experiment was conducted using a completely randomized approach. Eighteen (18) plastics tanks, each measuring 60 cm by 40 cm by 40 cm, were utilized. After a thorough cleaning, 20 liters of water were added to the well-labeled plastic tanks. Ten fish were weighed and randomly allocated each tank. Treatments were replicated thrice.

Range finding test

In the course of the range finding test, ten C. *gariepinus* juveniles were individually weighed using a sensitive electronic weighing scale (Mettler Toledo FB602) and stocked into the eighteen tanks that were filled with twenty litres of tap water. The ginger leaves powder weighing 0, 10mg, 12mg, 14mg, 16mg and 18mg were used per litre of water. The LC50 of ginger leaves powder was found when test fish were exposed to the plant for 96 hours. The fish's reaction to mild stimuli was utilized as an index of toxicity, and their inability to react to touch was used as an index of death.

Definitive Test

Results from range finding tests offered advice for the concentration level to be used in definitive test. Eighteen (18) plastic tanks were filled, each holding twenty litres of water, in order to conduct the final test. The amounts of ginger leaves powder utilized were 0, 7.5mg, 9mg, 10.50mg, 12mg and 13.5mg per liter of water (mg/l). The sensitive weighing balance was used to prepare the various concentrations. The fish's non-reaction ginger leaves powder was judged to be fatal to 50% of the test organism after 96 hours of exposure, whereas the fish's response to mild stimuli was employed as an indication of toxicity.

Statistical Analysis

Minitab 20 was used to analyze data and compile statistics on the water quality parameter. The mean lethal concentration (LC50) for 96 hours was calculated using probit analysis (Finney, 1971).

RESULTS AND DISCUSSION

Fish is an important indicator of water pollution as it remains in direct water for food and oxygen and thus is highly susceptible to any change in aquatic environment. Table 1 displays the mortality of *Clarias gariepinus* juveniles exposed to ginger leaves powder over the 96-hr period.

Table 1: Mortality of *Clarias gariepinus* juveniles exposed to ginger leaves over the 96-hr period

Treatments/ Concentration (mg/L)	Log Concentration	Number Stocked	Mortality							Probit
			12 hrs	24 hrs	48 hrs	72 hrs	96 hrs	Total	%	
T0 (Control, 0)	0	30	0	0	0	0	0	0	0	0
T1 (7.5)	0.88	30	0	1	3	3	2	9	30.00	3.59
T2 (9.0)	0.95	30	0	1	5	3	3	12	40.00	3.82
T3 (10.5)	1.02	30	3	4	5	4	3	19	63.33	4.12
T4 (12.0)	1.07	30	7	5	5	6	3	27	90.00	4.67
T5 (13.5)	1.13	30	12	7	5	3	2	29	96.67	4.46

It was observed that the mortality recorded in this investigation increased with increase in the concentration of toxicant. The first death was noticed 96 minutes after the introduction of toxicant in the bowl with the highes ginger concentration. This is in conformity with Isiyaku et al. (2021) who reported the first death in 93 minutes after introduction of tamarind seed husk powder to *Clarias gariepinus* in acute concentration. Olaifa et al., (2004) reported the first death three hours after the introduction of toxicant in the exposure of *Clarias gariepinus* to lethal and sub lethal concentration of copper. Datta and Kaviraj (2002), Fafioye et al. (2004) and Okomoda et al. (2010) recorded the first death 36 hours after the exposure to acute toxicity treatment of *Clarias gariepinus* with synthetic pyrethyroid Deltamethrin, Raphia vinifera extracts and formalin respectively. The LC50 found in this investigation is 9.25 mg/l similar to that of Fafioye et al. (2004) when *Clarias gariepinus* was exposed to acute concentration of Parkia biglobosa. Ayuba et al. (2012) reported LC50 of 0.20mg/l when *Clarias gariepinus* was exposed to Datura innoxia.

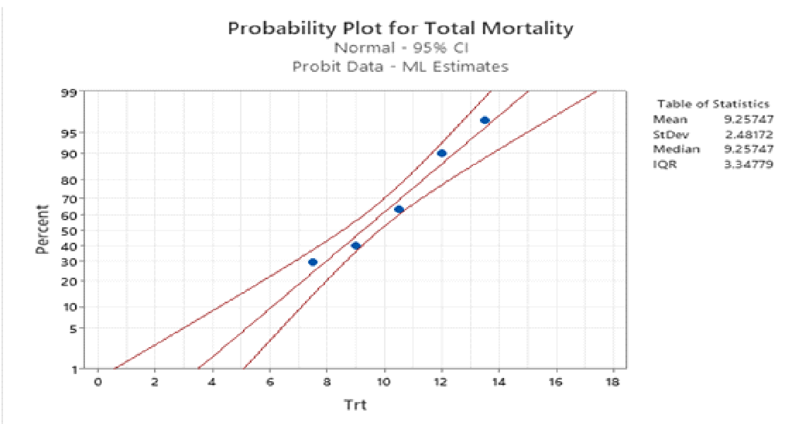


Fig 1: Linear relationship between mean probit mortality and log concentration of *Clarias gariepinus* exposed to various concentrations of ginger leaves powder for 96 hrs

Studies have revealed that organisms exposed to toxicants or chemicals usually exhibit changes in erratic sudden jerky swimming movements, hyperactivities and different behavioural activities as shown in this experiments which demonstrated to be a sensitive indicator of physiological stress in fish subjected to chronic concentrations of pollutants (Isiyaku et al., 2022). Several abnormal behaviours observed with fish exposed to various concentration of ginger leaves powder in this study were excessive gulping for air, erratic swimming behaviour, restlessness, loss of equilibrium, fin and barbell deformation, skin haemorrhage, discolouration and finally death agreed with Omitoyin et al., (2006), this also agrees with reports of Bobmanuel et al. (2006) who stated that "behavioural response of fish to toxicants and different reaction time are due to the effect of chemicals, their concentrations, species, size and specific environmental conditions".

Table 2: Behavioral changes in *Clarias gariepinus* juveniles after 96-hour exposure at different concentrations of ginger leaves powder

Behaviors	Concentration (mg/L)					
	0.00	**7.5**	**9.0**	**10.5**	**12**	**13.5**
Air gulping	-	-	+	+	+	
Barbel deformation	-	-	-	-	-	-
Discoloration	-	-	+	+	+	+
Erratic swimming	-	-	+	+	+	+
Jumping	-	-	+	+	+	+
Fin deformation	-	-	+	+	+	+

+ = Present
- = Absent

CONCLUSION
The study's findings clearly demonstrate that ginger leaf powder adversely affects water quality at 9.25mg/l and above leading to conditions that are detrimental to fish survival.

RECOMMENDATIONS
It is essential to regulate the concentration of ginger leaf extract used in aquaculture practices, ensuring that it does not exceed safe levels that could harm fish populations. Environmental agencies and aquaculture practitioners should establish guidelines for the safe use of ginger and similar plant extracts, particularly in regions where these substances are commonly used.

REFERENCES
Akintobi, O. A., Onoh, C. C., Ogele, J. O., Idowu, A. A., Ojo, O. V., and Okonko, I. O. (2013). Antimicrobial activity of Ginger (ginger) extract against some selected pathogenic bacteria. Nature and science, 11(1), 7-15.

Ayuba, V.O., Ofojekwu, P.C. and Musa, S.O (2012). Haematological Response and Weight Changes of the African Catfish Clarias gariepinus Exposed to Sub Lethal Concentrations of Datura innoxia Root Extract. PAT December, 2012; 8 (2): 134-143 ISSN: 0794-5213. www.patnsukjournal.net/currentissue

Ballantyne, B., and Mars, T.C. (2017). General and Applied Toxicology. John Wiley & Sons.

https://doi.org/10.1002/9781119348780.

Baser, K. H. C., Demici, B., Dekebo, A. and Dagne, E., (2003). Essential Oils of Some Boswellia SPP., Myrrh and Opopamax. Flarour and Fragrance Journal, 18, 153-156. DOI: 10.1002/ffj.1166.

Bobmanuel, N.O.K, Gabriel, U.U, and Ekweozor, I.K.E (2006). Direct Toxic Assessment of Treated Fertilizer Effluents to Oreochromis niloticus, and catfish hybrid (Heterobranchus bidorsalis x Clarias gariepinus). African Journal of Technology. 5 (8): 653-642.

Cavas, T. and Ergene-Gözükara, S. (2005). Micronucleus Test in Fish Cells, a Bioassay for in Situ Monitoring of Genotoxic Pollution in the Marine Environment. Environmental and Molecular Mutagenesis, 46: 64-70.

Datta, M. and Kaviraj, A. (2002) Acute Toxicity of Synthetic Pyrethroid Deltamethrin to Freshwater Catfish Clarias gariepinus, Bulletin. Environment Toxicology. 70: 296-29.

Fafioye, O. O., Adebisi, S. O. and Fagade, A. A. (2004). Toxicity of Parkia biglobosa and Raphia vinifera extracts on Clarias gariepinus juveniles. African Journal of Biotechnology. 3 (11):137—142.

Finney, D.J. (1971). Statistical Methods in Biological Assay, 2nd Ed. Hafner Pub.Co. New York. N.Y. Cambridge University Press, London, England. 68p

Isiyaku M. S., Fagbenro, O. A., and O. O. Olawusi-Peters (2021). Acute Toxicity and Behavioural Changes of Oreochromis niloticus Juveniles Exposed to Tamarind (Tamarindus indica) Seed Husk Powder. South Asian Research Journal of Agriculture and Fisheries. 3(3): 34-39. DOI: 10.36346/sarjaf.2021.v03i03.001.

Isiyaku, M. S., Laurat, H. T and Maimunatu, A. (2022). Histopathology of gills and liver tissues of the freshwater fish Oreochromis niloticus (Linnaeus 1758) exposed to Tamarindus indica seed husk powder. 37th Annual conference of the Fisheries Society of Nigeria. Held on 30th October to 4th November, 2022 at the Federal College of Education, Yola, Adamawa State

Ladipo, M.K. and Doherty, B.F. (2011). Acute Toxicity, Behavioural Changes and Histopathological Effect of Paraquat Dichloride on Tissues of Catfish (Clarias gariepinus). Internation Journal of Biology, 3(2): 67-74.

Markowicz, F., Krol, G., Szyman ska-Pulikowska, A., 2019. Biodegradable package innovative purpose or source of the problem. Journal of Ecological Engineering (JEE), 20(1):228-237.

Okomoda, J, Ayuba VO, Omeji, S. (2010). Heamatological Changes of Clarias gariepinus (Burchell, 1822), fingerlings exposed to Acute Toxicity of Formalin. Production Agriculture Technology. 6:100-109.

Okomoda, V.T. and Ataguba, G.A. (2011). Blood glucose response of Clarias gariepinus exposed to acute concentrations of glyphosate– isopropyl ammonium (Sunsate®). Journal of Agricultural and Veterinary Sciences, 3(6):69–75.

Olaifa F.E. Olaifa A. K. and Onwude T.E., (2004).Lethal and sub-lethal effects of copper to the African catfish (Clarias gariepinus) Juveniles, African Journal of Biomedical Research. 8: 65 -70.

Omitoyin B.O., Ajani, E.K. and Garus, O.A. (2006). Toxicity of Gramoxone (paraquat) to juvenile African Catfish, Clarias gariepinus (Burchell, 1822). American Eur. Journal of Agriculture and Environmental Science. 1(1):26-30.

Omoregie, E. and M. A.Onuogwu. (2015). Acute Toxicity of Water Extracts of Bark of the Neem Plant, Azadirachta indica (Lodd) to the Cichlid Tilapia zillii (Gervais). Acta Hydrobiology. 39: 47-51.

Svobodova, Z., Luskova, V., Drastichova, J., Svobodova, M. and Zlabek, V. (2003). Effect of Deltamethrin on Haematological Indices of Common Carp (Cyprinus carpio L.). Acta Veterinaria Brno, 72: 79-85 DOI: 10.2754/avb200372010079.

CHANGES IN HISTOLOGY OF FRESHWATER FISH, *Clarias Gariepinus* (BURCHELL) EXPOSED TO THE TOXICITY OF GINGER LEAVES POWDER

[1]Abdullahi, M., 1L. H. Tahir and 2 M. A. Nasir

[1]Department of Zoology, School of Life Sciences, Modibbo Adama University of Technology, Yola, Nigeria.
[2]Department of Fisheries and Aquaculture, Bayero University, Kano.

Correspondence Author:
maimunatuabdullahi@mau.edu.ng, 08137909568

ABSTRACT

The release of plant material into the aquatic environment causes water pollution problems because of their toxicity, persistence and bio-accumulation. An investigation on the effect of the plant material, ginger leaf, on Fresh water fish Clarias gariepinus was carried out in the laboratory. Fish weighing 18.36 ± 0.3g and 12.42±0.3cm length, were exposed to acute concentrations (derived, based on acute toxicity tests) of ginger leaf powder at 0, 7.5mg, 9mg, 10.50mg, 12mg and 13.5mg per liter of water (mg/l) for 4 days. During this period fishes were fed with artificially prepared feed. On the 1st, 2nd, 3rd and 4th days fishes were taken out, sacrificed and the tissues of gill and liver were excised out. The total autopsy was completed in less than 4 mins. The result showed that the degree of distortion of the gill and liver was proportional to the exposure period and concentration of the metals was found to be dose and time dependent.

Keywords:
Acute Toxicity,
Lethal concentration,
histology, ginger leaf,
Clarias gariepinus

INTRODUCTION

The degree of contamination in aquatic environment is frequently assessed by comparing contaminant concentration in associated biota (Yang and Chen, 1996). Since bioconcentration of compounds have been determined in the environment, it has been observed that there are many quantitative relationships between structure and biological activity of chemicals established in aquatic system. In aquatic pollution, organs such as the gills and liver have been identified as the storage sites in C. gariepinus (Gbem et al., 2001). However, the main sites of these plants uptake and accumulation are the gills and gastrointestinal tracts (Annume and Iyaniwura, 1993).

Ginger (Zingiber officinale) belongs to Zingiberaceae family. The used part of the plant is rhizome. This plant produces an orchid like flower with greenish yellow petals streaked with purple color. Ginger is cultivated in areas characterized by abundant rainfall. Even though it is native to southern Asia, ginger is also cultivated in tropical areas such as Jamaica, China, Nigeria and Haiti and it is an important spice crop in India (Akintobi, et al., 2013). Ginger, Zingiber officinalis, is a perennial herbaceous plant that is a part of the Zingiberaceae family. Ginger is an important plant with several medicinal, ethno medicinal and nutritional values.

Clarias gariepinus, an omnivore freshwater fish is a popular delicacy relished throughout tropical Africa. It is a prominent culture species because of its hardiness and fast growth rate. This paper is aimed at determining the gills and liver responses of C. gariepinus to sub lethal concentrations of lead which provide an early warning of potential problems.

MATERIALS AND METHODS

The Experimental Site

The experiment took place in the Fish Hatchery Laboratory of Bayero University's Department of Fisheries and Aquaculture in Kano, Nigeria.

Experimental fish

One hundred and Eighty (180) of C. gariepinus (mean weight, 18.36 ± 0.3g and mean length of 12.42±0.3cm juveniles were used for the study, fish were purchased from a reputable fish farm in Kano, Kano State.

Source and Preparation of Ginger leaves

Fresh samples of ginger leaves plant were taken from Zango Kataf Local Government Area of Kaduna State. The sample were separated into many component with special emphasis on the stems. The samples were set to air dry at a constant weight before being pounded into a fine powder in a sterile laboratory mortar and pestle. The resulting powder were sift (0.2mm) and store in air tight wide mouth bottle for analysis. 500g of each stored sample was dissolved in 2 litres each of distilled water at room temperature (27 ± 0.30C) for 24 hours (Omoregie and Onuogwu, 2015). Afterwards, a vacuum pump was used to decant and filter the settling aqueous component via Whitman filter paper. To prepare them for usage, the filtrates were freeze-dried and kept in a refrigerator at 100°C.

Experimental Design

The experiment was conducted using a completely randomized approach. Eighteen (18) plastics tanks, each measuring 60 cm by 40 cm by 40 cm, were utilized. After a thorough cleaning, 20 liters of water were added to the plastic tanks. Each plastic tank has a label on it. Ten fish were allocated each tank after each fish was weighed. 180 young C. gariepinus fish in total were randomized and put into the aquariums in triplicate, with 10 fish in each tank.

Range finding test

In the course of the range finding test, ten C. gariepinus juveniles were individually weighed using a sensitive electronic weighing scale (Mettler Toledo FB602) and stocked into the eighteen tanks that were filled with twenty litres of tap water. The ginger leaves powder weighing 0, 10mg, 12mg, 14mg, 16mg and 18mg were used per litre of water. The LC50 of ginger leaves powder was found when test fish were exposed to the plant for 96 hours. The fish's reaction to mild stimuli was utilized as an index of toxicity, and their inability to react to touch was used as an index of death.

Definitive Test

Results from range finding tests offered advice for the concentration level to be used in definitive test. We filled eighteen (18) plastic tanks, each holding twenty litres of water, in order to conduct the final test. The amounts of ginger leaves powder utilized were 0, 7.5mg, 9mg, 10.50mg, 12mg and 13.5mg per liter of water (mg/l). The sensitive weighing balance was used to prepare the various concentrations. The fish's non-reaction ginger leaves powder was judged to be fatal to 50% of the test organism after 96 hours of exposure, whereas the fish's response to mild stimuli was employed as an indication of toxicity.

Statistical Analysis

Minitab 20 was used to analyze data and compile statistics on the water quality parameter. The mean lethal concentration (LC50) for 96 hours was calculated using probit analysis (Finney, 1971).

RESULTS AND DISCUSSION

The histological changes on fish is a noteworthy and promising field to understand the extent to which changes in the structural organization are occurring in the organs due to environmental pollution. Isiyaku et al. (2021) studied environmental pollution and its effects on aquatic animals. The histological alteration of the gills and liver were observed and this was more pronounced at higher concentrations (13.5 ml/L, Plate 6) and exposure time. The gills showed lamella hypertrophy, some hyperplasia at the base of the secondary lamellae and desquamation of the epithelial lining and telangiectasia of the secondary lamellae at lower concentrations – 7.5mg/l (Plates 1).

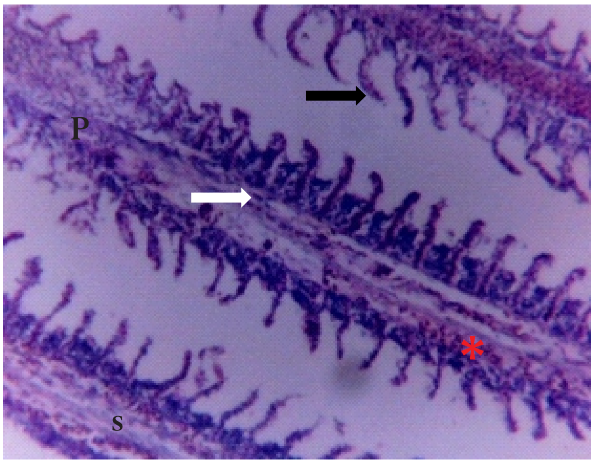


Plate 1: Gills of *Clarias gariepinus* in the control tank shows normal aspect of gill

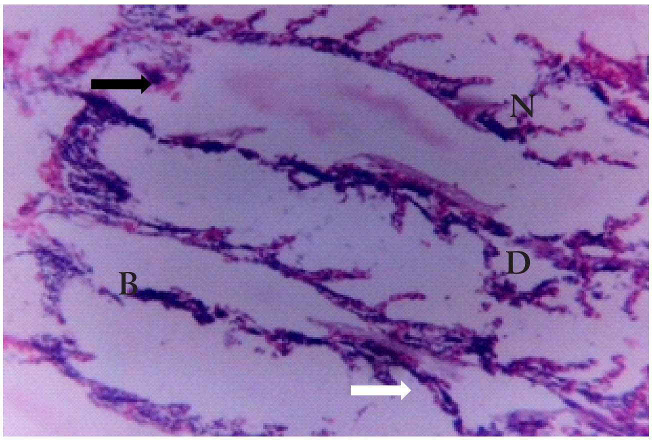


Plate 2: Gills of *Clarias gariepinus* exposed to 7.5 mg/l of ginger powder

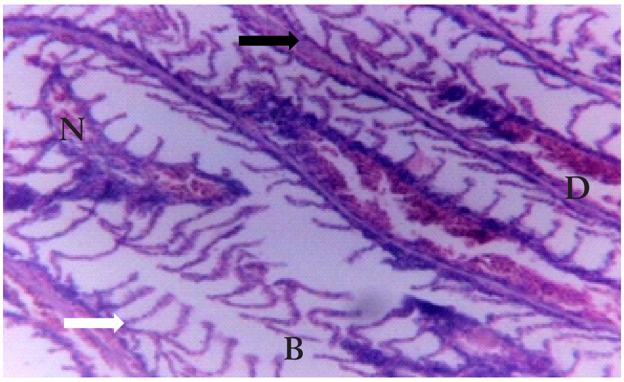


Plate 3: Gills of *Clarias gariepinus* exposed to 9.0 mg/l of ginger powder

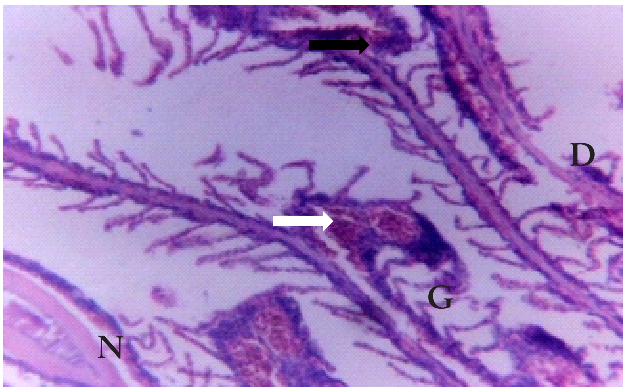


Plate 4: Gills of *Clarias gariepinus* exposed to 10.5 mg/l of ginger powder

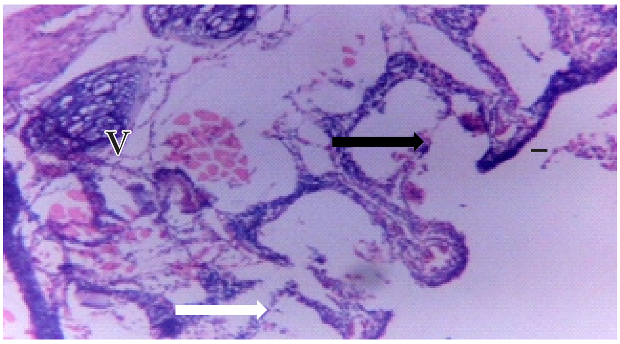


Plate 5: Gills of *Clarias gariepinus* exposed to 12 mg/l of ginger powder

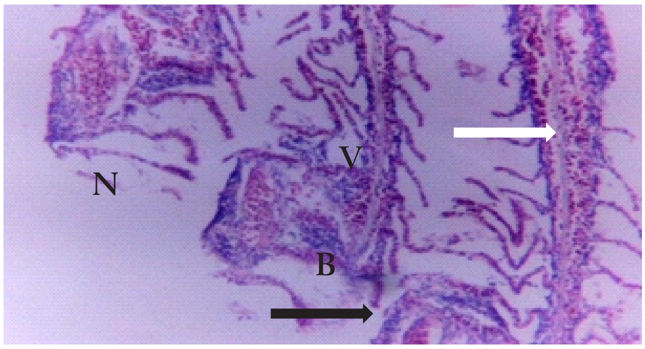


Plate 6: Gills of *Clarias gariepinus* exposed to 13.5 mg/l of ginger powder

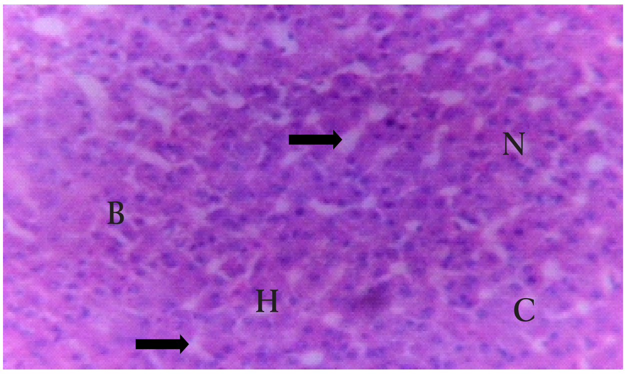


Plate 7: Liver of of *Clarias gariepinus* juveniles in the control tank shows normal architecture

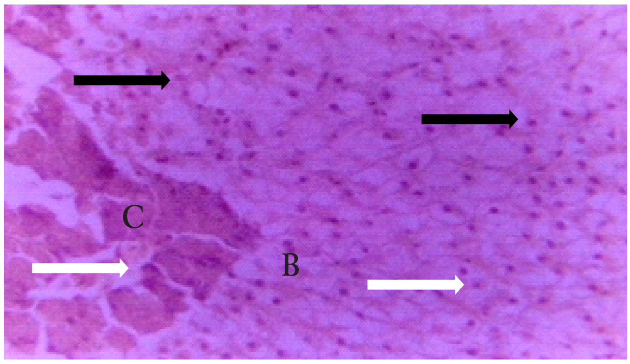


Plate 8: Liver of of *Clarias gariepinus* juveniles exposed to 7.5mg/l of ginger leaves powder

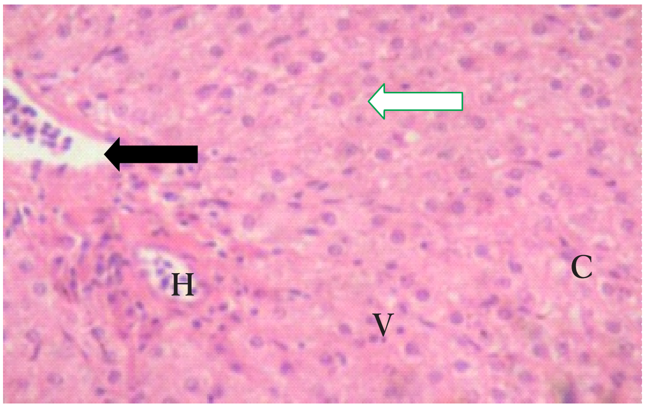


Plate 9: Liver of of *Clarias gariepinus* juveniles exposed to 9.0 mg/l of ginger leaves powder

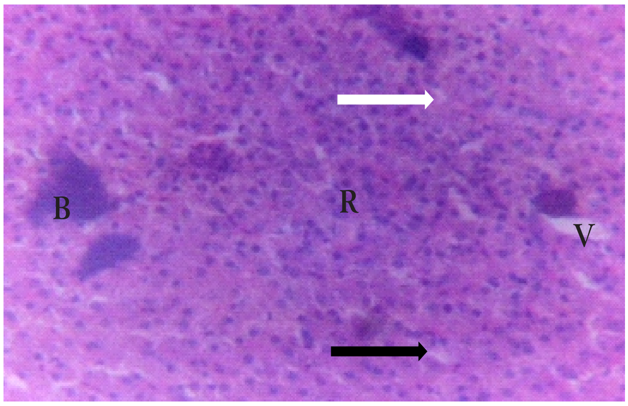


Plate 10: Liver of of *Clarias gariepinus* juveniles exposed to 10.5mg/l of ginger leaves powder

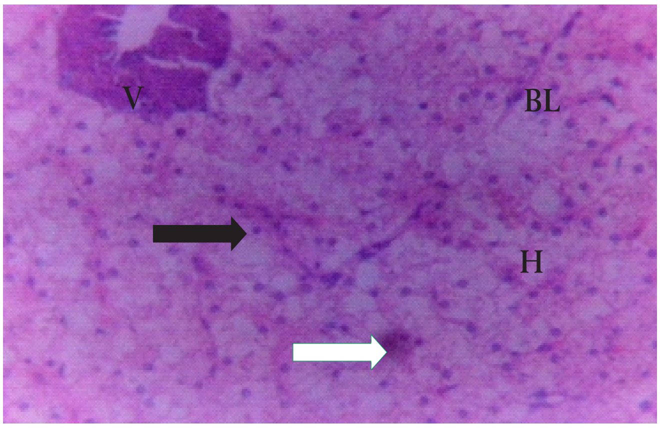


Plate 11: Liver of of *Clarias gariepinus* juveniles exposed to 12.0 mg/l of ginger leaves powder

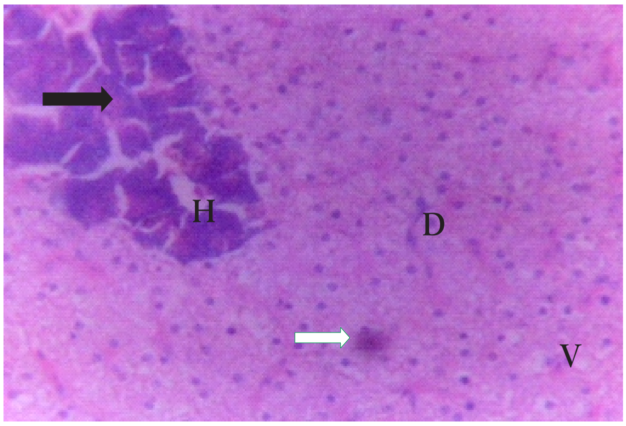


Plate 12: Liver of of *Clarias gariepinus* juveniles exposed to 13.5 mg/l of ginger leaves powder

Histological examination of *Clarias gariepinus* gave significant indication of toxicity of ginger leaves (Plates 1 to 12). The effects include gill alteration such as desquamation of the epithelial lining, telangiectasia, haemoragic and hyperplasia at the secondary lamellae (Plates 2, 3, 4, 5 and 6) while there was no pathological lesion in the control experiment (Plate 1). Oulmi et al. (1995) studied the effects of linuron herbicide on the rainbow trout (Oncorhynchus mykiss) and stated that small cytoplasmic vacuoles, nuclear deformation in the epithelium of the first and second segments of the proximal tubule were observed. The liver of the exposed fish had slightly vacuolated hepatocytes showing evidence of fatty degeneration, necrosis of some portions of the liver tissue that were observed probably resulted from the excessive work required by the fish to get rid of the toxicant from its body during the process of detoxification by the liver (Olufayo, 2009). Some changes such as karyolysis of nucleic material, vacuole formation of the tubular epithelial cells were also observed (Plates 8-12). The inability of fish to regenerate new liver cells may also have led to necrosis of hepatic cells of sinusoids. A similar study by Isiyaku et al. (2022) depicted that O. niloticus exposed to sub-lethal concentrations of the commercial glyphosate herbicide Roundup®, showed histopathological changes in the liver namely vacuolation of hepatocytes and nuclear pyknosis. Ramah (2011) observed that pathological changes observed in the liver tissues of grass carp exposed to different herbicides were congestion of sinusoids congestion of central vein and proliferation of bile ductular epithelium.

CONCLUSION

Aquatic species experience increased stress when their environment is contaminated by toxic plants, whether as a result of acute or long-term events. Plant components, especially the powdered ginger leaves, are rapidly absorbed by the aquatic biota and have negative consequences.

RECOMMENDATION

The current findings show that ginger weakened Clarias gariepinus immune system, which raises the possibility that it could also create serious physiological issues and finally cause the fish to die. As a result, quick action is needed to stop the release of different toxicants into our waterways. If not, it will have a direct impact on the aquatic biota and indirectly influence the dependent population through the food chain. As a result, it may result in a number of illnesses and the extinction of numerous species.

REFERENCES

Akintobi, O. A., Onoh, C. C., Ogele, J. O., Idowu, A. A., Ojo, O. V., and Okonko, I. O. (2013). Antimicrobial activity of Ginger (ginger) extract against some selected pathogenic bacteria. Nature and science, 11(1), 7-15.

Annune PA, Iyaniwura TT (1993). Accumulation of two trace metals in tissus of freshwater fishes, Oreochromis niloticus and Clarias gariepinus. J. Aqua. Food Prod. Technol. 2(3): 5-18.

Finney, D.J. (1971). Statistical methods in biological assay, 2nd Ed. Hafner Pub.Co. New York. N.Y. Cambridge University Press, London, England. 68p

Gbem, T.T., Balogun J, K., Lawal, F.A., Annune, P.A, (2001). Trace metal accumulation in Clarias gariepinus (Teugels) exposed to sublethal levels of tannery effluent. The Sci. of the total Environ. 271: 1-9.

Isiyaku M. S., Fagbenro, O. A., and O. O. Olawusi-Peters (2021). Acute Toxicity and Behavioural Changes of Oreochromis niloticus Juveniles Exposed to Tamarind (Tamarindus indica) Seed Husk Powder. South Asian Research Journal of Agriculture and Fisheries. 3(3): 34-39. DOI: 10.36346/sarjaf.2021.v03i03.001.

Isiyaku, M. S., Laurat, H. T and Maimunatu, A. (2022). Histopathology of gills and liver tissues of the freshwater fish Oreochromis niloticus (Linnaeus 1758) exposed to Tamarindus indica seed husk powder. 37th Annual conference of the Fisheries Society of Nigeria. Held on 30th October to 4th November, 2022 at the Federal College of Education, Yola, Adamawa State

Olufayo M.O. (2009). Haematological Characteristics of C. gariepinus juveniles exposed to Derris root powder. Afr. J. Food Agric. Nutr. Dev. 9(3):921-933.

Omoregie, E. and M. A.Onuogwu. (2015). Acute toxicity of water extracts of bark of the Neem plant, Azadirachta indica (Lodd) to the cichlid Tilapia zillii (Gervais). Acta Hydrobiology. 39: 47-51.

Oulmi Y, Negele RD, Braunbeck T (1995). Cytopathology of liver and kidney in rainbow trout (Oncorhynchus mykiss) after long-term exposure to sub lethal concentrations of linuron. Dis. Aqua. Org. 21:35-52.

Ramah, K. (2011). Histopathological study on the effect of rice herbicides on grass carp (Ctenopharyngodan idella). African Journal of Biotechnology, 10(7): 1112-1116. DOI: 10.5897/AJB09.1468.

Available online at http://www.academic journals.org/ AJB.
Yang, H.N., Chen, H.C. (1996). Uptake and elimination of cadmium by Japanese eel, Anguilla japonica, at various temperatures. Bull. Environ. Contam. Toxicol. 56 (4): 670-676.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

EFFECTS OF DIFFERENT FORMALIN CONCENTRATIONS ON SOME MORPHOMETRIC CHARACTERS OF PRESERVED *Oreochromis niloticus*

[1]Adedeji, H. A., [1]P. M. Tadawus, [2]R. A. Asiru and [3]R. Y. Oladunjoye

[1]Department of Fisheries, Modibbo Adama University, Yola, Adamawa State, Nigeria.
[2]Department of Biological Sciences, Federal University Gusau, Zamfara State, Nigeria.
[3]Department of Zoology & Environmental Biology, Olabisi Onabanjo University, Ago-Iwoye, Nigeria

Corresponding author:
bowaladeji@gmail.com; 07069593229

ABSTRACT

The effects of formalin (5% and 10% concentration) preservation on some morphometric characteristics of preserved Oreochromis niloticus collected from Upper River Benue were investigated. The total length, standard length, head length, body depth, eye diameter, and total weight of fresh and preserved O. niloticus were taken weekly for the period of nine weeks. The results showed varying degrees of shrinkage in the total length, standard length and eye diameter while the head length, body depth and total weight experienced varying degrees of increment in both 5% and 10% formalin concentration over the period of preservations. However, there was no significant differences in the studied morphometric characters in both fresh and preserved O. niloticus for both concentrations. The results also revealed that both concentrations affected the characters in a similar trend but a bit more pronounced at 10% concentration. The morphometric analyses that form the basic analysis for fields like systematics, growth analysis, fish population and dynamics and fishery stock management would ideally be performed on fresh specimens. However, recognizing that this is not always feasible due to some foreseeable challenges, it is important to be aware of the morphometric changes that can occur during preservation.

Keywords:
Morphometric Characters, Preservation, Formalin Concentration, Oreochromis niloticus

INTRODUCTION

Preservation methods play a critical role in maintaining the integrity of biological specimens, especially for long-term storage, enabling researchers to conduct detailed analyses over extended periods (Berbel-Filho et al. 2013). However, the conditions under which biological samples are preserved can vary significantly depending on their intended use and the desired outcomes (Jawad, 2003; Ghaly et al., 2010). For ichthyologists, accurately identifying fish specimens often involves using formalin, alcohol, freezing, and chilling to preserve key morphological traits in the absence or lack of access to fresh samples (Ghaly et al. 2010). Preservation techniques in general, whether used in the short or long term, have been shown to affect taxonomically significant morphometric characteristics such as total length, head length, eye diameter, and body depth (Jawad, 2003; Ghaly, 2010; Haubrock et al., 2018; Sotola et al., 2019; Adedeji et al., 2023). These distortions may lead to inaccuracies in morphometric measurements that no longer reflect the true dimensions in fish, a crucial concern when conducting subsequent biological or ecological analyses. Preservation-induced errors can lead to misleading conclusions, potentially affecting growth studies, biodiversity assessments, and fishery management practices (Porter et al., 2001).

Jawad et al. (2001), Jawad (2003) and Neve et al. (2006) have also documented the impacts of various preservation techniques on both pigmentation and morphological characteristics in several fish species. For instance, some fish experience significant color fading over time due to prolonged exposure to formalin or ethanol, which can hinder species identification or comparative taxonomic studies. These morphological changes are often attributed to multiple factors, such as the duration of preservation, concentration of the preservative, temperature conditions, and species-specific biological traits like age, size, and even the fish's osmoregulatory activity at the time of death (Yeh and Hodson, 1975). For example, rapid preservation at high ethanol concentrations might limit tissue degradation but could accelerate shrinkage, altering body proportions. The shrinkage effect caused by any preservation agents, be it ethanol, formalin or any other method, for instance, can lead to a significant underestimation of size, particularly for certain species. Therefore, this study aims to investigate the impact of formalin preservation on the length and weight of the preserved O*reochromis niloticus*.

MATERIALS AND METHODS

Experimental Set up

Forty (40) individuals of O. *niloticus* of possible similar recruits were obtained from the Upper Benue River, Yola. A set of twenty individuals of O. niloticus were introduced to 5% formalin preservation while the remaining set of twenty individuals were introduced to 10% formalin preservations. Each sample were introduced into individual glass bottles, filled with respective concentration of formalin after first been euthanized, after which samples were then labelled and preserved. The solution of formalin was prepared using distilled water

Morphometric Measurement

Morphometric characters like body weight (BW), total length (TL), standard length (SL), body depth (BD), head length (HL) and eye diameter (ED) were taken. The body weight was measured by electronic weighing balance to the nearest 0.01g, while the total length, standard length, body depth, head length and eye diameter were measured using digital vernier callipar. Measurement of the morphometric characteristics were done on the fresh samples prior to preservation and subsequently taken weekly for a total period of nine weeks (63 days).

Data Analysis

The data generated were analyzed using Statistical Package for Social Sciences (SPSS 22.0). A simple descriptive analysis is used to determine the means and one-way analysis of variance (ANOVA) was used to separate the means at (P= 0.05). The percentage shrinkage was also calculated to determine the changes in the measured morphometrics characters in the fresh samples compared to the preserved samples suing the formula below

$$\text{Percentage Shrinkage \%} = \frac{\text{fresh sample} - \text{preserved sample}}{\text{Fresh sample}} \times 100$$

RESULTS

The effects of different formalin concentrations on some morphometric characters of preserved O. niloticus are presented in Table 1 (5% formalin conc) and 2 (10% formalin conc.). Table 1 showed that the lowest percentage shrinkage (1.65) in the total length of O. niloticus preserved in 5% formalin concentration was observed at weeks 1 and 2 while the highest shrinkage (3.07) was observed at the fourth week of preservation. The lowest shrinkage in the standard length was observed in the first week (3.39) and the highest in the fifth week (6.14) of preservation. However, the head length, body depth and total weight experienced various degrees of increment during preservation. The highest weight increment was observed in the sixth week (-5.73) of preservation while the highest body depth increment was observed in the ninth week (-5.92). Table 2 showed that the highest percentage of shrinkage (3.12) in O. niloticus preserved in 10% formalin was observed in the ninth week while the lowest was recorded in the first week of preservation. The percentage shrinkage in standard length increases as the week progresses with the highest (5.11) at the ninth week. The head length, body depth and total weight also experienced increases in length and weight over the preservation period. The results reviewed that there were no significant differences between the measured morphometric characters of fresh and preserved O. *niloticus* in both concentration during the preservation period. Though the percentage shrinkage in both concentrations followed the same trend, however, the 10% formalin concentration seems to have higher effects (both shrinkage and increment) than of 5% formalin

DISCUSSION

The observed variations in the measured morphometric characters in the preserved O. *niloticus* from the fresh sample over the preservation period are in accordance with the results of previous works (Jawad et al., 2001; Jawad, 2003; Berbel-Filho, 2013; Hossaini, et al., 2016; Sotola et al., 2019; Nordeide, 2020; Kumar et al., 2021; Ghazwan, 2021; and Adedeji et al,. 2023) which revealed that different concentrations of different preservatives causes various degrees of variations in morphology of any preserved specimen. This present study agreed with the observations of Sotola et al, (2019), Nordeide (2020) Kumar et al., 2021, and Ghazwan (2021) that formalin preservation causes shrinkage in

Table I: Effects of 5% formalin preservation on the Morphometric characters of preserved *Oreochromis niloticus* for the period of sixty-three days (nine weeks)

	TL(cm)		SL(cm)		HL(cm)		BD(cm)		ED(cm)		TW(g)	
	Mean	% Shrinkage	Mean	% Shrinkage	Mean	% Shrinkage	Mean	% Shrinkage	Mean	% Shrinkage	Mean	% Shrinkage
Fresh	13.37±1.14		10.92±1.24		3.69±0.30		4.22±0.44		0.85±0.08		47.27±2.22	
Week 1	13.15±1.07	1.65	10.55±0.92	3.39	3.59±0.29	2.71	4.23±0.34	0.24	0.83±0.09	2.35	47.82±2.93	1.16
Week 2	13.15±0.95	1.65	10.45±0.79	4.30	3.63±0.47	1.63	4.25±0.34	0.71	0.82±0.07	c 3.53	48.24±2.54	2.05
Week 3	13.07±1.16	2.32	10.40±0.74	4.36	3.66±0.27	0.81	4.28±0.34	1.42	0.80±0.06	c 5.88	49.08±2.66	3.82
Week 4	12.96±1.04	3.07	10.33±0.75	5.40	3.66±0.27	0.81	4.31±0.34	2.13	0.79±0.06	7.06	49.26±2.85	4.21
Week 5	12.99±0.90	2.28	10.26±0.91	6.14	3.67±0.37	0.54	4.34±0.36	2.84	0.79±0.07	7.06	49.68±2.54	5.09
Week 6	13.01±0.97	2.77	10.29±0.75	5.77	3.72±0.29	0.81	4.38±0.32	3.79	0.78±0.05	8.24	49.98±2.32	5.73
Week 7	13.14±1.06	1.79	10.31±0.82	5.58	3.74±0.39	1.36	4.40±0.42	4.27	0.78±0.07	c 8.24	49.71±2.11	5.61
Week 8	13.10±1.04	2.02	10.35±0.74	5.22	3.78±0.27	2.44	4.44±0.37	5.21	0.79±0.04	7.06	49.51±2.44	4.74
Week 9	13.07±1.07	2.54	10.29±0.81	5.77	3.84±0.31	4.07	4.48±0.38	5.92	0.80±0.07	5.88	49.38±2.14	4.46

Table II: Effects of 10% formalin preservation on the Morphometric characters of preserved Oreochromis niloticus for the period of sixty-three days (nine weeks)

	TL(cm)		SL(cm)		HL(cm)		BD(cm)		ED(cm)		TW(g)	
	Mean	% Shrinkage	Mean	% Shrinkage	Mean	% Shrinkage	Mean	% Shrinkage	Mean	% Shrinkage	Mean	% Shrinkage
Fresh	12.18±0.89		9.78±0.50		3.18±0.69		4.04±0.35		0.87±0.03		42.54±3.9	
Week 1	12.01±0.87	1.40	9.56±0.62	2.25	3.17±0.24	0.31	4.07±0.36	0.74	0.85±0.03	2.30	42.98±3.05	1.03
Week 2	11.97±0.89	1.72	9.51±0.63	2.76	3.19±0.25	0.31	4.09±0.33	1.24	0.83±0.03	4.60	43.36±3.13	1.93
Week 3	11.95±0.85	1.89	9.44±0.62	3.48	3.22±0.38	1.25	4.12±0.34	1.98	0.84±0.02	3.48	43.89±3.18	3.17
Week 4	11.96±0.85	1.81	9.40±0.64	3.89	3.25±0.20	2.20	4.13±0.33	2.23	0.82±0.03	5.75	44.13±3.33	3.74
Week 5	11.93±0.92	2.05	9.37±0.58	4.19	3.26±0.16	2.52	4.15±0.24	2.72	0.81±0.03	6.90	44.91±3.21	5.97
Week 6	11.89±0.82	2.38	9.33±0.48	4.60	3.28±0.21	3.14	4.17±0.36	3.22	0.80±0.02	8.05	44.72±3.89	5.78
Week 7	11.87±0.90	2.55	9.32±0.64	4.70	3.29±0.23	3.46	4.18±0.38	3.47	0.81±0.02	6.90	44.65±3.01	4.96
Week 8	11.83±0.71	2.87	9.30±0.61	4.90	3.32±0.24	4.40	4.20±0.32	3.96	0.81±0.09	6.90	44.25±3.23	4.02
Week 9	11.80±0.87	3.12	9.28±0.62	5.11	3.35±0.23	5.35	4.22±0.34	4.46	0.82±0.01	5.75	43.74±3.17	2.82

total length and standard length but causes increment in the body depth and total weight. Furthermore, the observed continuous changes in the morphometric characters as the preservation period progresses are in accordance with the work of Sotola et al, (2019) that observed similar changes in the body after subsequent ethanol preservation. The observed increment in the head length, body depth and total weight may be a result of the use of distilled water in the preparation of the respective formalin concentrations as already reported by Ghazwan (2021) that formalin prepared with distilled water causes an increase in body depth and total weight compared to formalin prepared with brackish water. Changes in morphometric characters of preserved species have been reported to be influenced by various factors such as the method of preservation, concentration and type of chemical preservation agents, length of the preservation period, salinity and temperature of the preservative (Jawad, 2003; Hossaini, et al, 2016). The type of species, age, size and developmental state of the preserved fish are all factors that determine changes in morphometric characters of a preserved fish

CONCLUSION

It is concluded that morphometric analyses that form the basic analysis for fields like systematics, growth analysis, fish population and dynamics and fishery stock management would ideally be performed on fresh specimens. However, recognizing that this is not always feasible due to some foreseeable challenges it is important to be aware of the morphometric changes that can occur during preservation.

REFERENCES

Adedeji, H. A., Tadawus P. M., Idowu T. A. and. Asiru, R. A (2023). Effects of Different Ethanol Concentrations on the Morphometric Characteristics of Clarias gariepinus and Oreochromis niloticus. Asian Journal of Fisheries and Aquatic Research, 25(2): 1-6

Berbel-Filho, W.M., Jacobina, U.P. and Martinez, P.A. (2013). Preservation effects in geometric morphometric approaches: Freezing and alcohol in a freshwater fish. Ichthyological Research, 60(3):268–71.

Ghaly, A.E., Dave, D., Budge, S. and Brooks, M.S. (2010). Fish spoilage mechanisms and preservation techniques. American Journal of Applied Sciences, 7(7):859-877.

Ghazwan, M. I. (2021). Effect of Some Preservative Solutions on Some Morphometric Features of Planiliza abu (Heckel, 1843). Diyala Agricultural Sciences Journal, 13(2): 1-9

Haubrock, P.J., Balzani, P., Johović, I., Inghilesi, A.F. and Tricarico, E. (2018). The effects of two different preservation methods on morphological characteristics of the alien channel catfish Ictalurus punctatus (Rafinesque, 1818) in European freshwater. Croatian Journal of Fisheries, 76: 80-84.

Hossaini, S.A., Vajargah, M.F., Sattari, M. (2016). The effect of preservation in alcohol on the morphological characters of the Zagros Tooth-Carp, Aphanius vladykovi Coad, 1988. Journal of Environmental Treatment Techniques. 4(4):118-120.

Jawad, L.A. (2003). The effect of formalin, alcohol and freezing on some body proportions of Alepes djeddaba (Pisces: Carangidae) collected from the Red Sea coast of Yemen. Revista De Biología Marina Y Oceanografía, 38(2):77-80.

Jawad, L.A., Toumi, F.F.E., Barasi, H.M.E. and Silini, O.A.E. (2001). The effect of preservatives and freezing on the morphological characters of two sparid fishes. Indian Journal of Fisheries,48(4):423-426.

Kumar, G., Bano, F. and Serajuddin, M. (2021). Effect of formalin preservation on morphology and condition factor of the freshwater shark Wallago attu (Bloch and Schneider, 1801) using truss network system. Indian Journal of Fisheries, 68(3): 119-124

Neve, F.B., Mandrak, N.E., Docker, M.F. and Noakes, D.L. (2006). Effects of preservation on pigmentation and length measurements in larval lampreys. Journal of Fish Biology,68(4):991-1001.

Nordeide, J. T. (2020). Accuracy of body mass estimates of formalin-preserved fish - a review. Journal of Fish bIology, 96(2):288-296. doi: 10.1111/jfb.14146.

Porter, S.M., Brown, A.L. and Bailey, K.M. (2001). Estimating live standard length of net-caught walleye

Pollock (Theragra chalcogramma) larvae using measurements in addition to standard length. Fish. Bulletin,101:384—404.

Sotola, V.A., Craig, C.A, Pfaff, P.J., Maikoetter, J. D., Martin, N.H. and Bonner, T.H. (2019). Effect of preservation on fish morphology over time: Implications for morphological studies. PLoSONE 14(3): e0213915. https://doi.org/10.1371/journal. pone.0213915

Yeh, C.F. and Hodson, R.G. (1975). Effects of formalin on length and weight of bluegill and white crappie from Lake Nasworthy, Texas. Southwest Naturalist,20:315- 322.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

TOXICOLOGICAL STUDY OF *Clarias gariepinus* EXPOSED TO DIFFERENT LEVELS OF CAUSTIC SODA

[1] Akin-Obasola, B. J.,[1] T. A. Aiyelari, [1] M. A. Abubakar, [2] F. B. Oyekanmi and [1] O. A. Oyekanmi

[1]Department of Fisheries and Aquaculture Management, Ekiti State University, P.M.B. 5363, Ado Ekiti, Nigeria.
[2]Department of Agricultural Sciences University of Ilesa, Osun State, Nigeria

Corresponding Author:
bola.akinobasola@eksu.edu.ng +2348033100012, 0000-0002-3889-1553

ABSTRACT
The toxicity test of caustic soda was carried out for 96 hours and conducted under static bioassay. The fish were acclimated for 7 days before the experiments and the test was conducted in a rectangular tank with 26 × 20 × 30 cm dimension. Each concentration was tested in triplicates with 10 fish per tank The concentrations used in range finding test were 0ml, 10ml, 20ml, 30ml, 40ml /8 litres of water while in acute toxicity test, 0ml, 22ml, 24ml, 26ml and 28ml /8 litres of water were used. Upon exposure to the toxicant, the fish displayed behavioural changes such as restlessness, hyper -ventilation, air gulping, clustering and erratic swimming. The lethal median concentration (LC50) in acute test was determined graphically to be 23ml/8L. The results revealed that as the concentration of caustic soda increases, the percentage of mortality increased. There were histological alterations in the organs of Clarias gariepinus except in the control experiment. Also, the higher the concentration of caustic soda used, the higher the behavioral changes shown by the fish. Water quality war poorer in treatments with higher concentrations as the day of the experiments progressed especially in the dissolved oxygen concentration level which reduced greatly at day 4 (96 hours). These results indicate the need for careful use of caustic soda near aquatic ecosystems.

Keywords:
Toxicology, pollution, median concentration, catfish

INTRODUCTION

Toxicity in aquaculture refers to the harmful effects of elevated concentrations of metabolites (carbon dioxide, ammonia, nitrite, and hydrogen sulfide), algal toxins, heavy metals and agricultural and industrial chemicals (Boyd, 2017). Caustic soda is a strong alkali and very corrosive. It is an inorganic chemical and highly caustic base that decomposes proteins at ordinary ambient temperature (Ahmadi, 2019). Caustic soda is used in fresh water aquaculture for pH neutralization and also to scrape the aquatic environments off stains and algae deposits on an exposed pond/tank. It is mixed in water and then poured into the pond to disinfect the points of viruses and bacteria, as it kills these unwanted microorganisms within 1 hour depending on how evenly the mixture was spread in the pond (Khan and Khan, 2023). The need for pH requirement or neutralization of the water depends on the water source, the species farmed and the production system. The challenge in Nigeria, and globally is the resistance of these compounds to degradation and the leaching from disposal systems and landfills (Ishaq, 2022).

Clarias gariepinus, the African sharp tooth catfish is a large, eel-like fish, usually of dark grey or black coloration on the back, fading to a white belly. *Clarias gariepinus* belongs to the family Clariidae and phylum Chordata (Olanrewaju et al., 2022). *Clarias gariepinus* is a hardy fish, able to tolerate poor water quality parameters and therefore not easily susceptible to most common diseases encountered by other cultured fish species. Uncontrolled and unregulated use of toxic chemicals in Nigeria water bodies has resulted in pollution of the aquatic environment which has caused great risk in biotic organisms like *Clarias gariepinus* which is a major source of protein in Nigeria (Ishaq, 2022). These chemicals usage causes mortality and change in the composition of fish species, loss of abundance and affect the physiology of the fish. Chemicals like caustic soda have been used without checking its negative impact on fish which results in poisoned organs. This negatively affects the metabolism and well-being of fish, and these indirectly causes health problems when consumed by man. The objectives of this study are to determine the median lethal concentration (LC50) of caustic soda, assess the mortality rate of different concentrations, analyze the histology of some of the vital organs (gill, liver and heart) of *Clarias gariepinus* and study the behavioral changes of *Clarias gariepinus* fingerlings exposed to different levels of caustic soda.

MATERIALS AND METHODS

The site of the experiment was the Department of Fisheries and Aquaculture Management wet laboratory, Ekiti State University, Ado Ekiti, Ekiti, State. Caustic soda was purchased from a reputable Agro centre in Ado Ekiti. Range finding test and acute test of Caustic soda were carried out and flakes of 4.16g was dissolved in 50ml (0.05 liters) of well water and the solution was mixed with 8litres of water which was the concentration used for all treatments as described by Ward and Parrish (1982). The solution was mixed thoroughly with the water. Healthy 300 fingerlings of *Clarias gariepinus* of the same genetic stock were obtained from a reputable fish farm. The fish was acclimatized for 7 days before the commencement of the experiment.

Five treatments (0ml, 10ml, 20ml, 30ml, 40ml /8 litres of water) were used for Range finding test and five treatments (0ml, 22ml, 24ml, 26ml and 28ml/8 liters) were also used for definitive (acute toxicity) test and each treatments had three replicates each. The range finding test (preliminary test) was carried out following a static bio assay procedure described by Ward and Parrish (1982) to determine the toxic change in *Clarias gariepinus* exposed to different levels of caustic soda. The test material was prepared by weighing Caustic soda (flakes) using Top loading Metler balance to get 4.16g of soda weight, this was dissolved in 50ml (0.05 liters) of water to obtain a solution, and the solution was then added to 8liters of water. This was allowed to dissolve in water for 10 minutes before adding *Clarias gariepinus* fingerlings. Each fish was weighed using Top loading Metler balance with the weight 6.21g±0.05g and 10 fish per tank was introduced at the same time into the water in rectangular plastic tank already containing the solution of the test materials at different concentrations. The experiment was monitored at 3 hours interval and lasted for 96 hours.

In acute toxicity test, the histological analysis of liver, gills and heart of *Clarias gariepinus* were studied in order to determine the toxic effect of caustic soda on them. After four days the fish were taken out of each tank, killed by decapitation and the gill, heart and liver were removed, sectioned and examined. The organs were fixed in formalin saline solution, kept in cassettes after which they were embedded in wax, trimmed and sectioned. Sections were fixed on clean slides and stained with haemotoxylin and eosin stains. Photomicrographs were taken with Heitz (Ortholux II) microscope with camera, (Standard model BHTVIII). The temperature, pH and dissolved oxygen level was carried out at the beginning and the end of the experiment; to ascertain the cause of death in fish, using standard methods. All the results collated were analysed using Duncan multiple range test and the differences between means were determined using Turkey Post-Hoc test.

RESULTS AND DISCUSSION

In range finding test (Table 1), mortality increased as the concentration and number of hours increased.

Table 1: Range finding test: Percentage mortality of *Clarias gariepinus* fingerlings exposed to different levels of caustic soda

CONCENTRATION	Time (3 hours)	Time (6 hours)	Time (9 hours)	Time (12 hours)	Time (24 hours)
0ml/8 Liters	0	0	0	0	0
10ml/8 Liters	0	20	0	0	0
20ml/8 Liters	0	0	30	0	20
30ml/8 Liters	0	30	20	30	0
40ml/8 Liters	20	20	20	40	0

As shown in table 2, the results revealed that as the concentration of caustic soda increases, the percentage of mortality also increased. In acute toxicity, total mortality was recorded in the highest concentration, this agrees with Akin-Obasola et al. (2022) who recorded total mortality within 96 hours when Caterpilla granule of 16g/10L was used exposed to *Clarias garipienus*.

Table 2: Definitive test (Acute toxicity test): Mortality of *Clarias gariepinus* exposed to Caustic soda within 96 hours Bioassay.

CONCENTRATION	Time (24 hours)	Time (48 hours)	Time (72 hours)	Time (96 hours)	Total mortality
0ml/8L	0	0	0	0	0%
22ml/8L	10	10	0	10	30%
24ml/8L	10	20	20	10	60%
26ml/8L	10	20	40	20	90%
28ml/8L	30	30	40	0	100%

As shown in the table 3, the fish showed erratic swimming pattern, loss of reflex, discoloration and no reaction to external stimuli, these reactions increased with increase in concentration.

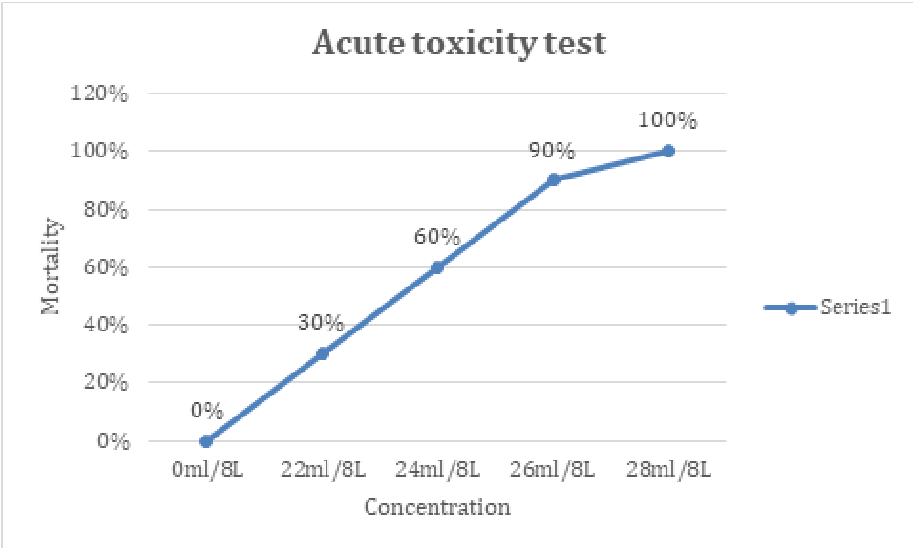
Table 3: Behavioural Changes to Acute toxicity test of *Clarias gariepinus* exposed to Caustic soda within 96 hours Bioassay.

Behavioural changes	**0ml/8L**	**22ml/8L**	**24ml/8L**	**26ml/8L**	**28ml/8L**
Loss of reflex	-	-	+	+	++
Erratic swimming	-	-	+	+	++
Discolouration	-	+	+	++	++
Behaviouralchages	-	+	++	++	++
Hyper-ventilation	-	+	+	++	++
Mortality%	0	30	60	90	100

Key: Absent: -, Present: +, Highly present: ++.

The fish showed erratic swimming pattern, loss of reflex, discolouration and no reaction to external stimuli, these reactions increased in concentration. This also corroborate the report of Akin-Obasola (2019) where erratic swimming pattern, loss of reflex, discoloration and molting was recorded when *Clarias gariepinus* was exposed to different levels of petrol and engine oil and these reactions increased with increase in concentrations.

LC50 determination:
The median lethal concentration (LC50) was determined graphically to be 23.5ml/8L



The histopathological analysis:
The histology of the exposed tissue with highest concentrations were analysed as shown in Plates 1-3.

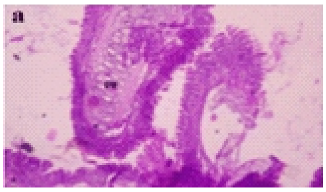


Plate 1: Gill showing degeneration in Treatment 5

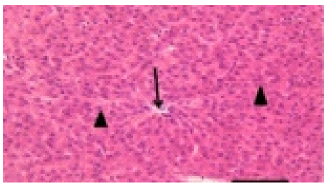


Plate 2: Liver showing necrosis in Treatment 5

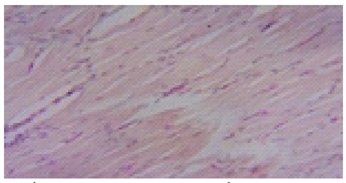


Plate 3: Heart showing infiltration of leukocytes in Treatment 5

African catfish *(Clarias garipienus)* exposed to different levels of caustic soda had the presence of the toxicant in the gills, heart and liver. This suggests that these organs could be useful as a marker for the toxicants in the aquatic environment. This work corroborates Ray et.al, (1999) who recorded a high concentration of mercury in the liver and other organs of *Clarias gariepinus* while the concentration of mercuric in the tissues increased with its concentration in the aquatic environment. As shown in plate 3, there was interstitial infiltration of leukocytes in the heart of *Clarias gariepinus* exposed to different levels of Caustic soda, this agrees with Akin-Obasola (2022) where deformation in the organs of C. *gariepinus* exposed to different levels of Caterpillar granule was recorded.

CONCLUSION
The results of this study show that caustic soda, an alkali chemical compound used in soap making, disinfecting the pond as well as to improve the alkalinity of the water, when carried by running water into fish farms, rivers, streams and so on causes toxic effects on fish. The 96 h LC50 value for *Clarias gariepinus* suggest that the fish showed a quick response to the chemical therefore, LC50 of 23.5ml/8L is therefore recommended as the tolerant level for Caustic soda.

Caustic soda is toxic to *Clarias gariepinus* at higher concentrations and its management is necessary. There is also need for more study to set maximum permissible levels of chemical compounds such as caustic soda for fish meant for human consumption in Nigeria.

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REFERENCES

Ahmadi, M., and Seyedin, S. H. (2019). Investigation of NaOH properties, production and sale mark in the world. J. Multidis. Eng. Sci. Techn, 6(10), 10809-10813.

Akin-Obasola, B. J., Dominic, D. N. and Oyekanmi F. B. (2022): Range finding and definitive (acute) test of Caterpillar granules on Clarias gariepinus fingerlings. Madridge Journal of Aquaculture Research and Development. 3(1):49-55.

Akin-Obasola, B. J. (2019). Range finding, acute and sublethal test of petrol and engine oil mixture on African catfish, Clarias gariepinus (Burchell, 1822). Int J Fisheries Aquat Stud, 7(6), 16-20.

Khan, S., and Khan, A. R. (2023). Water Quality Analysis and Treatment. BFC Publications.

Boyd, C. E. (2017). General relationship between water quality and aquaculture performance in ponds. In Fish diseases (pp. 147-166). Academic Press.Helfman G., Collette B. and Facey D. (1997). The diversity of fishes, 1st edition.

Ishaq, A., Said, M. I. M., Azman, S., Abdulwahab, M. F., and Alfa, M. I. (2022). Impact, mitigation strategies, and future possibilities of Nigerian municipal solid waste leachate management practices: a review. Nigerian Journal of Technological Development, 19(3), 181-194.

Olanrewaju, G. O., Sarpong, D. D., Aremu, A. O., and Ade-Ademilua, E. O. (2022). Growth performance and nutritional composition of Clarias gariepinus in flood-and-drain aquaponics coupled with three species of leafy vegetable. bioRxiv, 2022-10.

Ward G.S. and Parrish, P.R. (1982). Manual of methods in aquatic environmental research Part 6, Toxicity Tests. F.A.O. Fish tech. 185: 1-23.

Ray, D., Panerjeo, S. K. and Chattejee, M.I. (1999). Bioaccumulation of Nickel and Vanadium in tissues of Catfish Batracchus. Journal of Inorganic Biochemistry 38(I): 69-173. 29

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

CHANGES IN BLOOD COMPOSITION OF *Sarotherodon melanotheron* EXPOSED TO BUTACHLOR IN THE LABORATORY

[1]Isaac, Q. M1, [2]O. A. Akinrotimi, [3]K.N. Owhonda, [4]F.O.Omodu, [5]P.O.Nwosu, [6]P. Iteze, [7]L. S. Ogbuzuru-Ebe and [8]C. D. Ogolo

[1,7]African Regional Aquaculture Center, of Nigerian Institute for Oceanography and Marine Research, Port Harcourt, Victoria Island, Rivers State, Nigeria.
[2,3,4,5,6,8]Department of Mariculture, Nigerian Institute for Oceanography and Marine Research, Buguma, Rivers State, Nigeria.

Corresponding author:
ojoakinrotimi@gmail.com, +2348065770699, 0000-0003-2775-645X

ABSTRACT
The haematological features of Sarotherodon melanotheron that was subjected to butachlor treatment in the laboratory were assessed. Over the course of fifteen days, the fish were exposed to the chemical at five different concentrations: 0.00 (control), 0.05, 0.10, 0.15, and 0.20 mg/L. The five water quality indicators measured during the exposure were temperature, pH, dissolved oxygen, nitrite, and ammonia. Following the experiment, fish blood samples were collected, and their haematological parameters were assessed using standard laboratory procedures. The results of the investigation demonstrated that ammonia and nitrite levels increased in proportion to the chemical's quantity. The dissolved oxygen levels, on the other hand, dropped. While the temperature and pH were within the same range of 29.01-29.88 and 6.65-6.68 respectively. Significant reductions ($P<0.05$) in haemoglobin (Hb), packed cell volume (PCV), red blood cell count (RBC), and platelet concentrations were among the most significant toxic manifestations. Dose-dependent alterations were also observed in mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC).The chemical caused significant changes in the blood composition of S.melanotheron, which can be used to monitor the health status of the fish in aquatic medium.

Keywords:
Toxicology,
Blood composition,
Sarotherodon melanotheron,
Butachlor

INTRODUCTION

Wastes from homes, businesses, farms, and towns enter the aquatic environment, resulting in an increasing number of toxins. Pollutants have a broad range of impacts on organ function, reproductive status, species survival, population growth, and biodiversity that influence organisms at all levels, including humans and ecosystems (Gabriel et al., 2007a). Aquatic environments are impacted by pollutants and hazards released by mining, agriculture, and industry. This could have a harmful effect on aquatic life. One of these pollutants is biocides, which has a detrimental effect on fish and other aquatic organisms (Gabriel et al., 2007b). Numerous pathways, including direct application, spray-drift, runoff, leaching, manufacturing discharge, and sewage, allow toxic chemicals to infiltrate aquatic habitats. A variety of aquatic non-target creatures, particularly fish, are adversely affected by all of these in terms of health (Akinrotimi and Gabriel, 2012; Gabriel et al., 2007c). Furthermore, because fish react to hazardous substances similarly to bigger vertebrates, they can be used to evaluate compounds that may be dangerous to humans and are frequently utilized in biomonitoring (Akinrotimi *et al.*, 2017).

Haematological markers, which have been shown to be a reliable indicator of physiological alterations and general health in fish, can be altered by chemical exposure (Banee *et al.*, 2018). According to Gabriel et al. (2017), fish exposed to sublethal concentrations of toxins can change blood parameters like hemoglobin levels and red blood cell (RBC) counts. Substances, like herbicides have been employed in several investigations to evaluate the detrimental effects of various substances on fish. Fish can be used as helpful indicators of a chemical's toxicity. In addition to the kind of xenobiotic, exposure time, and concentration, fish under chemical stress may exhibit distinct hematological components based on a range of biological and non-biological parameters (Gabriel *et al.*, 2007c). Blood parameters play a crucial role in evaluating the structural and functional health of fish exposed to pollutants, as blood serves as a pathophysiological reflection of the entire organism. Investigating the mechanisms underlying the impacts of different pollutants is made possible by changes in the blood profile, which demonstrate variations in the organism's metabolism and biochemical processes brought on by these pollutants (Joseph and Raj, 2020). Fish are particularly sensitive to physical and chemical changes that may be reflected in the components of their blood because they interact with their environment so directly on a physical and chemical level (Carraschi, 2022). Fish that are exposed to chemical pollution may experience changes in their hemoglobin levels. An accurate depiction of the anatomical and molecular changes taking place within the body can be seen in blood tissue (Oruc, 2020).

Worldwide, herbicides are extensively used in agricultural practices followed by other pesticides like insecticides and fungicides (Liu *et al.*, 2019). Among different types of herbicides, butachlor have been widely used in Nigeria to control unwanted weeds in rice fields due to their low cost and broad-spectrum activity (Mave *et al.*, 2020). Due to its extensive use against target weed and its persistence on the soil, it can reach aquatic ecosystem via drainage, leaching, erosion and runoff water from treated areas (Joel and Edna, 2022). Consequently, it has detected at the range from 0.1 to 1.4 μg L-1 in surface waters (Mave *et al.*, 2020) The previous studies clearly envisage that the toxic nature of butachlor has been posing a potential threat to the agro-ecosystem, aquatic animals and human health (Liu *et al.*, 2019).To the best of our knowledge, there are no reports on the effects of butachlor on haematological parameters of *S. melanotheron*. We therefore report for the first time the influence of butachlor on blood composition of this specie in order to understand the mechanism of toxicity of this widely used herbicide on the internal physiology of fish. Thus, this study evaluated the haematological reactions of *Sarotherodon melanotheron* that were exposed to butachlor in a laboratory setting.

MATERIALS AND METHODS

Experimental Location and Fish

The study was carried out at the African Regional Aquaculture Center, a division of the Nigerian Institute for Oceanography and Marine Research, in Buguma, Rivers State, Nigeria. Three hundred (300) *Sarotherodon melanotheron* were harvested from the recruitment ponds of the center during low tide, of which 150 were juveniles (mean length: 10.99 cm; mean; weight: 60.77 g) and 90 adults (mean length: 14.77 cm; mean weight: 100.42g). Six 50-liter open plastic containers were used to transport the fish to the lab, where they acclimated for seven days.

Preparation of Test Solutions and Exposure of Fish

Butachlor with trade name butaforce was purchased for this experiment from a supermarket in Port Harcourt, Nigeria. *Sarotherodon melanotheron* were exposed to the chemical in triplicates at doses of 0.50, 1.50, 2.50, and 2.50 mg/L, this was based on previously conducted acute toxicity test, as well as 0.00 mg/L as the control. Ten fish were introduced at random into each test tank for each of the life stage. The fifteen-day test was carried out. The water in the experimental tanks was renewed every day from the stock solution based on the concentrations of each chemical. Commercial feed was supplied to the fish twice daily at 3% body weight.

Haematological Analysis

A small hand net was used to remove each fish one at a time, and they were then arranged belly up on a table. With the help of a 2 mL plastic syringe, blood samples of approximately 5 mL were taken from the caudal peduncle, and 2 mL of the blood were distributed into an anticoagulant-treated (EDTA) tubes' for hematological investigations. Blood samples were analyzed using an automated analyzer.

Evaluation of Water Quality Parameters

Water temperature was recorded using mercury-filled glass thermometers, while pH was measured using a pH meter (Model 3013, Jenway, China). Using standard laboratory technique described by APHA (2005), the values of dissolved oxygen, nitrite, and ammonia were assessed.

Data Analysis

The data obtained from the work was compiled and analyzed with the help of SPSS statistics program 22.0 for Window. To identify the significant differences in measured variables between the control and experimental groups, a one-way analysis of variance (ANOVA) was used. Tuckey's multiple comparison tests was used to distinguish between the treatments that differed significantly from one another.

RESULTS

The results of physico-chemical parameters in the experimental tanks during the exposure period are presented in Table 1. The values of temperature and pH were statistically similar in all concentrations of butachlor. While ammonia, and nitrite significantly increased as concentration increases. However, the dissolved oxygen reduced with increasing concentrations of the chemical. The effects of the chemical on the haematological of the juvenile and adult sizes of *Sarotherodon melanotheron* are shown in Tables 2 and 3 respectively. The result showed a significant reductions ($P<0.05$) in hemoglobin (Hb), packed cell volume (PCV), red blood cell count (RBC), and platelet concentrations and dose-dependent alterations were observed in mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) of the exposed fish.

Table 1: Physicochemical Parameters of Water in Tanks of *S. melanotheron* exposed to Chronic Concentrations of Sodium Bromide (Mean ± SD)

Concentrations (mg/L)	Physico- Chemical Parameters of Water				
	Temperature (^{0}C)	pH	DO (mg/l)	Nitrite(mg/l)	Ammonia(mg/l)
0.00	29.77±0.99^a	6.72±0.66^a	6.72±0.62^a	0.00±0.00^a	0.01±0.01^a
0.05	29.01±0.88^a	6.88±0.44^a	6.48±0.88^a	0.02±0.01^b	0.17±0.05^b
0.10	29.88±0.47^a	6.82±0.71^a	5.99±0.77^b	0.03±0.01^b	0.27±0.02^c
0.15	29.71±0.81^a	6.65±0.34^a	5.61±0.99^b	0.05±0.01^c	0.32±0.05^c
0.20	29.88±0.99^a	6.67±0.56^a	4.99±0.88^c	0.05±0.01^c	0.39±0.09^c

Means within the same column with different superscripts are significantly different ($P<0.05$)

Table 2: Haematological Parameters in Juvenile of S. melanotheron exposed to chronic concentrations of Butachlor (Mean ± SD)

Conc. (mg/l)	PCV (%)	HB (g/dl)	RBC (Cells x 10^{12})	Platelets (Cells x 10^{12})	MCV (fl)	MCH (pg)	MCHC (g/dl)
0.00	38.88±8.05^b	11.90±0.86^b	7.88±0.54^b	298.66±12.66^b	76.78±5.33^b	24.77±3.54^a	33.00±6.77^a
0.05	34.88±1.98^b	11.44±2.77^b	6.61±1.88^b	288.09±21.98^b	71.03±7.56^b	22.91±1.88^a	33.92±7.55^a
0.10	31.66±6.77^b	10.77±2.88^b	5.56±1.77^b	277.39±77.02^b	70.77±2.77^b	23.99±3.76^a	32.03±9.88^a
0.15	26.09±2.32^a	9.04±1.77^a	4.88±1.77^a	261.09±11.00^a	65.88±7.44^a	23.02±4.77^a	34.76±9.66^a
0.20	22.77±4.41^a	7.12±1.65^a	3.44±1.55^a	230.33±12.55^a	63.88±7.98^a	23.76±4.88^a	34.01±9.99^a

Means within the same column with different superscripts are significantly different ($P<0.05$)

Key: PCV – Packed Cell Volume, HB – Haemoglobin, RBC – Red Blood Cell, ,MCV – Mean Corpuscular Haemoglobin, MCH – Mean Corpuscular Haemoglobin, MCHC – Mean Corpuscular Haemoglobin Concentrations

Table 3: Haematological Parameters in Adult of *S. melanotheron* exposed to chronic concentrations of Butachlor (Mean ±SD)

Conc. (mg/l)	PCV (%)	HB (g/dl)	RBC (Cells x 10^{12})	Platelets (Cells x 10^{12})	MCV (fl)	MCH (pg)	MCHC (g/dl)
0.00	39.02±8.55 ^{b}	13.01±0.08 ^{b}	9.02±0.77^{b}	355.99±11.99 ^{b}	72.77±6.04 ^{b}	24.88±9.00 ^{a}	33.02±9.22^{a}
0.05	35.32±7.01^{b}	12.33±2.56 ^{b}	7.01±1.04 ^{b}	302.66±15.08 ^{b}	69.87±9.55^{a}	23.99±9.66 ^{a}	34.87±9.93 ^{a}
0.10	33.02±6.77^{b}	10.01±2.77 ^{b}	5.43±1.02 ^{a}	290.00±12.88 ^{a}	67.02±9.44 ^{a}	22.77±9.43 ^{a}	33.03±9.05 ^{a}
0.15	28.77±9.32^{a}	9.08±1.77 ^{a}	4.81±1.55 ^{a}	282.70±52.48 ^{a}	67.76±4.98 ^{a}	21.89±9.88 ^{a}	32.66±9.11 ^{a}
0.20	26.54±9.66 ^{a}	7.99±1.01 ^{a}	4.32±1.77^{a}	251.52±12.88^{a}	68,98±9.88 ^{a}	20.03±7.77 ^{b}	32.66±9.02^{a}

Means within the same column with different superscripts are significantly different (P<0.05)
Key: PCV – Packed Cell Volume, HB – Haemoglobin, RBC – Red Blood Cell, MCV – Mean Corpuscular Haemoglobin, MCH – Mean Corpuscular Haemoglobin, MCHC – Mean Corpuscular Haemoglobin Concentrations

DISCUSSION

Aquatic life health is indicated by the physical and chemical characteristics of natural features such temperature, pH, dissolved oxygen, nitrite, and ammonia (APHA, 2005). It was found that the values of dissolved oxygen, ammonia, and nitrite differed significantly (P<0.05) from the control. While the values of pH and temperature parameters were statically within the same range with no statical differences. Even though ammonia is an essential source of nutrients, fish that live in water with high ammonia concentrations risk dying. For an aquatic body, the average value of ammonia obtained in this work was high. Ammonia is naturally produced by fish metabolism, which consumes food to produce the energy, minerals, and proteins needed for life and growth. This may be the reason why the value of ammonia has increased in the chemical exposed experimental tanks when compared to the control tanks. In comparison to other physicochemical characteristics, nitrates usually have a smaller direct impact on marine organisms. However, excessive nitrite levels in the water might make it impossible for aquatic life to survive. The experiment's nitrate levels ranged from 0.01 to 0.39 mg/l. This is in line with studies conducted by Nte and Akinrotimi (2019), who found that nitrite are more harmful to aquatic invertebrates at higher concentrations and for longer exposure times.

Fish exposed to various aquatic pollutants and poisons have been employed as a sensitive stress indicator by using haematological markers. Aquatic creatures may not always die when sub lethal toxin quantities are present in the environment. However, these poisons have the potential to bioaccumulate over time and pose a serious health risk to aquatic organisms like fish as well as higher trophic levels like humans. (Carraschi, 2022). Because of the way that blood and water interact, contaminants can cause a variety of physiological dysfunctions in fish that affect haematological parameters. Essential indices of fish oxygen transport ability, such as packed cell volume (PCV), hemoglobin (Hb), and red blood cell counts (RBC), allow for the correlation between fish health and oxygen levels in their surroundings (Gabriel et al., 2019). *S. melanotheron* demonstrated a considerable reduction in PCV, Hb, and RBCs along with a large drop in the dissolved oxygen level with increasing concentration and duration of exposure to butachlor. The poisonous substance's inhibitory effect on the hemoglobin-producing enzyme system as a result of chemical exposure is another possible explanation, as is the disturbance of iron production. (Prasad et al., 2020). Moreover, a decrease in the RBC count, Hb concentration, and PCV values seemed to indicate erythrocyte hemolysis and/or permanent renal function impairment (Prasad et al., 2020).Besides, Adamu and Audu (2018) hypothesize that the notable decrease in PCV may be caused by gill injury and/or impaired osmoregulation, which can lead to hemodilution and anemia. Erythropoietic activity may have decreased, which would explain the dip in RBCs. Erythropoietin, which is made in the kidney, controls erythropoietic activity in most vertebrates, including fish.

In this study, decrease in Hb concentration in the exposed fish could be caused by either a slower rate of synthesis or a faster rate of Hb oxidation (Akinrotimi et al., 2019). Corresponding to this result, Akirotimi et al. (2020) found that fish exposed to cypermethrin had lower amounts of PCV, hemoglobin, and red blood cells, and they linked this to the pesticide's negative effects on cell death and/or shrinkage. Fish treated with malathion had lower levels of PCV, Hb concentrations, and RBC counts (Zaki et al., 2019). When juvenile C. gariepinus was treated with glyphosate herbicide similar outcomes were seen in the exposed fish as reported by Gluszaket al. (2016). The more sensitive erythrocyte indices, such as mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC), can cause reversible changes in the fish homeostatic system. Variations in these indicators are closely linked to variations in PCV levels, Hb concentration, and RBC count. The findings demonstrated MCHC's significant changes. There were slight variations observed between the MCV and the control. This pattern is consistent with research by Adeyemo (2008) who discovered that experimental fish exposed to lead had higher MCV, MCH, and MCHC levels.

CONCLUSION AND RECOMMENDATIONS

In summary, butachlor reduced the volume of packed and red blood cells, which had a detrimental effect on *S. melanotheron* health. These aberrant changes in the exposed fish's metabolic pathways occurred even at very low concentrations, demonstrating the chemical's degree of toxicity to living things. The toxicant's impact on the physicochemical characteristics of the water caused stress-related behaviors in the test fish, such as increased breathing rate, gasping for air, restlessness, and loss of balance. Therefore, efforts need to be focused on ensuring that this chemical are not allowed to leak into water bodies.

REFERENCES

Adamu, K.M, and Audu, B.S (2018). Haematological assessment of the Nile tilapia Oreochromis niloticus exposed to sublethal concentrations of Portland cement powder in solution. International Journal of Zoological Research, 4(1), 48-52.

Adeyemo, O.K. (2008). Histological Alterations Observed in the Gills and Ovaries of Clarias gariepinus Exposed To Environmentally Relevant Lead Concentrations. Journal of Environment and Health, 70, 48-51.

Akinrotimi, 0. A., Ansa, E. J., Owhonda, K. N., Edun, O.M., Onunkwo, D. N., Opara, J. Y., Anyanwu, P. E. and Amachree, D. (2007). Variations in oxygen carrying capacity of Sarotherodon melanotheron blood in different acclimation media. Journal Animal Veterinary Advances, 6(8), 932 – 937.

Akinrotimi, 0. A., Ansa, E. J., Owhonda, K. N., Onunkwo, D. N., Edun, 0. M., Anyanwu, P. E., Opara J. Y. ,and Cliffe, P. T.(2017). Effects of Transportation Stress on Haematological Parameters of Black Chin Tilapia, Sarotherodon melanotheron. Journal of Animal Veterinary and Advances, 6(7), 841-845.

Akinrotimi, O.A., and Gabriel, U.U. (2012). Haematological profiles of Clarias gariepinus brood fish raised in water recirculating aquaculture system. Advances in Agriculture, Science and Engineering Research, 2(2),97-103.

Akinrotimi, O.A., Aranyo, A.A., and Ibemere, I.F. (2019). Effects of capture, handling and confinement on the glucose levels of black jaw tilapia Sarotherodon melanotheron. Advances in Students Research, 1(2), 27-30.

Akinrotimi, O.A., Okereke, A.N., and Ibemere, I.F. (2011). Studies in plasma glucose as biomakers for stress response in Tilapia guineensis. African Journal of General Agriculture, 7(3), 125 – 130.

APHA, (2005) Standard Methods for the Examination of Water and Wastewater. 21st Edition, American Public Health Association/American Water Works Association/Water Environment

Federation, Washington DC.

Banaee, M, Sureda A, Mirvaghefi A.R., and Ahmadi, K. (2018). Effects of diazinon on biochemical parameters of blood in rainbow trout (Onchorhynchus mykiss). Pesticides Biochemistry and Physiology, 99,1-6.

Carraschi, S.P. (2022). Histopathological biomarkers in Pacu (Piaractus mesopotamicus) infected with Aeromonas hydrophila and treated with antibiotics. Ecotoxicology and Environmental Safety, 83,115-120.

Gabriel, U.U, Anyanwu, P.E, and Akinrotimi O.A (2007a). Effect of Freshwater Challenge on the Blood Characteristics of Sarotherodon melanotheron. Agricultural Research Journal, 2, 388-391.

Gabriel, U.U., Anyanwu, P. E. and Akinrotimi, O. A. (2007b). Comparative Effects of Different Acclimation Media on Haematological Characteristics of Brackish water tilapia, Sarotherodon melanotheron (Rupell, 1852). .Journal of Fishery International, 2 (3), 195 – 199.

Gabriel, U.U., Anyanwu, P.E. &Akinrotimi O. A. (2007c). Effect of Freshwater Challenge on the Blood Characteristics of Sarotherodon melanotheron. Agricultural Journal, 2(3), 388-391.

Gabriel U.U, Anyanwu P.E, and Akinrotimi OA (2007d). Comparative Effects of Different Acclimation Media on Haematological Characteristics of Brackish water tilapia, Sarotherodon melanotheron (Rupell, 1852). Journal of Fishery International, 2,195-199.

Gabriel, U. U., Akinrotimi, O. A., Anyanwu, P. E., Bekibele, D. O. and Onunkwo, D. N. (2017). The role of dietary phytase in formulation of least cost and less polluting fish feed for sustainable aquaculture development in Nigeria. African Journal of Agricultural Research, 2(7), 299-286.

Gabriel, U.U, Anyanwu, P.E, and Akinrotimi, O.A. (2019). Blood Characteristics Associated with Confinement Stress in Black Chin Tilapia Sarotherodon melanotheron. Journal of Fisheries. International, 2, 186-189.

Gluszak, L, Santos M.D, Crestani M, da Fonseca M.B, de Araujo Pedron F, Duarte M.F, and Vieira V.L.P. (2016). Effect of glyphosate herbicide on acetylcholinestrase activity and metabolic and hematological parameters in piava (Leporinus obtusidens). Ecotoxicology and Environmental Safety, 6, 237-241.

Joel I.O, and Edna E.O (2022). Toxic Stress Exhibited by Juveniles of Clarias gariepius Exposed to acute concentrations of Vestaline (Pendimethalin) Herbicide. American Journal of Aquaculture and Animal Science, 1(1), 21-26.

Joseph, B, and Raj S.J. (2020). Effects of Nuracron toxicity on the serum, protein content of Cyprinus carpio. Toxicology and Environmental Chemistry, 92,1889-1893.

Liu, Z., He, Y., Huang, P. and Jilani, G. (2019) The Ratio of Clay Content to Total Organic Carbon Content Is a Useful Parameter to Predict Adsorption of the Herbicide Butachlor in Soils. Environmental Pollution, 152, 163-171.

Mave J.B., Davis K.B. and Parker N.C. (2020). Plasma corticosteroid and electrolyte dynamics of hybrid striped bass (white bass x striped bass) during netting and hauling. Proceedings of the World Marciculture Society 11, 303-310

Nte, M.E., and Akinrotimi, O.A. (2019). Biochemical changes in black jaw tilapia (Sarotherodon melanotheron) treated with sub lethal levels of industrial effluents. Advances in Agriculture, Science and Engineering Research, 1(2), 25-33.

Oruc, E.O. (2020). Oxidative stress, steroid hormone concentrations and acetylcholinestrase activity in Oreochromis niloticus exposed to chlorpyrifos. Pesticide Biochemistry and Physiology, 96,160-166.

Prasad, M, Kumar A, Suzuki N, and Srivastav A.K. (2020). Botanical pesticide Nerium indicum alters prolactin cells of stinging catfish Heteropneustes fossilis. International Journal of Zoological Investment, 1,77-84.

Zaki MS, Mostafa SO, Nasr S, Noor El-Deen AI, Ata N.S, and Awad I.M (2019). Biochemical, clinic opathological and microbial changes in Clarias gariepinus exposed to pesticide malathion and climate changes Reports Opinion, 23, 6-11.

EFFECT OF AQUEOUS SOLUTION OF AFRICAN LOCUST BEAN TREE *(Parkia biglobosa)* LEAF EXTRACTS ON THE HAEMATOLOGY OF AFRICAN CATFISH *(Clarias gariepinus)* JUVENILES AND WATER QUALITY OF CULTURE MEDIUM.

[*1]Yusuf, A., [2] A. Yunusa,[1] M.M. Salaudeen, [1] D.Y. Gebi, [3] S.N. Anayeokwu
[1]Department of Fisheries and Aquaculture, Prince Abubakar Audu University, Anyigba. Kogi State, Nigeria.
[2] NAERLS Ahmadu Bello University, Zaria, Nigeria.
[3]Department of Marine Science, University of Delta, Agbor, Delta State.

Corresponding Author:
abelyusuf2001@gmail.com
08033944552

ABSTRACT

The acute toxicity of aqueous extract of African Locust Beans tree (Parkia biglobosa) leaf on African catfish (Clarias gariepinus) juveniles was investigated in a static bioassay to determine the median lethal concentrations (LC50) at 96 hours of exposure. The bioassay was conducted in the water quality laboratory of Prince Abubakar Audu University Anyigba, Kogi State. Six graded concentrations of 0, 85.5, 90.5, 95.5, 100.5 and 105.5 mg/l of the aqueous extract were applied to Clarias gariepinus juveniles in plastic containers. The 96 hours LC50 values (with 95% confidence limits) estimated by probit analysis was 90.241 mgl-1.Fishes exposed to extract of P.biglibosa leaf (0.0, 85.5, 90.5, 95.5, 100.5 and 105.5 mg/l) for 96 hours revealed that aqueous extract of Parkia biglobosa leaf causes alterations in various blood parameters. Red blood cell (RBC) and white blood cell (WBC) counts, haemoglobin concentration and haematocrit values were decreased. The toxicity of the aqueous extract of the plant against Clarias gariepinus was both time and dose dependent. It is thought that this plant extract, the leaf and other parts such as the bark and the roots, would be useful in aquaculture to eradicate predators and competing wild fish from nursery, rearing and stocking ponds prior to the stocking of commercially important fry and fingerlings of desired species

Key words:
African catfish, haematology, leaf extract, Parkia biglobosa, water quality

INTRODUCTION

Haematological analysis can be used for monitoring the health status of fish from the information's it provides (Ayanda et al., 2015). Hematological indices can vary depending on so many factors ranging from environmental factors to fish species, age, sexual maturity, the toxicant, length of exposure, water quality, and health condition (Ayoola, 2018). Clarias species is a widely distributed fish which constitutes one of the major fisheries in Asia and Africa. Some records have shown that Clarias species contributes about 14% of over 6,000 tonnes of annual fish production from all fisheries sectors in Nigeria (Akin-obasola, 2019). The common species found in Nigeria are Clarias gariepinus, Clarias anguillaris, Clarias pachynema, Clarias macromystax,Clarias agboyiensis, Clarias jaensis, Clarias buthupogon and Clarias camerunensis. (Idodo-Umeh 2003). The Clarias gariepinus is a prominent cultured species because of its hardiness and fast growth rate. Several investigations have been carried out on various toxicants with Clarias sp. (Ani *et.al.*, 2017). Parkia biglobosa (Jacq), African Locust Beans tree is a perennial deciduous tree of high commercial value; it is used as a source of food, medicinal agents, timber, fuel and fibre (Orwa, *et al.*, 2009). In West Africa, the seeds of P. biglobosa provide a rich source of vegetable protein for humans; the husks are not eaten by humans, but they serve as feed for livestocks (Ajibade and Soetan 2012). The fruits are fermented to a condiment called 'dawa-dawa' or 'iru' used as a flavour intensifier for soups and stews (Ladokun and Adejuwon 2013). The extracts from P. biglobosa have been used as natural pesticides against different pests and diseases due to the phytochemicals present in different parts of the plant. The study therefore investigate the hematological changes in C.gariepinus exposed to P. biglobosa leaf extract as a natural cure for fish disease

MATERIALS AND METHODS

Study Location: The study was conducted at the water quality laboratory of the Department of Fisheries and Aquaculture, Faculty of Agriculture, Prince Abubakar Audu University, Anyigba, Kogi State, located at latitude 7024'16"N and longitude 7037'50.6"E., within guinea savannah middle belt zones of Nigeria. The distribution of trees, grasses and other things in the area is determined by factors such as; fire, demographic pressure, patterns of cultivation, clearing and relief. Trees found in Anyigba do adapt to dry conditions (deciduous) and they shed their leaves in the dry season to control evapotranspiration (Ifatimehin et al., 2012).

Sample Collections and Preparations: Fresh samples of Parkia biglobosa leaf was obtained from Anyigba, Dekina, Kogi State, washed and air dried to constant weight. The dried samples were pounded using a clean laboratory mortar to a fine powder which was then sieved through 0.25 mm sieve. 500 g of the resultant powder was dissolved in two litres of water at room temperature (23± 0.5°C) for 24 h. The extract was filtered using a sieve.

Experimental Fish: Two hundred healthy Clarias gariepinus juveniles (mean weight of 18 ±0.02g) were purchased from Ifeoma farms, Lokoja, Kogi State. The fishes were acclimatized for two weeks under laboratory conditions, during the period, fish were fed 3% of their body weight with Blue Crown commercial fish feed (2mm)

Experimental set-up: Extracts was introduced into 18 circular plastic containers initially filled with 20 liters of dechlorinated, bore hole water at a concentration of 105.50, designated as (T6), 100.50 (T5), 95.50 (T4), 90.50 (T3) and 85.50 (T2) mg/L and 0.00 (T1) mgL-1 served as control. Each concentration had 3 replicates. Fish was randomly be selected and stocked at 10 juveniles per container. Fish was starved for 24hr prior to the commencement of the bioassay and throughout the exposure period which lasted 96hr.

Haematological Analysis

Blood Sampling: Haematology analysis was conducted on the fishes from each treatment in triplicate after the acute toxicity bioassay. The fish used were thoroughly washed according to the procedure of Ayoola (2018) to avoid contamination before their blood samples were collected. They were bled from caudal artery by severing the caudal fin and the blood were collected into anticoagulant bottle (EDTA bottle) labeled to represent each treatment (Ayoola 2018). All the samples collected were taken to Biochemistry Laboratory, Kogi State University, for Haematological analysis using Sysmex (KS-21N) digital. Parameters determined include direct measurement of erythrocyte otherwise known Red Blood Cells (RBCs) (10^12/L), White Blood Cells (WBCs) (10^9/L) Packed Cell Volume (PCV)(g/L) and Platelets. Haemoglobin (Hb) (g/L), Mean Corpuscular Haemoglobin Concentration (MCHC) (g/L), Mean Corpuscular Haemoglobin (MCH) (pg) and Mean Corpuscular volume (MCV)

(fL) and Procalcitonin Test (PCT) were calculated according to the formulae described by Fagbenro et al. (2020) and Oladimeji et al. (2022).
The following were determines as;
Haemoglobin (Hb)
= PCV (%)/3.
Mean Corpuscular Haemoglobin Concentration (MCHC)
(%) = Hb/PCV× 100.
Mean Corpuscular Haemoglobin (MCH)
(pg) = Hb/RBC× 10.
Mean Corpuscular Volume (MCV)
(fl) = PCV/RBC× 10

Water Quality Determination: During the experiment, physico-chemical parameters of bioassay water namely temperature, hydrogen-ion concentration (pH), total dissolved solids (TDS), electrical conductivity (EC) and dissolved oxygen (DO) were monitored (Okeke et, al,.2020). These were measured during the acute toxicity test. Temperature was measured using mercury in glass thermometer and is calibrated in degree Celsius (oc). pH was determined using pH meter (pH model 2602), while electrical conductivity and total dissolved solids were determined using Hanna "Combo" portable hand instrument (Hi 98129 Hanna Instruments, Mauritius). DO (mg/l) was measured using digital oxygen meter (portable DO model JPB 607).
Statistical Analysis: Data collected were subjected to one-way analysis of variance (ANOVA) using SPSS version 20. Significant means were set at $p<0.05$ and separated using Duncan multiple range test. Data also on LC50 (96hrs) were analyzed using the probit-logit transformation method
.

RESULTS

Haematological Analysis: Results of the haematological analysis (Table 1) shows significant differences ($P<0.05$) in the values of MCH, MCHC and WBC. In MCH, T3 was the highest with 33.37 and the lowest is 19.64 in T5. In MCHC, T5 was the highest with 33.47 while T6 was the lowest with 33.30 mean value. The analyzed result of haematology is shown in table 1.

Table 1 : Haematological analysis of *Clarias gariepinus* exposed to aqueous solution of *Parkia biglobosa* leaf extract

PARAMETERS	T1	T2	T3	T4	T5	T6
PCV(%)	10.00±1.41^{a}	8.50±0.70^{a}	11.00±4.2^{a}	10.00±2.8^{a}	8.50±0.71^{a}	8.50±2.12^{a}
RBC(10^6 cells/µL)	1.67±0.23^{a}	1.42±0.13^{a}	1.77±0.75^{a}	1.66±0.49^{a}	1.45±0.17^{a}	1.42±0.35^{a}
HB(g/dL)	3.34±0.47^{a}	2.84±0.24^{a}	3.67±1.41^{a}	3.34±0.94^{a}	2.85±0.25^{a}	2.83±0.71^{a}
MCV(fL)	60.22±0.31^{a}	60.02±0.01^{a}	62.31±3.13^{a}	60.54±0.76^{a}	58.67±1.91^{a}	59.86±0.04^{a}
MCH(pg)	20.03±0.04^{b}	20.00±0.10^{ab}	20.92±0.087^{a}	20.19±0.27^{ab}	19.64±0.56^{b}	19.93±0.02^{ab}
MCHC(%)	33.35±0.02^{ab}	33.41±0.04^{ab}	33.37±0.01^{ab}	33.36±0.04^{ab}	33.47±0.13^{a}	33.30±0.01^{b}
WBC(10^3cells/µL)	5465.00±1187^{b}	3222.50±837.^{c}	3570.00±763.^{c}	6375.00±1212^{a}	6715.00±636.^{a}	2660.00±912.^{c}
PCT(mm)	109.91±15.98^{a}	109.77±0.53^{a}	144.36±28.17^{a}	118.10±12.59^{a}	132.77±11.99^{a}	129.65±12.07^{a}

The value is expressed in mean and standard deviation. Values with different letter superscript in the rows are not significantly different ($p>0.05$).

Keys: PVC = Packed Cell Volume, RBC = Red Blood cell, Hb = Haemoglobin, MCV = Mean Corpuscular Volume, MCH = Mean Corpuscular Haemogblobin, MCHC = Mean Corpuscular Haemogblobin Concentration, WBC =White Blood Cell, PCT =Procalcitonin Test.

Water Quality Parameters: The physiochemical parameters of the test water measured during acute toxicity bioassay; it can be seen that there was significant difference in all the parameters except in the total dissolved solids. pH was highest in control concentration (T1) (6.90) while the lowest is seen in T6 (6.10); Temperature was highest in T5 (28.43oc) and lowest in the control T1 (27.20oc); Electrical conductivity (μS/cm) was lowest in 841.33 in the control concentration while the highest is seen in 991.33 in T6; Dissolved oxygen was highest in the control concentration T1 and lowest in concentration of T6 This is shown in table 2. Below.

Table 2. Water quality parameters during the ex periment.

Treatment (mg/L)	Ph	Temperature (°c)	Water Quality Parameter Electrical Conductivity (μS/cm)	Total Dissolved Solids (mg/L)	Dissolved Oxygen (mg/L)
Control	6.90 ± 0.00^{a}	27.20 ± 0.01^{f}	841.33 ± 0.00^{f}	420.33 ± 0.00	3.91 ± 0.00^{a}
85.5mg/L	6.41 ± 0.01^{b}	27.43 ± 0.00^{e}	870.00 ± 0.01^{e}	434.67 ± 0.00	3.56 ± 0.00^{b}
90.5mg/L	6.34 ± 0.01^{c}	27.65 ± 0.00^{d}	912.33 ± 0.00^{d}	456.33 ± 0.00	3.55 ± 0.01^{c}
95.5mg/L	6.27 ± 0.01^{d}	27.86 ± 0.00^{c}	919.67 ± 0.00^{c}	465.33 ± 0.00	3.42 ± 0.00^{d}
100.5mg/L	6.17 ± 0.00^{e}	28.43 ± 0.00^{a}	953.33 ± 0.00^{b}	478.67 ± 0.00	3.24 ± 0.00^{e}
105.5mg/L	6.10 ± 0.01^{f}	28.30 ± 0.00^{b}	991.33 ± 0.00^{a}	496.67 ± 0.00	3.10 ± 0.00^{f}

Mean in the same column with different superscripts differ significantly ($p<0.05$).

DISCUSSION

The result showed haematological changes in the blood parameters. The changes in blood variables suggest that there was osmotic disturbance and change of oxygen carrying capacity during the exposure of Parkia biglobosa leaf extracts. Similar values were reported for RBC, haemoglobin and hematocrit when fish was exposed to fiazinon (an organophosphate pesticide) (Banae et al. 2011). This was related to destruction of cells and/or decrease in size of cells due to adverse effects of pesticide. Zaki et al. (2009) also reported a decrease RBC count, haemoglobin concentration and packed cell volume (PCV) values in the fish exposed to extract of medicinal plant. Okeke, et.al. (2020) reported decreased haemoglobin, RBC count and haematorit values in Clarias gariepinus exposed to lead nitrate. Toxicants might cause adverse effect on the haemotopoietic organs which reduces the supply of RBC either due to less production and/or increased rate of removal from circulation. Fall in the level of haemoglobin may be the consequence of toxic effects of the extracts on the synthesis of this molecule. The Parkia biglobosa leaf may disrupt the synthesis pathway by affecting the activity of enzyme involved in the synthesis of haemoglobin. Blood cell indices seem to cause change that are more sensitive and cause reversible changes in the homeostatic system of fish. Fluctuations in these indices correspond with value of RBC counts and haemoglobin concentration. A similar respond was noted in common carp and other freshwater fish exposed to acute toxic level of pesticides (Rao, 2010). Physico-chemical parameters of the test water measured during acute toxicity bioassay were within suitable range for the survival and normal growth of C. gariepinus. Hence changes in fish behavior and subsequently death could not have arisen from poor water quality of the test water. On the optimum pH scale for fish growth developed by Badiru (2005), the range for this study (6.10-6.90) corresponds with the desirable range (6.5-9) for the fish production. However, dissolved oxygen range for this study (3.10-3.90mg/L) spans the range for slow growth following long term exposure (1-5mg/L) of the dissolved oxygen scale for warm water fishes by Badiru (2005). Similarly, the temperature range for this study (27.20-28.43) is within the normal range of temperature in the tropics to which fish are adapted (22-350C) as reported by Okeke et.al, (2020).The fact that mortality of fish during acute bioassay was concentration dependents could be directly linked with the direct effect of the toxicant. This is similar to the finding of Babalola and Oni (2018) where a direct relationship between mortality in C. gariepinus and concentration of diethyl phthalate was recorded as dose and time-dependent in such that as the exposure time increased from 12 to 96 hours, the median concentration reduced. The lack of mortality in the control group was also reported by Ayuba and Ofojekwu (2002) who exposed Clarias gariepinus fingerlings to the acute toxicity of the root of Jimsons weed (Datura innixia) seed extract. The concentration dependent nature of fish mortality in this study also agreed with the work of Fafioye et al. (2004) who exposed C. gariepinus to P. biglobosa extracts. However there is difference in the result of the present study and that of Abalaka and Auta (2010), which may be due to the difference in age, parts of the plants used (toxicants) and environment conditions. The result of this investigation agrees with the earlier works of Oti (2002) and Oshode et al. (2008).when they exposed fish to acute concentrations of different toxicants. This is similar to the findings of Okomoda and Ataguba (2011).

CONCLUSION

This result shows that aqueous extract of P. biglobosa leaf caused some clinical haematological change and ultimate death when exposed to C. gariepinus juvenile. This mean that the extract of P. biglobosa leaf equally have pesticide property like the extract of the barks of the same plant on C. gariepinus and can therefore, be used to eradicate unwanted fishes from ponds prior to the stocking of desired fish species. One can also deduce from this research work that the introduction of P. biglobosa into water bodies would threaten the life and existence of fish

RECOMMENDATION

This plant (Parkia biglobosa) is recommended to be used as a biological control in eradicating predators and unwanted organisms in the ponds by farmer instead of using agrochemical, but using for obnoxious methods of fishing (poison) in the wild should be discouraged and caution should be observed when it is being used as insecticides.

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REFERENCES

Abalaka, S.E and Auta, J. (2010). Toxic effects of the aqueous and ethanol extracts of Parkia biglobosa pods on Clarias gariepinus adults. World Journal of Biological Research, 3: 9 –17.

Ajibade, T.O., Soetan, K.O (2012). Evaluation of haematological and plasma biochemical effects of aqueous extracts of Parkia biglobosa seeds in rats. African Journal of Biotechnology. 2012;11(88):15446-15450.

Akin-Obasola, B.J., (2019). Range finding, acute and sub-lethal test of petrol and engine oil mixture on African cat fish Clarias gariepinus (Burchell, 1822). International Journal of Fisheries and Aquatic Studies 7(6): 16-20.

Ani, L.C., Nwamba, H.O., Ejilibe, C.O., and Nwani, C.D., (2017). Acute Toxicity of Glyphosate-Based Herbicide Glycot on Juvenile African Cat Fish Clarias gariepinus (Burchell 1822). Journal of fisheries and livestock production5:3DOI: 10.4172/2332-2608.1000252

Ayanda, O.I., Oniye, S.J., Auta J.and Ajibola, V.O. (2015). Acute toxicity of Glyphosate and Paraquat to the African Catfish (Clarias gariepinus, Teugels 1986) using some Biochemical Indicators. Tropical Zoology, 28 (4): 152–162, http://dx.doi.org/10.1080/03946975.2015.1076661

Ayoola,S.O.(2018). Histopathological effects of glyphosate on juvenile African Catfish (Clarias gariepinus), Am. Eurasian J. Agric. Environ. Sci. 4 (3) 65-78

Ayuba, V.O and Ofojekwu, P.C. (2002). Acute toxicity of the root extract of Jimson sWeed, Datura innoxia to the African catfish (Clarias gariepinus) fingerlings. Journal of Aquatic Science, 17(2):131- 133.

Babalola, O.O., and Oni, A.A (2018). Toxicity Testing of Industrial Wastewater Using Bioassays. Journal of Environmental Science and Health, B, 53(5), 321-329

Badiru, A.B. (2005).Water Quality Monitoring: A Practical Guide for Engineers and Scientists. CRC Press, 272 pp.

Fafioye, O.O., Adebisi, A.A. and Fagade, S.O. (2004). Toxicity of Parkia biglobosa and Raphia vinifera extracts on Clarias gariepinus juveniles. African Journal of Biotechnology, 3: 627-30.

Fagbenro, O.A., Bello-Olusoji, O.A., Oyediran, O.S., and Ayandiran, T.A. (2020). Haematological and biochemical changes in Clarias gariepinus fed diets containing different levels of protein. Journal of Animal Science, 98(2) 554-563

Idodo-Umeh, G (2003). Freshwater Fishes of Nigeria (Taxonomy, Ecological notes, Diet and Utilization) Idodo-Umeh Publishers Limited, 52 Ewan Road Benin City pp243. Ifatimehin, O.O., Odogbo, E.V. and Falola, O.O. (2012). An Analysis of the Spatial Distribution of Plasmodium sporozoites and Effects of Climatic correlates on Malaria Infection in Anyigba Town, Nigeria. Journal of Natural and Applied Sciences. 3(2): 93-104

Ladokun, O.A. and Adejuwon, A.O. (2013). Nutritive and microbial analysis of two types of fermented locust bean (Parkia biglobosa). Academia Arena. 2013;5(5):15-17. 16. Pankaja SC. Phytochemical analysis of Citrus sinensis Peel. International Journal of Pharma and Bio Sciences. 2013;4(1): 339–343.

Okeke, O.C, Nwani, C.D, Ugwu, D.O, Onyishi, G.C, Ekeh, F.N, Atama, C, Eneje, L.O. (2020). Toxicity of the chlorpyrifos-based pesticideTermifos: effects on behaviour and biochemical and haematological parameters of African catfish Clarias gariepinus. Tropical Journal of Natural Product Research 6 (11): 27-41

Oladimeji, B.O., Omitoyin, B.O., and Adejumo, A.O. (2022). Normal haematological values for Clarias gariepinus. Journal of Fisheries and Aquatic Science, 17(1)1-9.

Oshode, O.A., Bakare, A.A., Adeogun, A.A. and Sowunmi, A. A. (2008). Ecotoxicological Assessment using Clarias gariepinus and Microbial Characterization of Leachate from Municipal Solid Landfill, International Journal of Environmental Research, 2(4):391-400.

Oti, E.E. (2002). Acute toxicity of cassava mill effluent to the African catfish fingerlings. Journal of Environmental Biology, 20(3): 112-117.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. and Anthony, S. (2009). Agro forest tree database: A tree reference and selection guide; 2009.

Zaki, A. (2009) Medicinal plants, 8th edn. Tehran, Iran.Tehran University Publication, 889p

CHANGES IN SOME METABOLITES IN THE PLASMA OF *Coptodon guineensis* (Gunther, 1862), EXPOSED TO BUTACHLOR IN THE LABORATORY

[1]Akinrotimi O. A, [2]O. M. Edun, [3]K. N. Owhonda, [4]P. O. Nwosu, [5]F. O. Nwosu, [6]P. Iteze, [7]C. D. Ogolo and [8]L. S. Ogbuzuru-Ebe

[1,2,3,4,5,6]Department of Mariculture, Nigerian Institute for Oceanography and Marine Research, Buguma P.M.B. 5122, Port Harcourt, Rivers State, Nigeria
[7]African Regional Aquaculture Centre/Nigerian Institute for Oceanography and Marine Research, Aluu. P.M.B. 5122, Port Harcourt, Rivers State, Nigeria

Corresponding author:
ojoakinrotimi@gmail.com, +2348065770699, 0000-0003-2775-645X

ABSTRACT
This research investigated the metabolic responses in Coptodon guineensis subjected to varying concentrations of butachlor at 0.00 (control), 0.10, 0.20, 0.30, and 0.40 mg/L. During the study, some water quality parameters were evaluated: temperature, pH, salinity, dissolved oxygen, nitrite, and ammonia. A total of 150 C.guineensis were sourced from the creek and were divided into two size categories: Group 1 included juveniles with an average length of 15.77 ± 1.08cm and an average weight of 90.99 ± 7.55 g and group 2 consisted of adults with an average length of 22.59 ± 9.34 cm and an average weight of 188.94 ± 21.02 g. They were exposed to the chemical for a period of 15 days. Following the experiment, blood samples were collected from the fish, and metabolites profiles were analyzed using standard laboratory methods. The findings indicated that urea levels were significantly elevated ($P < 0.05$) in the exposed fish compared to the control group, while levels of creatinine, total bilirubin, and total protein were significantly reduced ($P < 0.05$) in the exposed C.guineensis. Notably, the juvenile fish exhibited more pronounced metabolic alterations. This study provides foundational data that may facilitate future comparative research on metabolic stress in aquatic organisms from contaminated coastal environments and enhance effective bio-monitoring of aquatic life.

Keywords:
Metabolites, Butachlor, Pollutants Tilapia, Toxicity.

INTRODUCTION

Pollutant levels in aquatic environments can lead to a substantial increase in mortality rates among aquatic organisms (Taka *et al.*, 2014). Conversely, low levels of these contaminants can result in bioaccumulation and biomagnification, ultimately affecting human health through the food chain (Akinrotimi *et al.*, 2018). It is imperative that we address the issue of water pollution with the highest priority to ensure the consumption of safe and healthy fish (Ariweriokuma *et al.*, 2018). The application of agricultural chemicals poses a significant threat to ecosystems and all forms of life, as these substances can easily contaminate water bodies, leading to severe consequences for non-target species, including fish. This situation has raised considerable social and scientific concerns globally (Mave *et al.*, 2020). The pollution of the environment by agrochemicals has emerged as a critical issue for both human health and wildlife conservation on a worldwide scale (Adedeji and Okocha, 2012).

Water contamination can occur through various means, whether intentional or accidental, including direct application into aquatic systems, spray drift, atmospheric deposition such as dust and rain, sewage discharge, industrial effluents, and, in rare cases, spills. While the use of chemicals in agriculture offers numerous benefits, it also presents significant drawbacks, including environmental degradation and pollution, which are closely linked to chemical usage. The contamination of the environment by agrochemicals poses a serious threat, with exposure to these substances potentially leading to adverse health effects, including cancer and neurological damage (Babatunde and Oladimeji, 2011). Unlike other pollutants, pesticides are intentionally introduced into the environment to exploit their toxic properties for pest and disease control. Alarmingly, less than 0.1% of insecticides applied reach their intended targets, with 99.9% dispersing into various environmental media (Nte *et al.*, 2011).

Pesticides in streams ultimately diminish due to various factors such as torrents, dilution, partitioning in water or air, adherence to sediment particles, accumulation in the tissues of aquatic organisms, or burial in sediment (George *et al.*, 2017). The primary mechanism for pesticide transfer from terrestrial environments to aquatic systems is surface runoff resulting from intermittent rainfall, which intermittently exposes non-target species, such as fish, to pesticides. In lentic (still) systems, this pulse exposure may arise from the dissipation of pesticides, while in lotic (flowing) systems, it is often linked to hydrological processes, characterized by continuous water movement (Gabriel and Akinrotimi, 2011). Biomarkers are defined as sub-organism responses in organisms that indicate exposure to or the effects of environmental contaminants. Commonly evaluated biomarkers in fish include oxidative damage, changes in hematology, biochemical and histological alterations, as well as genotoxicity and mutagenicity. These biomarkers can be instrumental in monitoring fish health and may act as early warning indicators for environmental threats (Ada *et al.*, 2019). Despite over two decades of research on aquatic organisms exposed to pesticides or other toxic substances, the biochemical responses of S. melanotheron to pesticides remain inadequately understood.

The herbicide butachlor, N-(butoxymethyl)-2-chloro-2',6'-diethyl acetanilide, is normally applied in agricultural fields to control weeds. It is a selective systemic herbicide, mainly used to control pre-emergent of annual grass with application rate 3000 - 4000 ($g \cdot ha-1$). It is now one of the top three herbicides used across the world (Geng *et al.*, 2020). It is widely applied in Nigeria, particularly in the form of granules, as a post-emergent herbicide in rice cultivation. It has a half-life of 18–19 days in soil, is a highly stable and persistent herbicide (Zhu *et al.*, 2020). Owing to this, a great deal of concern and interest has been involved regarding the behavior of this chemical and its effects on aquatic ecosystem including fish (Liu *et al.*, 2019). The environmental and economic implications of these organisms are significant. There is limited literature regarding the effects of butachlor on the metabolites in the plasma of T. guineensis. Consequently, this study aimed to assess the metabolic responses of C. *guineensis* exposed to varying concentrations of butachlor in a laboratory setting.

MATERIALS AND METHODS

Experimental Location and Fish

The research was carried out at the African Regional Aquaculture Center located in Buguma, Rivers State, Nigeria. During the low tide period, a total of 150 C. *guineensis* samples were collected from the recruitment ponds within the center for the experiment. These samples were subsequently sorted and categorized into two distinct groups based on their sizes. Group 1 included juveniles with an average length of 15.77 ± 1.08cm and an average weight of 90.99 ± 7.55 g and group 2 consisted of adults with an average length of 22.59 ± 9.34 cm and an average weight of 188.94 ± 21.02 g. They were exposed to the chemical for a period of 15 days. The fish were transported to the laboratory in six open, 50-liter plastic containers, where they underwent a seven-day acclimatization period.

Preparation of Test Solutions and Exposure of Fish

For this experiment, Butachlor, marketed under the trade name Butaforce, was procured from a supermarket in Port Harcourt, Nigeria. C.*guineensis* were subjected to the chemical at concentrations of 0.00 (control), 0.10, 0.20, 0.30, and 0.40 mg/L, with each concentration tested in triplicate. The concentrations used were calculated using the formula C1V1=C2V2 according to the methods described by Joel and Edna (2022). The test herbicide butachlor was measured using a micro-pipette and was introduced into the tanks containing 20litres of water. Five fish were randomly assigned to each test tank. The duration of the experiment was 15 days, during which the water in the tanks was refreshed daily. The fish were fed twice daily at a rate of 3% of their body weight using a commercial feed.

Determination of blood Plasma Metabolites

A 2ml sample of fresh blood was collected at the end of each experimental period by puncturing the caudal artery with a fine needle and transferring the sample into heparinized vials. Serum was isolated through centrifugation using a TG20-WS Tabletop High Speed Laboratory Centrifuge for a duration of 5-8 minutes at a speed of 10,000 rpm. In accordance with the guidelines established by APHA (1998), the samples were analyzed for the metabolites creatinine, total bilirubin, total urea, and total protein. Each test was conducted in triplicate. The methods outlined by APHA (1998) were also employed to assess water quality parameters.

Statistical Analysis

The mean and standard deviation of the mean were used to express all the data. The data analysis was done using SPSS Version 22, a statistical program. Using two-way ANOVA, the means were split, and the two means were deemed significant at 5% ($P < 0.05$).

RESULTS

The water quality parameters presented in Table 1 showed no significant variation, with the exception of dissolved oxygen (DO), which exhibited lower levels at higher chemical concentrations. Table 2 illustrates the impact of the chemical butachlor on the plasma metabolites of juvenile T.guineensis. An increase in butachlor concentrations correlated with a decrease in the levels of creatinine, total protein, and total bilirubin. In contrast, the urea levels showed a significant increase when compared to the control values. Furthermore, Table 3 details the effects of butachlor on the plasma metabolites of adult T.guineensis. Similar to the juvenile findings, elevated butachlor concentrations resulted in reduced levels of creatinine, total protein, and total bilirubin, while urea levels significantly increased relative to the control values.

Table 1: Physico-chemical Parameters of Water in Experimental Tanks (Meant± SD)

Parameters	Concentrations of Butachlor (mg/L)				
	0.00	0.10	0.20	0.30	0.40
Temperature (^{0}C)	28.82 ± 1.01^a	28.91 ± 1.82^a	28.71 ± 1.66^a	28.77 ± 1.08^a	28.09 ± 1.55^a
pH	6.66 ± 1.03^a	6.67 ± 1.07^a	6.65 ± 1.03^a	6.64 ± 1.44^a	6.62 ± 1.55^a
Ammonia (mg/l)	0.11 ± 0.01^a	0.32 ± 0.01^{ab}	0.40 ± 0.17^b	0.41 ± 0.01^b	0.50 ± 0.33^c
DO (mg/l)	6.69 ± 0.02^c	6.20 ± 0.88^c	5.32 ± 0.77^b	4.01 ± 0.22^b	3.72 ± 0.22^a
Nitrite (mg/l)	0.01 ± 0.00^a	0.05 ± 0.01^b	0.07 ± 0.01^b	0.08 ± 0.01^b	0.13 ± 0.02^c
Salinity (ppt)	13.00 ± 1.09^a	13.05 ± 1.09^a	13.07 ± 1.03^a	13.06 ± 1.07^a	13.07 ± 1.33^a

Means within the row with different superscripts are significantly different (P<0.05)

Table2: Metabolites Activities in Juveniles of C.*guineensis* Exposed to Butachlor in the Laboratory

Concentrations	Metabolites (mg/dl)			
(mg/l)	Creatinine	Urea	Total Bilurubin	Total Protein
0.00	81.221±1.44 [c]	2.09±0.77 [a]	11.99±1.77 [c]	24.01±1.02 [c]
0.10	72.49±5.04 [b]	3.23±0.55 [a]	10.08±1.12 [c]	18.44±1.65 [b]
0.20	65.77±5.22 [b]	4.87±1.41 [b]	8.55±1.77 [b]	15.88±1.87 [a]
0.30	55.55±6.23 [a]	5.90±1.44 [b]	7.32±0.88 [b]	14.54±1.77 [a]
0.40	51.99±8.77 [a]	6.52±1.66 [b]	4.88±0.87 [a]	12.43±1.87 [a]

Means within the same column with different superscripts are significantly different (P<0.05)

Table4: Metabolites Activities in Adults of C.*guineensis* Exposed to Butachlor in the Laboratory

Concentrations	Metabolites (mg/dl)			
(mg/l)	Creatinine	Urea	Total Bilurubin	Total Protein
0.00	94.89±2.99 [c]	5.01±0.05 [a]	22.60±1.71 [b]	35.03±3.65 [c]
0.10	81.77±9.81 [b]	5.82±0.15 [a]	20.17±1.65 [b]	29.58±1.02 [b]
0.20	72.65±8.47 [b]	6.82±1.09 [b]	16.76±1.51 [a]	26.02±6.77 [b]
0.30	60.88±4.03 [b]	6.90±1.98 [a]	12.02±0.98 [a]	23.02±3.66 [b]
0.40	54.09±4.33 [a]	7.98±1.55 [c]	10.03±0.88 [a]	20.08±1.55 [a]

Means within the same column with different superscripts are significantly different (P<0.05)

DISCUSSION

Water quality parameters are generally affected by chemicals under high concentrations (Oyelese et al., 2019). In this study there was no significant difference (P>0.05) in temperature, salinity, pH, ammonia, and nitrite levels between the different concentrations of the chemical and the control group. This may be due to lower concentrations of the chemical applied. However, the measurements of dissolved oxygen in the water indicated a decrease in all concentrations of exposure. The pattern observed in the water quality parameters is similar to the results of previous research that exposed fish to various chemical concentrations in a saltwater environment (Ada et al., 2019). The main role of blood or plasma is to transport waste materials to excretory organs for elimination from the body, as well as to facilitate the absorption of metabolites and nutrients (both organic and inorganic) throughout the body (Akinrotimi et al., 2019). A key clinical indicator is the level of metabolites in the blood, whether it is high or low. As the concentration of the chemical solution increased, the measurements of total bilirubin decreased. A decrease in total bilirubin levels suggests that the liver cells of C.*guineensis* may have been damaged. The inability of the liver to transform bilirubin into bile and urobilin, which is responsible for the yellow color of human urine, could be the reason for the decrease in total bilirubin levels in the blood (Foss et al., 2021).

A variety of both in-vivo and in-vitro methodologies have been employed to utilize urea and creatinine as important indicators for evaluating the impact of stress on renal function (Oyeleke et al., 2019). During the exposure period, the creatinine levels in the experimental fish exhibited a decline, whereas urea concentrations increased in correlation with the rising concentration of the chemical solution. Calbreath (2022) reported a reduction in the glomerular filtration rate alongside an elevation in urea levels, suggesting that the kidneys were compromised in their ability to excrete these waste products. Total protein content serves as a vital non-specific immunological parameter and is regarded as a key indicator of fish health (Imsland et al., 2022). In this study, a decrease in serum protein levels was observed in the experimental fish. Factors such as diminished amino transferase activity, altered hepatic architecture, and impaired regulation of fluid balance may contribute to the observed decline in total protein levels. This finding corroborates the results of Anyanwu et al. (2007) regarding the exposure of Sarotherodon melanotheron to varying salinities. The reduction in protein content is likely attributed to decreased or disrupted production of microsomal proteins. The degradation of proteins suggests an increase in proteolytic activity, which may be utilized for metabolic functions (Olusegun, 2021). An increase in protein content could be associated with enhanced protein synthesis due to elevated enzyme activity related to this process, while a temporary decrease in protein levels may result from reduced protein synthesis and heightened proteolysis. Nevertheless, a decline in fish protein content following stress has been documented by researchers (Nte et al., 2018).

CONCLUSION

This study has revealed that different levels of butachlor significantly affect the metabolites of C. *guineensis*, with this impact being most pronounced in juvenile fish. This aligns with previous studies indicating that stress can alter the normal operation of fish organs, especially the liver. In conclusion, the findings that show lower overall protein levels in this research suggest either a reduction in protein production or an increase in protein excretion, both of which point to kidney issues. A decrease in creatinine levels in the fish exposed to the toxin suggests the fish are experiencing stress. Higher levels of urea indicate that the kidneys are struggling to eliminate surplus waste. If fish exposed to the toxin display changes in total bilirubin levels, it's possible that the liver was not damaged by the toxin. The study's results indicate that the levels of total protein, total bilirubin, creatinine, and urea in the test organism's blood could be valuable indicators of sublethal butachlor impacts on aquatic life.

REFERENCES

Ada, F. B., Ayotunde, E. O. and Bayim, B. P. (2019). Some biological and hematological responses of Oreochromis niloticus juveniles exposed to atrazine herbicide. AACL Bioflux, 5(5), 369-379.

Adedeji, O.B and Okocha, R.O. (2012). Overview of pesticide toxicity in fish. Advances in Environmental Biology, 6(8),2344–2351.

Akinrotimi, O.A., Okereke, A.N., and Ibemere, I.F. (2019). Studies in plasma glucose as biomarkers for stress response in Tilapia guineensis. African Journal of General Agriculture, 7(3), 125 – 130.

Akinrotimi, O.A., Wilfred–Ekpripo, P. C, and Ukwe, O.I.K (2018). Oxidative Stress in Tilapia guineensis Exposed to Paraquat Dichloride in the Laboratory. Journal of Advanced Research in Medical & Pharmaceutical Sciences, 3(5), 14-18.

Anyanwu, P.E., Gabriel U.U., Anyanwu, A.O. and Akinrotimi, O. A. (2007). Effect of salinity Changes on Haematological Parameters of Sarotherodon melanotheron from Buguma Creek Niger Delta. Journal of Animal Veterinary Advances, 6(5), 658 - 662.

APHA (1998). Standard method for the examination of water and waste water (16th edition), Washington. Public Health Association, pp. 125 – 170.

Ariweriokuma, S.U., Akinrotimi, O.A., and Gabriel, U.U. (2011). Effects of Cypermethrin on condition factor and organosomatic indices of Clarias gariepinus. Journal of Agriculture and Social Research, 11(2), 67-72.

Babatunde, M.M., and Oladimeji A.A., (2014). Comparative study of Acute toxicity of Paraquat and Galex to Oreochromis niloticus. International Journal of Advanced Scientific and Technical Research, 3(4), 437 -444

Calbreath, C. A. (2022). Clinical Biochemistry. Cambridge press. Pp 50-56.

Foss, A., Evensen, T.H., Imsland A.K., and Oeistad, V. (2021). Effects of reduced salinities on growth, food conversion efficiency and osmoregulatory status in the spotted wolfish. Journal of Fish Biology, 59, 416- 420.

Gabriel, U.U and Akinrotimi, O.A. (2011). Management of Stress in fish for sustainable aquaculture development. Research, 3(4), 28 – 38.

Geng, B.R., Yao, D. and Xue, Q.Q. (2020) Genotoxicity of the Pesticide Dichlorovos and Herbicide Butachlor in Rhacophorus Megacephal us tadpoles. Acta Zoologica Sinica (China), 51, 447-454.

George, A.D.I., Akinrotimi O.A.,and Nwokoma,U. K. (2017).Haematological Changes in African Catfish (Clarias gariepinus) Exposed To Atrazine and Metolachlor in the Laboratory. Journal of Fisheries Science.com, 11 (3), 48-54.

Imsland,A.B., Gunnarson, S., Foss, A., Stefansson. S.D. (2022). Gill Na+, K+-ATPase activity, plasma chloride and osmolalilty in juvenile turbot (Scophthalmus maximus) reared at different temperatures and salinities. Aquaculture, 39, 1-13.

Joel I.O, and Edna E.O (2022). Toxic Stress Exhibited by Juveniles of Clarias gariepius Exposed to acute concentrations of Vestaline (Pendimethalin) Herbicide. American Journal of Aquaculture and Animal Science, 1(1), 21-26.

Liu, Z., He, Y., Huang, P. and Jilani, G. (2019) The Ratio of Clay Content to Total Organic Carbon Content Is a Useful Parameter to Predict Adsorption of the Herbicide Butachlor in Soils. Environmental Pollution, 152, 163-171.

Mave J.B., Davis K.B. and Parker N.C. (2020). Plasma corticosteroid and electrolyte dynamics of hybrid striped bass (white bass x striped bass) during netting and hauling. Proceedings of the World Marciculture Society 11, 303-310

Nte, M.D., Hart, A.I., Edun, O.M., and Akinrotimi, O.A. (2011a). Effect of industrial effluent on haematological parameters of Black jaw tilapia Sarotherodon melanotheron. Continental Journal of Environmental Science, 5(2), 29-37.

Nte, M.D., Hart, A.I., Edun, O.M., and Akinrotimi, O.A. (2011b). Alterations in enzymes activities as a biomarker in blackjaw tilapia (Sarotherodon melanotheron) exposed to industrial effluents. Continental Journal of Biological Science, 4(2),37-44.

Olusegun, S. A. (2021).Toxicity of Apron to juvenile mudfish (Clarias gariepinus Teugel). M.Sc thesis, Usman Danfodio University, Sokoto, Nigeria.

Oyelese, A.O., V.O. Taiwo, A.O. Ogunsanmi. and Faturoti, E.O. (2019).Toxicological effects of cassava peels on haematology serum biochemistry and tissue pathology of Clarias gariepinus fingerlings. Tropical Veterinarian, 17, 17-30.

Tak A.M, Bhat, F.A, Jan U, and Shah G.M. (2014). Changes in Carbohydrate Metabolism in Cyprinu scarpioVar. during Short Term Exposure to Dimethoate. Research Journal of Pharmaceutical, Biology and Chemical Sciences, 5(2), 1466-147.

Zhu, S.Q., Cao, Y.Z., Wang, Y., Du, X.M., Gu, Q.B. and Li, F.S. (2020). Adsorption Behavior of Herbicide Butachlor on Typical Soils in China and Humic Acids from the Soil Samples. Journal of Colloid and Interface Science, 285, 27-32.

EFFECT OF WATER-SOLUBLE FRACTION OF KEROSENE ON JUVENILES OF THE AFRICAN CATFISH

[1]Allison, N. L., [2]N. P. Jimmy, [3]P. J. Udo, [4]S. O. Ohaturuonye and [5]P. B. Opeh

[1]Department of Fisheries and Aquaculture, Faculty of Agriculture, University of Calabar, Nigeria
[2]Department of Animal Science, Faculty of Agriculture, University of Calabar, Nigeria
[3]Department of Fisheries and Aquaculture, Ministry of Agriculture, Calabar, Cross River State, Nigeria
4Department of Fisheries and Aquaculture, Nnamdi Azikiwe University Akwa, Nigeria
[5]Fisheries and Aquaculture unit, Institute of Oceanography, University of Calabar, Nigeria

Corresponding Author:
asikpor2023@gmail.com, +234 804 575 9817

ABSTRACT
The effect of water-soluble fraction of kerosene on the juveniles of African catfish Clarias gariepinus was investigated. The incidence of oil spills that finds their way into the aquatic ecosystem contains a serious threat to the welfare of fish species and other aquatic biotas. Many refined products of crude oil are poisonous to aquatic organisms, even at very low concentrations. The present study was carried out in the University of Calabar, in the institute of oceanography (IOC) laboratory for a period of 96 hours. A total of one hundred and fifty (150) juveniles of Clarias gariepinus were randomly allocated into fifteen (15) plastic containers measuring 25 x 10 x 15cm (10 juveniles in each plastic and filled with 4 litres of water. The water-soluble fraction (WSF) of the kerosene used for the experiment was prepared at five different concentrations of 0, 12, 24, 36 and 48mg/l. The 96-hour LC50 for the test organisms was determined to be a 12 mg/L concentration of the toxicant. Significant differences in the mortality rate of C. gariepinus juveniles were observed across the five concentrations ($P < 0.05$). Low feeding rate, uncoordinated swimming, gasping for air, restlessness and attempt to jump out of tanks were amongst the behaviour observed due to exposure of C. gariepinus to the water-soluble fraction of kerosene. Significant negative relationship existed between ammonia and pH ($r = 0.9969$, $P<0.05$), ammonia and Dissolve oxygen (DO) ($r = 0.9\ 465$, $P<0.05$) while a positive significant relationship was observed between pH and Dissolve oxygen (DO) ($r = 0.9688$, $P<0.05$). It therefore shows that the introduction of the toxicant into the test medium altered the physiochemical parameters.

Keywords:
Clarias gariepinus, physiochemical parameters, kerosene

INTRODUCTION

Pollution from petroleum resources, including kerosene, can indeed occur during oil exploration, even before fragmentation takes place. During the early stages of oil exploration, activities such as drilling, transportation, and pipeline construction can result in accidental releases or leaks of petroleum products, including kerosene, into the environment. These discharges, often occurring before full fragmentation or extraction processes begin, can significantly impact the aquatic ecosystem. Kerosene, in particular, tends to float on the surface of the water, exacerbating its harmful effects on both the aquatic environment and the organisms within it. Kerosene represents one of the crude oil refinery products widely used in many household as a sources of cooking energy (Yekini, 2021). Beyond this, kerosene is also used in the aviation industry as an energy source (Glenn *et al.* 2011). It is important to note that kerosene is immiscible in water and it floats on the water's surface at any slight spill or accidental discharge (Garry *et al.*, 2007). Unfortunately, these oil spills with the chemical constituents always find their way into most freshwater and marine water outlets and alters the aquatic ecosystem and inflicts serious health damage to the inhabiting fish species (Ayman 2014). Oil spills in water bodies can cause fish to suffocate by preventing oxygen from dissolving in it. It can also cause difficulty in respiration, interference with the functioning of various organs, abnormal behavior and the death of fish (Gabriel *et al.*, 2013).

Claria gariepinus, commonly known as African catfish, is considered a hardy fish species probably because they can tolorate adverse water quality conditions due to the presence of accessory breathing organs. In Africa, Clarias gariepinus is the most cultivated fish species (Fawole *et al.*, 2020).

Nigeria is Africa's largest oil and gas producer and a major exporter of crude oil and petroleum products to other countries (Egborge, 2000; Ayman, 2014). The economic sector of Nigeria is highly dependent on the oil sector. This study is aimed at assessing the effect of water-soluble fraction of kerosene on the juveniles of African catfish (C. gariepinus).

MATERIALS AND METHODS

Test Animals, Experiment Site and Stocking

A total of 150 juveniles of African catfish (Clarias gariepinus) with a mean size of 5.25 cm and a mean weight of 3.5 g were purchased from the University of Calabar Fish Farm. The farm is situated between latitutde 040510201N and longitude 0080201 4501E (Etim and Enyenihi, 1991). The test animals were transported to the Biological oceanography Research laboratory in the Institute of Oceanography (IOC), where the experiment was carried out. The animals were acclimatized to the conditions in the laboratory in 21 days. The tank was aerated with air stones for the test animals to get used to the environment. The juveniles were fed with commercial feed (coppens) at 5% body weight per day (bw.d1) into two rations (2.5% per ration).

To avoid stressing, ten (10) fishes were picked using hand net from the acclimatized tank and then distributed randomly into each of the fifteen (15) plastic containers measuring 25 x 10 x15cm and filled with 4 liters of water.

The kerosene was purchased from Ekoson filling station, Calabar Cross River State, in air tight plastic bottles and transported to the Biological oceanography Research Laboratory in the Institute of Oceanography (IOC).

Preparation of Water-Soluble Fraction (SWSF) of Kerosene

Water-soluble fractions (WSF) of kerosene were prepared using an oil-to-water ratio of 1:3. Five hundred milliliters (500 ml) of kerosene was mixed with 1500 ml of deionized water. The mixture was shaken vigorously for about 2 minutes to create an emulsion. After shaking, the mixture was allowed to stand for a minimum of 3 hours to establish a clear interface between the oil and water phases. The oil was decanted, and the remaining mixture was poured into a glass stopper separating funnel and allowed to stand overnight. Pure and clear WSF was obtained from the lower part of the funnel and siphoned into capped bottles to make the stock (100% WSF). This process was repeated until sufficient quantities of WSF were obtained.

Measurement of Physio-Chemical Parameters

Water quality parameters such as temperature (°C), dissolved oxygen (DO), ammonia (NH_3), and pH were measured using standard methods. Temperature was recorded using a mercury thermometer, dissolved oxygen was determined using the Winkler titration method, ammonia concentration was measured with a colorimetric method, and pH was assessed using a pH meter. These measurements were taken before the start of the experiment and daily thereafter.

Monitoring of Specimens for Mortality

The test animals were considered dead when their bodies were no longer moving, even when probed with a glass rod. Mortality was determined promptly before any fish had the chance to sink, as they began to float or exhibited no movement. Each dead fish was then removed from the test medium with a pair of forceps, placed in a clean empty petri dish, and recorded.

Definitive Test

Before the acute toxicity test, a range-finding test was conducted to determine the appropriate concentrations of WSF of kerosene for the definitive toxicity test. Based on the results of the range-finding test, concentrations of 0, 12, 24, 36, and 48 mg/L were selected for the definitive test on juveniles of *Clarias gariepinus*. The experiment lasted for 96 hours, and the LC50 was calculated using a modified method. The feeding rate, moribund behavior, and death rate were closely monitored and recorded at 24, 48, 72, and 96 hours, respectively. Additionally, dissolved oxygen, temperature, pH, and ammonia were monitored using a Lurton DO meter, pH meter, and mercury-in-glass thermometer throughout the experiment.

Statistical Analysis

Data from these studies were analyzed using SPSS versions 22. Analysis of variance (ANOVA) was tested for significant different concentrations at a probability level of 0.05. Means of the physiochemical parameters were calculated using descriptive statistics.

RESULTS

The death and survival of Clarias gariepinus juveniles at the end of the test period for each concentration are presented in Table 1. No mortality was recorded in the control (0 mg/l concentration) throughout the experiment. At the 12 mg/l concentration, 90% of the test organisms were dead after 96 hours. At the 24, 36, and 48 mg/l concentrations, 100% mortality was observed by the end of the 96-hour experiment.

TABLE 1: Mortality rate of C. *gariepinus* **juveniles in different concentrations at the end of the experiment (96) hours**

Tank	0mg/l	12mg/l	24mg/l	36mg/l	48mg/l
Treatment 1	0	7	10	10	10
Treatment 2	0	9	10	10	10
Treatment 3	0	5	10	10	10

Behavioral changes observed in the juveniles of C. *gariepinus* included erratic swimming, moribund state, restlessness, low feeding rate, and attempts to jump out of the test containers. These behavioral changes were more pronounced with increasing concentrations of the WSF of kerosene, demonstrating a dose-response relationship. The dead and moribund fish exhibited pale skin and brownish gills.

Physicochemical parameters in the test medium were recorded as follows: Temperature (27.63 ± 0.61°C), Dissolved Oxygen (1.90 ± 0.81 mg/l), Ammonia (1.90 ± 1.52 mg/l), and pH (4.43 ± 1.14) (Table 2). Significant negative correlations were observed between ammonia and pH ($r = 0.9969$, $p < 0.05$), and between ammonia and dissolved oxygen ($r = 0.9465$, $p < 0.05$). A significant positive relationship was found between pH and dissolved oxygen ($r = 0.9688$, $p < 0.05$).

TABLE 2: The mean + standard deviation of physicochemical parameters in the test medium in each 24 hours

Parameters	After 24 hours	After 48 hours	After 72 hours	After 24 hours
Temperature (^{0}C)	27.33±0.72	27.93±0.26	26.80±0.86	26.47±0.92
DO (mg/l)	2.60 ±0.38	1.21±0.42	1.26±3.8	1.14±0.30
Ammonia (mg/l)	0.51±0.39	3.29±0.71	3.85±0.58	4.41±0.57
pH	5.50±0.22	3.36±0.14	3.07±0.18	2.71±0.98

LC_{50} of toxicant on the juveniles of C. *gariepinus*

The 96-hour LC50 for C. *gariepinus* was determined to be at a log concentration of 1.08, indicating the concentration at which 50% of the test organisms were killed by kerosene after 96 hours of exposure. Analysis of variance (ANOVA) revealed a significant difference ($p < 0.05$) in the mortality rate of juveniles across the five concentrations, indicating that kerosene concentration significantly affected fish survival.

DISCUSSION

The results of this study show that C. *gariepinus* juveniles exhibit significant mortality when exposed to increasing concentrations of kerosene. The observed dose-response relationship suggests that higher concentrations of kerosene lead to higher mortality rates, with 100% mortality observed at concentrations of 24 mg/l and above. The absence of mortality in the control group confirms that the observed effects were directly attributable to the kerosene exposure.

The behavioral changes observed, such as erratic swimming and attempts to jump out, are consistent with the toxic effects of petroleum hydrocarbons on aquatic organisms. Similar behaviors have been reported in other studies, where exposure to hydrocarbon pollutants caused distress and impaired normal fish activities (Hicken et al., 2011). The pale skin and brownish gills of the moribund fish indicate respiratory stress, which is a common symptom of toxicity in fish exposed to petroleum products (Hicken et al., 2011). These signs of distress are indicative of the toxicological impact of kerosene, which likely interferes with the oxygen uptake and overall respiratory function of the fish.

The recorded physicochemical parameters were within ranges that are typical for freshwater systems, although the low dissolved oxygen (DO) levels and high ammonia concentrations could be indicative of stress or suboptimal environmental conditions for the test organisms. The significant negative relationships between ammonia and pH, and ammonia and DO, suggest that increased ammonia levels may have contributed to the observed mortality and behavioral changes by altering the water chemistry. The high ammonia concentration observed could have resulted from the decomposition of organic matter, which is commonly associated with petroleum contamination (Gauthier et al., 2017).

The 96-hour LC50 value for C. *gariepinus* at a log concentration of 1.08 supports the toxic potential of kerosene on this species. The significant difference in mortality rates across the concentrations, as revealed by ANOVA, further underscores the importance of kerosene concentration in determining the survival of juveniles. Similar studies on other fish species have found varying LC50 values depending on the type and concentration of petroleum products, highlighting the need for species-specific toxicity assessments (Capps et al., 2017).

Overall, this study provides insight into the toxicity of kerosene to C. *gariepinus* juveniles and highlights the potential risks posed by petroleum contamination in aquatic environments. Further research could investigate the long-term effects of such pollution and explore mitigation strategies to protect aquatic life. Continuous monitoring of water quality in areas prone to oil spills and drilling activities is essential to prevent significant ecological damage (Adams et al., 2019).

CONCLUSION

Kerosene oil is toxic to juveniles of *Clarias gariepinus*. Exposure to sub-lethal concentrations of kerosene under laboratory conditions negatively affected the welfare of the fish, leading to significant behavioral changes. Prolonged exposure to high concentrations of kerosene could have severe long-term impacts on the population, potentially contributing to the gradual decline or extinction of the species over time.

REFERENCES

Ayman, Y.I., 2014. Oil spills: Impact on water quality and Microbial community on the Nile River, "Egypt". International Journal of Environment 3, 192 – 198.

Egborge, A.B.M., (2000). "Wild life, In: Government, Oil Companies, the People and the Niger Delta Environment" (4th convocation lecture of Delta State University, Abraka. BEN Miller Books Nigeria Ltd.

Etim, L. and Enyenihi, U. K. (1991). Annual cycle of condition and flood season spawning in Galatea paradoxa (Born, 1977) from the Cross River, Nigeria. Tropical Freshwater Biology, 2: 243-248.

Fawole, F.J., Adeoye, A.A., Tiamiyu, L.O., Ajala, K.I., Obadara, S.O. and Ganiyu, I.O. (2020). Substituting fishmeal with Hermetia illucens in the diets of African catfish (Clarias gariepinus): Effects on growth, nutrient utilization, haemato-physiological response, and oxidative stress biomarker. Aquaculture 518, 734 - 849.

Gabriel, U. U., Amakiriand, E. U. and Ezeri, G. N. O. (2007). Haematology and gill pathology of Clarias gariepinus exposed to refined petroleum oil, kerosene under laboratory conditions. Journal of Animal and Veterinary Advances, 6(3): 461 –465.

Garry, J.H., Handwerk, G.E. and Kaiser, M.J., (2007). "Petroleum refining technology and Economics". 5thed

Glenn, R., Kenneth Still, John Rossi III, Marni Bekkedal, Bobb, A. and Arfsten, D., (2011). Biological and Health Effects of Exposure to Kerosene-Based Jet Fuels and Performance Additives. Journal of Toxicology and Environmental Health, Part B, 6, 357-351.

Hicken, C.E., Tiffany L.L., David H. B., Maryjean L.W., Mark S. M. and Larry H. (2011). Sub lethal exposure to crude oil during embryonic development alters cardiac morphology and reduces aerobic capacity in adult fish. Proceedings of the national academy of science 108(17), 7086-7090.

Yekini, O.L., (2011). "Kerosene adulteration in Nigeria: Causes and Effects". American journal of social and management sciences. 2011, 371-376.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

ASSESSMENT OF HEAVY METALS IN SURFACE WATER AND SILVER CATFISH FROM CALABAR RIVER, CROSS RIVER STATE, NIGERIA

[1]Idung, J. U., [2]E. A. Ivon, [3]N. L. Allison and [4]P. B. Opeh

[1]Department of Science and Laboratory Technology, Faculty of Biological Sciences, University of Calabar, Nigeria
[2]Department of Science and Laboratory Technology, Faculty of Biological Sciences, University of Calabar, Nigeria
[3]Department of Fisheries and Aquaculture, Ministry of Agriculture, Calabar, Cross River State, Nigeria
[4]Fisheries and Aquaculture unit, Institute of Oceanography, University of Calabar, Nigeria

Corresponding Author:
asikpor2013@gmail.com, +234 804 575 9817

ABSTRACT
The study assessed the levels of selected heavy metals in surface water and *Chrysichthys nigrodigitatus* from Calabar River in Cross River State. Ten surface water samples and sixteen fish samples were collected for six months across five stations and analyzed for metals and physicochemical parameters using spectrophotometer. Result showed that mean weight and length of the catfish samples collected during dry season were 290.78±5.64g and 31.23±3.16cm and wet season were 304.64±6.25g and 31.58±2.01 cm respectively. pH and temperature during dry season were 6.96±0.01 and 26.82±0.5°C and wet season were 6.38±0.02 and 27.12±0.5°C respectively. Mean values of metals in water samples during dry and rainy seasons were: Pb (2.440mg/L, 0.880mg/L), Ni (0.014mg/L, 1.31Omg/L), Cr (0.0012mg/L, 0.00062mg) and Cd (0.00018mg/L, 0.00160mg/L) respectively. Similarly, values of metals recorded in fish samples during the dry and rainy seasons were: Pb (10.513 mg/kg, 3.488 mg/kg), Ni (8. 844mg/kg, 3.293 'mg/kg), Cr (7.519 mg/kg, 0.650 mg/kg) and Cd (1.638 mg/kg, 0.669 mg/kg) respectively. There was seasonal difference ($p<0.05$) in the proportion of the heavy metals, pH and temperature. There was also significant association ($p<0.05$) between heavy metals and physicochemical parameters. The concentrations of Pb and Ni were higher than the recommended safe limits for drinking water.

Keywords:
Chrysichthys nigrodigitatus, heavy metals, physicochemical parameters

INTRODUCTION

The escalating contamination of the environment by toxic substances is of growing global concern especially in Nigeria (Omole, 2017). The concern about heavy metals stems from their accumulation in the environment as they are not easily degraded through biological or chemical means unlike most organic pollutants (Sabo *et al.*, 2013). The term heavy metal refers to metallic chemical elements that have relatively high density and are toxic or poisonous at low concentrations. They are natural components of the earth's crust which would mainly include the transition metals, some metalloids, lanthanides and actinides (Nwankwoala and Ekpewerechi, 2017). The eight most common heavy metals listed by the Environment Protection Agency (EPA) are: Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu),

Mercury (Hg), Nickel (Ni), Lead (Pb), Zinc (Zn) (Oronsaye *et al.*, 2010).
Among animal species, fishes are the inhabitants that cannot escape from the detrimental effects of heavy metals (Agatha, 2010). Fishes are at the apex of the aquatic food chain and can bioaccumulate some of these substances into their tissues (Olaifa *et al.*, 2014). Fish have been considered as one of the most significant indicators in water systems for the estimation of metal pollution level (Oguzie and Izevbigie, 2019). The transfer factor of heavy metals in fish organs such as gills, liver, muscles and scales in respect to water and sediments, has been studied to give information on how these metals are transferred to fish from aquatic ecosystem (Authman and Abbas, 2017).
The Calabar River is of great importance to inhabitants of the coastal region through which it flows. The inhabitants of these coastal communities rely mainly on the river for their domestic water supply, fishing, sand mining and inter-village transportation (Offiong *et al.*, 2012). The Calabar River is bordered by the Calabar Port Authority, residential, agricultural and mangrove land-use. Although, the Calabar Port ecosystem contributes immensely to the economic development and environmental security of the state and country as a whole; the presence of industries and increasing urbanization in the area are immensely affecting the Calabar River (Offiong *et al.*, 2012).

MATERIALS AND METHODS

Fish Sample Collection

A total of 16 C*hrysichthys nigrodigitatus* (Silver catfish) samples were collected from commercial catches made by local fishermen at the landing site for 6 months from November 2022 to April 2023, covering both wet and dry season. The fish samples were immediately place in clean plastic bags, kept on ice in a closed ice-chest, and transferred to the laboratory.

Water Sample Collection

Ten surface water samples were collected for six months (November 2022 to April 2023) within the industrial distance area of 16,704.3 meters seaward (author field survey) that is, from Adiabo bridge head to Esuk. Samples were representation of the whole water body.

Fish Sample Preparation

In the laboratory (Institute of Oceanography Centre laboratory, University of Calabar, Calabar) the collected fishes were brought out of the closed ice-chest to allow them to thaw at room temperature. Each fish sample was properly washed with distilled water and labeled accordingly. Total body length was determined using a measuring board and recorded to the nearest 0.1 cm while weight was determined using a top loader (Mettler, P. E. 230) and recorded to the nearest 0.1 g respectively. The fish samples were dissected into gills and muscle, using stainless steel dissecting instruments, while wearing surgical gloves. After dissection, all tissue samples were separately oven-dried at 100°C for 48 hours to ensure that all the water content was removed to get a constant weight. Each sample was homogenized using clean porcelain mortar and pestle and stored at a temperature of -10°C.

Wet Digestion of Fish Sample

Exactly 1.0g of each homogenized fish sample was weighed. The digestion of the homogenized fish sample followed the method described by Authman and Abbas (2017). Briefly, 2ml of distilled water, 5ml nitric acid, and 3ml sulphuric acid were added to the sample, followed by heating on a heating mantle at 85°C for 30 min. Complete digestion was ascertained when the solution turns into a clear light yellow. The solution was allowed to cool at room temperature. The sample solution was then pass through a Whatman 0.45um paper filter into a 100ml volumetric flask, and the filtrate diluted with distilled water to the 50ml mark.

Digestion of Water Sample

Water digestion was carried out according to the method described by Omole, (2017). 2ml of water sample was digested using 15ml concentrated nitric acid (HNO) in a 250ml conical flask. The mixture was heated over an electric hot plate at a temperature of between 200°C and 250°C under a hood until the volume was reduced to 5ml. The digest was stored the same way as the fish digest.

Determination of Heavy Metal Concentration in Standard and Sample Solutions

Heavy metals determination in samples were performed using the Perkin Elmer® Analyst 400 atomic absorption with wavelengths set at: 228.9nm (Cd), 357.9 nm (Cr), 279.5nm (Mn), 232.0 nm (Ni), 232.0 nm (Pb) and 213.9nm (Zn). All the samples were run in triplicates. The analysis of the standard, reagent blanks and replicates were run in the same way.

Statistical Analysis

The data obtained from the experiments were statistically analyzed for mean and standard deviation among the various samples in triplicates. The independent t-test was used to determine significance difference between mean concentration of heavy metal in dry and rainy seasons. Correlation among physicochemical parameters and heavy metals was done using Pearson's correlation matric. All analyses were done using the software, IBM SPSS Statistics, version 20 at the $p<0.05$ level of significance.

RESULTS

The study revealed that the mean weight and length of catfish samples collected during the dry season were 290.78 ± 5.64 g and 31.23 ± 3.16 cm, respectively. In contrast, the mean weight and length during the wet season were slightly higher at 304.64 ± 6.25 g and 31.58 ± 2.01 cm, respectively. The physicochemical parameters measured showed that pH and temperature during the dry season averaged 6.96 ± 0.01 and 26.82 ± 0.5°C, while during the wet season, the averages were 6.38 ± 0.02 and 27.12 ± 0.5°C, respectively (Table 1).

Table 1: Average Levels of Physicochemical Parameters and Heavy Metals in Water and Fish Samples

Parameter	Dry Season	Rainy Season	WHO Permissible Levels
pH	6.96	6.38	6.5 - 8.5
Temperature (°C)	26.82	27.12	25.0 - 30.0
Lead (Pb) in Water (mg/L)	2.440	0.880	0.01
Nickel (Ni) in Water (mg/L)	0.014	1.310	0.07
Chromium (Cr) in Water (mg/L)	0.0012	0.00062	0.05
Cadmium (Cd) in Water (mg/L)	0.00018	0.00160	0.003
Lead (Pb) in Fish (mg/kg)	10.513	3.488	0.3
Nickel (Ni) in Fish (mg/kg)	8.844	3.293	0.5
Chromium (Cr) in Fish (mg/kg)	7.519	0.650	0.1
Cadmium (Cd) in Fish (mg/kg)	1.638	0.669	0.05

Heavy metal concentrations in water samples varied significantly between seasons. During the dry season, the mean levels of lead (Pb), nickel (Ni), chromium (Cr), and cadmium (Cd) were 2.440 mg/L, 0.014 mg/L, 0.0012 mg/L, and 0.00018 mg/L, respectively. In comparison, the rainy season showed reduced concentrations for Pb (0.880 mg/L) and Cr (0.00062 mg/L) but elevated levels of Ni (1.310 mg/L) and Cd (0.00160 mg/L). Similarly, the concentrations of these metals in the fish samples

reflected seasonal differences. The dry season recorded higher metal accumulation in fish tissues, with Pb at 10.513 mg/kg, Ni at 8.844 mg/kg, Cr at 7.519 mg/kg, and Cd at 1.638 mg/kg. During the rainy season, these values were notably lower for Pb (3.488 mg/kg), Ni (3.293 mg/kg), Cr (0.650 mg/kg), and Cd (0.669 mg/kg).
Statistical analysis revealed significant seasonal differences ($p<0.05$) in the levels of heavy metals, pH, and temperature. Furthermore, a strong association ($p<0.05$) was observed between heavy metal concentrations and the physicochemical parameters of the water. Notably, the concentrations of Pb and Ni in the water samples exceeded the recommended safe limits for drinking water, indicating potential environmental and health risks.

DISCUSSION

This present study shows that the Calabar River is highly contaminated with heavy metals attributed to chemical waste from various activities including automobile servicing, dumps, and pesticides discharge. The water and fish samples taken in this vicinity and analyzed were found to contain high concentration of heavy metals. The concentration of heavy metals in fish samples correlate well with the metal concentration observed in the water samples and the result of analyses provided valuable quantitative information as reported by Ayoola and Aina (2017), that heavy metals and their salts constitute the most widely distributed group of highly toxic and long retained pollutants and exposure to them even at low concentration is associated with diverse health effect (Omogoriola and Ayoola, 2017). This study establishes the significant pollution index of the Calabar landing site, as it clearly shows the stress exposure of fish resident in this location and seems to adequately explain the preponderance of observed lesions and these are attributable to the measurable levels of heavy metals as reported in the Ologe Lagoon by Ayoola and Aina (2017). The pH value is high in the dry season and low in the wet season with average values of 7.03 and 6.30 respectively. A river with high alkalinity levels according to Ipeaiyeda and Onianwa (2011) will be able to supply adequate amounts of carbonate, bicarbonate and hydroxide ions in solution to bind up free protons and metals.
Increase in alkalinity level during the dry season reduces water acidity of the Calabar River as reflected in measures of water pH (7.03). A river with high pH generally contains elevated levels of dissolved solids (Ipeaiyeda and Onianwa, 2011). For nickel (Ni), high value in surface water was recorded in the wet season with an average value of 1.310 mg/L, while low concentration in Ni was noticed in the dry season with an average value of 0.014mg/L. Ni values in the dry season happened to fall within WHO tolerable level of 0.5 mg/L, its concentration in the wet season was above WHO tolerable limit of 0.5 mg/L

CONCLUSION

The results reveal that the proportion of heavy metal in the Calabar River indicates potential threat to aquatic life as the measured parameters are above WHO/FAO and FEPA permissible levels for surface water and fish food. The water body and silver catfish are contaminated with heavy metals. Both seasons have substantial influence on the proportion of metals in the Calabar River, and the proportions of Pb and Ni differ in both seasons.

REFERENCES

Agatha, A.N. (2010) Levels of Some Heavy Metals in Tissues of Bonga Fish, Ethmalosa fimbriata from Forcados River. Journal of Applied Environmental and Biological Sciences, 1, 44 - 47

Authman, M. and Abbas, H. (2017) Accumulation and distribution of copper and Dou water and some vital tissues of two fsh snecies (tilapia zilii and Mugilcephalus) O Lake, Qarun, Fayoumn province. Egypt. Pakistan Journal of Biological Science, 10, 13 – 16.

Ipeaiyeda, A. R. and Onianwa, P. (2011). Pollution effect of food and beverages effluents on the Alaro River in Ibadan City, Nigeria. Bulletin of the Chemical Society of Ethiopia, 25(3), 347 – 360.

Nwankwoala, H. O. and Ekpewerechi, P. O. (2017). Human activities and heavy metal concentrations in aba rive, Abla state, Nigeria. British Journal of Earth Sciences Research, 5(1), 26-36

Offong, R. A., Iwara, A. I., Njar, G. N. and Atu, J. E. (2012). Effects of industrial activities on the structure and floristic pattern of vegetation within the Calabar Port Authority, south-southern Nigeria. Journal of Geography and Geology, 4(1): 203 – 211.

Oguzie, F. A. and Izevbigie, E. E. (2009). Heavy metals concentration in the organs of the silver Catfish, Chrysichthys nigrodigitatus (Lacèpéde) caught upstream of the Ikpoba River and the reservoir in Benin City. Bioscience Research Communications, 21, 189 – 197.

Olaifa, F. E., Olaifa, A. K., Adelaja, A. A. and Owolabi, A. G. (2014). Heavy Metal Contamination of Clarias garieninus from a lake and fish farm in Ibadan, Nigeria. African Journal of Biomedical Research, 7, 145 – 148.

Omogoriola, H. O and Ayoola. S. O. (2017). Acute toxicity of water accommodated fractions (WAFs) of three Nigerian crude oils to Clarias gariepinus (Burchell, T822). African Journal of Resources Management Fisheries and Aquatic, 2(1), 9 – 20.

Omole. I. A. (2017). Concentration of Heavy Metals in Fish (Synodontis clarias) of Benin River, Delta State, Nigeria. Journal of Energy, Environmental and Chemical Engineering, 2(1), 6 – 9.

Oronsaye, J. A. O., Wangboje, O. M. and Oguzie, F. A. (2010). Trace metals in some benthic fishes of the Ikpoba River dam, Benin City, Nigeria. African Journal of Biotechnology, 9, 8860 – 8864.

Sabo, A., Gani, A. M. and Ibrahim, A. O. (2013) Pollution Status of Heavy Metals in Water and Bottom Sediment of River Delimi in Jos. Nigeria. American Journal of Environmental Protection, 1 (3), 47-53

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

ASSESSMENT OF BIOACCUMULATION OF HEAVY METALS IN WATER, SEDIMENTS AND SOME SELECTED IMPORTANT COMMERCIAL FISH OF RIVER CHANCHAGA, NIGER STATE, NIGERIA

Abba, S. E., R.O. Ojutiku, and S.U. Ibrahim
Department of Water Resources Aquaculture and Fisheries Technology, Federal University of Technology P.M.B 65 Bosso, Minna, Niger State

*Corresponding Author:
sylviaabba60@gmail.com,
+2348138665958

ABSTRACT
The study investigated heavy metal bioaccumulation in water, sediments, and commercially important fish species in River Chanchaga, Niger State, Nigeria. Sampling was conducted monthly from January to June 2024 at five stations along the river, with each sample triplicated. Water parameters measured included temperature, dissolved oxygen, pH, total alkalinity, conductivity, biochemical oxygen demand (BOD), calcium, magnesium, phosphate, and nitrate, analyzed using standard methods. Sediments were collected using an Eckman grab, while fish samples (Clarias gariepinus and Oreochromis niloticus) were transported to the laboratory in ice. Fish muscle and sediment samples underwent acid digestion and were analyzed for heavy metals using an Atomic Absorption Spectrophotometer. Data were statistically analyzed using SPSS and One-Way ANOVA with significance set at $p<0.05$.Results showed the highest concentration of metals in all stages (water and sediments) were zinc, chromium and corper. This was probably due to the sources of pollution . Most physical and chemical parameters were within WHO standards for fish survival, with exceptions for temperature and BOD. Significant differences were observed for Cd, Cu, Pb, Zn, Ni, and Cr levels in fish species. The findings highlight critical implications for environmental monitoring and sustainable fisheries in River Chanchaga.

Keywords:
Heavy metal, Bioaccumulation, Sediments, River, Fish

INTRODUCTION

Water is a vital renewable resource, essential for sustaining life, food production, economic development, and general well-being. Its unique role in supporting human and ecological systems makes it irreplaceable for most uses, challenging to purify once polluted, and expensive to transport (Singh and Gupta, 2016). Surface and groundwater resources play critical roles in agriculture, power generation, livestock production, industrial processes, forestry, fisheries, navigation, and recreational activities. Freshwater ecosystems, which account for only about 0.5% of the Earth's surface and a volume of 2.84×10^5 km³, are invaluable yet highly vulnerable to degradation (Singh and Gupta, 2016).

In recent years, the quality of freshwater resources, including River Chanchaga in Niger State, has been under increasing pressure from anthropogenic activities. Pollution from industrial discharge, agricultural runoff, domestic waste, and other human activities has led to the increase of heavy metals in water bodies. These pollutants not only degrade water quality but also pose significant risks to aquatic ecosystems and human health. Despite the importance of the river for local communities, there is limited data on the extent of heavy metal contamination and its impacts on the river's biodiversity and the safety of its aquatic resources.

This study is therefore critical for understanding the environmental health of River Chanchaga, as it serves as a vital source of water for agriculture, fishing, and domestic use. Assessing heavy metal bioaccumulation in the river's water, sediments, and fish is essential for determining it's safety for human consumption and aquatic life. The findings will provide valuable data for policymakers, enabling the development of strategies for sustainable management and pollution control in freshwater ecosystems.

The objectives of this study are: To determine the physical and chemical parameters of water in River Chanchaga, to analyze heavy metal concentrations in water, sediment, and fish species and to evaluate the bioaccumulation of heavy metals in fish.

MATERIALS AND METHODS

Study Area and Site Selection

The study was carried out in River Chanchaga located in the southern parts of Minna metropolis with Latitude: 9.6140° N, Longitude: 6.5478° E . The area has a tropical climatic condition with mean annual temperature, relative humidity and rainfall of 20-30oC, 61% and 1334 cm respectively. The climate presents two separate seasons: raining season between May and October and dry season between November and April each year. The vegetation is a typical Guinea Savannah type consisting majorly of grassland with scattered trees (Omalu et al., 2017).

The study selected five (5) sampling stations as station I, II, III, IV and V along the river basin.

Station 1: A village along River Kaduna in Niger State where sand packing, domestic and farming activities are done around the water body.

Station 2: Gidan Waya located along River Kaduna. Washing and farming activities are carried out around this water body.

Station 3: located behind Niger State Water Board. Discharge of waste materials from industrial companies are done around this station.

Station 4: Chanchaga River along Lapai Gwari Fish Farm. Farming and domestic activities takes place around the water body.

Station 5: Gidan Ponpo, a settlement around Gidan Kwano where farming activities takes place.

Sample Collection

Water, sediment, and fish samples were collected from five stations along River Chanchaga over six months. Water sampling was done according to the procedure described by Ndimele and Kumolu-Johnson (2012). Water samples from all five (5) sampling stations was collected at a depth of about 0.3m below water surface into 500 ml plastic bottles. Sediment samples was taken from the bottom surface (1-2 cm thick) using an Eckman grab according to Osman and Kloas (2010). Fish samples (Clarias gariepinus and Oreochromis niloticus) were caught using gill nets, stored in ice boxes, and transported to the laboratory for analysis.

Heavy Metal Analysis

The fish muscle and sediment samples were acid-digested and analyzed for heavy metals, including cadmium (Cd), copper (Cu), lead (Pb), zinc (Zn), nickel (Ni), and chromium (Cr), using Atomic Absorption Spectrophotometer (AAS). The physico-chemical parameters of the water, such as temperature, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), and nitrates, were measured using standard methods.

Statistical Analysis

Data were analyzed using SPSS software, and significance was established at $p<0.05$ using one-way

Analysis of Variance (ANOVA).

RESULTS AND DISCUSSION

Table 1 and 2 presents the concentrations of heavy metals (Cd, Pb, Zn, etc.) in water and sediment samples respectively from the study sites. These values highlight significant spatial differences, particularly in areas influenced by industrial discharge and agricultural runoff.

The results in Table 3 illustrate the bioaccumulation of heavy metals in Clarias gariepinus and Oreochromis niloticus. Elevated levels of Zn and Pb in fish tissues, especially in Station 3, underscore the potential health risks associated with fish consumption from this river.The concentration of heavy metals varied significantly across the stations and between sample types (water, sediment, and fish tissues).

Water and Sediment: Heavy metals such as Cd, Pb, and Zn exceeded permissible limits in certain stations, particularly those near industrial and farming zones. For instance, high levels of Cd and Pb in sediment from Station 3 suggest contamination from industrial discharges.

Fish Tissues: Clarias gariepinus and Oreochromis niloticus showed significant bioaccumulation of Zn and Pb. This finding aligns with their trophic positions and feeding behaviors, which make them more susceptible to heavy metal uptake. The bioaccumulation of non-essential metals like Pb raises concerns about their consumption safety.

Finally, the results showed the highest concentration of metals in all stages (water and sediments) were zinc, chromium and corper. This was probably due to the sources of pollution (sewage, and the use of toxic chemicals around the station) which had high levels of these metals. There might be some contribution from the geology of the region, which might contain naturally higher concentrations of these metals (Algül and Beyhan, 2020).

CONCLUSION

The study highlights the bioaccumulation of heavy metals in water, sediments, and fish from River Chanchaga, with concentrations of cadmium, lead, and zinc exceeding regulatory limits in some areas. These pollutants pose serious health risks to both aquatic life and humans consuming fish from the river. It is critical to enforce regulations on waste disposal and industrial discharges to protect the ecosystem and public health.

Table I: Heavy Metals Concentration of Water in Stations of River Chanchaga

PARAMETERS	STATION 1	STATION 2	STATION 3	STATION 4	STATION 5
Zn (mg/L)	0.14±0.04b	0.14±0.04b	0.14±0.04b	0.14±0.04b	0.14±0.04b
Ni (mg/L)	0.01±0.01a	0.01±0.01a	0.01±0.01a	0.01±0.01a	0.00±0.01a
Cu (mg/L)	0.08±0.06ab	0.07±0.05b	0.12±0.08a	0.08±0.06ab	0.10±0.05ab
Pb (mg/L)	0.02±0.03a	0.01±0.02ab	0.01±0.01ab	0.01±0.01ab	0.00±0.00b
Cr (mg/L)	0.08±0.06ab	0.04±0.03b	0.06±0.05ab	0.08±0.04a	0.08±0.08ab
Cd (mg/L)	0.01±0.01b	0.01±0.01b	0.01±0.01b	0.01±0.01b	0.12±0.47a

Mean values in the same row followed by the same superscript are not significantly different (P>0.05)

Table II: Heavy Metals Concentration in Sediments of River Chanchaga

PARAMETERS	STATION 1	STATION 2	STATION 3	STATION 4	STATION 5
Zn (mg/kg)	56.80±14.18^{c}	59.53±7.24^{c}	84.47±33.17^{a}	63.00±29.12^{b}	68.40±26.18^{b}
Ni (mg/kg)	4.33±1.66^{b}	3.37±1.45^{b}	8.40±1.67^{a}	4.83±1.92^{b}	5.03±1.45^{b}
Cu (mg/kg)	18.93±6.12^{b}	17.67±5.25^{b}	30.17±8.60^{a}	20.00±8.85^{b}	21.50±9.78^{ab}
Pb (mg/kg)	1.20±0.91^{b}	0.93±0.52^{b}	2.73±1.08^{a}	1.70±1.16^{ab}	1.60±0.59^{b}
Cr (mg/kg)	27.57±12.75^{b}	22.27±7.93^{c}	35.80±22.07^{a}	29.20±13.14^{b}	23.50±10.47^{c}
Cd (mg/kg)	11.23±6.48^{b}	7.30±2.75^{b}	16.30±8.54^{a}	12.17±10.33^{ab}	11.37±7.91^{b}

Mean values in the same row followed by the same superscript are not significantly different (P>0.05)

Table IIIa: Concentration of Heavy Metals in CatFish muscles of river Chanchaga

PARAMETERS	STATION 1	STATION 2	STATION 3	STATION 4	STATION 5
Zn (mg/kg)	19.63±4.69^{a}	18.89±4.93^{a}	20.52±5.09^{a}	21.10±2.77^{a}	19.87±4.38^{a}
Ni (mg/kg)	0.74±0.36^{b}	1.21±1.13^{ab}	2.37±2.29^{a}	1.07±0.88^{ab}	0.57±0.21^{b}
Cu (mg/kg)	0.25±0.04^{a}	0.18±0.11^{ab}	0.11±0.05^{b}	0.03±0.05^{c}	0.11±0.04^{b}
Pb (mg/kg)	0.07±0.06^{b}	0.14±0.02^{a}	0.11±0.03^{ab}	0.14±0.07^{a}	0.06±0.03^{b}
Cr (mg/kg)	0.70±0.11^{ab}	0.76±0.32^{ab}	0.48±0.06^{bc}	0.81±0.38^{a}	0.31±0.06^{c}
Cd (mg/kg)	0.04±0.04^{a}	0.05±0.02^{a}	0.02±0.02^{a}	0.03±0.03^{a}	0.03±0.05^{a}

Mean values in the same row followed by the same superscript are not significantly different (P>0.05)

Table 111b: Concentration of Heavy Metals in Tilapia muscles of river Chanchaga

PARAMETERS	STATION 1	STATION 2	STATION 3	STATION 4	STATION 5
Zn (mg/kg)	17.41±2.38^{a}	18.18±2.36^{a}	17.75±2.20^{a}	18.82±2.45^{a}	19.34±2.33^{a}
Ni (mg/kg)	0.75±0.42^{a}	1.22±1.04^{a}	1.04±1.20^{a}	1.24±2.02^{a}	0.73±0.37^{a}
Cu (mg/kg)	0.06±0.06^{b}	0.09±0.06^{ab}	0.15±0.07^{a}	0.09±0.04^{ab}	0.11±0.02^{ab}
Pb (mg/kg)	0.04±0.03^{b}	0.09±0.06^{ab}	0.13±0.07^{a}	0.13±0.07^{a}	0.11±0.06^{ab}
Cr (mg/kg)	0.33±0.12^{b}	0.55±0.30^{a}	0.54±0.21^{a}	0.49±0.18^{a}	0.36±0.10^{b}
Cd (mg/kg)	0.03±0.02^{b}	0.05±0.02^{ab}	0.08±0.05^{a}	0.03±0.02^{b}	0.04±0.02^{b}

Mean values in the same row followed by the same superscript are not significantly different (P>0.05)

REFERENCES

Algül, F., and Beyhan, M. (2020). Concentrations and sources of heavy metals in shallow sediments in Lake Bafa, Turkey. Scientific reports, 10(1), 11782.

Baruah, M. P., Das, S., Rajkonwar, M., and Thirumala, M. (2023). Heavy Metal Contamination Assessment in Sediments, Soils and Surface Waters in Agriculture-Based Rural Chhattisgarh, India, and Evaluation of Irrigation Water Quality. Nature Environment & Pollution Technology, 22(4).

Jeong, H., Choi, J. Y., Lee, J., Lim, J., and Ra, K. (2020). Heavy metal pollution by road-deposited sediments and its contribution to total suspended solids in rainfall runoff from intensive industrial areas. Environmental Pollution, 265, 115028.

Ndimele, P. E., and Kumolu-Johnson, C. A. (2012). A review on the phyto-remediative potentials of wetlands: Nutrient load and heavy metal detoxification. Journal of Environmental Management, 24(3), 139–146.

Omalu, I. C., Shokunbi, M. T., Ejima, A. A., Pam, D. D., Nnaji, C. I., Adeniyi, K. A., and Hassan, S. C. (2017). Gastrointestinal parasites of fish as bio-indicators of the ecology of Chanchaga river, Minna, Niger state.

Osman, A. G. M., and Kloas, W. (2010). Water quality and heavy metal monitoring in water, sediments, and tissues of the African catfish Clarias gariepinus from the River Nile, Egypt. Journal of Environmental Protection, 1(4), 389–400.

Singh, M. R., and Gupta, A. (2016). Water pollution-sources, effects and control. Centre for Biodiversity, Department of Botany, Nagaland University, 1-16.

Wang, Y., and Fang, P. (2016, May). Analysis of the impact of heavy metal on the Chinese aquaculture and the ecological hazard. In 2016 International Forum on Energy, Environment and Sustainable Development (pp. 42-47). Atlantis Press.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

PRODUCTION OF BACTERIAL ISOLATES FOR USE IN HEAVY METALS BIOSORPTION IN POLLUTED WATER BODIES.

Atiribom, R. Y., M. M. Muazu, I. Y. Yem, N. Abiodun, E. O. Ngwu and K. E. Ogbuebuno

National Institute for Freshwater Fisheries Research, New- Bussa, Niger State – Nigeria

Corresponding Author:
atirimam@gmail.com, +234 8063446678

ABSTRACT

Heavy metal pollution in aquatic environment is a major concern on a world scale because of its toxic effects on both aquatic lives and man consume them. The used of bacterial isolates as biosorbents for the removal or sequestration of these heavy metals from polluted water body is therefore imperative. Bacterial isolates were screened for biosorption potentials. Bacillus pumilus and Macrococcus equipercicus were identified and used for the removal of lead (Pb) and Chromium (Cr) in polluted pond water. Percentage removal of lead by Bacillus pumilus were 97.3%, 98.1% and 97.1% for stations 1, 2, and 3 respectively while removal of chromium were 76.2%, 76.6% and 71.4% for stations 1, 2, and 3 respectively. Percentage removal of lead by Macrococcus equipercicus were 9.4%, 9.5% and 7.6% for station 1, 2 and 3 respectively while removal of Chromium were 76.8%, 76.4% and 76.3% for stations 1, 2 and 3 respectively. Bacillus pumilus has high biosorption capacity for lead hence can be used as a bacterium of choice for removal of lead in lead polluted aquatic environment.

Keywords:
Bacterial Isolates, Heavy metals, Biosorption, Inoculum

INTRODUCTION

Heavy metal pollution in aquatic environment is of major concern on a world scale because they are indestructible and most of them have toxic effects on both aquatic lives and man that consume them (ÖztÜrk *et al.*, 2009). Heavy metal damages the kidney, testicular tissue and central nervous system in man especially among children. It also causes lung cancer, ulcer and liver damage in man (Etim *et al.*, 2013).

Heavy metals bioaccumulate in fish tissues and over time leads to the suppression of fish immunity hence allowing normal flora to cause ulceration and possible septicaemia (Mutuku, 2010). Heavy metals are known to reduced growth rate in fishes, delayed embryonic development, change in biochemistry such as enzyme activity and blood chemistry, changes in reproduction (Bio-ellite, 2000). Lead (Pb) ions combine with mucus on the gills of fish and this interferes with its respiration, causing death due to suffocation. It is also reported that prolonged exposure of fish to lead causes damage to the liver, spleen and blood (Dawson, 1985). High concentrations of chromium in surface waters, can damage the gills of fish (Abioye *et al.*, 2015). The toxic inorganic form causes damage in the liver and other internal tissues of fish (WHO, 2008b).

The quality of surface water (including fish ponds) in present day has been greatly affected due to overexploitation of resources, urbanization and improper waste disposal practices (Ojutiku *et al.*, 2013). Biosorption is the use of biological materials as sorbents for the uptake of metal ions from aqueous solutions. This process utilizes inexpensive biomass for selective sequestration of toxic heavy metals and is particularly useful for the removal of heavy metal contaminants from water and sediments.

This study is aimed at production of different bacterial isolates which will be used for heavy metal removal in polluted water body.

MATERIALS AND METHOD

Collection of water samples for bacteriological analyses

Water samples were collected from five (5) different sampling stations in Jebba Lake where mining activities is being carried out. This was carried out in the month of August, 2023. With the help of a boat, water samples were collected at 150 m away from the bank and at a depth of 30 cm below the surface using van-dorn water sampler. The water was collected directly into 250 ml sterilized plastic bottles and corked as described by the American Public Health Association (APHA, 1985). The bottle containing each water sample was labeled and stored in portable ice box at temperature of not more than 5oC so as to stop or reduce microbial activity. These samples were transported to microbiology laboratory at National Institute for Freshwater Fisheries Research, New Bussa, Niger State for preliminary analyses.

Screening of Isolates for Biosorption Potentials

Screening of isolates for metal biosorption potential were carried out by well diffusion method, using nutrient agar (Abioye et al. 2018). Three (3) ppm of each heavy metal (lead, chromium) was prepared and the metal pH solution was adjusted to 7.0. Nutrient agar were sterilized using autoclave at 121oC for 15 minutes, poured into petri dishes and allowed to solidify. With the help of a sterilized cork borer of 5.0 mm diameter, a well was made on the media. The test organisms were inoculated and spread using sterilized bent glass rod as previously carried out by Abioye et al. (2018). One millilitre (1 ml) of 3ppm heavy metal was inoculated into the well and the plate was incubated at 37oC + 2oC for 24 hours. Development or presence of bacterial colonies around the well is an indication of its ability to tolerate the heavy metal hence its affinity. Zone of clearance is an indication that the test organism cannot tolerate the heavy metal, hence cannot grow in presence of the heavy metal.

Bacterial Identification

Primary isolation was carried out following standard procedures of Bergey's Manual of Systematic Bacteriology (Krieg and Holt, 1994) and Cheesbrough (2000). Water samples were inoculated into Nutrient agar, MacConkey agar, Eosin Methylene blue agar, Thiosulfate Citrate Bile Salt Sucrose agar and incubated at 37 oC for 24 hours using Thermo scientific incubator, 51028063, USA. Pure colonies were sub-cultured into nutrient agar slants and stored in the refrigerator for further tests.

Biochemical analysis of the bacterial isolates was also carried out using microbact identification kits.

Molecular characterization of bacterial isolates was carried out using molecular technique (Luo et al., 2017). The use of 16S-rDNA identification has become more acceptable due to its greater degree of accuracy and specificity.

Preparation of inoculum/ biosorption

Five hundred milliliters (500.0 ml) of sterilized distilled water was measured each into two conical flask and 6.5g of nutrient broth each was added. This was sterilized at 121oC for 15 minutes and allowed to cool.

A sterilized inoculation loop was used to pick isolates of *Bacillus pumilus* and *Macrococcus equipercicus* from a petri dish and these were inoculated each into the nutrient broth to obtain a homogenous bacterial suspension in the flask. These were incubated at 35oC ± 2oC for 24 hours to obtain the inoculum. Five hundred milliliters of the inoculum each (2.0 x109 CFU/ml) was added to water in an abandon fish pond to undertake biosorption.

Collection and digestion of water samples for determination of heavy metals

Water samples were collected from each sample stations of the ponds. One litre capacity polyethylee sampling bottles were used to collect the water samples at each sampling station. Samples were acidified with 2 cm3 of 10 % HNO3. This was placed in an ice box in order to stabilize the metal ions and prevent volatility of the constituents (APHA, 1992). This was transported to the laboratory and digested according to APHA (2005).

Determination of heavy metals

After digestion, the filtrate of each sample was analyzed using atomic absorption spectrophotometer (PG instrument model, AA500 Spectrophotometer, UK). These determinations after initials, were carried out at 7 days interval for a period of 28 days (7th, 14th, 21st and 28th) according to the method of Abioye et al. (2015).

Analysis of data

Percentage removal (% R) of heavy metal was calculated using:

$$R(\%)\ \frac{C1 - C2}{C1}\ X\ 100$$

Where C1 = Initial concentration, C2 = Final concentration, R (%) = Percentage removal.

RESULTS AND DISCUSSION

Biosorption of heavy metals by *Bacillus pumilus* from experimental pond A

Biosorption of heavy metals by *Bacillus pumilus* shows a significant removal of lead (Table 1). Percentage removal of lead by *Bacillus pumilus* were higher (97.3%, 98.1% and 97.1% for stations 1, 2, and 3 respectively) when compared to that of chromium (76.2%, 76.6% and 71.4% for stations 1, 2, and 3 respectively). This result agrees with the findings of Abioye et al. (2018), where Bacillus species had higher uptake level of lead in tannery effluent compared to uptake of chromium.

Bacillus species secretes hydrolytic enzymes, which are capable of tolerating heavy metals (Abioye et al., 2018), this may be the reason for high biosorption. This study revealed that Bacillus pumilus has effectively carried out biosorption/removal of lead, this may also be due to the fact that it is a gram positive bacteria with techoic acid as source of carbxyl groups which are main agents in heavy metal uptake. Though the biosorption of chromium by *Bacillus pumilus* was also high within one month, the concentration is still above maximum permissible limit of 0.05Mg/L (FEPA, 2003).

Table 1: Biosorption of Heavy Metals by *Bacillus pumilus* from experimental pond A

Time(Day)	Pb(ppm)			Cr(ppm)		
	St 1	St 2	St 3	St 1	St 2	St 3
1	1.314	2.377	0.648	0.256	0.303	0.021
7	1.086	1.487	0.230	0.130	0.162	0.016
14	0.706	0.825	0.060	0.084	0.098	0.009
21	0.068	0.092	0.031	0.072	0.086	0.006
28	0.036	0.046	0.019	0.061	0.071	0.006
% R	97.3	98.1	97.1	76.2	76.6	71.4

Key: ppm = part per million, % R = Percentage removal of heavy metal, Pb = Lead, Cr = Chromium, St1 = Station 1, St 2 = Station 2, St 3 = Station 3

Biosorption of heavy metals by *Macrococcus equipercicus* from experimental pond B

Biosorption of heavy metals by *Macrococcus equipercicus* shows a high removal of chromium (Table 2). The removal rate of chromium was much higher (76.8%, 76.4% and 76.3%) for stations 1, 2 and 3 respectively compared to lead (9.4%, 9.5% and 7.6%) for stations 1, 2 and 3 respectively. This result demonstrates high selectivity/affinity of the bacteria to chromium. *Macrococcus equipercicus*, though a gram positive bacteria has very low affinity for lead

Table 2: Biosorption of Heavy Metals by *Macrococcus equipercicus* from experimental pond B

Time(Day)	Pb(ppm)			Cr(ppm)		
	St 1	St 2	St 3	St 1	St 2	St 3
1	1.806	1.907	1.848	0.654	0.660	0.718
7	1. 798	1.807	1.810	0.368	0.370	0.380
14	1. 702	1.752	1.748	0.253	0.250	0.240
21	1. 684	1.732	1.714	0.185	0.200	0.210
28	1.636	1.726	1.708	0.152	0.156	0.170
% R	9.4	9.5	7.6	76.8	76.4	76.3

Key: ppm = part per million, % R = Percentage removal of heavy metal, Pb = Lead, Cr = Chromium St1 = Station 1, St 2= Station 2, St 3= Station 3

Plate I: Affinity for Chromium (Cr)

Plate II: Affinity for Lead (Pb)

Table 3: Bacteria Screened for Biosorption Potentials

S/N	Bacteria	Pb	Cr
1	*Bacillus pumilus*	-	-
2	*Enterobacter cloacae*	+	+
3	*Escherichia coli*	-	+
4	*Macrococcus equipercicus*	+	-
5	*Aeromonas enteropelogenes*	+	+

Key: - = Not Sensitive/ Ability to tolerate heavy metal hence development of bacterial colony
+ = Sensitive/ Inability to tolerate heavy metal hence no development of bacterial colony

CONCLUSION AND RECOMMENDATION

The bacteria Bacillus pumilus has high biosorption capacity for lead compared to chromium. *Macrococcus equipercicus* is selective for chromium compared to lead. Though the screening on biosorption showed that Escherichia coli had the potential for uptake of lead, it could not be used for fear of been opportunistic. It can be concluded that Bacillus pumilus can be used for removal of lead in lead polluted aquatic environment.

REFERENCES

American Public Health Association (1985). Standard Methods for the examination of water and wastewater. 16th ed. APHA, AWWA and WPCE,

American Public Health Association (1992). Standard Methods for the examination of water and wastewater. 17th ed. APHA, Inc. Washington, D.C.

American Public Health Association (2005). Standard methods for the examination of water and wastewater, 21st edn. American Public Health Association. Washington DC.

Abioye, O.P., Abubakar, M. and Aransiola, S.A. (2015). Biosorption of zinc and manganese by Micrococcus varians and Staphylococcus aureus isolated from soil. Proceedings of the 14th International Conference on Environmental Science and Technology. Rhodes, Greece.

Abioye, O. P., Oyewole, O. A., Oyeleke, S. B., Adeyemi, M. O. and Orukotan, A. A. (2018). Biosorption of lead, chromium and cadmium in tannery effluent using indigenous microorganisms. Brazillian Journal of Biological Sciences, 5(9), 25–32. Bio-Ellite (2000). Webmaster@bio-ellite.com.

Cheesbrough, M. (2000). District laboratory manual for tropical countries. Part 2 Cambridge university press. pp 143- 147.

Dawson, A.B. (1985). The lemopoitic response in the cat fish, Ameriurus nebulosus to chronic lead poisoning. Biological Bulletin 68, p. 335 - 346.

Etim, E.E., Andrew, C., Ushie, O.A. and Lawal, U. (2013). Analysis of heavy metal levels in mudfish (clarias gariepineus) in itu river. Bioinfo Environment and Pollution, 3(1), 016-018.

Federal Environmental Protection Agency (FEPA) (2003). Guidelines and standards for Environmental Pollution Contol in Nigeria. 238P.

Krieg, N. R. and Holt, J. G. (Eds.) (1994). Bergey's Manual of Systematic Bacteriology. Baltimore, William and Wilkins Ltd.

Luo, R., Sickler, J. and Vahidnia, F. (2017). Use of PCR for diagnosis of Group A Streptococcal pharyngitis in the United States, 2011–2015. Open Forum Infectious Diseases 4(S1): S618.doi: https://doi.org/10.1093/ofid/ofx163.1630.

Mutuku, C. S. (2010). Association of heavy metal tolerance with multiple antibiotic resistance in bacteria isolated from wetland of Lake Victoria basin, Kenya. Msc. thesis, Unpublished. Kenyatta University.

Ojutiku, R. O., Ibrahim, A. and Raymond, A. (2013). Assessment of water quality parameters and trace metal contents of drinking water sources in Minna, Niger State. 28th Annual FISON Proceedings, Pp 192- 196.

OztUrk, M., Ozozen, G., Minareci, O. and Minareci, E. (2009). Determination of Heavy Metals in fish, Water and Sediments of Avsar Dam Lake in Turkey. Iranian Journal of Environmental Health Science and Engineering, 6 (2), 73-80.

World Health Organization (2008b). Guidelines for drinking-water quality: incorporating 1st and 2nd addenda, Vol.1, Recommendation, 3rd edition.

SUBLETHAL EFFECTS OF CYPERMETHRIN (PESTICIDE) ON GROWTH AND NUTRIENT UTILIZATION OF FRESHWATER FISH *(Oreochromis niloticus*, TREWAVAS) IN FLOW-THROUGH BIOASSAY

[*1]Yaji, A.J.,[1]B.J. Samuel, and[2]B. Ezekiel

[1]Department of Fisheries, Modibbo Adama University, P.M.B. 2076, Yola, Nigeria
[2]Department of Fisheries Technology, Federal College of Horticulture, P.M.B. 108, Dadin kowa, Gombe State

Correspondence Author:
abubakaryaji@gmail.com, Phone: +2348062555491

ABSTRACT
This study aimed to determine the growth and nutrient utilization parameters of Oreochromis niloticus exposed to cypermethrin. Juveniles were exposed in aquaria of 20 litres capacity containing 0.0005, 0.0011, and 0.0021 mg/l sub lethal concentrations of cypermethrin in flow-through bioassay. The final mean weight for control was 21.33 g, while the exposed group had 20.03 g, 15.60 g, and 13.23 g for 0.0005, 0.0011 and 0.0021mg/l sub lethal concentrations respectively. WG and SGR were significantly lower ($p < 0.05$) and dose dependent compared with the control fish. In flow through bioassay, feed conversion ratio (FCR) of the exposed fish increased significantly ($p < 0.05$) as the concentration of the toxicant increases. Gross feed conversion efficiency (GFCE), feed efficiency (FE) and nitrogen metabolism (NM) of the control fish increased significantly ($p < 0.05$) than those fish exposed to 0.0011 and 0.0021 mg/l concentrations of cypermethrin. Cypermethrin adversely affected the growth and nutrient utilization of Oreochromis niloticus. Farmers are therefore advice to avoid the application of this pesticide near or into water bodies.

Keywords:
Cypermethrin, Oreochromis niloticus,growth, flow through bioassay. Nutrient Utilization

INTRODUCTION

Pyrethroids are synthetic forms of pyrethrins extracted from species of chrysantemum. Pyrethroids are groups of insecticides use for control of insects. Excessive application of pesticides on farmlands enters into water body through surface runoff, accidental spillage from tanks during transportation, atmospheric precipitation and sometimes through direct application into water during pest control programs.

Introduction of pesticide into water affects the physiology of non-target aquatic organisms including fish Type 1 and 11 pyrethroids inhibit the sodium channels of nerve filaments. Type 11 pyrethroids inhibits the gamma aminobuttyric acid (GABA) receptors of the nerve filaments and affects the calcium and chloride channels (Bradbury and Coats 1989; Hayes, 1994; Burr and Ray, 2000; Svobodova et al., 2003).

Borges et al. (2007) observed increased levels of sodium ($Na+$), potassium ($K+$), magnesium ($Mg2+$), phosphorus (P), Urea, glucose, cholesterol, creatinine, aspartate aminotransferase (AST)

and alkaline phosphatase (ALP) and decreased levels of total protein, triglyceride and ALT in silver carp exposed to cypermethrin. . Reduced levels of free amino acids with increased AST, alanine aminotransferase (ALT) and glutamate dehydrogenase (GDH) were as a result of decreased catabolism in fish (Kumar et al., 2011). The change in the external environment of fish affects the physiology and overall health status of fish as a result of their relationship with energetic (haemoglobin level), and defense mechanism (leucocyte level) as a measure of health status of fish, which overtime manifest into changes in weight. Yaji and Auta, 2007 reported a significant reduction in weight gain, specific growth rate, gross feed conversion efficiency, feed efficiency, protein efficiency ratio and nitrogen metabolism in *Clarias gariepinus* exposed to sub lethal concentrations of monochrotophos. Exposure of *Oreochromis niloticus* to sub lethal concentrations of cypermethrin induced a reduction in weight gain, specific growth rate and protein efficiency ratio (Rajib and Anilava. 2017).
Contamination of environment by pesticides is a problem of worldwide concern. Therefore, data on pesticide toxicity on fish is important for the assessment of the safety for man and level of environmental contamination. There are dearth information on the effects of pesticides on Nigerian fish species. This research investigated the effects of sublethal concentrations of cypermethrin on growth and nutrient utilization of *Oreochromis niloticus* in static and flow-through bioassays.

MATERIALS AND METHODS

Collection and maintenance of test organisms

Juveniles of *Oreochromis niloticus* of mixed sexes and fairly uniform size were obtained from Bagauda fish farm in Kano and transported in plastic containers to the laboratory in the Department of Biological Sciences, Ahmadu Bello University (ABU), Zaria. In the laboratory, the water from the farm was gradually replaced with dechlorinated tap water and acclimatized for two weeks. The natural day and night photoperiods was maintained. During the time of acclimatization, the fish were fed with commercial feeds (coppens) three times a day at 9.00 am 1.00 pm and 7.00 pm.

Experimental Design for Static Bioassay

Healthy fish were randomly selected, weighed and distributed into twelve (12) glass aquaria with dimensions; 30..5 x 30.5 x 46.25cm, each containing 20 litres of dechlorinated water. Ten *Oreochromis niloticus* (18.87 g and 9.1 cm mean weight and length) regardless of sex were randomly sorted into each aquarium. The experiment was replicated three times including the control.

Experimental Design for Flow through Bioassay

The system set-up consists of the delivery and test tanks as prescribed in (EPA, 1996) and (OECD, 1992) guidelines for acute toxicity tests with fish. Healthy juveniles of Oreochromis niloticus of uniform weight and size (18.83 g and 8.9 cm mean weight and length) were randomly sorted and distributed into the test tanks. Ten fish were distributed into each test tank including the control and the experiment was replicated three times. Flow rate was controlled to allow continuous flow of sub lethal concentrations of the toxicant from the delivery tanks into the test tanks at 4 L/hour.

Sub-lethal Bioassay

The 96 hour LC50 value as described by Yaji et al., (2011) was divided by 1/5, 1/10, 1/20, to determine sub-lethal concentration range of the toxicant. The experiment lasted for eight weeks. Group of ten fish were exposed to sub-lethal concentrations of the toxicant including the control. During the time of exposure, fresh solution was added every 48 hours to maintain the concentration level. Water quality parameters such as temperature, pH, and dissolved oxygen were monitored at the time of the experiment (APHA, 1985).

Growth studies and Nutrient Utilization

The fish were fed at 3% body weight with commercial feeds (coppens). Daily ratio was divided into three and fed thrice (at 9, 00 am, 1.00pm and 7,00pm) a day. Quantity of daily ration was adjusted weekly, based on fish weight . The average weight of the fish as at commencement of the experiment was recorded, as well as at the end of the experiment (Shalaby et al., 2006).

The data collected during the experiment were analysed for fish growth, specific growth rate, feed conversion ratio, gross feed conversion efficiency, nitrogen metabolism and protein utilization using the appropriate indices.

Weight Gain (W G)

The fish fresh weight gain (W G) was calculated as the difference between the final weight of the fish at the end of the experiment and the initial weight in grams.

Specific Growth Rate (SGR)

The SGR was calculated as described by (Hepher, 1988), that is: $SGR= \frac{\text{Log Wt - Log Wo}}{t-to}$

Where:

Wt= Weight at time of observation (g)

Wo = initial weight (g)

t-to= the period under study (days)

Feed conversion Ratio (FCR)

FCR was computed as the dry weight of feed offered divided by the wet weight gain of fish (Stickney, 1979; APHA, 1985; Shalaby *et al.,* 2006). This was expressed as

$$FCR = \frac{\text{Feed supplied (g)}}{\text{Net feed produced (g)}}$$

Gross Feed Conversion Efficiency (GFC E)

The G F C E is the reciprocal of the F C R express as percentage (APHA, 1985; Hepher, 1988) that is;

$$GFCE = \frac{1 \text{ X } 100}{FCR}$$

Feed efficiency (FE)

Feed efficiency (FE) was computed as a ratio that expresses the fish weight gain to the quantity of feed.

$$FE= \frac{\text{Weight gain (g)}}{\text{Feed fed (g)}}$$

2.14 **Nitrogen metabolism (NM)**

The value of nm will be calculated with the formula of (APHA, 1985).

$$Nm = \frac{(0.549\ (b-a)\ h}{2}$$

Where:

a. = initial weight of fish (g)
b. = final weight of fish (g)
c. = experiment period in days

Statistical analyses

Data obtained were subjected to Analysis of variance (ANOVA) at $p < 0.05$ and least significant difference (LSD) was used as post-hoc test to separate means

RESULTS

Results on growth of *Oreochromis niloticus* after 8 weeks of exposure to sub-lethal concentrations of cypermethrin in static bioassay is shown on Table 1. The final mean weight for control was 21.33 g, while the exposed group had 20.03 g, 15.60 g, and 13.23 g for 0.0005, 0.0011 and 0.0021mg/l sub-lethal concentrations respectively. Weight gain (WG) of the control fish were significantly higher ($p < 0.05$) than those exposed to 0.0011 and 0.0021 mg/l concentrations but not significantly different from those exposed to 0.0005mg/l concentrations of the toxicant. Specific growth rate (SGR) of the exposed groups decreased significantly ($p < 0.05$) compared with the control fish.

Table 1: Growth of *Oreochromis niloticus* Exposed to Sub-lethal Concentrations (mg/l) of Cypermethrin after 8 Weeks in Static Bioassay.

Treatment/Parameter	T0 (0.00)	T1(0.0005)	T2(0.0011)	T3(0.0021)
No. of fish	10	10	10	10
Mortality %	0	0	0	0
AV. Initial weight (g)	18.87	19.04	18.33	18.97
A.V final Weight (g)	21.33	20.03	15.60	13.25
Weight gain (g)	2.46 ± 0.16^{a}	0.99 ± 0.11^{a}	2.73 ± 0.19^{b}	-5.72 ± 1.01^{b}
SGR	0.006 ± 0.013^{a}	0.0013 ± 0.11^{ab}	-0.0088 ± 0.02^{b}	-0.0196 ± 0.21^{c}

Means with the same superscript along rows are not significantly different ($p<0.05$)

Table 2 shows the growth of *Oreochromis niloticus* exposed to cypermethrin in flow through system. The initial mean weight for control was 18.83 g, while the exposed groups had 19.00g, 17.83 g, and 19.30 g for 0.0005, 0.0009 and 0.0018 mg/l sub-lethal concentrations respectively. WG and SGR were significantly lower ($p < 0.05$) and dose dependent compared with the control fish.

Table 2: Growth of *Oreochromis niloticus* Exposed to Sub-lethal Concentrations (mg/l) of Cypermethrin after 8 Weeks in Flow through Bioassay.

Treatment/Parameter	T0 (0.00)	T1(0.0005)	T2(0.0011)	T3(0.0021)
No. of fish	10	10	10	10
Mortality %	0	10	0	10
AV. Initial weight (g)	18.83	19.00	17.83	19.30
A.V final Weight (g)	24..33	23.07	18.60	16.23
Weight gain (g)	5.50 ± 1.22^{a}	4.07 ± 0.14^{a}	0.77 ± 0.06^{bc}	-3.07 ± 1.02^{c}
SGR	0.0150 ± 0.01^{a}	0.0104 ± 0.05^{ab}	0.0029 ± 0.01^{b}	-0.0096 ± 0.03^{c}

Means with the same superscript along rows are not significantly different ($p<0.05$)

Results of nutrients utilization in *Oreochromis niloticus* in static bioassay is shown in Table 3. Feed conversion ratio (FCR) of the exposed fish increased significantly ($p < 0.05$) as the concentration of the toxicant increases compared with the control value. Gross feed conversion efficiency (GFCE), feed efficiency (FE) and nitrogen metabolism (NM) of the control fish increased significantly ($p < 0.05$) than those fish exposed to 0.0011 and 0.0021mg/l concentrations of cypermethrin but not significantly varied with those fish exposed to 0.0005 mg/l of the same toxicant.

Table 3: Nutrient Utilization of *Oreochromis niloticus* Exposed to Sub -lethal Concentrations (mg/l) of Cypermethrin after 8 Weeks in Static Bioassay

Treatment/Nutrient Utilization	T0 (0.00)	T1 (0.0005)	T2 (0.0011)	T3 (0.0021)
FCR	1.49±0.54^{c}	1.63±0.21^{bc}	1.98±0.16^{ab}	2.43±1.34^{a}
GFCE	67.21±4.36^{a}	61.49±5.22^{a}	50.60±3.32^{b}	41.98±3.29^{b}
FE	0.43±0.11^{a}	0.10±0.02^{a}	- 0.55±0.06^{b}	- 0.98±0.92^{b}
NM	5.42±2.45^{a}	1.39±0.87^{a}	- 6.59±2.91^{b}	- 12.59±4.37^{b}

Means with the same superscript across the rows are not significantly different (P>0.05)

Nutrient Utilization of *Oreochromis niloticus* Exposed in Flow-through Bioassay.

FCR value of the control fish shows no significant difference compared with those fish exposed to 0.0005 and 0.0009 mg/l concentration of cypermethrin, but significantly lower ($p < 0.05$) than those exposed to 0.0018 mg/l concentration of the toxicant (Table 4). GFCE, and FE value of the control were higher significantly ($p < 0.05$) compared to those exposed to the various sub-lethal concentrations of cypermethrin. The decreases with the exposed groups were observed to be dose dependent.

Table 4: Nutrient Utilization of *Oreochromis niloticus* Exposed to Sub-lethal Concentrations (mg/l) of Cypermethrin after 8 Weeks in Flow through Bioassay

Treatment/Nutrient Utilization	T0 (0.00)	T1 (0.0005)	T2 (0.0011)	T3 (0.0021)
FCR	1.31±0.33^{b}	1.41±0.27^{b}	1.62±0.25^{b}	2.01±1.01^{a}
GFCE	77.63±6.45^{a}	71.42±4.87^{ab}	61.92±2.44^{bc}	50.22±3.45^{c}
FE	0.99±0.09^{a}	0.71±0.09^{ab}	0.15±0.03^{bc}	- 0.52±0.24^{c}
NM	9.85±2.27^{a}	8.93±3.28^{a}	1.68±0.95^{ab}	- 6.74±2.32^{b}

Means with the same superscript across the rows are not significantly different (p>0.05

DISCUSSION

This study shows that there is significant difference between the control and the various concentrations of the toxicant and the effects are dose dependant. Significant decrease in percentage life weight gain (LWG%), weight gain (WG), specific growth rate (SGR), gross feed conversion efficiency (GFCE), feed efficiency (FE) and nitrogen metabolism (NM) were observed with fish exposed to sub lethal concentrations of the toxicant. This is similar to the report of Ndimele et al., (2012) on fingerlings of *Clarias gariepinus* exposed to dichlorvos (2, 2-dichlorovinyl phosphate) but disagrees with Ramota et al., (2021) on growth response and nutrient utilization of *Clarias gariepinus* fingerlings exposed to Dichlorvos who reported that growth and nutrient utilization parameters of *C. gariepinus* fingerlings were generally not dependent on the concentration group to which they belong; This may be due to different conditions to which the fishes were subjected in their study. Increase in

FCR could be as a result of under utilization of food in these concentrations. A reduction in growth may also be attributed to an increase activity associated with attempt to avoid the contaminated water, or an increased expenditure of energy on chemical detoxification and tissue repairs (Yaji and Auta, 2007). In sub lethal tests, growth parameters such as specific growth rate, food conversion efficiency and protein efficiency ratio conversion decreased as the concentration of cymbush pesticide increased (Aguigwo, 2022). Growth effects in rohu were accompanied by impaired fuel conversion efficiency for lipids, proteins and carbohydrates (Rajib and Anilava. 2017). Fishes are noted to increase their metabolic activities for the excretion of toxicants, hence, making more energy available for homeostatic maintenance than storage, which could be used for growth (Rao et al., 2017). Dietry levels of 500 μ/kg resulted in only minor sublethal effects, such as reduction in condition factor and transient changes in haematological parameters (Dietrich, et al., 2006).

Shallangwa and Auta (2008), reported a reduction in growth of *Clarias gariepinus* exposed to sub lethal concentrations of 2,4-Dichlorophenoxy – acetic acid. The authors attributed this to lower feeding rate and or the toxicant made the feed unsuitable for consumption. They further opined that it could be due to an increased expenditure of energy on chemical detoxification and tissue repair.

CONCLUSION

In conclusion, exposure of *Oreochromis niloticus* at chronic concentrations of cypermethrin in both static and flow through systems adversely affected the growth and better utilization of feed by this fish. It is recommended that application of cypermethrin near water body should be avoided and further research should be focus on biological control of insect pest.

REFERENCES

Aguigwo J.N. (2002). The Toxic Effect of Cymbus Pesticide on Growth and Survival of African Catfish, Clarias gariepinus (Burchell). Journal of Aquatic Sciences. 17(2):81-84.

American Public Health Association (APHA). (1985). Standard Methods for Examination of Water and Waste Water, 16th ed. Washington, D.C.

Borges A, Scotti LV, Siqueira D. R. (2007). Changes in Hematological and Serum Biochemical Values in jundiá Rhamdia quelen due to Sub-lethal Toxicity of Cypermethrin. Chemosphere. 69: 920–6.

Bradbury, S.P, Coats, J.R. (1989). Toxicokinetics and Toxicodynamics of Pyrethroid Insecticides in Fish. Environ Toxicol Chem. 8: 373–80.

Burr S.A, Ray D.E. (2000). Structure-activity and Interaction Effects of 14 different Pyrethroids on Voltage-gated Chloride ion Channels. Toxicological Science: 77: 341–6

Dietrich, P., Chris, N.G., Sonja, Y., Kjersti, K., Gro, F., Rune, W., and Mare, H.G.B. (2006). Sensitivity of Atlantic salmon (Salmo salar) to Dietary Endosulphan as Assessed by Haematology, Blood Biochemistry, and Growth Parameters. Aquatic Toxicology. 80(3):207-216.

EPA. (1996). Ecological Effects Tests Guidelines, Fish Acute Toxicity Test, Fresh water and Marine. U.S. Environmental Protection Agency OPPTS: 850. 1075.

Hayes AW. (1994). Principles and Methods of Toxicology .New York: Raven Press. 1468.

Hepher, B. (1988). Nutrition of Pond fishes. Cambridge University Press. 388.

Kumar A, Sharma B, Pandey R.S. (2011). Cypermethrin Induced Alterations in Nitrogen Metabolism in Freshwater Fishes. Chemosphere. 83: 492–501.

Organization for Economic Corporation and Development (OECD). (1992). Ecological Effects Test Guidelines. Fish Toxicity Tests Method.

Oti, E. E. (2003). Acute Toxicity of Gammalin 20 to Chrysichthys nigrodigitatus (leacede). Science Forum. Journal of Pure and Applied Science, 6: 219-225

Rajib, M. and Anilava. (2017). Cypermethrin Induced Stress and Changes in Growth of Freshwater Fish Oreochromis niloticus. International Journal of Aquatic Research, DOI: 1.10.1007/s40071-017-0161-6

Shalaby, A.M., Khattab, Y.A., and Abdel-Rahman, A.M. (2006). Effect of Garlic (Allium sativum) and Chlororamphenicol on Growth Performance, Physiological parameters and Survival of Nile Tilapia (O.niloticus). Journal of Venomous Animals and Toxins including Tropical Diseases. 12(2): 365 – 378.

Shallangwa, S.M. and Auta, J. (2008). Sublethal Effect of 2,4 – Dichlorophenoxy-acetic acid on Growth and Food utilization of the African Catfish Clarias gariepinus (Teugels). Journal of Fisheries International. 3(3):65-67.

Stickney, R.R. (1979). Principles of Warm water Aquaculture. John Wiley and Sons. New York., 116-124.

Svobodova Z, Luskova V. Drastichova J. (2003). Effect of Deltamethrin on Haematological Indices of Common carp (Cyprinus carpio L.). Acta Vet Brno. 72: 79–85

Yaji, A. J and Auta, J. (2007). Sublethal Effects of Monochrotophos on Growth and Food Utilization of the African Catfish Clarias gariepinus (Teugels). Journal of Fisheries International: 2 (2): 127- 129

Yaji, J. A., Auta, J., Oniye, S.J., Adakole, J.A and Usman, J. I. (2011). Effects of Cypermehtrin on Behaviour and Biochemical Indices of Freshwater Fish Oreochromis niloticus. Electronic Journal of Environmental, Agricultural and Food Chemistry: 10 (2): 1927-1934.

Ndimele, P., Owodeinde, F and Ojo, D. (2012). The effects of dichlorvos (2, 2-dichlorovinyl phosphate (DDVP) induced stress on the growth of fingerlings of Clarias gariepinus (Burchell, 1822). In: Proceedings of the 27th Annual Conference and Biennial General Meeting of the Fisheries Society of Nigeria (FISON), Bayelsa, Nigeria. 2012, p. 57-9.

Rao, J. C. S., Neelima, P and Rao, K. G. (2017). A review on the toxicity and other effects of Dichlorvos, an organophosphate pesticide to the freshwater fish. Bioscience Discovery. 8(3): 402-415.

Ramota T. T., P. E. Ndimele, A. O.Saba and M. A. Ibrahim (2021). Growth response and nutrient utilization of Clarias gariepinus fingerlings exposed to Dichlorvos. International Journal of Applied Biology, 5(1), pp64-72

COMPARATIVE ANALYSIS OF WATER QUALITY AND HEAVY METALS IN THE NEW CALABAR RIVER AGAINST WORLD HEALTH ORGANIZATION STANDARDS

[1]Ogubunka, S.O, [2]*J.C. Igwe, [3]C. G. Gift

[1]African Regional Aquaculture Centre/Nigerian Institute for Oceanography and Marine Research, Aluu. P.M.B. 5122, Port Harcourt, Rivers State, Nigeria
[2,3]Department of Geography and Environmental Management, Faculty of Social Sciences, University of Port Harcourt, Port Harcourt, Rivers State, Nigeria

*Corresponding Author email:
phinasteco@yahoo.ccom, +2348037404742

ABSTRACT
This study compares the water quality and heavy metals in the New Calabar River, assessing its compliance with World Health Organization (WHO) standards. By evaluating physicochemical l parameters such as pH, dissolved oxygen, turbidity, and heavy metal contamination, the research aims to identify pollution levels in the river.. Data were analysed using ANOVA to compare water quality parameters against WHO benchmarks. Results indicate that most water quality parameters, including total dissolved solids, turbidity, and nitrate levels, fall within acceptable limits. However, high concentrations of iron were recorded in several communities, exceeding the WHO standard of 0.3 mg/l. Trace elements, including lead and copper, were generally within safe levels, though slight exceedances were observed in some areas. The ANOVA analysis reveals significant differences ($p<0.05$) in water quality and heavy metals between the results obtained and WHO standard across the sampled communities. The study highlights the need for targeted interventions to address specific contaminants, particularly iron, and emphasizes the importance of improving water management practices to safeguard public health. Recommendations include stricter monitoring, treatment facilities, and community education on waterborne diseases.

Keywords:
Water Quality,
New Calabar River,
WHO standard,

INTRODUCTION

Water is an invaluable resource requiring stringent protection from contamination. However, factors like rapid urbanization, population growth, industrialization, and inadequate environmental management have degraded many water sources, making them unsafe for human use. This problem is particularly severe in countries with weak environmental regulations. Access to clean water is crucial for health and economic development, as emphasized by Bhat *et al.* (2018). Despite Earth's freshwater abundance, only 3% is accessible, and pollution increasingly threatens this supply (Taruna and Alankarita, 2013). Globally, around 450 billion cubic meters of wastewater are discharged into surface waters annually, carrying pollutants like organic and inorganic compounds and microorganisms (Taruna and Alankarita, 2013). This affects rivers, lakes, and oceans, degrading water quality (Onyegeme-Okerenta *et al.*, 2016).

Urbanization and intensified economic activities lead to environmental challenges, such as water pollution from industrial and domestic waste (Rashid et al., 2018). Pollutants entering rivers degrade water quality, posing risks to both human health and aquatic ecosystems. In developing countries, untreated sewage is a major source of pollution, with 95% being discharged into water bodies untreated. For example, two-thirds of surface waters in India are dangerously polluted (Shah, 2016). Solid waste dumping into rivers further compromises water quality (Akungah, 2003; Chindah *et al.*, 2004). Studies from the Niger Delta highlight how industrial and human activities contribute to water pollution (Marcus and Ekpete, 2014; Iyama and Edori, 2016; Ekpete *et al.*, 2019). Monitoring water quality provides critical data on pollutant concentrations, which helps assess water suitability for various uses. The World Health Organization (WHO) sets water quality standards to assess pollution levels and determine water's suitability for different uses (WHO, 2017). Ensuring safe water quality is essential for public health and sustainable development, and the WHO provides acceptable limits for contaminants in drinking water (WHO, 2017).

Contaminated water poses severe health risks and can damage aquatic life by depleting oxygen and stunting organism growth (Ndeda and Manohar, 2014). Parameters like pH, temperature, and dissolved oxygen are crucial in assessing water quality. For example, water with a high pH can cause gastrointestinal issues, while low pH irritates the eyes (Taruna and Alankarita, 2013; WHO, 2017). The New Calabar River is increasingly affected by activities that introduce contaminants, necessitating regular monitoring to maintain ecosystem health (Seiyaboh *et al.*, 2016). Polluted water endangers life. Akpe *et al.* (2018) stress that water is among the most essential natural resources, directly impacting life. Polluted water not only affects ecosystems but also poses significant health risks. Water quality is influenced by seasonal changes, water levels, and runoff (Ezekiel et al., 2020; Rahman *et al.*, 2021; Romin *et al.*, 2021).This study focuses on a comparative analysis of water quality and heavy metals in the New Calabar River, this research aims to assess the extent of pollution in the river. Thus provide insight into the current state of the New Calabar River's water quality and heavy merals, identify areas of concern and recommend measures to improve water management practices and safeguard public health.

MATERIALS AND METHODS

Study Area and Samples Collection

The New Calabar River is a low lying deltaic river located in Rivers States, in the oil-rich Niger Delta Region of Nigeria. The New Calabar River lies between 4°30 and 4°49N and 6°59 and 7°00 and empties into the Atlantic Ocean. Water samples were collected at Aluu, Emouha, Mbousi, Choba, Rumuokparali, and Ogbogoro sections of the river to ensure a representative and comprehensive understanding of water quality across different contexts and transported to the laboratory of the University of Port Harcourt for immediate analysis.

Physicochemical Analysis

Turbidity, temperature, pH, Dissolved Oxygen (DO), Total Dissolved Solid (TDS), salinity and conductivity were analysed in situ with a HORIBA, U-51 series Multi-parameter water quality checker. Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), chloride, sulphate, phosphate, nitrate, oil and grease were determined as described by the American Public Health Association (1998). Atomic absorption Spectrophotometry was used for heavy metals analysis.

Statistical Analysis

Analysis of Variance (ANOVA) was used to establish significant differences within parameters from different sampling points of the river at ($P<0.05$). The values obtained were compared with the WHO Standard.

RESULTS

Table 1 provides a comparison of water quality of the New Calabar River in different sampling stations with the World Health Organization (WHO) standards. The values of electrical conductivity, total dissolved solids, pH, turbidity, nitrates, sulphates, phosphates and hardness were below the WHO standard, indicating that their levels in the water are within safe limits. For the heavy metals, the values of Copper , lead, manganese, and zinc were well below the WHO standard, suggesting minimal metal contamination. However, Iron concentrations are notably high, ranging from 1.84 mg/l in Choba to 72.17 mg/l in Emuoha. These values exceed the WHO standard of 0.3 mg/l, indicating a potential issue with iron contamination in some communities.

Table 2 provides a detailed ANOVA analysis comparing water quality across various sampled communities and the WHO standard.The ANOVA results revealed significant differences in water quality. The between-groups sum of squares is 284,249.5 with 6 degrees of freedom, yielding a mean square of 47,374.92. The F-value of 3.70, coupled with a p-value of 0.0025, indicates that the differences in water quality across the sampled communities are statistically significant. This F-value exceeds the critical value of 2.20, suggesting that the observed differences are unlikely to have occurred by chance. Overall, the ANOVA analysis confirms that water quality differs significantly among the sampled communities when compared to the WHO standard, underscoring the varying levels of water quality across these locations

Table 1 Comparison of Water Quality Sampled in New Calabar River with WHO Standard

	Aluu	Choba	Emuoha	Isiodu	Ogbogoro	Rumuokparali	WHO
Electrical Conductivity (µs/cm)	143	69	83	69	65	108	400
Total Dissolve Solute (mg/l)	101	48	59	49	46	76	1000
Measure of Acidity or Alkalinity	5.87	5.2	5.52	6.08	5.48	5.2	8.5
Turbidity (FAU)	2	3	2	2	2	2	5
Chloride (mg/l)	65.68	32.33	39.51	38.38	31.33	49.59	250
Nitrate (mg/l)	27.54	12.41	18.81	20.38	15.54	23.66	50
Sulphate (mg/l)	4.69	2.6	2.1	6.56	3.4	1.2	500
Phosphate (mg/l)	7.09	4.46	5.86	4.23	1.85	7.1	
Total Hardness (mg/l)	62.03	29.64	37.96	28.49	25.37	46.9	
Iron (mg/l)	4.41	1.84	68.57	72.17	4.54	2.47	0.3
Copper (CFU/100ml)	0.07	0.01	0.04	0.03	0.04	0.05	2
Lead (mg/l)	0.02	0.01	0.02	0.01	0.01	0.02	0.01
Manganese (mg/l)	0	0	0	0	0	0	0.4
Zinc (mg/l)	0.02	0.01	0.02	0.01	0.01	0.02	3

Table 2. Difference in Water Quality Across Sampled in Some Fishing Communities and WHO Standard

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Aluu	14	423.42	30.24429	2068.783
Choba	14	208.51	14.89357	469.4912
Emuoha	14	322.41	23.02929	852.001
Isiodu	14	296.34	21.16714	684.5985
Ogbogoro	14	200.57	14.32643	415.6825
Rumuokparali	14	322.21	23.015	1179.377
WHO	12	2219.21	184.9342	96791.16

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	284249.5	6	47374.92	3.703728	0.002477	2.202234
Within Groups	1138412	89	12791.14			
Total	1422661	95				

DISCUSSION

Findings from this study reveals significant variations in water quality across communities along the New Calabar River, revealing both compliance and concerns when compared to WHO standards. Generally, the electrical conductivity, total dissolved solids, pH, turbidity, chloride, nitrate, sulphate, and phosphate levels across the sampled communities meet or fall below WHO guidelines, indicating that most of these parameters are within acceptable limits for safe drinking water. These findings align with previous studies, such as those by Oko et al. (2014), which also reported that most water quality parameters in rural and peri-urban settings are within acceptable thresholds. However, the study identifies elevated iron concentrations in several communities, significantly exceeding WHO standards. This highlights a localized issue with iron contamination, which could pose health risks over time, such as gastrointestinal problems or other iron-related disorders. This concern is corroborated by other literature, such as Dahunsi et al. (2014), which emphasizes the importance of monitoring and managing metal contaminants in water sources.

Copper, lead, manganese, and zinc levels are generally within safe limits, with copper levels particularly low and well below WHO standards. Lead concentrations are slightly above the WHO standard in some areas, but they are still within acceptable ranges, reflecting a minor concern. Manganese levels being consistently low aligns with the findings of previous research, such as that of Ukpong et al. (2013), which found that manganese contamination was not a significant issue in similar settings.The ANOVA analysis reveals substantial variability in water quality scores among the different communities, with Aluu showing particularly high variability, while other communities like Choba and Ogbogoro exhibit lower and more consistent scores. This variation suggests that while some communities are generally meeting safety standards, others, such as Aluu, face greater challenges with water quality management. This variability highlights the need for targeted interventions and more detailed local assessments to address specific issues effectively, a recommendation also supported by the broader literature on water quality management and infrastructure needs (Edokpayi et al., 2018).Overall, while the study finds that many water quality parameters align with WHO standards, the elevated iron levels in some communities and the significant variability in water quality scores underscore the necessity for ongoing monitoring and localized interventions to ensure safe and consistent water quality across all sampled areas.

CONCLUSION AND RECOMMENDATIONS

In conclusion, the study underscores the critical need for enhanced water quality management and infrastructure improvements in some fishing communities along the New Calabar River. The significant reliance on bottled or sachet water for drinking reflects widespread concerns about the safety and reliability of alternative water sources. Borehole water, while preferred for non-potable uses, highlights a perceived lack of trust in other sources like wells and river water. The variability in water quality parameters across the fishing communities, including elevated levels of iron and inconsistencies with WHO standards, reveals a pressing issue of contamination and potential health risks.

REFERENCES

Akpe, A.R., Femi, I.J., Okwu, G.I., and Obiazi, H. (2018). Seasonal variations in the physicochemical parameters of Ikpoba River water samples. International Journal of Life Science Research, 4(3), 1810-1821.

Akungah, D.N. (2003). Assessment of Physical and biochemical parameters of pollution of freshwater reservoirs in Kericho tea estates, Kenya (Unpublished Masters' Thesis). Kenyatta University: Kenya.

Bhat, N.B., Parveen, S., and Hassan, T. (2018). Seasonal assessment of physicochemical parameters and evaluation of water quality of River Yamuna, India. Advances in Environmental Technology, 1, 41–49

Chindah, A., Davies, O.A., Allison, M.E., and Oyi, H.S. (2004). Bioaccumulation of heavy metals in water. African Journal of Biotechnology, 5(10), 968- 973.

Dahunsi, S. O., Owamah, H. I., Ayandiran, T. A., and Oranusi, S. U. (2014). Drinking water quality and public health of selected towns in South Western Nigeria. Water Quality, Exposure and Health, 6, 143-153.

Edokpayi, J. N., Rogawski, E. T., Kahler, D. M., Hill, C. L., Reynolds, C., Nyathi, E., and Dillingham, R. (2018). Challenges to sustainable safe drinking water: A case study of water quality and use across seasons in rural communities in Limpopo Province, South Africa. Water, 10(2), 159.

Ekpete, O.A., Edori, O.S., Kieri, B.S.I. (2019). Assessment of heavy metals concentrations in surficial water of Silver River, Southern Ijaw, Bayelsa State, Niger Delta, Nigeria. Journal of Basic and Applied Research International, 25(4), 186–193.

Ezekiel, E.N., Sarogoro, N.S. and Charles, K .(2020). Seasonal variation of physicochemical parameters of Rivers in Trans-Amadi, Port Harcourt, Rivers State. European Academic Research, 7(12), 5945–5958

Iyama, W.A., and Edori, O.S. (2016). Comparative analysis of the water quality status of the Bassan Rivers in Bayelsa State. Nigeria. International Journal of Chemistry and Chemical Engineering, 6(2), 99-109.

Marcus, A.C., and Ekpete, O.A. (2014). Impact of discharged process wastewater from an oil refinery on the physicochemical quality of a receiving waterbody in Rivers State, Nigeria. IOSR Journal of Applied Chemistry, 7(12), 1-8

Ndeda, L.A., and Manohar, S. (2014). Determination of heavy metals in Nairobi dam water, Kenya. IOSR Journal of Environmental Science, Toxicology and Food Technology, 8 (5), 68-75.

Oko, O. J., Aremu, M. O., Odoh, R., Yebpella, G., and Shenge, G. (2014). Assessment of water quality index of borehole and well water in Wukari Town, Taraba State, Nigeria. Assessment, 4(5), 1-9.

Onyegeme-Okerenta, B. M., Obia, C., and Wegwu, M. O. (2016). Physicochemical properties of water quality of Imeh, Edegelem and Chokocho communities located along Otamiri-oche River in Etche Ethnic Nationality of Rivers State, Nigeria. Journal of Applied Sciences and

Environmental Management, 20(1), 113-119.

Rahman, A., Jahanara, I., and Jolly, Y.N. (2021). Assessment of physicochemical properties of water and their seasonal variation in an urban river in Bangladesh. Water Sciences and Engineering, 14(2), 139 – 148.

Rashid, H., Manzoor, M. M., and Mukhtar, S. (2018). Urbanization and its effects on water resources: An exploratory analysis. Asian Journal of Water, Environment and Pollution, 15(1), 67-74.

Romin, M.R., Al Azad, S., and Saleh, E. (2021). Variations in the physicochemical water parameters and phytoplankton community in coastal water of Kudat, Sabah, Malaysia. Journal of Geosciences and Environmental Protection, 9(7), 86-99.

Seiyaboh, E.I., Angaye, T.C.N. and Okogbue, B.C. (2016). Physicochemical quality assessment of River Orashi in Eastern Niger Delta of Nigeria. Journal of Environmental Treatments and Technology, 4(4), 143-148

Shah, M. (2016). Urban water systems in India: a way forward (No. 323). Working Paper.

Taruna, J., and Alankarita, C. (2013). Assessment of water quality and its effects on the health of residents of Jhunjhunu district, Rajasthan: A cross sectional study. Journal of Public Health Epidemiology, 5(4), 189-191

Ukpong, E. C., Ogarekpe, N. M., and Bejor, E. S. (2013). Comparative analysis of water quality in hand dug well and borehole in Calabar South Local Government Area in Nigeria. The International Journal of Engineering and Science (IJES), 2(8), 95-101.

WHO (World Health Organisation) (2017). Children: reducing mortality. http://www.who.int/newsroom/fact-sheets/detai l/children-reducing mortality. Acessed on 16th November, 2023.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

VARIATION IN WATER QUALITY AND HEAVY METALS OF WELL AND BORE HOLE WATER IN SOME FISHING COMMUNITIES ALONG THE NEW CALABAR RIVER, RIVERS STATE, NIGERIA

[1]Ogubunka, S.O., [2]*O.A Akinrotimi, [3]K.N. Owhonda, [4]B.U.Eze, [5]C.A. Onwujiariri

[1,4,5]African Regional Aquaculture Centre/Nigerian Institute for Oceanography and Marine Research, Aluu. P.M.B. 5122, Port Harcourt, Rivers State, Nigeria
[2,3]Department of Mariculture, Nigerian Institute for Oceanography and Marine Research, Buguma P.M.B. 5122, Port Harcourt, Rivers State, Nigeria

*Corresponding author:
joakinrotimi@gmail.com, +2348065770699, 0000-0003-2775-645x

ABSTRACT
The New Calabar River plays a vital role in the daily lives of surrounding fishing communities, providing water for domestic, agricultural, and industrial purposes. However, concerns about the quality of water from wells and boreholes in the region have emerged due to increasing pollution. This study assesses the variation in water quality across six fishing communities—Aluu, Choba, Emuoha, Isiodu, Ogbogoro, and Rumuokparali—along the New Calabar River, focusing on key physico-chemical and microbial parameters. Water samples were collected from boreholes, wells, and river points and tested for electrical conductivity, total dissolved solids (TDS), pH, turbidity, chloride, nitrate, sulphate, phosphate, and total hardness. The results revealed significant variability in water quality. Electrical conductivity ranged from 65 μs/cm in Ogbogoro to 143 μs/cm in Aluu, indicating higher dissolved ion concentrations in the latter. TDS levels also varied, with Aluu recording the highest at 101 mg/l and Ogbogoro the lowest at 46 mg/l. pH values ranged from 5.20 to 6.08 across the communities, suggesting slightly acidic to neutral water. Chloride concentrations were highest in Aluu (65.68 mg/l) and lowest in Ogbogoro (31.33 mg/l), while nitrate levels ranged from 12.41 mg/l in Choba to 27.54 mg/l in Aluu. Total hardness showed substantial variation, with Aluu having the highest mean at 62.03 mg/l and Ogbogoro the lowest at 25.37 mg/l. Metal contamination was also evaluated, with iron levels ranging from 1.84 mg/l in Choba to 4.57 mg/l in Emuoha. Copper and lead concentrations were low across all communities, indicating minimal contamination. These findings highlight the disparities in water quality across the studied areas and emphasize the need for continuous monitoring and interventions to ensure safe drinking water for the communities along the New Calabar River.

Keywords:
Fishing Communities,
New Calabar River,
Water Quality, Rivers State.

INTRODUCTION

Rivers are essential natural resources that significantly contribute to the biosphere due to their diverse applications (Ukpong et al., 2013). Although water covers 70% of Earth's surface, only 3% is fresh and

found in rivers, lakes, aquifers, glaciers, and atmospheric sources. The remaining 97% is saltwater. Rivers provide crucial services such as transportation, fishing, hydropower generation, and water supply for domestic, industrial, and agricultural use (Coles *et al.*, 2010). Water quality is a key factor in sustaining both human populations and aquatic ecosystems. Rivers, especially, are vital sources of freshwater for various uses. The New Calabar River in southern Nigeria is a lifeline for local communities, supporting drinking water, fishing, irrigation, and daily activities. However, the river's water quality has been increasingly compromised by industrial activities, agricultural runoff, and improper waste disposal, raising serious concerns (Seiyaboh *et al.*, 2016).
The health of aquatic ecosystems largely depends on their physicochemical properties and biological diversity (Cantonati *et* al., 2020). Water plays a crucial role in human development and ecosystem function, facilitating processes like drinking, cooking, and industrial applications. In the human body, water is vital for nutrient absorption, waste expulsion, and transporting organic substances (Dey *et al.*, 2021). Rivers must, therefore, be regularly monitored to assess their ecological health. Rivers can originate from sources such as springs, lakes, glaciers, or rainwater runoff. Groundwater also contributes to river flow (Romin *et al.*, 2021). As they traverse various terrains, rivers serve as cost-effective transportation routes but also face pollution from unregulated transport activities, contributing to global greenhouse gas emissions and particulate pollution (Iyama and Edori, 2016). Given the importance of rivers like the New Calabar, which support domestic and industrial use, regular water quality assessments are critical. Industrial discharge, agricultural runoff, and domestic waste have severely degraded the river's quality, threatening both the environment and public health. This study therefore assessed the variation in well and borehole water quality in some fishing communities along the New Calabar River, Rivers State, Nigeria.

MATERIALS AND METHODS

Study Location

The population of this study encompassed boreholes, water samples, and residents within the various fishing communities sampled along the New Calabar River. This approach ensures that the study captures a holistic view of the water quality and its impact on the local population. Boreholes represent a significant source of drinking water for many residents in the communities along the New Calabar River. These underground water sources are often considered more reliable and safer compared to surface water, given their lower susceptibility to surface contaminants. By including boreholes in the study, the research aims to evaluate their water quality, including potential contaminants and seasonal variations. This data is crucial for understanding the overall safety and reliability of boreholes as a primary water source and for identifying any need for additional water treatment or infrastructure improvements.

Experimental Procedures

Water samples was collected at various points in some fishing communities along the course of the New Calabar River. Also, Boreholes and wells will be randomly sampled across the selected communities. Residents of the selected fishing communities were randomly sampled for survey through questionnaires. Representative sampling points along the New Calabar River was selected, encompassing both urban and rural communities. The samples represented different sections of the river to capture a comprehensive picture of water quality. Water samples were collected from the selected points at the same time using standard laboratory methods described APHA (1998) to test for various physico-chemical and biological parameters, such as pH, turbidity, dissolved oxygen, biochemical oxygen demand, total dissolved solids, and microbial content. Each fishing community along the New Calabar River—Aluu, Emouha, Mbousi, Choba, Rumuokparali, and Ogbogoro—were sampled to ensure a representative and comprehensive understanding of water quality across different contexts. Water samples was collected at the river, boreholes and wells in the study area. This samples was collected in plastic HDPE bottles for proper laboratory test.

Sample Preparation for AAS Analysis

Sample preparation is a very important step in analytical chemistry which should be done very carefully without any mistake or carelessness. Sample preparation involving digestion of water samples for metal ion analysis by atomic absorption spectrophotometer can be achieved by adopting the standard method by APHA (1998): 50 ml of well mixed, acid preserved sample is measured into a beaker. 5 ml conc. HNO3 + few glass beads were added. It was then slowly boiled and evaporated on a hot plate upto 10-20 ml. Conc. HNO3 (few ml) was added until the completion of digestion (Sample was not allowed to dry). The beaker was washed down with deionized water (3 times). It was then filtered and poured in 100 ml volumetric flask and made up to 100 ml, mixed thoroughly.

Heavy Metal Determination

The digested samples were taken to the Laboratory, for AAS determination of heavy metals including Cadmium, Zinc, lead, and Copper. Three replicates determination was done for each metal analysis and the instrument gives the mean of the results.

Statistical Analysis

The mean and standard deviation of the mean were used to express all the data. The data analysis was done using SPSS Version 22, a statistical program. Using one way ANOVA, the means were split, and the two means were deemed significant at 5% ($P < 0.05$).

RESULTS

Table 1 provides an overview of the variation in physico-chemical properties of well and borehole water across different communities. The electrical conductivity of water varies significantly across the communities, ranging from a low of 65 μs/cm in Ogbogoro to a high of 143 μs/cm in Aluu. This indicates that the water in Aluu has a higher concentration of dissolved ions compared to other locations. Similarly, the total dissolved solids (TDS) follow a comparable trend, with Aluu having the highest mean value at 101 mg/l, while Ogbogoro has the lowest at 46 mg/l.The measure of acidity or alkalinity, as reflected by pH, is relatively consistent across all communities, ranging from 5.20 to 6.08. This suggests that the water is generally within a slightly acidic to neutral range. Turbidity remains low across all locations, ranging from 1.85 FAU in Ogbogoro to 3 FAU, indicating that the water is relatively clear in all communities. Chloride concentrations show notable variation, with Aluu having the highest mean value of 65.68 mg/l and Ogbogoro the lowest at 31.33 mg/l. Nitrate levels also vary, with Aluu recording the highest mean concentration of 27.54 mg/l, compared to the lowest at 12.41 mg/l in Choba. Sulphate concentrations range from 1.20 mg/l in Rumuokparali to 6.56 mg/l in Isiodu, highlighting some variation in water quality related to sulphate content. Phosphate levels are notably higher in Rumuokparali and Aluu, with means of 7.10 mg/l and 7.09 mg/l, respectively, compared to lower levels in other communities. Finally, total hardness varies significantly, with Aluu having the highest mean hardness at 62.03 mg/l and Ogbogoro the lowest at 25.37 mg/l. This variation in hardness levels suggests differences in the mineral content of the water across the communities.

Table 2 showed the variation in metal concentrations in well and borehole water across different communities. Iron concentrations in the water vary significantly, with Aluu having the highest mean level of 4.41 mg/l and Choba the lowest at 1.84 mg/l. Emuoha also shows a high mean concentration of 4.57 mg/l, indicating elevated iron levels in some areas. Copper levels are consistently low across all locations, ranging from a mean of 0.01 CFU/100ml in Choba to a maximum of 0.07 CFU/100ml in Aluu. This suggests that copper contamination is minimal and does not vary greatly between

communities. Lead concentrations are similarly low across the surveyed communities, with values ranging from 0.01 mg/l in Choba and Isiodu to 0.02 mg/l in Aluu, Emuoha, and Rumuokparali. This indicates that lead levels are generally within acceptable limits across the locations.
Manganese levels are consistently low in all communities, with no measurable variation, as all locations report a mean concentration of 0.00 mg/l. This indicates that manganese is not a significant concern in the water quality of these communities. Zinc concentrations also show minimal variation, ranging from a mean of 0.01 mg/l in Choba, Isiodu, and Ogbogoro to 0.02 mg/l in Aluu, Emuoha, and Rumuokparali. This suggests that zinc levels are low and similar across the different communities.

Table 1. Variation in Physico-Chemical Properties of Well and Borehole Water in Some Fishing Communities Along the New Calabar River

Location	Electrical Conductivity (µs/cm) Mean	Total Dissolve Solute (mg/l) Mean	Measure of Acidity or Alkalinity Mean	Turbidity (FAU) Mean	Chloride (mg/l) Mean	Nitrate (mg/l) Mean	Sulphate (mg/l) Mean	Phosphate (mg/l) Mean	Total Hardness (mg/l) Mean
Aluu	143	101	5.87	2	65.68	27.54	4.69	7.09	62.03
Choba	69	48	5.20	3	32.33	12.41	2.60	4.46	29.64
Emuoha	83	59	5.52	2	39.51	18.81	2.10	5.86	37.96
Isiodu	69	49	6.08	2	38.38	20.38	6.56	4.23	28.49
Ogbogoro	65	46	5.48	2	31.33	15.54	3.40	1.85	25.37
Rumuokparali	108	76	5.20	2	49.59	23.66	1.20	7.10	46.90

Table 2. Variation in Metal Concentration InWell and Borehole Water in Some FishingCommunities Along the New Calabar River

		Iron (mg/l) Mean	Copper (CFU/100ml) Mean	Lead (mg/l) Mean	Manganese (mg/l) Mean	Zinc (mg/l) Mean
Location	Aluu	4.41	.07	.02	.00	.02
	Choba	1.84	.01	.01	.00	.01
	Emuoha	4.57	.04	.02	.00	.02
	Isiodu	2.17	.03	.01	.00	.01
	Ogbogoro	4.54	.04	.01	.00	.01
	Rumuokparali	2.47	.05	.02	.00	.02

DISCUSSION

Findings from this reveals significant differences in key parameters, which have important implications. The observed variation in electrical conductivity, total dissolved solids (TDS), chloride concentrations, and nitrate levels suggests that local geological and environmental conditions greatly influence water quality. For instance, higher conductivity and TDS levels in Aluu indicate a greater concentration of dissolved ions, potentially affecting the taste and mineral content of the water. This finding is consistent with the observations of Dahunsi *et al.* (2014), who also reported variations in metal concentrations and physicochemical parameters across different towns in Nigeria. The presence of elevated nitrate and chloride levels in certain areas underscores the need for localized management strategies to address these specific quality issues (Akpe *et al.*, 2018). Despite these variations, pH levels across the communities remained relatively stable, suggesting that the water is generally within a slightly acidic to neutral range, which is generally acceptable for human consumption. The low turbidity values indicate that the water is relatively clear, aligning with the findings of Ekpete *et al.* (2019), where turbidity levels in groundwater were found to be within acceptable limits. However, the consistency in turbidity should not overshadow other critical quality parameters, such as chemical contaminants, which can impact health. (Ezekiel *et al.*, 2020).

The variability in metal concentrations, particularly the elevated iron levels in some areas, raises concerns about potential health risks associated with long-term exposure. This finding aligns with Dahunsi *et al.* (2014), who emphasized the importance of monitoring metal contamination, especially iron, in groundwater. On the other hand, the low levels of copper, lead, manganese, and zinc across the communities suggest that these metals are not significant contaminants, consistent with the findings of Oko *et al.* (2014) and Ukpong *et al.* (2013).The study underscores the need for targeted interventions to address specific water quality issues identified in different communities. Improving water infrastructure, enhancing monitoring practices, and addressing local contamination sources are crucial steps. These needs resonate with broader literature, such as the work of Edokpayi *et al.* (2018), which highlights the importance of consistent water treatment and infrastructure improvements. Additionally, the findings reflect the challenges observed in other rural and peri-urban areas, as noted by Ekpete *et al.* (2019) and Ukpong *et al.* (2013), where microbial contamination and seasonal variations significantly impact water quality. Furthermore, the study illustrates a complex landscape of water quality variations, emphasizing the necessity for ongoing monitoring and maintenance to prevent health risks. The results align with existing literature on the importance of targeted interventions and infrastructure improvements to ensure safe drinking water and protect public health.

CONCLUSION

Significant variations in water quality parameters such as electrical conductivity, total dissolved solids (TDS), chloride concentrations, and nitrate levels were observed across different fishing communities. For example, Aluu exhibited higher conductivity and TDS levels, indicating a greater concentration of dissolved ions that could affect water taste and mineral content. Although pH levels remained relatively stable and turbidity was low, the variability in metal concentrations, particularly elevated iron levels, raises health concerns. These findings highlight the need for localized management strategies and infrastructure improvements to address specific water quality issues.

REFERENCES

Akpe, A.R., Femi, I.J., Okwu, G.I. and Obiazi, H. (2018) Seasonal variations in the physicochemical parameters of Ikpoba River water samples. International Journal of Life Sciences, J. Life Sci. Sci. Res., 4(3): 1810-1821.

APHA (1998) Standard Methods for the Examination of Water and Wastewater. 20th Edition, American Public Health Association, American Water Works Association and Water Environmental Federation, Washington DC.

Cantonati, M., Poikane, S., Pringle, C. M., Stevens, L. E., Turak, E., Heino, J., and Znachor, P. (2020). Characteristics, main impacts, and stewardship of natural and artificial freshwater environments: consequences for biodiversity conservation. Water, 12(1), 260.

Coles, L. J., Stockan, J., and Helliwell, R. (2020). Managing riparian buffer strips to optimise ecosystem services: A review. Agriculture, Ecosystems and Environment, 296, 106-117.

Dahunsi, S. O., Owamah, H. I., Ayandiran, T. A., and Oranusi, S. U. (2014). Drinking water quality and public health of selected towns in South Western Nigeria. Water Quality, Exposure and Health, 6, 143-153.

Dey, S., Haripavan, N., Basha, S. R., and Babu, G. V. (2021). Removal of ammonia and nitrates from contaminated water by using solid waste bio-adsorbents. Current Research in Chemical Biology, 1, 100-105.

Edokpayi, J. N., Rogawski, E. T., Kahler, D. M., Hill, C. L., Reynolds, C., Nyathi, E., ... and Dillingham, R. (2018). Challenges to sustainable safe drinking water: A case study of water quality and use across seasons in rural communities in Limpopo Province, South Africa. Water, 10(2), 159.

Ekpete, O.A., Edori, O.S., and Kieri, B.S.I. (2019). Assessment of heavy metals concentrations in surficial water of Silver River, Southern Ijaw, Bayelsa State, Niger Delta, Nigeria. Journal of Basic Applied Research International, 25(4), 186–193.

Ezekiel, E.N., Sarogoro, N.S., and Charles, K. (2020). Seasonal variation of physicochemical parameters of Rivers in Trans-Amadi, Port Harcourt, Rivers State. European Academic Research, 7(12), 5945 – 5958

Iyama, W.A., and Edori, O.S. (2016). Comparative analysis of the water quality status of the Bassan Rivers in Bayelsa State. Nigeria. International Journal of Chemistry and Chemical Engineering, 6(2), 99-109.

Oko, O. J., Aremu, M. O., Odoh, R., Yebpella, G., and Shenge, G. (2014). Assessment of water quality index of borehole and well water in Wukari Town, Taraba State, Nigeria. Assessment, 4(5), 1-9.

Romin, M.R., Al Azad, S., and Saleh, E. (2021). Variations in the physicochemical water parameters and phytoplankton community in coastal water of Kudat, Sabah, Malaysia. Journal of Geosciences and Environmental Protection, 9(7), 86-99.

Seiyaboh, E.I., Angaye, T.C.N., and Okogbue, B.C. (2016). Physicochemical quality assessment of River Orashi in Eastern Niger Delta of Nigeria. Journal of Environmental Treatment and Technology, 4(4), 143-148.

Ukpong, E. C., Ogarekpe, N. M., and Bejor, E. S. (2013). Comparative analysis of water quality in hand dug well and borehole in Calabar South Local Government Area in Nigeria. The International Journal of Engineering and Science (IJES), 2(8), 95-101.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

CHANGES IN ENZYME ACTIVITIES IN BLACK JAW TILAPIA *(Sarotherodon Melanotheron)* EXPOSED TO BUTACHLOR IN THE LABORATORY

Eze, B.U[1]., [2]O.A. Akinrotimi, [3]K.N. Owhonda,[4]F.A.Omodu, and [5]P.O. Nwosu

[1]African Regional Aquaculture Centre/Nigerian Institute for Oceanography and Marine Research, Aluu. P.M.B. 5122, Port Harcourt, Rivers State, Nigeria
[2,3,4,5]Department of Mariculture, Nigerian Institute for Oceanography and Marine Research, Buguma P.M.B. 5122, Port Harcourt, Rivers State, Nigeria
Corresponding author:
ojoakinrotimi@gmail.com, +2348065770699, 0000-0003-2775-645X

ABSTRACT
The changes observed in enzyme activities serve as reliable indicators of stress resulting from fish exposure to toxic substances. Disruptions in these activities can lead to diminished immune responses and reduced intestinal microflora activity. This study investigates the impact of varying concentrations of butachlor (0.00, 0.50, 1.00, 1.50, and 2.00 mg/l) on the activities of some enzymes, including aspartate transaminase (AST), alanine transaminase (ALT), acid phosphatase (ACP), alkaline phosphatase (ALP), and lactate dehydrogenase (LDH) in the plasma of Sarotherodon melanotheron over a 15-day exposure period. The findings indicate that the enzyme levels in the exposed fish were significantly ($P < 0.05$) elevated compared to control values. The extent of these alterations was concentration-dependent and more pronounced in juvenile fish than in adults. In summary, changes in plasma enzyme levels may indicate tissue damage and dysfunction caused by toxicants, making these parameters effective and prompt indicators for assessing the effects of toxicants on aquatic life and, by extension, the broader ecosystem.

Keywords:
Toxicology, Tilapia, Enzymes, Butachlor, Aquatic environment

INTRODUCTION

Pesticides have been recognized as significant pollutants in aquatic ecosystems, capable of inflicting both immediate and prolonged adverse effects on living organisms. These substances have been shown to induce various metabolic alterations in fish, occurring at both lethal and, more commonly, sublethal concentrations. Fish species are particularly susceptible to hormonal and enzymatic disruptions caused by stress and pesticide exposure. Chronic exposure to low levels of these chemicals tends to have a more profound impact on fish populations compared to acute toxicity. Subtle physiological and behavioral changes that hinder reproduction and survival are linked to pesticide levels that are insufficient to cause mortality in fish (Karan *et al.*, 1998). Research by Raja *et al.* (1992) has established a connection between pesticides and alterations in fish ion concentrations, organic compounds, enzyme activity, endocrine function, and chemo-regulatory mechanisms. In the field of human medicine, serum enzyme activity assessments are commonly utilized as diagnostic indicators. In recent years, there has been a notable rise in the application of enzyme activity as a predictive measure for pesticide toxicity in aquatic organisms, particularly fish (Begum, 1994). Among lower animals, especially teleost fish, a diverse array of enzymes, including amino transferases, phosphatases, and lactases, constitutes the most extensive enzyme collection (Ogundiran *et al.*, 2009). Transferases, which encompass alanine transaminase (ALT) and aspartate transaminase (AST), facilitate the conversion of keto acids into amino acids (Gabriel *et al.*, 2012). Phosphatases, specifically acid phosphatase (ACP) and alkaline phosphatase (ALP), are hydrolase enzymes that cleave phosphate groups from various substrates, including nucleotides, proteins, and alkaloids. Additionally, lactate dehydrogenase, or lactase, plays a crucial role in converting lactic acid produced in muscles into pyruvic acid, a vital process for cellular energy production (Vander-Oost *et al.*, 2003).

Fish exhibit physiological adaptations to maintain homeostasis when confronted with toxins, which are known to disrupt enzymatic functions. Prolonged exposure to various toxicants can lead to modifications in protein metabolism in fish (Tamas *et al.*, 2002). The observed reduction in total protein levels in fish subjected to significant toxicant exposure may be attributed to alterations in water balance and hydration status, or potentially a disruption in liver protein synthesis, or a combination of both factors. Enzymes and hormones, both of which are proteins, regulate all biological processes. Consequently, the assessment of protein and enzyme activities can serve as a diagnostic tool for evaluating the physiological condition of cells or tissues (Gabriel *et al.*, 2011). Butachlor, a herbicide belonging to the acetanilide class, functions as a selective pre-emergent herbicide by inhibiting acetylcholinesterase, an essential enzyme for the proper functioning of the central nervous system (Celik, 2004). Fish are the primary aquatic organisms affected by toxicants and are often utilized to assess the health of aquatic ecosystems, thereby serving as bioindicators of environmental pollution. *Sarotherodon melanotheron*, a widely distributed teleost with significant commercial importance in fisheries and aquaculture, represents an excellent biological model for toxicological research (Celik, 2004). While several studies have investigated the effects of butachlor on fish, there is limited information available regarding *S. melanotheron*, highlighting the need for the current study. This research aims to evaluate the alterations in enzyme activities in *S. melanotheron* exposed to butachlor in a controlled laboratory setting.

MATERIALS AND METHODS

Experimental Location and Fish

The study was conducted at the African Regional Aquaculture Center in Buguma, Rivers State, Nigeria, which is a branch office of the Nigerian Institute for Oceanography and Marine Research. During low tide, ponds yielded 300 *S. melanotheron*, of which 150 were juveniles and 150 were adults. The fish were brought to the laboratory in six open, 50-liter plastic containers, where they acclimated for seven days.

Preparation of Test Solutions and Exposure of Fish

In the current investigation, Butachlor was utilized. This herbicide belongs to the acetanilide class and serves as a selective pre-emergent herbicide. It is widely applied in Nigeria, particularly in the form of granules, as a post-emergent herbicide in rice cultivation. For this experiment, Butachlor, marketed under the trade name Butaforce, was procured from a supermarket in Port Harcourt, Nigeria. *S. melanotheron* were subjected to the chemical at concentrations of 0.00 (control), 0.05, 0.10, 0.15, and 0.20 mg/L, with each concentration tested in triplicate. Five fish each of juveniles with an average length of 12.02 ± 1.44cm and an average weight of 70.44 ± 3.22 g and adults with an average length of 19.04 ± 6.09 cm and an average weight of 142.05 ± 12.54 g, were randomly assigned to each test tank. The duration of the experiment was 15 days, during which the water in the tanks was refreshed daily. The fish were fed twice daily at a rate of 3% of their body weight using a commercial feed.

Analytical procedure

A 2ml sample of fresh blood was taken at the conclusion of each experimental period by puncturing the caudal artery with a tiny needle and pouring the sample into heparinized sample vials. Blood samples were immediately centrifuged at 5000 rpm for 15 minutes. Separated plasma samples were pipetted into eppendorf tubes and kept in a /freezer at -20°C until they were analyzed. A Jenway visible spectrophotometer (Model 6405) with a universal microplate reader was used to read the data. The blood of the exposed S.melanotheron was examined for five enzymes: aspartate amino transaminase (AST), alanine amino transaminase (ALT), alkaline phosphatase (ALP), acid phosphatase (ACP), and lactate dehydrogenase (LDH). AST was examined using the method of Bessey et al. (2010) approach since it may be done manually using a colorimetric end-point technique. While ALP, ACP, and LDH were performed using the Huang *et al.,* (2020) technique.

Statistical Analysis

The mean and standard deviation of the mean were used to express all the data. The data analysis was done using SPSS Version 22, a statistical program. Using two-way ANOVA, the means were split, and the two means were deemed significant at 5% (P <0.054).

RESULTS

The water quality parameters (Table 1) were within the same range except in DO, where a lesser values were obtained at higher concentration of the chemical. The effects of butachlor on the enzymes in the plasma of *S. melanotheron* juveniles are presented in Table 2. It was observed that the values of AST, ALT, ACP. ALP AMD LDH significantly increased (P<0.05) with increasing concentrations of the herbicide. The same trend was equally observed in the enzymes activities of adult fish exposed to the chemical (Table 3).

Table1: Physico-Chemical Parameters of Water in Experimental Tanks of *S. melanotheron* Exposed to Butachlor

Concentrations (mg/L)	DO (mg/L)	Temperature (°C)	pH	NH3 (mg/L)	Salinity (ppt)
0.00	5.94±0.22 ^{b}	28.22±2.09^{a}	6.62±0.66 ^{a}	0.01±0.00 ^{a}	11.77±0.32 ^{a}
0.50	5.60±0.55^{b}	28.76±3.01 ^{a}	6.61±0.22 ^{a}	0.02±0.00 ^{a}	11.79±0.04 ^{b}
1.00	5.03±0.77 ^{b}	28.04±1.71 ^{a}	6.60±0.59 ^{a}	0.02±0.00 ^{a}	11.74±1.09 ^{a}
1.50	4.11±0.44 ^{a}	28.55±5.01 ^{a}	6.61±0.21 ^{a}	0.03±0.00 ^{a}	11.75±0.65 ^{a}
2.00	4.01±0.76^{a}	28.64±4.77 ^{a}	6.62±0.90 ^{a}	0.03±0.00 ^{a}	11.79±1.45 ^{a}

Means within the same column with different super scripts are significantly different (P<0.05)

Table 2: Enzymes Activities in *S. melanotheron* Juveniles Exposed to Butachlor

Concentrations		Enzymes (IU/L)			
(mg/L)	AST	ALT	ACP	ALP	LDH
0.00	57.12±1.04^{a}	44.56±1.06 ^{a}	14.08±0.66 ^{a}	50.21±2.11 ^{a}	220.88±9.90 ^{a}
0.50	62.05±1.77 ^{a}	47.88±1.04 ^{a}	17.45±1.04 ^{a}	55.03±1.54 ^{a}	247.98±9.66 ^{a}
1.00	70.04±3.12 ^{b}	55.03±1.98 ^{b}	21.66±1.55 ^{b}	66.11±2.66 ^{b}	261.02±4.06 ^{b}
1.50	77.90±3.09 ^{b}	74.05±1.91 ^{c}	25.44±1.33 ^{b}	75.22±1.43 ^{c}	270.33±3.01 ^{b}
2.00	84.02±4.01 ^{c}	77.03±1.02 ^{c}	33.66±2.33 ^{b}	80.09±2.21 ^{a}	290.21±9.06 ^{b}

Means within the same column with different super scripts are significantly different (P<0.05)

Table 3: Enzymes Activities in *S. melanotheron* Adults Exposed to Butachlor

Concentrations	Enzymes (IU/L)				
(mg/L)	AST	ALT	ACP	ALP	LDH
0.00	70.99±1.21 [a]	54.22±1.05 [a]	16.77±1.03 [b]	61.11±5.04 [a]	320.54±9.01 [a]
0.50	81.55±6.03 [b]	59.45±1.07 [a]	19.56±1.55 [a]	63.04±8.55 [a]	352.07±9.87 [a]
1.00	82.99±2.02 [b]	67.05±1.12 [b]	24.76±1.04 [b]	71.03±9.54 [b]	380.02±9.76 [b]
1.50	86.11±3.01 [b]	70.02±1.44 [c]	35.77±1.88 [c]	75.56±8.77 [b]	390.99±7.01 [b]
2.00	93.01±3.54 [c]	77.44±1.45 [c]	36.04±1.33 [c]	86.01±1.66 [c]	399.88±9.87 [b]

Means within the same column with different super scripts are significantly different ($P<0.05$)

DISCUSSION

Standard laboratory protocols for detecting abnormalities in animals involve the assessment of various enzymes, such as ALP, AST, ALT, ACP, and LDH (Celik, 2004). The detection of non-plasma specific enzymes like ALT, AST, and ALP in the bloodstream can yield critical insights into organ dysfunction, as these enzymes are primarily found in the tissue cells of the liver, heart, gills, kidneys, muscles, and other organs (Das *et al.*, 2004). Research has indicated that the activity levels of these enzymes can vary due to the effects of toxicants or pollutants in different fish organs across various species (Das *et al.*, 2004). Several soluble enzymes in blood serum have been identified as valuable indicators of stress. The activities of serum ALT, AST, ALP, and LDH have been extensively utilized for diagnosing fish diseases and assessing tissue damage caused by environmental pollutants (Anderson *et al.*, 2019). Palanivelu *et al.*, (2015) noted that an elevation in the activities of these enzymes in serum or extracellular fluid serves as a sensitive indicator of even minor cellular damage, reflecting stress-related tissue deterioration. In this study, all measured enzymes exhibited elevated levels in the plasma of S. melanotheron exposed to butachlor. This finding aligns with the results reported by Gabriel *et al.* (2012), which indicated that exposure to cypermethrin increased the plasma activities of ALT, AST, and ALP in Clarias gariepinus.

The findings of this study align with those reported by Jee et al. (2015), who found that Korean rockfish (Sebastes schlegeli) exposed to cypermethrin exhibited increased serum activities of ALT, AST, and LDH. Similarly, significant increases in plasma ALP and LDH activity were observed in Rhamdia quelen (Borges *et al.*, 2017) and Labeo rohita (Das and Mukherjee, 2003) following cypermethrin exposure. In another study, Nile tilapia subjected to sub-acute doses of pyrethroid and deltamethrin over a 28-day period also showed elevated serum ALP levels (El-Sayed and Saad, 2008). The researchers suggested that the increase in these enzyme levels in the bloodstream may be attributed to liver necrosis, leading to the release of these enzymes. Elevated levels of ALT, AST, ALP, and LDH are generally indicative of liver degeneration and dysfunction, as the impact of toxicants on hepatocytes often results in tissue damage, which in turn causes the release of cellular enzymes into the blood plasma. Consequently, the observed increases in enzyme activities in S. melanotheron serum are primarily due to the leakage of these enzymes from the liver cytosol into the bloodstream, a consequence of liver damage induced by metals and pesticides, thereby demonstrating the hepatotoxic effects of these toxicants. According to Harvey et al. (1994), heightened serum levels of these enzymes are commonly associated with liver disease and necrosis in animals, with blood concentrations of ALT, AST, and ALP potentially rising due to cellular damage within the liver.

CONCLUSION

The exposure of juvenile and adult *S. melanotheron* to sub-lethal levels of butachlor can lead to a range of toxicological effects characterized by enzymatic degradation. Since blood is the first organ to respond to adverse environmental changes, analyzing blood biochemical profiles can provide critical insights into the internal state of an organism. The findings of this study indicated that changes in the plasma enzyme activities of fish subjected to pesticide exposure are likely biochemical indicators of the detrimental effects of these toxicants. All plasma enzyme parameters exhibited significantly higher levels in pesticide-treated fish compared to the control group that was not exposed. In summary, the observed changes in plasma enzyme parameters may result from damage and dysfunction in target tissues caused by toxicants, and these parameters can serve as rapid and reliable indicators for assessing the impact of toxicants on aquatic organisms and, ultimately, the broader ecosystem.

REFERENCES

Anderson, T., Forlin L., Hardig J, and Larsson. A. (2019). Physiological disturbances in fish living in Coastal water polluted with bleached Kraft pulp mill effluents. Canadian Journal of Fisheries and Aquatic Sciences, 45,1525-1536.

Begum, G. (2004). Carbofuran insecticide induced biochemical alterations in liver and muscle tissues of the fish Clarias batrachus (linn) and recovery response.Aquatic Toxicology,66, 83-92.

Bessey, M.M., Benfey, T.J. and Kieffer, J.D. (2010) Haematology and stress physiology of juvenile diploid and triploid short nose sturgeon (Acipenser brevirostrum). Fish Physiology and Biochemistry, 31, 303-313.

Borges, A., Scotti, LV., Siqueira, D.R., Zanini, R., Amaral, F., and Jurinitz D.F, Wassermann G.F. (2017). Changes in hematological and serum biochemical values in jundiá Rhamdia quelen due to sub-lethal toxicity of cypermethrin. Chemosphere, 69, 920–926.

Celik, E.S. (2004). Blood chemistry (electrolytes, lipoproteins and enzymes) values of black scorpion fish (Scorpaena porcus) in the Dardanelles. Turkey Journal of Biological Sciences, 4,716-719.

Das, B.K, and Mukherjee, S.C. (2003). Toxicity of cypermethrin in Labeo rohita fingerlings: biochemical, enzymatic and haematological consequences. Comparative Biochemistry and Physiology,134C, 109–121.

Das, P.C., Ayyappan, S., Das, B.K., and Jena J.K. (2004).Nitrite toxicity in Indian major carps: sublethal effect on selected enzymes in fingerlings of Catla catla, Labeo rohita, and Cirrhinus mrigala. Comparative Biochemistry and Physiology, 138, 1006 -1011.

El-Sayed, Y.S, and Saad, T. T. (2008). Sub-acute intoxication of a deltamethrin-based preparation (Butox® 5% EC) in monosex Nile tilapia, Oreochromis niloticus L. Basic Clinical Pharmacology and Toxicology,102, 293–299.

Gabriel U.U., Akinrotimi O.A. and Ariweriokuma V.S. (2012). Changes in metabolic enzymes activities in selected organs and tissues of Clarias gariepinusexposed to cypermethrim. Journal of Chemical Engineering. 1(1), 25 -30.21.

Gabriel, U.U., Akinrotimi, O.A., and Eseimokumo, F. (2011). Haematological responses of wild Nile tilapia (Oreochromis niloticus) after acclimation to captivity. Jordan Journal of Biological Sciences, 4, 223-230.

Harvey, R.B., Kubena, L.F., and Elissalde, M. (1994). Influence of vitamin E on aflatoxicosis in growing swine. American Journal of Veterinary Research,55, 572–577.

Huang, C., Chao, L.C., and Lin, H.A. (2020). Na+, k+ AT pase and vacuolar-type H+-AT pase in the gill of the aquatic air breathing fish (Trichogaster microlepis) in response to salinity variation. Comparative Biochemistry and Physiology, 155, 309-318.

Jee, J.H., Masroor, F., and Kang, J.C. (2015). Responses of cypermethrin-induced stress in haematological parameters of Korean rockfish, Sebastes schlegeli (Hilgendorf) Aquatic Research, 36, 898–905.

Karan, V., Vitorovic., Tutundzic, V., and Poleksic V. (1998).Functional enzymes activity and gill histology of carp after copper sulfate exposure and recovery. Ecotoxology and Environmental Safety, 40, 49–55.

Ogundiran, M.A., Fawole, O.O., Adewoye, S.O. and Ayandiran, T.A. (2009). Pathologic Lesions in the

Gills structures of Clarias gariepinus on exposure to sub-lethal concentrations of soap and detergent effluents. Journal of Cell and Animal Biology, 3, 078-082.

Palanivelu, V., Vijayavel, K., Ezhilarasibalasubramanian, S., and Balasubramanian, M.P. (2015). Influence of insecticidal derivative (Cartap Hydrochloride) from the marine polychaete on certain enzyme systems of the freshwater fish Oreochromis mossambicus. Journal of Environmental Biology, 26, 191–196.

Raja, M., Al-Fatah, A., Ali, M., Afzal, M., Hassan, R.A., Menon, M., and Dhami, M.S.(1992). Modification of liver and serum enzymes by paraquat treatment in rabbits. Drug ,Metabolites and Drug Interactions, 10, 279–291.

Tamas, L., Huttova, J. and Mistrik, L. (2002). Effect of carboxymethyl chitin-glucan on activity of hydrolytic enzymes. Chemical Pathology, 56, 326-329.

Van der Oost, R., Beyer, J., and Vermulen, N.P.E. (2003) Fish bioaccumulation and biomarker environmental risk assessment a review. Environmental Toxicol Pharmacology, 13, 57-149.

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EPILITHON ASSEMBLAGE AND NUTRIENT STATUS OF UPPER BONNY ESTUARY AT AMADI-AMA AND NKPOGU COMMUNITIES, PORT HARCOURT, RIVERS STATE, NIGERIA

+Bubu-Davies, O. A., P. A. Anwuri and A. Atua

Department of Fisheries and Aquatic Environment, Rivers State University, Oroworukwo, Port Harcourt, Rivers State, Nigeria.

+Corresponding Author's Email:
davies.onome@ust.edu.ng, +2348030879120, https: //orcid.org/0000-0001-8998-3901

ABSTRACT

The Upper Bonny Estuary in Rivers State, Nigeria, and its resources are of economic value, but the Upper Bonny Estuary at Amadi-Ama and Nkpogu Communities is a refuse dump for anthropogenic waste. Epilithon assemblage and some nutrients (phosphate, ammonia, and nitrate) of the estuary at Amadi-Ama and Nkpogu Communities were studied. Epilithon and surface water samples were collected following standard methods from three stations between May and July 2023. Epilithon samples were analyzed microscopically and surface water samples for nutrients by APHA methods. Data were analyzed using the SPSS Version 23 for analysis of variance. A total of 824 individual epilithic algae from six families [Chlorophyceae (46%), Bacillariophyceae (19%), Cyanophyceae (25%), Chrysophyceae (3%), Dinophyceae (5%), and Xanthophyceae (2%)], 48 genera, and 68 species were recorded. Spatially, phosphate (0.23 ± 0.11 mg/L), ammonia (0.014 ± 0.005 mg/L), and nitrate (0.17 ± 0.06 mg/L) were within the permissible levels of NESREA of 3.5 mg/L, 0.05 mg/L, and 9.1 mg/L, respectively, for fisheries. The presence of pollution-indicator species *Melosira italica*, *Melosira pusilla*, *Melosira sp. and Melosira virians*, *Cyclotella glomerata*, *Cyclotella meneghiniana*, *Cyclotella operculata*, *Cyclotella stelligera*, *Navicula placentula*, *Nitzschia acicularis*, and *Nitzschia closterium (Bacillariophyceae)*, *Anabaena spirades*, *Lynbya limnetica*, *Lynbya birgei*, *Lynbya limnetica*, *Lynbya major*, *Microcystis aeruginosa*, *Oscillatoria lacustris*, *Oscillatoria lutea*, *Oscillatoria rubescens*, *Oscillatoria tenuis*, and *Oscillatoria lutea (Cyanobacteria)* indicate organic pollution of the Upper Bonny Estuary at Amadi-Ama and Nkpogu Communities. Proper environmental awareness on the impacts of anthropogenic activities and strict policies on waste disposal to preserve the health of the estuary are recommended.

Keywords:
Epilithic algae, species composition, sink, bio-indicator, biological integrity

INTRODUCTION

Epilithon algae are a type of periphyton that are attached to hard surfaces such as stones within the shoreline splash zone (Davies, 2018). Periphyton and nutrients are used to assess health of the aquatic environments (Bubu-Davies *et al.*, 2022). Human activities impact organisms and nutrient levels in the aquatic bodies (Davies *et al.*, 2008; Davies *et al.*, 2009a; Davies and Ugwumba, 2013). Based on literature review, no information on the health status of the Upper Bonny Estuary at Amadi-Ama and Nkpogu Communities using epilithon has been provided. This study evaluated epilithon assemblage and nutrients (phosphate, ammonia, and nitrate) as pollution indicators in this part of the Upper Bonny Estuary, Rivers State.

MATERIALS AND METHODS

The study was conducted in the Amadi-Ama and Nkpogu Creeks, brackish and tidal tributaries of the Upper Bonny Estuary in Rivers State between coordinates of latitude 4046'00" N and longitude 703'00"E (Figure 1). The vegetation around the creek is nypa palm, while human activities such as fishing, boating, refuse disposal, welding, mechanic works, washing, excreta disposal, and bathing were observed around the water body. Effluent discharges were observed to flow into the creek from nearby companies such as Liquefied Natural Gas (LNG) plant, Julius Berger, and Hypercity Supermarket. Three stations were established at least 500 m apart (Station 1- Koko-Ama by Eastern Bypass Bridge, Station 2: Nkpogu Block Industry and Station 3-Foursquare Gospel Church, Nkpogu) as the anthropogenic activities listed above were seen around these stations. Samples of epilithic algae and surface water for nutrients determination (phosphate, ammonia and nitrate) were collected once a month for three months (May – July 2023) during the low tide.

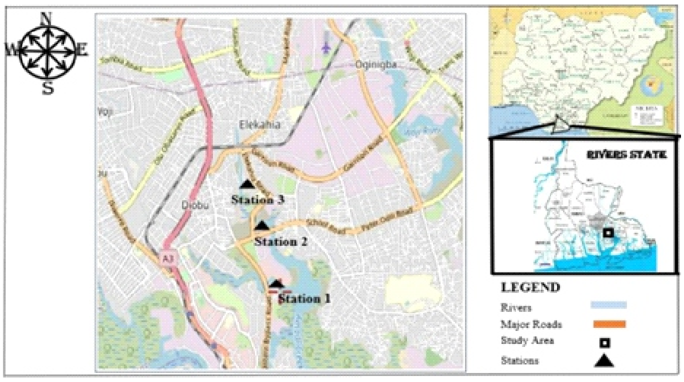

Figure 1: Map of the Study Area

The epilithon samples were homogenized. One (1) ml subsample was collected and transferred into a Sedgwick Rafter counting chamber for identification under a Leitz-Wetzler binocular microscope with magnification between 100x and 400x. For each sample, 5 replicates were treated (Bubu-Davies *et al.*, 2022). One (1) ml sub-sample of homogenized sample was collected with a stampel pipette and transferred into a Sedgwick Rafter counting chamber for identification and enumeration under a digital microscope (PD2451) using a combined magnification of between 10x and 40x. Three replicates of the sub-samples were analyzed. Identification of epilithon was done using descriptive keys of Krammer and Bertalot (2000), Botes (2003) and Nwankwo (2004). Phosphate, Ammonia and Nitrate levels were determined by standard tests (AHPA, 1998).

RESULTS AND DISCUSSION

A total of 824 individual epilithon from six families *[Chlorophyceae* (22 species, 18 genera, 379 individuals), *Bacillariophyceae* (18 species, 11 genera, 152 individuals), *Cyanophyceae* (22 species, 18 genera, 209 individuals), *Chrysophyceae* (2 species, 2 genera, 20 individuals, *Dinophyceae* (2 species, 2 genera, 42 individuals) and Xanthophyceae (2 species, 2 genera, 14 individuals], 48 genera and 68 species were recorded in the study (Table 1). Table also presents the percentage composition of the families as well as number of individuals and densities of the epilithic algae in relation to station.

Table 1: Epilithon assemblage of Upper Bonny Estuary at Amadi-Ama and Nkpogu Communities, Rivers State

Family/Stn/Ind/Den	Species	Family/Stn/Ind	Species
Chlorophyceae (46%)	*Actidesmium hookeri*	**Cyanophyceae** (25%)	*Anabaena spirades*
Stn 1 n = 190	*Ankistrodesmus braunii*	Stn 1 n = 37	*Aphanizomenon flas-aquae*
Stn 2 n = 136	*A. falcatus*	Stn 2 n = 102	*Aulosira sp*
Stn 3 n = 53	*Chlorella elegaris*	Stn 3 n = 70	*Dactylococcopsis acicularis*
Stn 1 Den = 19772.73	*C. vulgaris*	Stn 1 Den = 8409.09	*Dactylococcopsis fascicularis*
Stn 2 Den = 5454.545	*Closteridium lunula*	Stn 2 Den = 23181.82	*Gloeocapsa alpicola*
Stn 3 Den = 9318.18	*Closteriopsis longissimi*	Stn 3 Den = 15909.09	*Gomphosphaeria lacustris*
	Closterium Cynthia		*Lynbya limnetica*
	C. intermedium		*L. birgei*
	C. strigosum		*L. limnetica*
	Cosmarium granatum		*L. major*
	Gloeocystis major		*Microcystis aeruginosa*
	Gloeotaerium		*Nodularia spumigena*
	loitlesbergerianum		
	Gonatozyon aculeatum		*Oscillatoria lacustris*
	Mycanthococcus sp		*O. lutea*
	Ourococcus bicaudatus		*O. rubescens*
	Radiococcus planktonicus		*O. tenuis*
	Rediopfilum flavescens		*O. lutea*
	Scenedesmus obliquus		*Phormidium tenue*
	Schroederia setigera		*P. valderiae*
	Stichococcus bacillaris		*Planktothrix sp*
	Tetraddro minimum		*Raphidiopsis mediterranea*
Bacillariophyceae (19%)	*Cerataulina bicornis*	**Chrysophyceae** (3%)	*Mallomonas acrocomas*
Stn 1 n = 87	*Closterium strigosum*	Stn 1 n = 0	*Chromullra sphaeriea*
Stn 2 n = 24	*Coscinodesmus sp*	Stn 2 n = 8	
Stn 3 n = 41	*Cyclotella glomerata*	Stn 3 n = 12	
Stn 1 Den = 19772.73	*C. meneghiniana*	Stn 1 Den = 0	
Stn 2 Den = 5454.545	*C operculata*	Stn 2 Den = 1818.182	
Stn 3 Den = 9318.18	*C. stelligera*	Stn 3 Den = 4545.45	
	Entophysalis sp	**Dinophyceae** (5%)	*Amphidinium sp*
	Licmophora sp	Stn 1 n = 38	*Cochlodinium fulvescens*
	Melosira italica	Stn 2 n = 0	
	M. pusilla	Stn 3 n = 4	
	M. sp	Stn 1 Den = 9134.19	
	M. virians	Stn 2 Den = 0	
	Navicula placentula	Stn 3 Den = 909.09	
	Nitzschia acicularis	**Xanthophyceae** (2%)	*Ophiocytium parvulum*
	N. Closterium	Stn 1 n = 2	*Botryococcus braunii*
	Spirirella spiralis	Stn 2 n = 0	
	Tebellaria binalis	Stn 3 n = 12	
		Stn 1 Den = 454.54	
		Stn 2 Den = 0	
		Stn 3 Den = 2727.27	

Stn- Station; Ind- Individual; n=Number of individuals; Den=Density

Spatial variation of epilithon species indicated: Station1 – C*hlorophyceae*, highest (21.78±8.57%), Chrysophyceae, lowest (0.00±0.00%). Station 2 – C*hlorophyceae*, highest (14.67±6.53%), *Dinophyceae* and *Xanthophyceae* lowest (0.00±0.00%). Station 3 - C*yanophyceae* highest (7.78±2.00%), *Dinophyceae* lowest (0.44±0.29%). Overall means were: C*hlorophyceae* highest (14.04±9.29), *Xanthophyceae* lowest (0.52±0.27). Spatial means for phosphate, ammonia, and nitrate were 0.23±0.11mg/l, 0.014±0.005mg/l, 0.17±0.06mg/l respectively (Table 2).

Table 2: Spatial Distribution of taxonomic groups of epilithon and nutrients of Upper Bonny Estuary Amadi-Ama and Nkpogu Commnunity

Parameter	Station			Overall mean	Standard for surface water (Fisheries)
	1	2	3		
Bacillariophyceae	9.67±5.07^{a}	2.67±1.04^{b}	4.56±2.45^{b}	5.63±0.90	-
Chlorophyceae	21.78±8.57^{a}	14.67±6.53^{b}	5.67±1.40^{c}	14.04±9.29	-
Cyanophyceae	4.11±2.89^{b}	11.33±2.23^{a}	7.78±2.00^{ab}	7.74±4.92	-
Chrysophyceae	0.00±0.00^{b}	0.89±0.51^{ab}	2.22±1.25^{a}	1.04±0.47	-
Dinophyceae	3.11±1.55^{a}	0.00±0.00^{b}	0.44±0.29^{ab}	1.19±0.57	-
Xanthophyceae	0.22±0.22^{a}	0.00±0.00^{a}	1.33±0.74^{a}	0.52±0.27	-
Phosphate (mg/L)	0.23±0.12^{a}	0.22±0.10^{a}	0.24±0.13^{a}	0.23±0.11	≤3.5 (NESREA, 2011)
Ammonia (mg/L	0.013±0.005^{a}	0.016±0.005^{a}	0.013±0.006^{a}	0.014±0.005	≤0.05 (NESREA, 2011)
Nitrate (mg/L)	0.14±0.06^{b}	0.19±0.05^{a}	0.18±0.05^{a}	0.17±0.06	≤9.1 (NESREA, 2011)

Means within the column with different superscripts are significant at $p<0.05$ Unit for taxonomic group - Mean ± SEM %

The presence of some species of *Bacillariophyceae (Melosira italica, Melosira pusilla, Melosira sp and Melosira virians, Cyclotella glomerata, Cyclotella meneghiniana, Cyclotella operculata, Cyclotella stelligera, Navicula placentula, Nitzschia acicularis* and *Nitzschia closterium)*, and *Cyanobacteria (Anabaena spirades, Lynbya limnetica, Lynbya birgei, Lynbya limnetica, Lynbya major, Microcystis aeruginosa, Oscillatoria lacustris, Oscillatoria lutea, Oscillatoria rubescens, Oscillatoria tenuis*, and *Oscillatoria lutea)* in the study can indicated pollution of Upper Bonny Estuary at Amadi-ama and Nkpogu Commnuities, Port Harcourt, Rivers State. These observed species are known as harmful algae in aquatic environments by Davies *et al.* (2008), Davies *et al.* (2009a), Davies et al. (2009b), Davies and Ugwumba (2013), Davies and Otene (2013), Davies *et al.* (2015) and Davies (2018). The availability of nutrients, especially phosphorus, in aquatic environments leads to algae assemblage (Roelke *et al.*, 2007). Elevated nitrate levels may indicate the presence of contaminants like disease-causing organisms, pesticides, or other compounds (Singh et al., 2022). Phosphates can impact aquatic bodies by increasing algae levels, including cyanobacteria (Davies, 2018; EFS, 2019). Excess nitrate and phosphate can lead to significant water quality issues and accelerate eutrophication (EPA, 2012). The spatial mean values of phosphate, ammonia, and nitrate in the study area indicated were below the NESREA (2011) standard values for surface water (fisheries) of 3.5 mg/L, 0.05 mg/L and 9.1 mg/L, respectively. Phosphate and ammonia levels in this study were lower than those of Alice Creek, Rivers State as reported by Bubu-Davies et al. (2022).

CONCLUSION AND RECOMMENDATIONS

The study discovered, identified, and recorded a total of 824 individuals from 6 families, 48 genera, and 68 species of epilithic alage with Chlorophyceae and Cyanophyceae as dominant families in terms of number of species. The presence of pollution-indicator species *Melosira italica, Melosira pusilla, Melosira sp.* and *Melosira virians, Cyclotella glomerata, Cyclotella meneghiniana, Cyclotella operculata, Cyclotella stelligera, Navicula placentula, Nitzschia acicularis*, and *Nitzschia closterium (Bacillariophyceae), Anabaena spirades, Lynbya limnetica, Lynbya birgei, Lynbya limnetica, Lynbya major, Microcystis aeruginosa, Oscillatoria lacustris, Oscillatoria lutea, Oscillatoria rubescens, Oscillatoria tenuis*, and *Oscillatoria lutea (Cyanobacteria)* indicate organic pollution of the Upper Bonny Estuary at Amadi-Ama and Nkpogu Communities. The study recommends Constant awareness and enlightenment to preserve the health of the estuary.

REFERENCES

American Public Health Association (APHA) (1998). Standard methods for the examination of water and waste water.20th(Ed), Washington D.C1213pp

Botes, L. (2003). Phytoplankton identification catalogue at Saldanha Bay, SouthAfrica, April 2001. GloBallast Monograph Series No. 7. IMO London.

Bubu-Davies, O.A., Teere, M.B. and Igilar, G. (2022). Evaluation of Epiphytic Algae Assemblage and Nutrient Status as Bioindicator of Organic Pollution in Alice Creek, Rivers State, Nigeria. Journal of Aquatic Sciences, 37(1):17-29.

Davies, O.A., Abulode, D.S. and Ugwumba, A.A.A. (2008). Phytoplankton of the lower reaches of Okpoka Creek, Niger Delta, Nigeria. Journal of Fisheries International, 3(3): 83-90.

Davies, O.A., Abowei, J.F.N. and Tawari, C.C. (2009a). Phytoplankton Community of Elechi Creek, Niger Delta, Nigeria- A nutrient polluted Tropical Creek. American Journal of Applied Sciences, 6(6):1143-1152.

Davies, O.A., Abowei, J.F.N. and Otene, B.B. (2009b). Seasonal abundance and distribution of plankton of Minichinda Stream, Niger Delta, Nigeria. American Journal of Scientific Research, 2:20-30

Davies, O. A. (2018). The indispensable creation in our planet. Rivers State University Press. Inaugural Lecture Series No. 57. 200pp

Davies, O.A. and Ugwumba, O.A. (2013). Tidal influence on epiphyton population of Okpoka Creek, Upper Bonny estuary, Nigeria. Journal of Scientific Research in Knowledge, 1(10): 373-387.

Davies, O.A. and Otene, B.B. (2013). The epipelic algae distribution of Upper Bonny Estuary, Amadi-Ama Creek, Niger Delta in relation to Sediment quality indices. Scientific Journal of Animal Science, 2(1): 26-34.

Davies, O.A., Ikenweiwe, N.B. and George, A.D.I. (2015). Preliminary study on phytoplankton and nutrient status of Oya Lake, Bayelsa State, Nigeria. Nigerian Journal of Fisheries, 12(2):878-888.

Environmental Fact Sheet (EFS) (2019). Phosphorus: Too much of a good thing. Retrieved from https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/2020-01.pdf

Environmental Protection Agency (EPA) (2012). Nitrates: In Water Monitoring and Assessment. Retrieved from https://archive.epa.gov/water/archive/web/html/vms57.html

Krammer, K. and Lange-Bertalot, H. (2000). Bacillariophyceae 5. English and French translation of the keys. In: Büdel, B., Gärtner, G., Krienitz, L. and Lokhorst, G. M. (eds.). Süßwasserflora von Mitteleuropa. 2(5), 311 pp. Spektrum Akademischer Verlag, Heidelberg-Berlin

National Environmental Standards and Regulations Enforcement Agency (NESREA) (2011). National Environmental (Surface and groundwater quality) regulations. Federal Republic of Nigeria

Nwankwo, D.I. (2004). Studies on the Environmental Preference of Blue Green Algae(Cyanophyta) in Nigeria Coastal Waters. Nigerian Environmental Society Journal, 2(1):44-51.

Roelke, D.L., Errera, R.M., Kiesling, R., Brooks, B.W., Grover, J.P., Schwierzke, L., Urena-Boek, F., Baker, J. and Pinckney, J.L. (2007). Effects of nutrient enrichment on prymnesium parvum population dynamics and toxicity: results from field experiments, Lake Possum Kingdom, USA. Aquatic Microbiology Ecology, 46:125-14.

Singh, S., Anil, A.G., Kumar, V., Kapoor, D., Subramanian, S., Singh, J. and Ramamurthy, P.C. (2022). Nitrates in the Environment: A critical review of their distribution, sensing techniques, ecological effects and remediation. Chemosphers, 278. Retrieved from https://doi.org/10.1016/j.chemosphere.2021.131996.

POLYETHYLENE MICROPLASTICS AND THEIR IMPACT ON FISH BLOOD HEALTH: A STUDY ON *Clarias gariepinus*

NWACHUKWU, N.E., F.P.D. SATIMEHIN, Y.E. AGBEJA, G.O. ADEWUYI AND E.K. AJANI

University of Ibadan, Ibadan, Oyo State, Nigeria.

Corresponding Author:
nkechinwachukwu69@gmail.com, +2348107919561

ABSTRACT
Microplastics (MPs) are an increasing environmental and public health concern, particularly in aquatic ecosystems. MPs disrupt biodiversity, carry pollutants, and infiltrate food chains, posing risks to aquatic organisms and humans. Polyethylene MPs, among the most common, significantly threaten C. *gariepinus*, a crucial species in aquaculture and ecosystems. This study assessed the hematology and serum biochemistry of C. *gariepinus* fed polyethylene microplastics over a 21-day exposure period. A total of 120 fish, with an average weight of 20.26 ± 0.5g and an average length of 11.58 ± 0.52cm, were acclimatized for two weeks in the laboratory at the Department of Aquaculture and Fisheries Management, University of Ibadan, and stocked at a density of 10 fish per tank. Fish were fed diets containing 0.0%, 0.5%, 1.5%, and 3.0% polyethylene MPs in a completely randomized design, with each treatment conducted in triplicate. Blood samples collected post-exposure were analysed for hematological and biochemical changes. Results showed significant reductions in red blood cells ranging from 3.62 ± 0.82 to 2.85 ± 0.55, hemoglobin ranging from 6.90 ± 0.98 to 6.15 ± 0.017, and hematocrit ranging from 21.5 ± 3.53 to 19.5 ± 0.70, indicating hemolysis and cellular damage. Total protein levels decreased, and the values ranged from 3.43 ± 0.18 to 2.84 ± 0.71, suggesting osmotic imbalances. Liver enzymes AST ranging from 36.2 ± 3.85 to 41.9 ± 3.03 and ALT ranging from 33.1 ± 2.39 to 38.6 ± 3.17 increased with higher MP exposure, signaling liver damage. Microplastics harm aquatic health, disrupting ecosystems and urging further research on their long-term consequences.

Keywords:
Fish physiology,
Aquatic toxicology,
Environmental stress,
Aquatic Organism Health

INTRODUCTION

Polyethylene, a synthetic polymer widely used in the production of plastics, has become a significant environmental pollutant, particularly in aquatic ecosystems. Its ubiquitous presence in water bodies is a growing concern due to its persistence, potential for accumulation, and adverse effects on aquatic organisms, including fish.

The ingestion of polyethylene by fish is often incidental, as these synthetic particles are mistaken for food due to their size, shape, and sometimes the biofilms that form on their surfaces. Once ingested, polyethylene particles can cause a range of physical and chemical impacts on fish. Physically, ingesting polyethylene can lead to gastrointestinal blockages, reducing the ability of fish to feed and potentially leading to starvation. Chemically, polyethylene can act as a vector for harmful contaminants, including persistent organic pollutants (POPs), heavy metals, and endocrine-disrupting chemicals, which adhere to the surface of the plastic particles (Rochman *et al.*, 2014; Wright *et al.*, 2013).

The internal health status of fish can be characterized by indices describing hematological, and serum biochemical characteristics. Haematological properties such as red blood cell (RBC), haemoglobin concentration (Hb), haematocrit (Ht), mean corpuscular haemoglobin concentration (MCHC), white blood cell (WBC), monocytes are important indicators for evaluating the health status of fish following exposure to various environmental stresses, chemical toxicity, and bacterial infection. The study of serum biochemistry reflects the metabolic condition of several biochemical processes and the health status of the organism. Several researchers used haematological and serum biochemical parameters effectively as reflective bioindicators in ecotoxicological studies. These studies reveal internal alterations before the animal shows any external signs of toxic stress Serum biochemical parameters like AST, ALT, ALP, glucose, urea, creatine, total protein, and albumin of fish serum may reflect health status and several biochemical pathways in the metabolism of fish. In fish, the haematological parameters represent important laboratory indices useful in the diagnosis of many diseases and therefore for the evaluation of the state of health, physiological state of fish, food conditions, and quality of the water in which they live. The values of blood parameters provide useful information in various body processes and are of great importance in evaluating the harmful effects of anthropogenic pollution on the aquatic environment . Fish live in intimate contact with the aquatic environment which significantly influences their blood homeostasis. In the past few years, there has been a significant increase in the experimental studies conducted in the hope of achieving a better understanding of the impact of microplastics on diverse organisms including fish. Fish homeostasis is altered by exposure to polluting substances and materials of various kinds (including microplastics), causing a series of protective mechanisms such as changes in blood parameters. Therefore, the hematological and biochemical parameters are useful bioindicators in evaluating the effect of different pollutants on fish.

MATERIALS AND METHOD

Collection And Acclimation of Test Fish

120 samples of *Clarias gariepinus* of mean weight and mean total length 20.26 ± 0.5g and 11.58 ± 0.52cm respectively, were bought live from a fish farm in Ibadan, Oyo state. The fish was acclimatized in a holding tank in the laboratory at the Department of Aquaculture and Fisheries Management, University of Ibadan. Acclimation of fish was done in freshwater by gradually changing the tank water for two weeks. The fish was fed daily to satiation during acclimation, with a pelleted commercial feed (35% crude protein) to remove any problem that could arise because of starvation.

Feed Preparation for Microplastic Exposure

Microplastics (MPs) raw powders with irregular-shaped particles were purchased from a plastic industry in Ibadan. Four (4) iso-nitrogenous and iso-lipidoneous test diets were prepared for this experiment. Diets were formulated with different percentage inclusion of Polyethylene (PE) microplastic- 0.0% (control), 0.5%, 1.5%, and 3.0%. Although the amount of microplastic of plastic polymer ingested by fish in the wild is not known (Jovanović, 2017), however, the PE dietary inclusion levels hypothetically reflect low, medium, and high exposure presumably. (Jovanovic, 2017) hypothesized that daily consumption of microplastics in the aquatic environment was about 0.3% which translates to 3.33 g kg1 feed during dietary exposure in a laboratory experiment. Formulated fish diets were mechanically mixed and pelletized into 2 mm diameter sizes using a locally fabricated machine. Pelleted diets were air-dried. Feed Ingredients for experimental Diets and percentage composition were: Fish meal (40%), soybean (15%), Corn (15%), Wheat Offal (15%) Vitamin premix((4%) starch (5%), Mineral Premix(5%) fish oil (1%).

Fish Exposure to Polyethylene, And Blood Collection

In this study of *Clarias gariepinus*, four treatment groups of fish were exposed to polyethylene microplastics (PE-MPs) in their feed for 21 days. The fish were kept in randomized tanks, with water quality maintained by siphoning and replacing the tank water every three days. Blood was collected from the fish using a heparinized syringe, following a procedure to avoid contamination, and stored for hematological and blood chemistry analysis.

Statistical Analysis

The data obtained were subjected to descriptive statistics (Means and Standard error). Further statistical test was performed with inferential statistics (One way ANOVA and Duncan Multiple Range Test) at $p < 0.05$ using IBM SPSS Version 22.

RESULTS

Table 1: Mean serum biochemistry parameters of PE microplastic at varying concentrations

Serum Chemistry Parameters	Control	0.5%	1.5%	3.0%	P<0.05
Total Protein (%)	3.43±0.18	3.18±0.45	3.02±0.38	2.84±0.71	0.04
Albumin(dL)	1.29±0.29	1.16±0.03	1.12±0.92	1.10±0.03	0.03
Globulin(dL)	2.14±0.52	2.00±0.29	1.67±0.85	1.52±0.46	0.04
AST(µL)	36.2±3.85	35.4±3.37	42.2±2.29	41.9±3.03	0.03
ALT µL)	33.1±2.39	32.8±3.84	40.3±3.74	38.6±3.17	
Creatinine (mg/dL)	0.08±0.03	0.50±0.05	0.89±0.04	1.05±0.06	0.03

Means within the same row carrying different superscripts are significant at $p < 0.05$

Table 2: Mean hematological parameters of polyethylene

Hematology Parameters	Control	0.5 %	1.5%	3.0 %
PCV (%)	21.5±3.53^{ab}	19.5±2.12^{ab}	18.7±2.0^{a}	19.5±0.70^{ab}
Hb (dL)	6.90±0.98^{d}	6.35±0.77^{bc}	6.30±0.84^{b}	6.15±0.017^{a}
RBC (x10^{6}/µL)	3.62±0.82^{c}	2.84±0.56^{a}	2.93±0.90^{ab}	2.85±0.55^{a}
WBC (x10^{3}/µL)	5.60±1.03^{a}	7.00±0.57^{b}	7.80±0.66^{bc}	7.00±1.14^{b}
Platelets (x10^{5}/µL)	7.00±1.14^{a}	7.00±1.20^{a}	7.10±0.18^{a}	7.20±1.30^{a}
MCV (fL)	59.5±5.33^{b}	68.5±3.63^{c}	56.50±0.90^{a}	69.5±3.50^{cd}
MCH (pg)	19.00±1.41^{ab}	22.00±3.12^{bc}	21.5±18.00^{b}	21.4±4.95^{b}
MCHC (%)	31.5±0.70^{a}	32.00±1.20^{a}	31.00±0.56^{a}	31.00±2.30^{a}
Lymphocytes (%)	31.5±2.12^{a}	40.50±2.12^{d}	36.50±4.20^{b}	38.5±2.14^{c}
Heterophils (%)	69.50±1.40^{d}	59.0±0.70^{a}	64.5±0.92^{c}	61.5±2.21^{ab}
Monocytes (%)	0.50±0.01^{a}	0.05±0.01^{a}	0.00±0.001^{a}	0.00±0.0^{a}

Means within the same row followed by different letters are significantly different ($P < 0.05$). PE= concentration of Polyethylene, HB = haemoglobin, PCV = packed cell volume, RBC = red blood cells, WBC = white blood cells, MCV = mean cell volume, MCH = mean cell haemoglobin, MCHC = mean cell haemoglobin concentration mean cell haemoglobin

DISCUSSION

This study reveals significant impacts of polyethylene (PE) microplastic exposure on the hematological and biochemical parameters of C. *gariepinus*, with important implications for aquatic ecosystems and food security. Key hematological indicators such as RBC, hematocrit (Ht), hemoglobin (Hb), total protein, AST, and ALT are crucial for assessing fish health after exposure to environmental stresses, chemical toxicity, and infections (Kim et al., 2021). Results showed reductions in RBC, Hb, PCV, and total protein levels, indicating hemolysis, anemia, and impaired protein synthesis, consistent with findings by

(Kim *et al.*, 2021) and (Iheanacho and Odo 2020). MP exposure also causes physical and chemical damage to red blood cell membranes, resulting in hemolysis, reduced hemoglobin, and hematocrit levels (Kim *et al.*, 2021; Iheanacho and Odo, 2020) Elevated AST, ALT, and creatinine levels suggest liver and kidney damage, corroborating (Hamed et al., 2022). Increased WBC and lymphocyte percentages reflect immune responses, aligning with observations by (Hamed *et al.*, 2022). The implications are profound: microplastics in aquatic environments can compromise fish health, leading to reduced growth rates, increased susceptibility to diseases, and potential declines in fish populations, all of which threaten aquaculture productivity. Furthermore, these disruptions to fish physiology may affect human health through the biomagnification of microplastics and their associated toxins in the food chain, as suggested by Digka *et al.* (2018) and Banaee *et al.* (2019). This highlights the urgency of mitigating microplastic pollution to safeguard aquatic biodiversity, ecosystem balance, and food security

CONCLUSION

The current study thus confirmed that hematological parameters are very responsive parameters for evaluating the toxic responses of the fish following exposure to microplastics. MPs intoxication reveals the anaemic condition in fish species. It is believed that alterations in hematological indices and serum biochemistry may be a protective mechanism against MPs toxicity. Overall, the present study offers supplementary shreds of evidence for the usage of serum biomarkers in assessing the health of fish

REFERENCES

Banaee, M., Sureda, A., Mirvaghefi, A. R. and Ahmadi, K. (2019). Effects of polyethylene microplastic particles on bioaccumulation and oxidative stress in the African catfish, Clarias gariepinus. Environmental Pollution, 249, 940–947. https://doi.org/10.1016/j.envpol.2019.03.084

Bello, O. S., Olaifa, F. E. and Emikpe, B. O. (2014). Haematological and blood biochemical changes in African catfish (Clarias gariepinus) fed walnut (Tetracarpidium conophorum Mull Arg) leaf and onion (Allium cepa Linn) bulb-supplemented diets. Journal of Experimental Agriculture International, 4(12), 1593–1603. https://doi.org/10.9734/ajea/2014/6622

Bisht, V. S. and Negi, D. (2020). Microplastics in the aquatic ecosystem: Sources, trophic transfer, and implications. International Journal of Fisheries and Aquatic Studies, 8(3), 227–234.

Digka, N., Tsangaris, C., Torre, M., Anastasopoulou, A. and Zeri, C. (2018). Microplastics in mussels and fish from the Northern Ionian Sea. Marine Pollution Bulletin, 135, 30–40. https://doi.org/10.1016/j.marpolbul.2018.06.063

Espinosa Ruiz, C., Esteban, M. and Cuesta, A. (2016). Microplastics in aquatic environments and their toxicological implications for fish. In Toxicology - New aspects to this scientific conundrum (pp. 113–145). https://doi.org/10.5772/64815

Fazio, F., Saoca, C., Sanfilippo, M., Capillo, G., Spanò, N. and Piccione, G. (2019). Response of vanadium bioaccumulation in tissues of Mugil cephalus (Linnaeus, 1758). Science of the Total Environment, 689, 774–780. https://doi.org/10.1016/j.scitotenv.2019.06.476

Hamed, M., Monteiro, C. E. and Sayed, A.E.H. (2022). Investigation of the impact caused by different sizes of polyethylene plastics (nano, micro, and macro) in common carp juveniles (Cyprinus carpio L.) using multi-biomarkers. Science of the Total Environment, 803, 149921. https://doi.org/10.1016/j.scitotenv.2021.149921

Iheanacho, S. C. and Odo, G. E. (2020). Neurotoxicity, oxidative stress biomarkers, and haematological responses in African catfish (Clarias gariepinus) exposed to polyvinyl chloride microparticles. Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology, 232, 108741. https://doi.org/10.1016/j.cbpc.2020.108741

Jovanović, B. (2017). Ingestion of microplastics by fish and its potential consequences from a physical perspective. Integrated Environmental Assessment and Management, 13(3), 510–515.

https://doi.org/10.1002/ieam.1913
Kavitha, C., Ramesh, M., Kumaran, S.S. and Lakshmi, S. A. (2012). Toxicity of Moringa oleifera seed extract on some hematological and biochemical profiles in a freshwater fish, Cyprinus carpio. Experimental Toxicology and Pathology, 64(7-8), 681–687. https://doi.org/10.1016/j.etp.2011.01.001
Kim, J. H., Yu, Y. B. and Choi, J.H. (2021). Toxic effects on bioaccumulation, hematological parameters, oxidative stress, immune responses, and neurotoxicity in fish exposed to microplastics: A review. Journal of Hazardous Materials, 413, 125423.https://doi.org/10.1016/j.jhazmat.2021.125423
Narra, M.R. (2016). Single and cartel effect of pesticides on biochemical and haematological status of Clarias batrachus: A long-term monitoring. Chemosphere, 144, 966–974. https://doi.org/10.1016/j.chemosphere.2015.09.065
Osman, A.G., Koutb, M. and Sayed, A.E.D. (2010). Use of hematological parameters to assess the efficiency of quince (Cydonia oblonga Miller) leaf extract in alleviation of the effect of ultraviolet-A radiation on African catfish Clarias gariepinus (Burchell, 1822). Journal of Photochemistry and Photobiology B: Biology, 99(1), 1–8. https://doi.org/10.1016/j.jphotobiol.2010.01.002
Rochman, C. M., Kurobe, T., Flores, I. and Teh, S. J. (2014). Early warning signs of endocrine disruption in adult fish from the ingestion of polyethylene with and without sorbed chemical pollutants from the marine environment. Science of the Total Environment, 493, 656–661. https://doi.org/10.1016/j.scitotenv.2014.06.051
Sayed, A.E.H. and Soliman, H.A.M. (2018). Modulatory effects of green tea extract against the hepatotoxic effects of 4-nonylphenol in catfish (Clarias gariepinus). Ecotoxicology and Environmental Safety, 149, 159–165.
Shugart, L. R., McCarthy, J. F. and Halbrook, R. S. (1992). Biological markers of environmental and ecological contamination: An overview. Risk Analysis: An Official Publication of the Society for Risk Analysis, 12(3), 353–360. https://doi.org/10.1111/j.1539-6924.1992.tb00687.x
Srivastava, B. and Reddy, P. (2020). Haematological and serum biomarker responses in Heteropneustes fossilis exposed to Bisphenol A. Nature Environment and Pollution Technology, 19, 1577–1583. https://doi.org/10.46488/NEPT.2020.v19i04.024
Wright, S. L., Thompson, R. C. and Galloway, T.S. (2013). The physical impacts of microplastics on marine organisms: A review. Environmental Pollution, 178, 483–492. https://doi.org/10.1016/j.envpol.2013.02.031

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

MICRONUCLEAR ASSAY ANALYSIS OF *Clarias gariepinus* FED POLYETHYLENE INDUCED DIET

Olajide, A. Y., F. P. D. Satimehin, A. Jenyo-Oni, G. O. Adewuyi and E. K., Ajani

University of Ibadan, Ibadan, Oyo State, Nigeria.

Corresponding author:
Olajideaishat23@gmail.com, +234 803 064 5931

ABSTRACT
Aquatic ecosystems are at risk due to global pollution by microplastics (MPs). Despite growing scientific interest, the presence of microplastics in African aquatic habitats and their impact on aquatic life remain unclear. This study investigated the effects of microplastics on the genotoxicity of Clarias gariepinus.
120 samples of C. gariepinus from a commercial fish farm were fed microplastic-included diet for 21 days. Microplastic inclusion percentages were 0%, 0.5%, 1.5%, and 3%. Genotoxicity was assessed using the micronucleus test, and data were analyzed with ANOVA at $p<0.05$. Micronuclear abnormalities (miconuclei) were significantly higher ($p<0.05$) in the MP groups compared to the control. Abnormalities were highest (6.30±0.05 MnRBCs/1000) at 3% inclusion rate and least in the control group (0.00±0.00 MnRBCs/1000). The findings indicate that MPs are capable of inducing erythrocyte mutations, posing health risks to humans consuming contaminated fish.

Keywords:
Genotoxicity,
Erythrocytes,
Microplastic pollution,
Micronucleus assay

INTRODUCTION

Microplastics is defined as the plastic particles in the size range of 1 nm to <5 mm (GESAMP, 2015). Fish consume plastic fragments accidentally, usually mixed with their natural prey or feed (Enyoh et al., 2020). Microplastics are of increasing concern in aquatic environments due to the ecotoxicological risks they pose. Microplastic ingestion by a range of species can compromise energy reserves and can bioaccumulate and biomagnify through the food chain. They are also prone to adsorbing many substances including heavy metals, and may transfer priority pollutants, such as Polycyclic Aromatic Hydrocarbons (PAHs) and Polychlorinated Biphenyls (PCBs), to aquatic life (Bakir *et al.,* 2014). Micro and nano plastic particles can be transferred to living cells through the lymphatic or circulatory system. This results in Micro Plastics' dispersion in the whole body and the induction of severe effects such as decreased feeding activity (Campos et al., 2021), genotoxicity (Guimarães et al., 2021) and even mortality (Naidoo and Glassom, 2019). Many scientists have recently focused on the effects of MPs in fish and on human health. Despite the fact that the number of publications is growing, the possible consequences are still largely unknown (Muniasamy *et al.*, 2020).
Fish are commonly used as model species to assess aquatic ecosystem health due to their accumulation of pollutants, which can lead to adverse effects like death. The analysis of environmental genotoxicity provides early warning signals of adverse long-term effects of the contamination (Rybakovas *et al.*, 2009). The micronucleus test, a reliable assay for detecting genetic damage, identifies erratic nuclei formed during cell division. Generally, there is a scarcity of knowledge about the impacts of

microplastics (MPs) on the early juvenile stage of freshwater fish (Hamed *et al.*, 2019). Hence, this study was conceived to examine the toxicity of concentrations of Polyethylene microplastic in the African catfish (Clarias gariepinus) juveniles using the micronucleus assay.

MATERIALS AND METHODS

Experimental Fish

120 samples of *Clarias gariepinus* (average weight of 19±0.5g) were obtained from a private farm in Ibadan, Oyo State. The fish was acclimated in a plastic tank for a period of 2 weeks to ensure that disease-free fish were used for the experiment.

Feed Preparation for microplastic exposure

Four (4) iso-nitrogenous and iso-lipidoneous test diets were prepared for the experiment. Diets were formulated with the following ingredients: Fish meal (40%), Soybean meal (15%), Corn (15%), Wheat offal (15%), Vitamin premix (4%), Starch (5%), Mineral premix (5%), Fish oil (1%) (Iheanacho and Odo, 2020).

Experimental design and fish exposure

Four treatment samples, each containing 10 fish were prepared in the laboratory. Formulated fish diets were mechanically mixed and pelletized into 2 mm pellets using a locally fabricated machine, then air-dried and fed to experimental fish. Fish were randomly allocated to four tanks containing varying levels of microplastic microplastics (0.0% (control), 0.5%, 1.5%, and 3.0%). Tank water was siphoned every three days and replaced with clean tap water to maintain water quality by removing faecal materials and feed remnants.

DNA Damage Estimation using Micronucleus Assay

Preparation of slides

Peripheral blood samples obtained from the caudal vein were smeared on clean, grease free frosted glass slides. Slides were fixed in methanol for 10 minutes and left to air-dry at room temperature, it was then stained with 10% May and Graunwald stain solution for 10 minutes and finally stained with 5% Giemsa in Sorenson's buffer (pH 6.9) for 30 minutes, all fixing and staining process was done in a coupling jar. Each slide was rinsed in distilled water after each staining process before air drying, 1000 erythrocyte cells were scored from each slide under light biological Microscope (XSZ-PW206 Series, oil immersion lens, 100/1.25).

Scoring of slides

The slides were analysed for Micronuclear abnormalities at x 1000 using microscope. Micro bodies which are 1/3 to 1/10 in length and 1/3 in diameter, have same colour, refraction and clearly separated from the main nucleus were scored as micronuclei.

Statistical analysis

The frequencies of induced macronuclei per thousand cells was calculated as

$$\text{Micronuclei frequencies per 1000 erythrocytes} = \frac{\text{No of micronucleus}}{\text{Total numbers of cells counted}}$$

The frequencies of micronuclei were analysed using Excel 2019. Significant differences between treatment and control groups were compared using one-way ANOVA. Dunnett multiple post hoc tests ($p < 0.05$) were conducted with GraphPad Prism 8.0 to assess significance between treated groups.

RESULTS AND DISCUSSIONS

Table 1: Frequency of micronuclei cells in the peripheral erythrocytes of C. *gariepinus* **fed Microplastic induced diets for 21 days.**

MnRBCs= Micronuclei Red Blood Cells, Values are Mean±Standard Deviation. Means within the same row

Frequency of micronucleus	Control	0.5%	1.5%	3.0%	P < 0.05
MnRBCs/900 RBCs	0.00±0.00	1.57±0.01	2.30±0.01	4.85±0.50	0.00040
Cell counted	900±4.67		300±8.10	270±70.00	0.00030
MnRBCs/1000 RBCs	$0.00±0.00^{a}$	$2.90±0.01^{b}$	$4.00±0.01^{c}$	$6.30±0.05^{d}$	0.00035

row with different superscripts are significantly different (p<0.05)

Table 2: Mortality rate of C. *gariepinus* **during the 21 days exposure to MP induced diets.**

Inclusion percentage	No of fish exposed	Mortality	Mortality (%)	Survival (%)
0.0	30	0	0	100
0.5	30	4	13.33	86.67
1.5	30	8	26.67	73.33
3.0	30	10	33.33	66.67

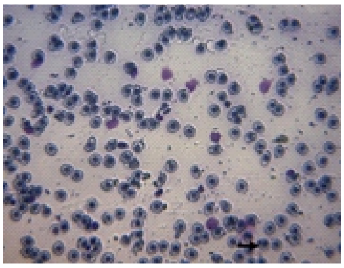

Plate 1: Micronuclei cells

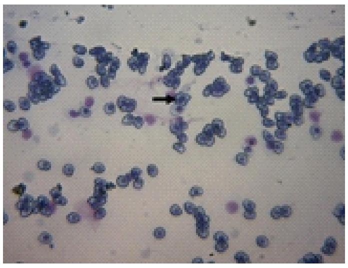

Plate 2: Micronuclei cells

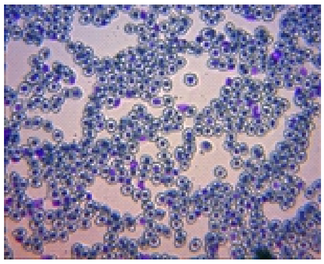

Plate 3: Normal peripheral erythrocyte

Magnification: x1000

Micronuclear abnormalities of C. *gariepinus* **exposed to Microplastic** C. *gariepinus* **for 21 days**

The results of this study indicate the activation of a genotoxicity indicator; nuclear morphological abnormalities in tissues of C. *gariepinus* exposed to Polyethylene microplastic. The genotoxic impacts of pollutants can be attributed to the excessive generation of reactive oxygen species (ROS) (Reeves et al., 2008). In specific, DNA damage as well as induction of micronucleus in animal tissue is a consequence of ROS production (Rehman et al., 2014). The micronucleus test has been widely used in fish to assess the mutagenic effects of various pollutants, both in laboratory and field conditions (Canedo et al., 2021). A review of research on the effects of exposure to MPs (concentration ≤1 mg L-1) on aquatic organisms (Sun et al., 2021) reported a notable genotoxic challenge. In this study, it was found that exposure to PE-MPs at various concentrations led to a significant decrease in cells with normal nuclei morphology in C. *gariepinus*, compared to cells of fish not exposed to MPs. Furthermore, a significant increase in nuclear abnormalities such as the formation of cells with micronucleus was observed after exposure to microplastics. Romdhani et al., 2022 observed that the frequency of micronuclei in hemocytes of *Mytilus galloprovincialis* mussels significantly increased compared to the control group after 3 days of exposure to a mixture of microplastics collected from the northern Mediterranean beach. However, in contrast to this findings, Mediterranean mussels *(M. galloprovincialis)* exposed over 21 days to both virgin and weathered PE particles (0.01 mg mL^{-1}; 50-570 μm), showed that the ingestion of PE particles led to structural alterations in the gills and digestive gland, along with necrosis in other tissues like the mantle. However, no discernible differences were observed in the extent of tissue modifications, including micronucleus formation, between exposures to virgin and weathered PE (Bråte et al., 2018). Other investigators suggest the induction of nuclear abnormalities after the effect of virgin MPs on adult Danio rerio (da Costa Araújo et al., 2020a). According to the latter, the increase in the frequency of displaced nuclei suggests the intervention of MPs in structures that centralize the nucleus, such as the cytoskeleton. Increased numbers of cells with micronuclei and other nuclear abnormalities were also reported after exposing tadpoles of the frog *Physalaemus* cuvieri to Polyethylene microplastics (da Costa Araújo et al., 2020b). However, research by Pittura et al., 2018 showed that exposure for 7–14 days to MPs (20–25 μm) had no effect on micronucleus formation in hemocytes of *M. galloprovincialis*.

CONCLUSION

Micronucleus assay indicated that there was a dose-response relationship between the DNA damage and micoplastic dose in the feed. Given their toxicity, it is important to understand the mechanisms associated with their eco-toxicity and to reduce their adverse impacts in the environment.

REFERENCES

Bakir, A., Rowland, S. J., and Thompson, R. C. (2014). Enhanced Desorption of Persistent Organic Pollutants from Microplastics under Simulated Physiological Conditions. Environ. Pollut. 185, 16–23. doi:10.1016/j.envpol.2013.10.007

Bråte, I.L.N., Blázquez, M., Brooks, S.J. and Thomas, K. V. (2018). Weathering impact the uptake of polyethylene microparticles from toothpaste in Mediterranean mussels (M. galloprovincialis). Sci. Total Environ. 626, 1310–1318. https://doi.org/10.1016/J.SCITOTENV.2018.01.141

Campos, D., Rodrigues, A.C.M., Rocha, R.J.M., Martins, R., Candeias-Mendes, A., Castanho, S., Soares, F., Pousão-Ferreira, P., Soares, A.M.V.M. and Gravato, C. (2021). Are Microplastics Impairing Marine Fish Larviculture?—Preliminary Results with Argyrosomus regius. Water 2021, 13, 104

Canedo, A., de Jesus, L.W.O., Bailão, E.F.L.C. and Rocha, T.L. (2021). Micronucleus test and nuclear abnormality assay in zebrafish (Danio rerio): Past, present, and future trends. Environ. Pollut. 290, 118019. https://doi.org/10.1016/J.ENVPOL.2021.118019

da Costa Araújo, A.P., de Melo, N.F.S., de Oliveira Junior, A.G., Rodrigues, F.P., Fernandes, T., de Andrade Vieira, J.E., Rocha, T.L. and Malafaia, G. (2020b). How much are microplastics harmful to the health of amphibians? A study with virgin polyethylene microplastics and Physalaemus cuvieri. J. Hazard. Mater. 382, 121066. https://doi.org/10.1016/J.JHAZMAT.2019.121066

da Costa Araújo, A.P., Luz, T.M., da Rocha, T.L., Ahmed, M.A.I., Silva, D., Rahman, M.M. and Malafaia, G. (2020a). Toxicity evaluation of the combination of emerging pollutants with polyethylene microplastics in zebrafish: Perspective study of genotoxicity, mutagenicity, and redox unbalance. J. Hazard. Mater. 432, 128691. https://doi.org/10.1016/J.JHAZMAT.2022.128691

Enyoh, C.E., Shafea, L., Verla, A.W., Verla, E.N., Qingyue, W., Chowdhury, T. and Paredes, M. (2020). Microplastics Exposure Routes and Toxicity Studies to Ecosystems: An Overview. Environ. Anal. Health Toxicol. , 35, e2020004.

GESAMP. (2015). Sources, Fate and effects of Microplastics in the Marine Environment: A global Assessment. (Kershaw PJ (ed.) (IMO7FAO7UNESCO-IOC7UNIDO7WMO7IAEA7UN7UNEP7UNDP Joint Group Experts on the Scientific Aspects of Marine Envtal. Protection 96.

Guimarães, A.T.B., Estrela, F.N., Pereira, P.S., de Andrade Vieira, J.E., de Lima Rodrigues, A.S., Silva, F.G. and Malafaia, G. (2021). Toxicity of polystyrene nanoplastics in Ctenopharyngodon idella juveniles: A genotoxic, mutagenic and cytotoxic perspective. Sci. Total Environ., 752, 141937

Hamed M., Soliman H.A.M., Osman A.G.M. and Sayed A.E.H. (2019). Assessment of the effect of exposure to microplastics in Nile Tilapia (Oreochromis niloticus) early juvenile: I. Blood markers. J. Chemosphere. 2019 Aug;228:345-350. doi: 10.1016/j.chemosphere.2019.04.153. Epub 2019 Apr 22. PMID: 31039541.

Iheanacho, S. C. and Odo, G. E. (2020). Neurotoxicity, oxidative stress biomarkers, and haematological responses in African catfish (Clarias gariepinus) exposed to polyvinyl chloride microparticles. Comparative Biochemistry and Physiology. Toxicology & Pharmacology: CBP, 232, 108741. https://doi.org/10.1016/j.cbpc.2020.108741

Kutralam-Muniasamy, G., Pérez-Guevara, F., Elizalde-Martínez, I. and Shruti, V.C. (2020). Review of Current Trends, Advances and Analytical Challenges for Microplastics Contamination in Latin America. Environ. Pollut. 267,115463.doi:10.1016/j.envpol.2020.115463

Naidoo, T. and Glassom, D. (2019). Decreased growth and survival in small juvenile fish, after chronic exposure to environmentally relevant concentrations of microplastic. Mar. Pollut. Bull., 145, 254–259.

Pittura, L., Avio, C.G., Giuliani, M.E., d'Errico, G., Keiter, S.H., Cormier, B., Gorbi, S. and Regoli, F. (2018). Microplastics as vehicles of environmental PAHs to marine organisms: Combined chemical and physical hazards to the mediterranean mussels, Mytilus galloprovincialis. Front. Mar. Sci. 5. https://doi.org/10.3389/fmars.2018.00103

Reeves, J.F., Davies, S.J., Dodd, N.J.F. and Jha, A.N. (2008). Hydroxyl radicals (OH) are associated with titanium dioxide (TiO2) nanoparticle-induced cytotoxicity and oxidative DNA damage in fish cells. Mutat. Res. Mol. Mech. Mutagen. 640, 113–122. https://doi.org/10.1016/J.MRFMMM.2007.12.010

Rehman, S.U., Yaseen, Z., Husain, M.A., Sarwar, T., Ishqi, H.M. and Tabish, M. (2014). Interaction of 6 mercaptopurine with calf thymus DNA - Deciphering the binding mode and photo induced DNA damage. PLoS One 9, 1–11. https://doi.org/10.1371/journal.pone.0093913

Romdhani, I., De Marco, G., Cappello, T., Ibala, S., Zitouni, N., Boughattas, I. and Banni, M. (2022). Impact of environmental microplastics alone and mixed with benzo[a]pyrene on cellular and molecular responses of Mytilus galloprovincialis J. Hazard. Mater. 435, 128952. https://doi.org/10.1016/J.JHAZMAT.2022.128952

Rybakovas, A., Barsiene, J. and Lang, T. (2009). Environmental Genotoxicity and Cytotoxicity in Offshore Zones of the Baltic and North Seas. Marine Environmental Research, 68, 246-256. http://dx.doi.org/10.1016/j.marenvres.2009.06.014

Sun, C.Z., Li, F.Y., Tu, H.F., Jia, F.L., Li and F.M. (2016). Review on the impact of phthalate esters on aquatic food chain. Asian Journal of Ecotoxicology 11 (6), 12–24. https://doi.org/10.7524/AJE.1673-5897.20160308006

ASSESSMENT OF SOME HEAVY METALS CONCENTRATION IN WATER AND SEDIMENT SAMPLES FROM UPPER RIVER NIGER AT LOKOJA, KOGI STATE.

Omuwa, J.W[1], A. L. Shaibu[2], O. A. Ikongbeh[1] and A. Yakubu[2]

[1]Department of Fisheries and Aquaculture, Joseph Sarwuan Tarka University. P.M.B 2373, Makurdi.
[2]Department of Fisheries and aquaculture, Kogi State University. P.M.B 108 Lokoja.

Corresponding Author:
jennifersoom@gmail.com; +234 706 218 8202

ABSTRACT
The rapid industrialization, urbanization, population growth, agricultural and other human activities have resulted in severe pollution of the environment with heavy metals around the world, especially in developing countries. Significant quantities of heavy metals from these activities are discharged into rivers, which can be strongly accumulated and biomagnified in water, sediment, and aquatic food chain, resulting in sub-lethal effects or death of fish and other aquatic organisms. The industrial, agricultural and other anthropogenic activities around the river at Lokoja are capable of releasing some heavy meals into the water body, thus the need to consistently monitor the concentration of these heavy metals in the water, sediments and aquatic organisms such as fish. This study was carried out to determine the level of heavy metal concentration in water and sediment from Lower River Niger at Lokoja. Results obtained shows that the highest mean values for Pb (3.91±1.50 mg/l), Cr (1.35±0.17 mg/l) and Mn (10.45±2.61 mg/l) were recorded at location B. the value of Zn was highest at location C (0.18±0.04 mg/l) while Cu was higher at location A and B (0.04±0.01 mg/l). The lowest mean values for Pb (0.23±1.50 mg/l), Cu (0.05±0.01 mg/l), Cr (0.86±0.17 mg/l) and Mn (2.40±2.61 mg/l) were recorded at location C, while that of Zn (0.12±0.04 mg/l) was recorded at location A. The mean Monthly variations in the concentration of heavy metals in soil sediments shows that Pb (4.125) and (Cu 0.054) recorded the highest value in June, Cr (0.9478) and Mn (7.929) had the highest values in May while Zn (0.198) recorded the highest value in July. The lowest concentrations of Pb (0.00±1.48), Cu (0.00±0.01) and Zn (0.082±0.03) were recorded in May while Cr (0.94±0.18) and Mn (3.20±2.80) recorded lowest values in June respectively. There were no significant differences ($p>0.05$) in concentration of the heavy metals across the locations. The concentration of heavy metals were below the limit set by World Health Organization (WHO). However, Pb and Cr concentrations at location B exceeded the World Health Organization (WHO) permissible limits for drinking water (0.01 mg/l and 0.05 mg/l respectively), indicating a contamination and potential health risks to both aquatic life and humans.

Keywords:
Pollution, Anthropogenic, Aquatic, Contamination

INTRODUCTION

Heavy metals pollution has become a major concern worldwide due to their toxicity, intrinsic persistence, non-biodegradable nature, and accumulative behaviors (Islam *et al.*, 2018). They are inert in the environment and are often considered to be conservative if left undisturbed (Hossain *et al.*, 2018). The rapid industrialization, urbanization, population growth, agricultural and other human activities have resulted in severe pollution of the environment with heavy metals around the world, especially in developing countries (Ahmed *et al.*, 2018). Significant quantities of heavy metals from such activities are discharged into rivers, which can be strongly accumulated and biomagnified in water, sediment, and aquatic food chain, resulting in sub-lethal effects or death in local fish populations (Khan 2018). Contamination of freshwater ecosystems by heavy metals such as cadmium, lead, mercury, copper, zinc, arsenic, chromium, and cobalt has become a public health concern due to their eventual build-up in living organisms, particularly in the food chain. (Pandiyan, *et al.*, 2020). Aquatic ecosystems such as rivers, dams and lakes provide livelihood for rural populations in many developing countries in Africa. However, in the recent past, they have been subjected to various forms of degradation due to pollution arising from domestic wastes, industrial effluent, agricultural run offs, power generation and bad fishing practices (Ndimele, 2018). According to Amin *et al.*, (2021), heavy metals tend to accumulate in soils and sediments after weathering processes and can be deposited in water bodies due to surface run-offs. The Lower River Niger serves as the main source of water in the community used for fishing activities, irrigation farming and domestic uses. There are small industries, mechanic workshops and scrape refuse dumps found around the lower River Niger. These activities are capable of releasing some heavy metals into the river thus; the need to consistently monitor the concentration of these heavy metals in the water, sediments and aquatic organisms such as fish. This research was carried out to determine some heavy metals concentration in water and sediment from lower River Niger at Lokoja.

MATERIALS AND METHODS

The study was carried out at Kogi State University Ayingba, Kogi State, Nigeria. Located on latitude 8.1046°N and longitude 6.7976°E in the Northern part of Nigeria. The area is predominantly inhabited by the Ebiras, Yorubas, Igbos, Bassas, and Nupes who engage mostly in peasant farming, fishing with crude methods and trading.

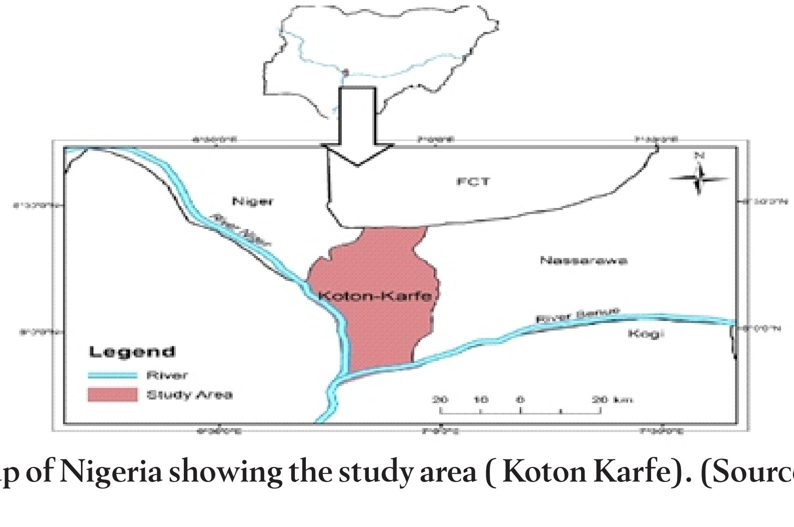

Figure 1: Map of Nigeria showing the study area (Koton Karfe). (Source: Google).

Water Sample Collection, Pre-treatment and Digestion.

Water samples were collected twice a month within May and July 2024. Sampling was done along the river at three selected sites labelled location A, B and C which were 500m apart. Water sample was taken below the water surface (depth of 1.5m) using one (1) liter acid-leached polypropylene containers. To avoid contamination, the collected water samples were samples were placed in an ice bath, taken to the laboratory and kept in 1% HNO3 at 4 °C. Samples were filtered using a Whatman no.1 (0.45 mm) filter paper, 100 ml was measured in a conical flask, five ml of concentrated H2SO4 was added and heated for about two hours at 105 °C until the volume reached to 25 ml and the sample was transferred in a 100 ml volumetric flask. Deionized H2O was gradually added to the flask until 100 ml volume of the sample was reached. The sample solution was kept in a well cleaned and labelled analytical bottle until metal analysis.

Collection and Digestion of Soil Sediment Samples

Soil sediment were collected from the three marked locations. At each location, three different soil samples were collected and mixed thoroughly to get a composite sample. The samples were collected using a core sampler rinsed with HNO3 (10%), and the samples were kept for analysis. The preserved soil sediment was dried for three days to remove the moisture content. The dried soil sample was crushed to fine powder and filtered using a 2 mm sieve. The filtered sample was transferred in to a 100 ml volumetric flask and deionized H2O was added until 100 ml was reached and samples were kept until analysis.

Determination of Heavy Metals in the Samples

Sample were poured into an auto-analyzer cup and concentration of heavy metals (Copper (Cu) chromium (Cr), Zinc (Zn), Manganese (Mn) and Lead (Pb) were analyzed according to the Environmental Protection Agency method as described by Martin (2003). The concentrations of metal ions of the samples were measured using the standard procedure with the Atomic Absorption Spectrophotometer (AAS). Perkin Elmer Model 306.

Statistical Analysis

Data was analyzed using ANOVA. 5% level probability was considered to indicate statistical significant difference. Means of significant differences were separated using Duncan's Multiple Range Test.

RESULTS

Heavy metal concentration in water sample

The highest mean concentration of Pb (3.91±1.50 mg/l) was recorded at Location B, while the lowest (0.23±0.10 mg/l) was observed at Location C. The highest mean concentration of Cu (0.04±0.01 mg/l) was recorded at both Location A and B, while the lowest (0.02±0.01 mg/l) was observed at Location C. The highest mean concentration of Zn (0.18±0.04 mg/l) was recorded at Location C, while the lowest (0.12±0.04 mg/l) was observed at Location A. There is no significant. The highest mean concentration of Cr (1.35±0.17 mg/l) was recorded at Location B, while the lowest (0.86±0.17 mg/l) was observed at Location C. The highest mean concentration of Mn (10.45±2.61 mg/l) was recorded at location B while the lowest (2.40±2.61) was seen at location C. There were no significant differences (p>0.05) in concentration of Cu and Zinc across the locationsthe locations.

Table 1: Concentration of Heavy Metals in Water Sample of River Niger at Lokoja

Parameter	Location A (Mean±SEM)	Location B (Mean±SEM)	Location C (Mean±SEM)
Pb (mg/l)	$0.30±0.10^{a}$	$3.91±1.50^{b}$	$0.23±0.10^{a}$
Cu(mg/l)	$0.04±0.01^{a}$	$0.04±0.01^{a}$	$0.02±0.01^{a}$
Zn(mg/l)	$0.12±0.04^{a}$	$0.13±0.04^{a}$	$0.18±0.04^{a}$
Cr(mg/l)	$0.95±0.17^{a}$	$1.35±0.17^{b}$	$0.86±0.17^{a}$
Mn(mg/l)	$4.41±1.61^{a}$	$10.45±2.61^{b}$	$2.40±2.61^{c}$

Treatment means with similar superscripts within the same row are not significantly different (p>0.05)

Monthly Variation in the Concentration of heavy Metals in Lower River Niger at Lokoja

The monthly variation in concentration of heavy metals is shone in table 2. The highest value for Pb (4.13±1.48 mg/l) and Cu (0.05±0.01 mg/l) were recorded in the month of June, Zn (0.20±0.03 mg/l) recorded highest in July while Cr (1.18±0.18 mg/l) and Mn (7.93±2.78 mg/l) recorded highest values in May. The lowest values for Pb (1.48±0.08 mg/l), Cu (0.00±0.00 mg/l) and Zn (0.08±0.03 mg/l) were recorded in May, while Cr (0.94±0.18 mg/l) and Mn (3.12±2.80 mg/l) were lowest in June.

Table 2: Monthly Variation in the Concentration of heavy Metals in sediment from Lower River Niger at Lokoja

Parameter	May (Mean±SEM)	June (Mean±SEM)	July (Mean±SEM)
Pb (mg/l)	1.48 ± 0.08^{a}	4.13 ± 1.48^{b}	1.48 ± 0.31^{a}
Cu(mg/l)	0.00 ± 0.00^{a}	0.05 ± 0.01^{a}	0.05 ± 0.01^{a}
Zn(mg/l)	0.08 ± 0.03^{a}	0.15 ± 0.03^{a}	0.20 ± 0.03^{a}
Cr(mg/l)	1.18 ± 0.18^{a}	0.94 ± 0.18^{a}	1.04 ± 0.18^{a}
Mn(mg/l)	7.93 ± 2.78^{a}	3.12 ± 2.80^{b}	6.12 ± 2.80^{c}

Treatment means with similar superscripts within the same row are not significantly different ($p>0.05$)

DISCUSSION

One way in which Pb is distributed in the environment is through agricultural practices such as the application of fertilizers and pesticides (Hashmi, *et al.*, 2013). Generally the presence of Zn in the aquatic ecosystem is facilitated from the atmosphere and it can be settled in soils and water (Kumar, *et al.*, 2012). The source of Zn in the Lower River Niger could be attributed to the construction activities, national highways, solid waste burning, aquaculture industries and agricultural practices. Pesticides and fungicides containing Zn sulphate are an additional source of Zn in the aquatic system. Copper (Cu) is a trace nutrient for all known living organisms. Its role is vital in the physiology of cells, structure and functions of proteins in living organisms (Janssens *et al.*, 2002). Cu in the aquatic environment could be due to severe quarrying, manufacturing of various types of equipment, and refineries as well as farm lands and waste treatment sites (Pandiyan, et al., 2020). The mean concentrations of heavy metals such as Pb, Cu, Zn, Cr, and Mn at the three different locations along River Lokoja showed variations in the concentrations though the differences in some metals were not statistically significant ($p>0.05$). The highest concentration of Pb as recorded at Location B (3.91±1.50 mg/l), suggest localized contamination, possibly from anthropogenic activities like industrial discharge or runoff from agricultural farm lands. However, the overall Pb levels were relatively low at other locations, with the lowest value at Location C (0.23±0.10 mg/l). These values, particularly the high concentration at Location B, exceed the World Health Organization (WHO) permissible limits for drinking water (0.01 mg/l for Pb), (as reported by Ugwu, *et al.*, 2022) indicating potential health risks to both aquatic life and humans. The concentrations of Cu and Zn were uniform across the locations, with Cu showing no significant difference between locations, and Zn exhibiting slightly higher concentrations at Location C. The consistency in Cu levels might indicate a widespread but low-level source of contamination, which could result from agricultural runoff or natural mineral deposits. The Zn levels, while higher at Location C, are still within acceptable limits, suggesting that the river is not heavily impacted by Zn pollution. Chromium (Cr) levels were highest at Location B (1.35±0.17 mg/l), surpassing the WHO maximum permissible limit (0.05 mg/l). This could point to specific industrial or municipal waste discharges near Location B, making this area a critical point for further investigation and possible remediation efforts. Heavy metals in soil sediment during May, June, and July indicates fluctuations in concentration levels, with certain months exhibiting significantly higher concentrations. The concentration of Pb was at its peak in June (4.13±1.48 mg/l), which may be attributed to seasonal variations in runoff and water volume, potentially increasing the influx of contaminants. Similarly, Mn concentration was highest in May (7.93±2.78 mg/l), which may be influenced by the effect of early rainy season on sediment disturbance and the release of bound metals into the water body. The significant difference in Cu concentrations between May (0.000 mg/l) and the other months suggests a decrease in dilution capacity during the dry season. The levels of heavy metals recorded in this study were higher than those reported by Kamzati, *et al.,* (2019) but were similar to those reported by Ogaga and Tari (2018). This variations may be due to differences in the sampling locations, time, and the extent of anthropogenic activities affecting these water bodies. This findings brought to light the gradual pollution of the water body, the importance of continuous monitoring and possible remediation processes of this water body to avoid future implications.

CONCLUSIONS

It was found from the study that Pb and Cr concentrations in the River were high compared to the permissible limits by WHO which indicates that the upper River Niger at Lokoja is contaminated with these heavy metals which could pose a threat to the water body, aquatic organisms and man. The concentration of other heavy metals in the water body were low and safe for consumption. This research calls for further study of other heavy metals contamination in the area including other aquatic organisms like fish.

REFERENCES

Ahmed, M.K, Baki, M.A., Islam, M.S, Kundu, G.K., Habibullah-Al-Mamun, M. and Sarkar, S.K, et al. (2019) Human health risk assessment of heavy metals in tropical fish and shellfish collected from the river Buriganga, Bangladesh. Environmental Science and Pollution Research; 22:15880–15890.

Amin, N., Hussain, A., Alamzeb, S. and Begum, S. (2021). Accumulation of heavy metals in edible parts of vegetables irrigated with waste water and their daily intake to adults and children, District Mardan, Pakistan, Food Chemistry, 136, 1515–1523.

Hashmi, H.Z., Malik, R.N. and Shahbaz, M. (2013). Heavy metals in eggshells of cattle egret (Bubulcus ibis) and little egret (Egrettagarzetta) from the Punjab province, Pakistan. Ecotoxcology and Environmental Safety; 89:158–165.

Hossein, K.P, Takhsha, M, Aein J.K. and Aghshenas A. (2018) Assessment level of heavy metals (Pb, Cd, Hg) infour fish species of Persian Gulf (Bushehr-Iran). International Journal of Advanced Technology and Engineering Research; 4:7–11.

Islam, M.S, Hossain, M.B, Matin, A. and Sarker, M.S.I. (2018). Assessment of heavy metal pollution, distribution and source apportionment in the sediment from Feni River estuary, Bangladesh. Chemosphere; 202:25–32.

Janssens, E., Dauwe T., Bervoets L. and Eens M. (2002). Inter and intraclutch variability in heavy metals in feathers of Great tit nestlings (Parus major) along a pollution gradient. Archives of Environmental Contamination and Toxicology; 43:323–329.

Kamzati, L. L. J., Kaonga, C. C., Mapoma, H. W. T., Thulu F. G., Abdel dayem, M., Anifowose, J., Chidya R. C. G., Chitete Mawenda, U. and Sakugawa, H. (2019). Heavy metals in water, sediment, fish and associated risks from an endorheic lake located in Southern Africa. International Journal of Environmental Science and Technology. 17 (1) 253-266

Khan, E. (2018) Bioaccumulation of non-essential hazardous heavy metals and metalloids in freshwater fish. Risk to human health. Environmental Chemistry Letters; 16:903–917.

Kumar B. and Sajwan K.S., Mukherjee D.P. (2013). Distribution of Heavy Metals in Valuable Coastal Fishes from North East Coast of India. Turkish Journal of Fisheries and Aquatic Science. 12:81–88.

Ndimele, P.E. (2018). The levels of lead (Pb) in water, sediment and a commercially important fish species

(Chrysichthys nigrodigitatus) (Lacepède, 1803) from Ologe Lagoon, Lagos, Nigeria. Journal of Environmental Extension 8: 70-75.

Ogaga, A.A. and Tari, T.E. (2018). Heavy Metal Concentrations in the Tissues of Synodontis membranaceous along Upper Taylor Creek, Bayelsa State Nigeria. Journal of Humanities and Social Science, 19(3): 67-70

Pandiyan, J., Mahboob, S., Jagadheesan, R., Elumalai, K., Krishnappa, K., Al-Misned, F., Kaimkhani, Z.A. and Govindarajan, M. (2020). A novel approach to assess the heavy metal content in the feathers of shorebirds: A perspective of environmental research. Journal of King Saud University, Science. 32:3065–3307.

Ugwu, C. E., Maduka I., Suru, S. M. and Anakwuo, I. A. (2022). Human health risk assessment of heavy metals in drinking water sources in three senatorial districts of Anambra State, Nigeria. Toxicology report 9. 15; 9:869–875. doi: 10.1016/j.toxrep.04.011

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

HAEMATOLOGICAL INDICES OF TILAPIA *(OREOCHROMIS NILOTICUS)* FROM KALGWAI DAM, HADEJIA, JIGAWA STATE, NIGERIA

[*1]Idris, S., [2]A. A. Adam, [3]M. U. Sambo, [4]F. Sambo, [5]J. Ukeyima and [6]H. Jibrin
[1,2,3,4&5]Department of Fisheries Technology, Binyaminu Usman Polytechnic Hadejia, Jigawa State, Nigeria
[6]Department of Fish Nutrition and Physiology, Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos
*Correspondence Author:
safiyanuidris003@gmail.com, GSM NO: +2348065460052, 08125454549

ABSTRACT
The present study investigated the hematological indices of Oreochromis niloticus (Nile tilapia) from Kalgwai Dam, Hadejia, Jigawa State, for the period of twenty-four months (24) with a focus on assessing the health status of the fish population in relation to potential environmental stressors and parasitic infections. Haematological indices count such as Packed cell volume (PCV), Red blood cell (RBC), Haemoglobin (Hb), Mean corpuscular volume (MCV), Mean corpuscular haemoglobin (MCH), Mean corpuscular haemoglobin concentration (MCHC), White blood cell (WBC), Neutrophils, Lymphocytes were analyzed using standard laboratory procedures. The mean value recorded for PCV. were 15.00 % to 34.50%, RBC were 1.35±0.21to 2.70±0.28, (Hb) were 6.50 g/dL to 11.50 g/dL, mean of MCV, MCH and MCHC ranged from 26.00±14.14 to 61.00±28, 34.50±16.26 to 52.50±17.68 and 24.50±9.19 to 49.00±7.07 for MCV, MCH and MCHC respectively. WBC were 120.00±28.28 to 230.50±57.28, Neutrophils ranged from 33.50±14.85 to 56.00±21.21, Lymphocytes were 34.00±12.73 to 61.50±27.58. The observed variations in hematological parameters are indicative of sample fish health conditions, potentially linked to water quality issues or parasite prevalence in the dam. This study underscores the importance of regular monitoring of hematological indices as bioindicators of fish health, which can serve as an early warning system for ecological disturbances and the presence of disease-causing agents in aquatic ecosystems.

Keywords:
Water pollution,
Heavy metals,
Aquatic ecosystem,
Physiological changes

INTRODUCTION

Water pollution has become a menace in recent times, causing a great damage to the aquatic ecosystems. Waste from farms, industries and domestic uses gradually find their way into the aquatic environment. Most of the water bodies have become polluted due to haphazard and extravagant pouring of wastes into them and making it unfavorable for aquatic organism (Chindah *et al.,* 2008).
Tilapia *(Oreochromis niloticus)* is an important fish species in Nigeria, with Kalgwai Dam in Hadejia, Jigawa State being one of the major sources of this fish. However, there is limited information on the

haematological indices of tilapia from this dam. Haematological indices are important indicators of fish health, and changes in these indices can indicate exposure to environmental stressors, diseases, or pollution. Therefore, this study aims to investigate the haematological indices of tilapia from Kalgwai Dam in order to provide baseline data for future studies and to assess the health status of the fish. The main objectives of the study are to determine the haematological indices of tilapia *(Oreochromis niloticus)* from Kalgwai Dam, Hadejia, Jigawa State, Nigeria.

MATERIALS AND METHODS

Description of Study Site

Kalgwai Dam is located about 50 m away from Kalgwai village in Auyo Local Government Area of Jigawa State, Nigeria. It was impounded on River Hadeja in 1984 by the Federal Government of Nigeria for the purpose of irrigation under the then Hadejia Valley Irrigation Project which was coordinated by Hadejia-Jama'are River Basin Development Authority (H.J.R.B.D.A). It covers an estimated area of 3,800 sqkm2 (Matthes, 1990). The study was carried out in twenty-four (24) months, between January 2022 and December, 2023.

Fish samples collection

Samples of Tilapia *(Oreochromis niloticus)* were collected fortnightly from January, 2022 to December, 2023. The fishes were transported to the laboratory for further analysis.

Blood Collection and Haematological Examination

Blood samples were collected from the caudal pendluncle with the use of 5ml syringe and needle that has been treated with anti-coagulant such as heparin to prevent clotting into small sampling bottles containing Ethylene diamine tetra-acetic acid (EDTA). After the collection, the blood samples were taken to the laboratory of the Department of Biology, Binyaminu Usman Polytechnic, Hadejia, Jigawa State where the haematological examination was carried out.

Packed cell volume

Blood were collected into microhaematrocrit haprinised tube which was sealed with critaseal at one end. The sampled tubes were then centrifuged for 5 minutes at 12000rpm using Hawksley microhaematocrit centrifuge. The haematocrit values were read on a microhaematocrit reader. A mean of two readings was recorded as percentage for the fish haematocrit

Determination of Red blood cells counts

Standard haemocytometer was used in the counting of the red blood cells according to method of Blaxhall and Daisley (1973)

RBC (106/ml) =

Where, C = Number of cells counted

D = Diluting factors

S = Number of 1mm square counted

Determination of White blood cells counts

White blood cells were determined using the method described by Blaxhall and Daisley, 1973; Ibu and Adeniyi, 1989

WBC (103/ml) =

Where C = Number of cells counted

D = diluting factor

S = Number of 1mm square counted.

Determination of haemoglobin

The cyanmet-haemoglobin method was used as described by Larsen and Snieszko (1961)

Determination of mean corpuscular hemoglobin (MCH)

The mean corpuscular hemoglobin (MCH) was calculated using the formula described by dacie and lewis (1977)

WBC (103/ml) =

Determination of mean corpuscular volume (MCV)

The mean corpuscular volume (MCV) was determined as described by Dacie and lewis (1977)

$$MCV\ (dL) = \frac{\text{Packed cell volume /dL x 10}}{\text{RBC/uB (in 106)}}$$

Determination of mean corpuscular haemoglobin concentration (MCHC)

The mean corpuscular haemoglobin concentration (MCHC)
was calculated using the formula described by Dacie and lewis (1977)

MCHC (g/dL) =

RESULTS AND DISCUSSION

Hematological parameters

The monthly mean values of blood parameters of the examined O. niloticus from January, 2022 to December, 2023 shown in table1. The Parked cell Volume (PCV) of O. niloticus values ranged from 15.00 % to 34.50% in the month of July and October 2022 respectively. The obtained values are higher than 10.12 % to 24.90 % reported by Kefas et al., (2015). But, is in line with the finding of Ayandiran et al. (2010), who stated that normal haematocrit values usually fall within the range of 20-35% and are rarely greater than 50% for fish.

The monthly mean of red blood cell (RBC) ranged from 1.35±0.21 in November 2023, to 2.70±0.28 in October, 2023, the values tally with Ayoola et al. (2014), findings reporting 2.13±1.47. More so, higher than what observed by Kefas et al. (2015). Likewise, is in agreement with (Witeska, 2013), revealing that RBC usually ranges from 0.5–1.5 × 106/L in less active species to 3.0–4.2 × 106/L in more active ones.

The monthly mean of O. *niloticus* Hemoglobin (Hb) were 6.50 g/dL and 11.50 g/dL in July and March 2022, the finding is in agreement with what observed by (Adedeji and Adegbile 2011), who reported 9.280 and 8.325 Hb for Clarias gariepinus and Chrysichthys nigrodigitatus respectively, but slightly differs with 4.05 g/dL to 10.43 g/dL revealed by Kefas et al., (2015). The decrease in Hb corresponds with the decrease in dissolved oxygen; an indication that the decrease in haemoglobin resulted in haemo dilution. Gafaar et al. (2010). The monthly mean of Derived erythrocyte parameters (MCV, MCH and MCHC) of O. niloticuswhich describe the morphology and properties of red blood cells, i.e. MCV (mean corpuscular volume), MCH (mean corpuscular hemoglobin) and MCHC (mean corpuscular hemoglobin concentration) ranges from 26.00±14.14 to 61.00±28.28, 34.50±16.26 to 52.50±17.68 and 24.50±9.19 to 49.00±7.07 for MCV, MCH and MCHC respectively. However, previous researches and findings are in close agreement with the current value in some parameters and differs in others, while others in total disagreements as in the case of Ayoola et al. (2014), Kefas et al. (2015) and (Adedeji and Adegbile 2011). The analysis of these parameters may be useful in diagnostics of some fish diseases, e.g., anemia. The increase of MCV is a "low cost" response to anaemic state in some fish species. However, fish suffering with anemia can exhibit decreased values of all red blood cell parameters (Witeska, 2015).

The white blood cells (WBC) of O. *niloticusmonthly* meanvalue was 120.00±28.28 in the month of February, 2023, maximum value was 230.50±57.28 in October, 2022. The value observed is lower

than (Adedeji and Adegbile 2011), revealed value of 14692.50 and 19385.00 for Clarias gariepinus and Chrysichthys nigrodigitatus respectively. But higher than what is obtained by Ayoola et al. (2014), nevertheless, similar to Kefas et al. (2015) findings.
The temperature ranging between 25.51°C in Marke and 25.87°C in Kalgwai, this is in line with the work of Oniye et al. (2002) who reported Mean annual surface water temperature of 26.56°C in Zaria Dam with the highest values recorded in April, May, June and October and the lowest recorded in December. However, coincide with the report of Lawal and Ahmed (2014) who reported that the normal range of temperature in the tropics to which fish is adapted is between 8°C and 30°C and these make the critical thermal minimum and maximum respectively. The mean transparency ranged between 0.25 m and 0.28 m. this finding is in line with the finding of Tegu, Ekemube, (2023) who reported higher turbidity value during the rainy season (28.50) than that obtained during the dry seasons (11.64), The PH, mean value ranged between 6.52 and 6.64 and were within the acceptable limits of 6.5- 8.5 for fresh water bodies set by National Standard for Drinking Water Quality (2007). this finding agreed with the work of Teame and Abergelle (2016) who reported Seasonal variations of pH values in dry season as (7.80 ± 0.58) significantly lower) than wet season (8.30 ± 0.34). The mean DO of Kalgwai Reservoir ranged between 6.03 mg/l and 6.09 mg/l. this finding is in line with the finding of (Chindah & Braide, 2003) who reported on the amount of dissolved oxygen in water not to be constant but fluctuates, depending on temperature depth and number of biological activities. However, coincide with the finding of (Hanna, 2003). Who revealed that dissolved oxygen level of 5mg/l or greater will support healthy growth of most fishes. The mean value of alkalinity varied between 24.93 ppm and 25.26 ppm for the stations. The alkalinity values recorded in this study were within the recommended values between 5-500mg/l (Lawson, 1995). The findings Agreed with the finding of (USEPA, 1976), who reported that Alkalinity is important for fish and other aquatic life because it buffers pH changes that occur naturally due to photosynthesis. The mean value of ammonia ranged between 1.55 ppm and 1.56 ppm in Kalgwai Reservoir. The mean value of hardness ranged between 78.56 ppm and 80.25 ppm. the finding is in conformity with the findings of (Mustapha, 2009). Who reported that water having hardness less than 5ppm calcium carbonate $CaCO_3$ equivalent cause low growth, distress and eventually death of fish, total hardness value, which is the sum of calcium and magnesium hardness concentrations, was found to be significantly higher in the wet season; this was the same for calcium and magnesium ions. Also, in line with the finding of (Wetzel, 2001). Who revealed productive water to however, qualified to have hardness <500,

Table 1: Haematological analysis of *Oreochromis niloticus* from Kalgwai reservoir

Parameter	Site			P-value
	Kalgwai	Dingare	Marke	
PCV (%)	22.50 ± 6.36^{b}	24.50 ± 4.95^{a}	25.50 ± 2.12^{a}	0.025*
RBC ($\times 10^6$ cells/mm^3)	1.55 ± 0.21^{a}	1.20 ± 0.28^{a}	1.75 ± 0.21^{a}	0.051
Hemoglobin Conc. (g/dL)	6.00 ± 2.83^{b}	8.00 ± 2.83^{a}	9.00 ± 3.54^{a}	0.001*
MCHC	41.50 ± 20.5^{a}	39.00 ± 16.9^{b}	37.00 ± 18.3^{c}	0.022*
MCH (pgm)	53.50 ± 19.09^{a}	46.00 ± 16.9^{b}	44.00 ± 18.3^{c}	0.005*
MCV (fL)	29.00 ± 14.44^{a}	29.00 ± 15.56^{a}	26.00 ± 12.02^{b}	0.037*
WBC ($\times 10^3$ cells/mm^3)	130.50 ± 36.06^{c}	153.00 ± 36.77^{a}	148.00 ± 32.53^{b}	0.015*
Neutrophils/Heterophils (%)	47.50 ± 9.19^{b}	51.00 ± 21.21^{a}	47.00 ± 25.46^{b}	0.001*
Lymphocytes (%)	45.00 ± 14.14^{b}	51.00 ± 16.97^{a}	43.00 ± 13.44^{b}	0.004*

Means in rows having same letters were not significantly different (P >0.05)

from Lake Geriyo, Yola, Adamawa State, Nigeria. International Journal of Fisheries and Aquatic Studies, 3(1): 09-14

Larsen, H.N. and Snieszko, S. (1961). Comparison of Various Method of Determintion of Haemoglobin trout blood fish Culture; 23:8-7.

Lawal, I. and Ahmed, A. (2014). Physicochemical Parameters in Relation to Fish Abundance in Daberam Reservoir, Katsina State, Nigeria. Entomology and Applied Science Letters, 1(3): 43-43.

Lawson, T. B. (1995). of aquacultural engineering, Chapman and Hall. New York. 357pp.

Matthes, H. (1990). Report on fisheries related aspects of the Hadejia – Nguru wetlands conservation project. Unpublished internal report. HNWLCP, Nguru Nigeria, 250 pp.

Nigerian Standard for Drinking Water Quality (2007). Nigerian Industrial Standard. NIS 554, Standard Organization of Nigeria. Lagos. Pp 30.

Oniye, S. J., Ega, R. A. I., Ajanusi, O. J. and Agbede, R. I. S. (2002). Some aspects of the physico-chemical parameters of Zaria Dam. Journal of Agriculture and Environment, 3 (2): 367-379.

Teame, T. and Abergelle (2016) Seasonal Variation in Physico-chemical parameters of Tekeze Reservoir, Northern Ethiopia team Agricultural Research Centre, Tigray Agricultural Research Institute (TARI), PO Box 492 Mekelle, Tigray, Ethiopia. Animal Research International. 13(2): 2413–2420.

Tegu, T. B., Ekemube, R. A., Ebenezer, S. O., and Atta, A. T. (2023). Monitoring the Variability of the Pollutants Level in Urban Water Front during Dry and Wet Seasons. European Journal of Applied Sciences, 11(1). 60-69.

United State Environmental Protection Agency, (USEPA), (1976). Quality Criterion for water, Report No. EAP - 440/9-76-023. Washington, 501pp.

Walker, C. H., Hopkin, S. P., Sibly, R. M. and Peakal, D. B. (2006). Principles of Ecotoxicology, CRC Press, Taylor and Francis Group, Boca Raton.

Witeska, M. (2013). Erythrocytes in teleost fishes: a review Zool. Ecol., 23 (4) (2013), pp. 275-281

Witeska, M. (2015). Anemia in teleost fishes Bull. Eur. Assoc. Fish Pathol, 35 (4) (2015), Pp148-160.

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Table 2: Physicochemical parameters of Kalgwai Reservoir from January 2022 to December 2023

Parameter	Kalgwai	Dingare	Marke	P-value ANOVA
Temperature (°C)	25.87 ± 2.52^a	25.52 ± 2.55^b	25.51 ± 2.45^b	0.025*
Transparency (m)	0.28 ± 0.02^a	0.25 ± 0.03^b	0.28 ± 0.02^a	0.001*
Ph	6.64 ± 0.58^a	6.52 ± 0.49^b	6.56 ± 0.49^{ab}	0.022*
Dissolved oxygen (mg/l)	6.03 ± 0.27^c	6.07 ± 0.23^b	6.09 ± 0.20^a	0.005*
Alkalinity (ppm)	25.26 ± 1.59^a	24.93 ± 1.35^b	25.12 ± 1.44^{ab}	0.073*
Ammonia (ppm)	1.56 ± 0.54^a	1.55 ± 0.51^a	1.56 ± 0.53^a	0.691
Hardness (ppm)	80.25 ± 11.26^a	78.56 ± 11.23^b	80.02 ± 11.25^a	0.001*

Means in rows having same letters were not significantly different (P>0.05)

REFERENCE

Adakole, J. A. (2012). Changes in some Haematological parameters of the African catfish (Clarias gariepinus) exposed to a metal finishing company effluent. Indian Journal of Science and Technology, 5(4):2510- 2514

Adedeji, O.B. and Adegbile, A.F. (2011). Comparative Haematological Parameters of the Bagrid Catfish (Chrysichthys Nigrodigitatus) and the African Catfish (Clarias Gariepinus) from Asejire Dam in Southwestern Nigeria. Journal of Applied Sciences Research, 7(7): 1042-1046

Akinrotimi, O.A., Abu, M.G O, George, O.S., Ucdeme, N.B. and Aranyo, A.A. (2010). Haematological characteristics of Tilapiaguineensis from Buguma creek Niger Delta, Nigeria.League Res. Nig; 11:177-182.

Augustine, O. E. (2020). Potential menace posed by invasive grass and water quality deterioration on macro invertebrates' structural distribution in a dam in NorthWestern Nigeria, Water Science, 34:(1),75-84

Ayandiran, T.A., Fawole, O.O., Adewoye, S.O., and Ogundiran, M.A. (2010). Bioconcentration of metals in the head capsule and skeleton of Clarias gariepinus exposed to sublethal concentrations of soap and detergent effluents. Journal of Agriculture and Biology. North America.

Ayoola, S.O, Adejumobi K.O., and Adamson, O.H. (2014). Haematological Indices and Enzymatic Biomaker of black jaw Tilapia (Sarotherodon melanotheron) from Lagos Lagoon. Agrosearch; 14(1):62-75.

Bagenal T. B. and Tesch, F. W. (1978). Methods of Assessment of Fish Production in Fresh Waters. IBP Handbook No 3, 3rded. Oxford Blackwell Scientific Publication, London. 101-136.

Benthem, W. (1990). Wetland Conservation. The world conservation union: A review of current issues and required action. IUCN publication.

Blaxhall, P.C. and Daisley, K.W. (1973). Routine Haematological Methods for use with fish blood. Journal of Fish Biology; 5:771-781.

Chindah, A.C., Braide, A.S. and Oraye, O. (2008). Response of Sarotherodon melanotheron in the Niger Delta Wetland, Nigeria to changes in pH. Revista UDO Agricola; 8(1):143-153.

Dacie, J.V. and Lewis, S.M. (1977). Practical hematology. 5th Ed. Churchill Livingstone. London, 297.

Gafaar, A.Y., El-manakhly, E.M., Soliman, M.K., Soufy, H., Monas, Z, and Mohammed, S.G. (2010). Some pathological, biochemical and Hematological investigation on Nile tilapia (Oreochromis niloticus) following chronic exposure to edifenphos pesticide. Journal of American Science. 6(10):542-551.

George, A.D.I., Akinrotimi, O.A. and Nwokoma, U.K. (2017). Haematological Changes in African Catfish (Clarias Gariepinus) Exposed to Mixture of Atrazine and Metolachlor in the Laboratory. Journal of FisheriesSciences, 11(3): 048-054.

Ibu I.O., and Adeniyi, K.O. (1989). A Manual of Practical Physiology University of Jos, Press Ltd. Nig, 249.

Kefas, M., Abubakar, K.A. and Ja'afaru, A. (2015). Haematological indices of tilapia (Oreochromis niloticus)

STUDENTS' KNOWLEDGE AND PERCEPTION OF *Penaeus monodon* AS INVASIVE SPECIES IN NIGERIA

Nwafili Sylvanus A. and N. Zabbey

Department of Fisheries, University of Port Harcourt, P.M.B. 5323 Choba, Rivers State, Nigeria

Sylvanus.nwafili@uniport.edu.ng

ABSTRACT

This study assessed the awareness of Fisheries Society of Nigeria student members regarding biological invasions and their knowledge of Penaeus monodon as an invasive species in Nigerian coastal waters. A survey of 73 students showed that 54.79% could not identify P. monodon as invasive, though 62% viewed it positively due to its economic value. The study showed that students were partially informed about the environmental threat posed by the species, emphasizing the need to integrate invasive species education into Fisheries curricula.

Keywords:
Biodiversity, Penaeus monodon, hitchhiking, ballast water discharge

INTRODUCTION

Invasive aquatic species (IAS) are ranked top as one of the global threats to aquatic biodiversity, second to habitat loss and degradation (Simberloff et al., 2013; Hogue and Breon, 2022). IAS are species that are introduced outside their natural distribution range, with extensive dispersal capabilities and causing harm to biodiversity, ecosystems and economies. The speed at which invasive species are reaching new habitats and crossing biogeographic barriers is facilitated by aquaculture, hitchhiking and ballast water discharge.

Penaeus monodon (Asian tiger prawn) is distributed naturally in the Indo-Pacific but was first reported in Nigeria in early 1990s. It's occurrence outside the natural distribution range, including the Nigerian coastal region, is a major concern. Public knowledge, perception and attitudes towards IAS are key to tackling invasions. This study assesses the knowledge and perception of undergraduate Fisheries students regarding P. monodon as an invasive species in Nigeria. Undergraduate fisheries students are important stakeholders who will play future roles in managing aquatic invasive species, leveraging their education and future industry positions.

MATERIALS AND METHODS

The Fisheries Society of Nigeria (FISON) trains fisheries professionals, with students from various institutions registered as members. A survey of some students' members of FISON was conducted to assess their knowledge of P. monodon in Nigeria. Semi-structured questionnaire and picture of the Asian tiger prawn was used to gather information on species identification, knowledge of IAS, perceptions, and potential environmental threats. Data were analysed using EXCEL and PAST 4.1 statistical software. Results were presented using frequency and descriptive statistics.

RESULTS AND DISCUSSION

A total of 73 students participated in the survey. About 34.25% of the participants were males while 65.75% were females. The age bracket of the students fell within the traditional university age in Nigeria with 94.52% in the range of 18-30 years. Majority of the students (82.19%) were enrolled in the 5-year B. Fisheries Programme while 15.07% and 2.74% were enrolled into B.Sc Zoology and HND programmes, respectively.

Knowledge and identification: Of the total participants, 69.86% could rightly identify the coloured photograph of the species as Asian tiger prawn while 23.29% were not sure. Others simply called it "shrimp". Also, majority of students (54.79%) could not identify the species as non-native to the Nigerian coastal environment, while 5.48% of the students were not sure whether the species is non-native or native (Fig. 1). The students' ability to identify the species was high, indicating improved knowledge of systematic biology of shrimps among the students.

There was spread of opinion with respect to mechanism of introduction of the species, showing a significant gap in knowledge about the introduction pathway of *Penaeus monodon* with 38.36% of the students admitting they do not know how the species arrived the coastal waters of Nigeria. However, 20.54% attributed its presence to natural colonization, and 16.44% pointed to shipping and trade. Furthermore, 12.33% each believed it was introduced accidentally or deliberately, indicating uncertainty about human intervention. The diversity of views expressed by the students imply a general lack of clarity and understanding among students about the mechanisms through which invasive species are introduced. This scenario underscores the need for more education on pathways of biological invasions. Cordeiro de Melo et al. (2021) made similar observation in Brazil.

More than one-half of the students (55%) had previous knowledge of invasive species (Fig. 2) while about 41% never had. The study further revealed a wide range of knowledge levels about the invasive species among participants, with only 4.1% having extensive knowledge and 41.1% having no knowledge at all (Fig. 3). A significant portion, 26%, had some knowledge, while 20.5% had little, and 8.2% had much. This shows a general lack of deep understanding amongst most students.

Students' perception of *P. monodon*: Majority of the students perceive *P. monodon* as good (Fig. 4), may be due to its rising economic value. This is concordant with the earlier perception of the species as "God-sent" (Zabbey et al., 2010). Only 14% of the students view the species as bad in the environment and 9% were neutral in their view. This suggests a need for greater awareness of the ecological risks associated with invasive species. Zabbey et al., (2010) also noted that the economic benefits of *P. monodon* appear to be receiving more attention than environmental concerns.

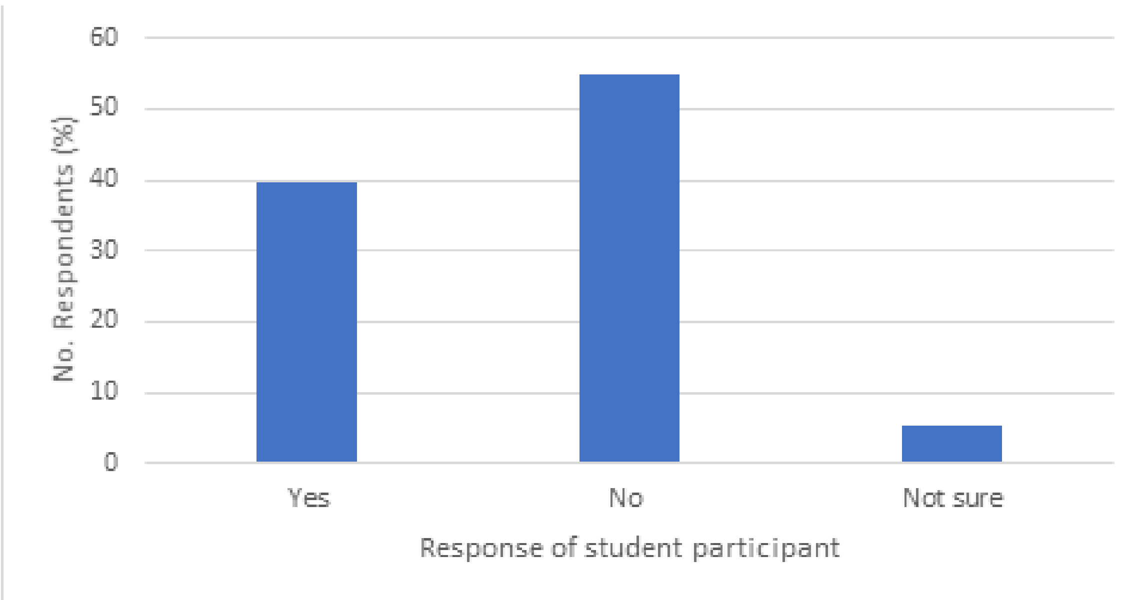

Fig. 1. Students' identification of *Penaeus monodon* as non-native species

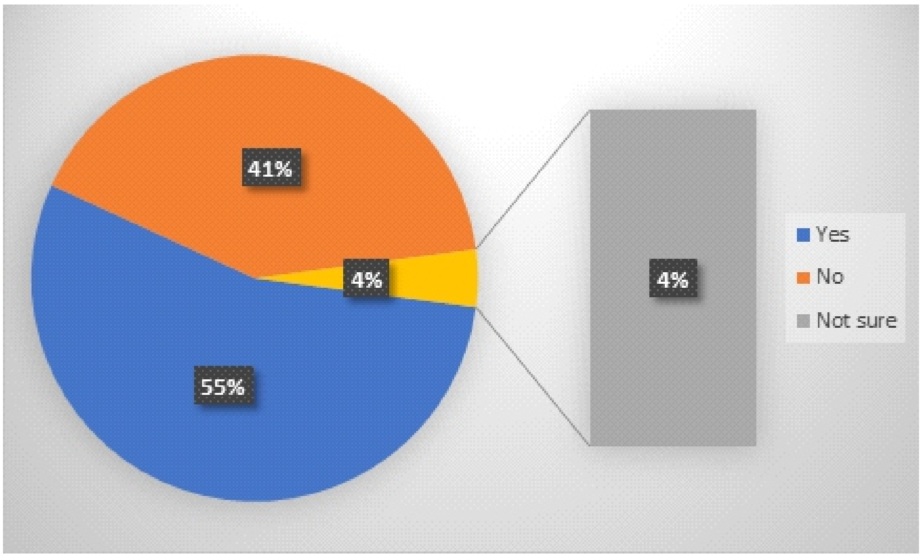

Fig.2 Students prior knowledge of P. monodon as Invasive Alien Species in Nigeria.

On the threat posed by Penaeus monodon in Nigeria's coastal waters, students perception were primarily ecological, with concerns focused on loss of biodiversity (35.62%) and possible extinction or decline of native shrimp resources (35.62%). However, while 20.55% of the students observed that disease transmission was a concern, economic loss — including the disruption of livelihoods was not mentioned as a significant threat (Fig. 5). This implies that students may not fully understand the socio-economic dimensions of the invasion, despite its potential to disrupt local fisheries and related industries.

Management of invasive species: The preventive and management strategies in the perception of students are shown in Fig. 6. This suggests integrated management strategies for addressing the invasive species (Hameed et al., 2024), reflecting a balanced approach that combines proactive measures, regulation, and education to prevent and manage the species' impact effectively

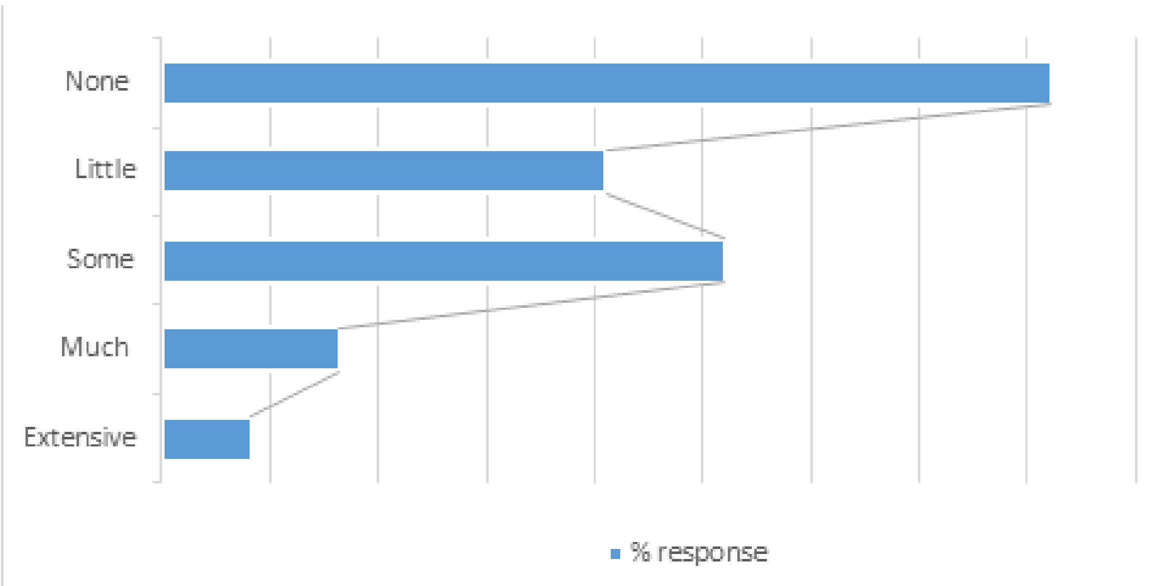

Fig. 3 Students' extent of knowledge of *P. monodon* as Invasive Alien Species in Nigeria

Perception of potential benefits of P. monodon

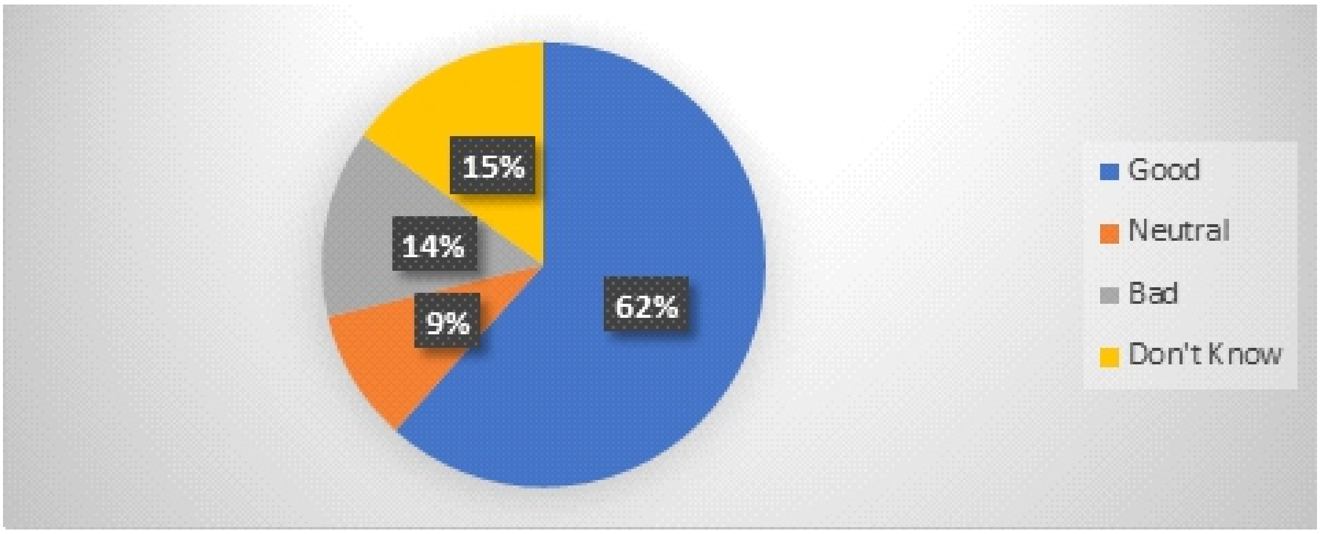

Fig 4. Students' perception of the benefits from *P. monodon*

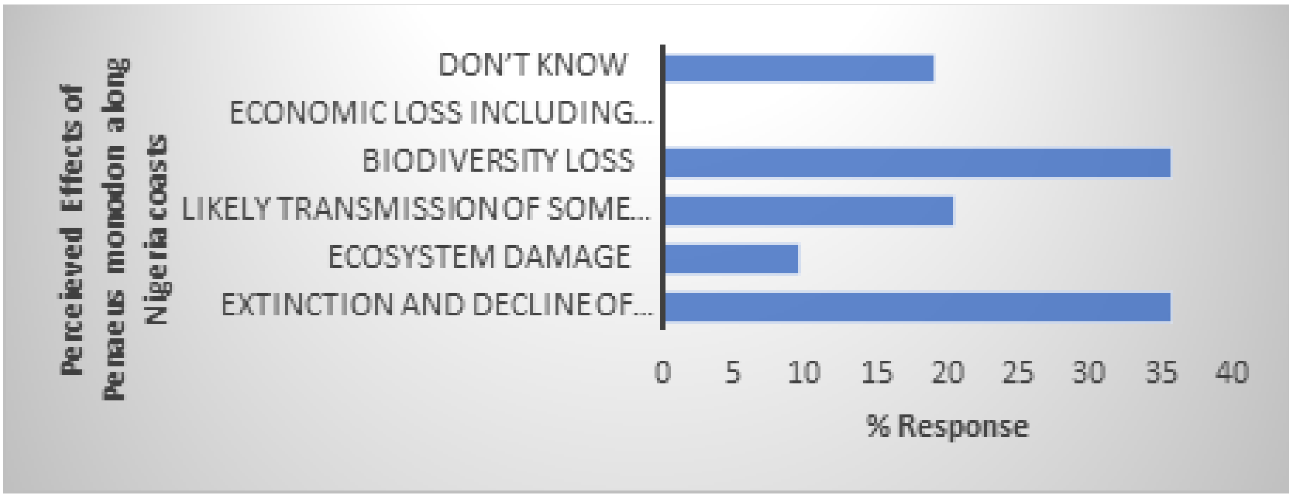

Fig. 5. Potential effects of *Penaeus monodon* in Nigeria's coastal waters

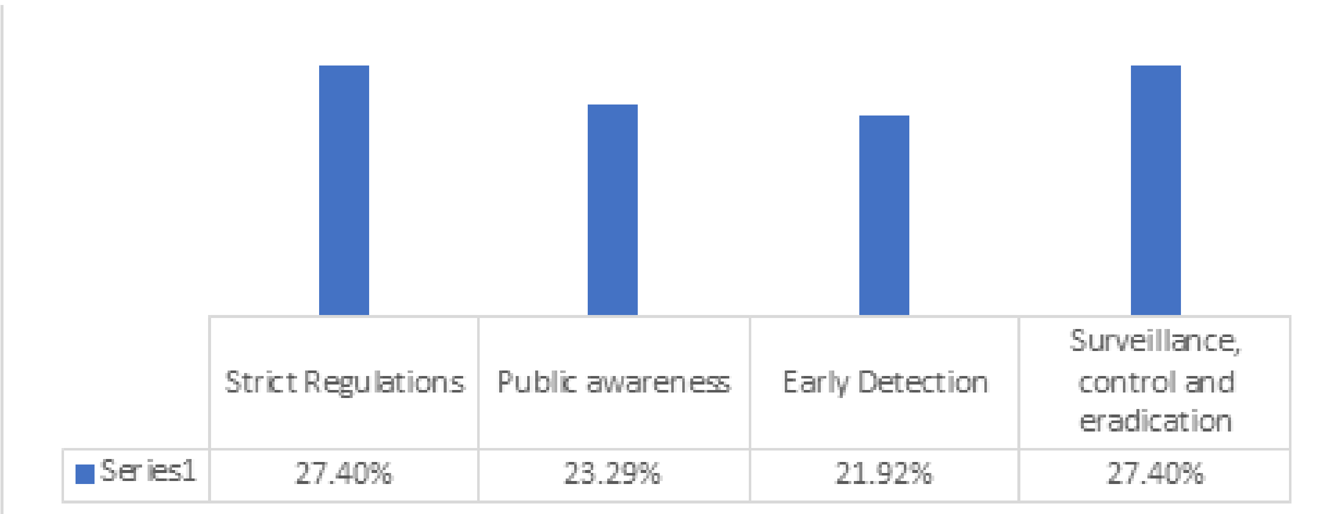

Fig. 6. Options for prevention of spread and management of *Penaeus monodon*

CONCLUSION

The study revealed that the fisheries students had disproportionate knowledge of invasive species. The majority of students were not able to identify the species as invasive. Furthermore, they did not demonstrate adequate understanding and awareness of the introduction pathways and socio-economic dimensions of P. monodon invasion of Nigeria's coastal waters. Therefore, further education is necessary to shape attitudes towards IAS and biodiversity conservation. Notably, invasive species are absent from the curricula of fisheries, highlighting a gap in IAS education. Well-designed educational programs based on existing perceptions can raise awareness and mitigate the spread of invasive species.

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REFERENCES

Hameed, A., Ali, F., Riaz, K., Alam, M.,Ali, S., Rasheed, R. and Sarfraz, S. (2024). Management Approaches for Biological Control of Invasive Species. In: Abd-Elsalam, K.A., Abdel-Momen, S.M. (eds) Plant Quarantine Challenges under Climate Change Anxiety. Springer, Cham. https: 10.1007/978-3-031-56011-8_14.Hogue, A.S. and Breon, K. (2022). The greatest threats to species. Conservation Science and practices, 4(5): e12670.

Cordeiro de Melo, E.P.C., Simião-Ferreira, J., Melo, H.P.C., Godoy, B.S., Daud, R.D., Bastos, R.P and Silva, D.P. (2021). Biological invasions in Brazilian environmental science courses: Do we need new approaches? Neotropical Biology and Conservation, 16: 221-238.

Simberloff, D., Martin, J.L, Genovesi, P., Maris, V., Wardle, D.A., Aronson, J., Courchamp, F., Gali, l..B., García-Berthou, E., Pascal, M., Pyšek, P., Sousa, R., Tabacchi, E. and Vilà, M. (2013). Impacts of biological invasions: What's what and the way forward. Trends in Ecology and Evolution, 28: 58–66.

Zabbey, N., Erondu, E.S. and Hart, A.I. (2010). Nigeria and the prospect of shrimp farming: critical issues. Livestock Research for Rural Development. 22(198). Retrieved October 5, 2024, from http://www.lrrd.org/lrrd22/11/zabb22198.html.

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COMPARATIVE EFFECTS OF ETHANOLIC AND AQUEOUS LEAF EXTRACTS OF *Carica papaya* ON BEHAVIOURAL AND HEAMATOLOGICAL PARAMETERS OF *Clarias gariepinus*

Ajayi C. T[1]., R. N. Oladosu- Ajayi[1], A. S. Ojukannaiye[2] and O. P. Olateju[3]

[1]Department of Fisheries Technology, Federal college of Freshwater Fisheries Technology New Bussa, Niger State.
[2] Department of Fisheries Technology, Federal Polytechnic Nekede, Owerri Imo State.
[3]Department of Fisheries and Aquaculture, Faculty of Agriculture, Bayero University Kano.

Corresponding Author:
acossyajayi@gmail.com, +2348035311635

ABSTRACT
Medicinal plants always play vital role in human healthy living. *Carica papaya* (pawpaw) is one of such plant with a high traditional and modern medicinal values. However there is a dearth of information on the piscicidal potentials of the extracts of this plant. This study examines the comparative toxicity of ethanol and aqueous extracts of different concentrations of Carica papaya on behavioural and heamatological parameter of exposed fish *(Clarias gariepinus)*.
Papaya leaf was extracted from air dried leaves of *Carica papaya* (Pawpaw plant) using water and ethanol and 500 *Clarias gariepinus* juveniles of average weight 10.12 ± 1.5g were used for a range finding test and acute toxicity was carried out using three doses each of aqueous and ethanol (0.5, 1.0, 1.5mg/l), while the negative (0mg/l) and positive (4mg/l of Cyclophosphamide) serves as controls. Behavioural and haematological parameters alterations were recorded.
Abnormal behavioural effects such as abnormal locomotive activities, gasping, hyperactivity, skin wrinking in some cases, decline in reflex and skin discoloration were all noticed in the treated samples but more pronounced and early detected in the ethanol extracts, Hematological assay showed changes in the packed cell volume (PCV), red blood cell count (RBC), haemoglobin concentration (Hb), mean corpuscular volume (MCV), and mean corpuscular haemoglobin (MCH) as they were significantly increased in comparison to the control but there was also no significant difference in the WBC concentration across the treatments and between the extraction media used. The outcome suggests that Papaya leaf contained substances capable of inducing haematological alteration due to its anti anemic properties but not directly cause damage to the fish since the white blood cell did not increase to a significant point..
The research therefore confirm the nontoxic effect in *Carica papaya* leaf (pawpaw leaf) from both extraction methods

Keywords:
Papaya leaf, bioassay,
acute toxicity,
heamatological parameters

INTRODUCTION

Fish abundance and diversity in water bodies are vulnerable to environmental impacts caused by man, worthy of note are; introduction of exotic species, industrial waste, oil spills, pesticides, herbicides, toxin from piscicidal plants and other agents that directly affect the ecology and the survival of the inhabitant fish species. Piscicidal plants have been widely used by traditional fishermen all over the world as a means of catching fish. Some of these plants are non-selective in destruction, thereby interfering with ecological balance of the immediate environment. Piscicidals are phytochemical substances that are poisonous to fish the plants contain different active ingredients such as alkaloid, micotine, tannins, saponins, piparine, resin, amide, ricin, glycoside, carbazole, curcin, coumanin, parkine, resoranol and cardol (Fafioye et al., 2009.) Test like standardized acute and chronic toxicity tests lasting 96 hours (4 days or more) are conducted to measure the effect on survival, organs and physical look of the fish measured at each concentration, along with a control test. (EPA 2001) (OECD, 1992). This work therefore seek to check the comparative effect of ethanol and water extracts of pawpaw leaf on the behavior of fish and also study if the different concentration from the two extracting medium has effect on the fish heamatological parameters.

MATERIALS AND METHODS

Experimental Site and Experimental Fish

The experiment was carried out at the Fisheries Technology Department Museum, of Federal College of Freshwater Fisheries technology, New Bussa, Niger State and the fish were purchased from a reputable farm in New Bussa.

Source of Pawpaw leaf and extracts preparations

The fresh leaves where collected from the college environment and identified in the Horticulture unit of the department of Agricultural technology in the Federal college of Freshwater Fisheries Technology, New Bussa. It was air dried, the dried leaves was crushed in to fine particles and stored in air tight container. The crushed leaf was weighed in grams and then water and ethanol were added to the dried leaves weighed in a container at 1g dried leave to 3 ml of water and ethanol. The samples were allowed to last in the solution for 24hrs and then decanted and filtered first through muslin cloth and then Whatman No.1 filter paper. The solutions were allowed to air-dry and the extracts was kept in sterile, clean bottles before used.

Experimental Design

Five hundred (500) healthy catfish of C. *gariepinus* Juveniles (10.12 ± 1.5g) were acclimated for 7 days, in plastic bowls. Twenty (20) juvenile each were distributed randomly among dose/exposure duration groups. Twenty-four (24) 30 liters rectangle white plastic tanks were used for the bioassay of various concentrations of the toxicant. A completely randomized design (CRD) was used. Each of the samples (aqueous and ethanol extracts) were in triplicate ant they were introduced to the fish.

Acute Toxicity Test and Water Quality Parameters Assessment

Acute toxicity test was used to determine the short-term toxicity (4 days) of the active ingredient on the fish species, measuring lethality. A definitive test in a static system was carried out in a laboratory according to (standard methods of OECD guideline No 203 (OECD, 2019) probit test was conducted to determine the LC50 . Toxicity experiment was performed by the method of Singh and Agarwal, (1988). A set of 20 sample each were randomly exposed to each of the six concentrations of the toxicant (three concentrations each of aqueous and ethanol extracts) and at concentrations, 0.5, 1.0 and 1.5g/l named PEEI, PEEII and PEEIII, respectively for ethanol extract and PWEI, PWE II, and PWE III, respectively for aqueous extracts. The ranges were obtained after the range finding test for both extraction methods and 0mg/l as negative control and Cyclophosphamide (4.00g/l) as positive control of the bioassay. Physico-chemical parameters of water were taken after the introduction of the toxicant.

Haematological Examination of Fish

Haematology samples were taken on the 4th day of the acute test. Three samples each from each of the treatments were taken and blood samples collected in a sample bottles were taken to the laboratory in the General hospital in New Bussa for analysis. The aliquot of the blood in EDTA bottle was analysed to determine the concentration of the fish haemogram.

Statistical Analysis

Data were analysed using descriptive statistics. One way analysis of variance (ANOVA) was used to determine variance and Duncan multiple range test (DMRT), was used to separate means that are significant different among heamatological parameters of the various treatments at < 0.05 using IBM SPSS statistics 20

RESULTS AND DISCUSSION

Table 1 shows the behavioural responses of juveniles of *Clarias gariepinus* exposed to various concentration of *Carica papaya* leaf ethanol extract for 96 hrs.

Hours	24				48				72				96			
Behavior/ conc.	Con.	PEE I	PEE II	PEE III	Con.	PEE 1	PEE II	PEE III	Con.	PEE I	PEE II	PEE III	Con.	PEE I	PEE II	PEE III
Gasping	-	-	-	+	-	+	+	+	-	+	+	+	-	+	+	+
Unstable swimming	-		+	+	-	+	+	+	-	+	+	+	-	+	+	+
Hyperactivity	-	+	+	+	-	+	+	+	-	+	+	+	-	+	+	+
Skin wrinkling	-	-	-	-	-	-	-	-	-	+	+	+	-	+	+	+
Declining in reflex	-	-	-	-	-	-	-	+	-	+	+	+	-	+	+	+
Haemorrhage	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Discoloration	-	-	-	-	-	+	+	+	-	-	+	+	-	+	+	+

+ = Observed. - = Not notice, PEEI (0.5g/l), PEE II (1.0g/l), PEEIII (1.5g/l,) ethanol extract PWE I (0.5g/l), PWE II (1.0g/l), PWE III (1.5g/l) aqueous extract.

Table 2 shows the behavioural responses of juveniles of *Clarias gariepinus* exposed to various concentration of *Carica papaya* leaf aqueous extract for 96 hrs.

Hours	24				48				72				96			
Behavior/ conc.	Con.	PWEI	PWE II	PWE III	Con.	PWE 1	PWE II	PWE III	Con.	PWE I	PWE II	PWE III	Con.	PWE I	PWE II	PWE III
Gasping	-	-	-	+	-	+	+	+	-	+	+	+	-	+	+	+
Unstable swimming	-	-	-	-	-	+	+	+	-	+	+	+	-	+	+	+
Hyperactivity	-	-	-	+	-	+	+	+	-	+	+	+	-	+	+	+
Skin wrinkling	-	-	-	-	-	-	-	-	-	+	+	+	-	+	+	+
Declining in reflex	-	-		-	-	-	-	-	-	+	+	+	-	+	+	+
Haemorrhage	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Discoloration	-	-	-	-	-	-	+	+	-	+	+	+	-	+	+	+

+ = Observed. - = Not notice, PEEI (0.5g/l), PEE II (1.0g/l), PEEIII (1.5g/l,) ethanol extract PWE I (0.5g/l), PWE II (1.0g/l), PWE III (1.5g/l) aqueous extract.

Table 3: Mean physico-chemical parameters of water during the 4 days exposure of African Cat fish *Clarias gariepinus* juveniles to various concentrations of Papaya leaf

Treatments (mg/l)	Ph	Temperature (^{0}C)	Dissolved Oxygen (mg/l)	Nitrite (mg/l)	Ammonia (mg/l)
Negative control	7.10 ± 0.20^{c}	27.99 ± 0.00^{cd}	8.09 ± 0.00^{h}	0.14 ± 0.00^{a}	0.05 ± 0.01^{a}
PEE I	7.00 ± 0.00^{bc}	27.45 ± 0.05^{bc}	6.80 ± 0.10^{f}	0.17 ± 0.00^{b}	0.47 ± 0.02^{a}
PEE II	6.71 ± 0.01^{a}	26.30 ± 0.10^{a}	6.34 ± 0.04^{c}	0.30 ± 0.00^{d}	0.51 ± 0.01^{a}
PEE III	6.69 ± 0.01^{a}	26.22 ± 0.02^{a}	5.86 ± 0.01^{a}	0.33 ± 0.03^{e}	0.68 ± 0.01^{a}
PWE I	6.68 ± 0.00^{a}	27.01 ± 0.01^{ab}	6.70 ± 0.05^{e}	0.20 ± 0.01^{c}	0.46 ± 0.01^{a}
PWE II	6.71 ± 0.01^{a}	26.56 ± 0.00^{ab}	6.58 ± 0.04^{d}	0.31 ± 0.01^{de}	0.55 ± 0.05^{a}
PWE III	6.89 ± 0.01^{b}	26.71 ± 1.00^{ab}	6.10 ± 0.10^{b}	0.19 ± 0.00^{bc}	0.60 ± 0.00^{a}
Positive control (CYP- 4.00)	7.00 ± 0.00^{bc}	28.54 ± 1.00^{cd}	7.22 ± 0.02^{g}	0.18 ± 0.02^{bc}	0.06 ± 4.01^{a}

Value with different superscript from negative control are significantly different ($p<0.05$) along the columns CYP = Cyclophosphamide; PEEI (0.5g/l), PEE II (1.0g/l), PEEIII (1.5g/l,) ethanol extract PWE I (0.5g/l), PWE II (1.0g/l), PWE III (1.5g/l) aqueous extract.

Table 4: Heamatological parameters of African Cat fish *Clarias gariepinus* juvenile exposed to acute toxicity test of Papaya leaf at acute toxicity bioassay

Parameters	Negative Control (0.00g/l)	Positive Control CYP (4.00g/l)	PEE I 0.50g/l	PEE II 1g/l	PEE III 1.5g/l	PWE I 0.50g/l	PWE II 1g/l	PWE III 1.5g/l
PVC (%)	16.41 ± 0.01^{c}	20.00 ± 2.00^{d}	12.11 ± 1.00^{a}	12.80 ± 0.20^{a}	14.80 ± 0.00^{b}	12.20 ± 0.10^{a}	12.80 ± 1.00^{a}	$14.90 \pm 0\ .20^{bc}$
Hb (g/dl)	5.30 ± 0.30^{c}	6.80 ± 1.00^{d}	4.40 ± 0.00^{b}	4.00 ± 0.10^{ab}	3.20 ± 0.30^{a}	4.40 ± 0.40^{b}	3.20 ± 5.00^{a}	3.20 ± 0.20^{a}
RBC (10^6/µl)	7.10 ± 0.10^{e}	1.83 ± 0.03^{d}	1.14 ± 0.04^{a}	1.20 ± 0.02^{b}	1.24 ± 0.00^{c}	1.20 ± 0.04^{b}	1.14 ± 0.04^{a}	1.24 ± 0.04^{c}
WBC (10^3/mm^3)	$13.57 \pm .10^{a}$	13.30 ± 0.70^{a}	13.13 ± 0.03^{a}	14.60 ± 0.10^{a}	13.79 ± 1.10^{a}	13.89 ± 0.00^{a}	12.87 ± 0.00^{a}	13.12 ± 1.00^{a}
Platelet(10^3/mm^3)	263.00 ± 3.00^{a}	12000.00 ± 0.00^{g}	490.00 ± 10.00^{f}	303.00 ± 3.00^{b}	468.00 ± 1.00^{e}	365.00 ± 1.00^{d}	363.00 ± 3.00^{d}	313.00 ± 3.00^{c}
Lym (10^3/mm^3)	20.00 ± 0.00^{b}	54.00 ± 4.00^{f}	15.00 ± 0.00^{a}	32.44 ± 2.00^{d}	20.32 ± 0.02^{b}	24.54 ± 0.04^{bc}	25.54 ± 1.00^{cd}	43.12 ± 10.00^{e}
Mon (10^3/mm^3)	1.90 ± 0.10^{b}	4.00 ± 1.00^{e}	0.00 ± 0.00^{a}	3.68 ± 0.08^{de}	2.64 ± 1.00^{bc}	3.06 ± 0.06^{cd}	3.06 ± 0.06^{cd}	4.17 ± 0.03^{e}
Eo (10^3/mm^3)	1.80 ± 0.10^{b}	3.00 ± 0.50^{bc}	0.00 ± 0.00^{a}	8.00 ± 2.00^{d}	1.86 ± 0.03^{b}	2.29 ± 0.01^{b}	4.26 ± 0.00^{c}	3.82 ± 0.02^{c}
MCH	1.80 ± 0.00^{a}	42.33 ± 17.21^{ab}	$53.47 \pm .06^{abc}$	100.11 ± 0.93^{c}	28.40 ± 0.00^{ab}	38.30 ± 0.07^{ab}	47.80 ± 0.00^{abc}	93.53 ± 118.36103^{bc}
MCV	23.21 ± 0.00^{b}	70.00 ± 2.00^{d}	60.03 ± 2.00^{c}	111.10 ± 0.00^{f}	$111.03 \pm .06^{f}$	106.30 ± 1.00^{e}	122.30 ± 0.00^{g}	18.00 ± 2.00^{a}
MCHC	32.16 ± 2.00^{b}	80.00 ± 4.00^{e}	88.90 ± 0.20^{f}	112.70 ± 0.10^{g}	125.50 ± 1.50^{b}	$36.60M \pm 0.00^{c}$	39.33 ± 0.58^{d}	21.90 ± 1.00^{a}

Value with different superscript from negative control are significantly different ($p<0.05$) along the row. PCV = Packed Cell Volume, Hb = Haemoglobin, RBC = Red blood cell count, WBC = White blood cell count, LYM = Lymphocyte, Mon = monophils, EO = Eosinophils, MCH = Mean cell haemoglobin, MCV = Mean cell volume MCHC = Mean cell haemoglobin concentration CYP = Cyclophosphamide PWE (Pawpaw leave ethanol extracts) PEE (Pawpaw leave aqueous extracts

The water quality parameters taken were within tolerable levels and since the water quality variables were within acceptable ranges for toxicity test (APHA, 1985) they may not have acted synergistically with the toxicant to affect the fish species, this is in accordance with Ajayi (2021) who observed similar water quality parameters in fish exposed to ricin extract. Behavioral response (table 1&2) fish were normal in control group however behavioral anomaly like gasping, unstable swimming, Hyperactivity, skin wrinkling declining in reflex and discoloration were all observed in the treatments but was detected earlier in the ethanol extracts, behaviour alterations were noted to be time, concentration and extraction method dependent this may be attributed to the effect of the solvent of extractions., this observed behaviors may be an attempts by the stressed fish to get away from, adapt and/or to get use to the stress condition. Similar to these observations were reported by Aguigwo (2002); Omoniyi et al.,

(2002) Ayoola and Ajani, (2008) and Ikele, *et al.*, (2011) in the fishes exposed to different stress conditions. These progressive stress responses with progressive increase in toxicant concentration over time are comparable to the observations made by Omoniyi *et al.*, (2002); Suleiman *et al.*, (2019) and Ajayi, (2021).

Heamatological parameters of fish are considered a suitable tool for evaluating the effects of pollutants (Roche and Boge, 1996). Cyriac *et al.*, (1989); Gbem et al., (2004) and Ajayi (2021) also reported the several changes in haematological parameters as indicators of stressor exposure. The present results indicate that the acute exposure of *Clarias gariepinus* to *Carica papaya* leaf extracts has altered some of the blood parameters. Data presented in table 4, indicated an increase all the blood parameters of exposed fish compared to the fish in the control treatments. A hypoxic condition in fish is expected to occur due to the cloudy nature of the water of the bioassay which is further expected to reduced supply and increase the demand for oxygen. This is in agreement with the work of Panday *et al.*, (1979). The PCV, RBC and Hb values were found to be significantly increased when compared among the treatments but lower to the control this may show that the extracts introduced is anti anemic to the fish this is in agreement with the works of Oparaku *et al.*, (2024) and Estella *et al.*, (2020), that the exposure did not alter the proper functioning of the red blood cells rather it increased it. Other authors have also reported similar effects on RBC and Hb in fish (Li *et al.*, 2011; Ogueji *et al.*, 2019). Significant increases were also observed in mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC). This is contrary to the observations of Timothy et al. (2022) who reported no significant changes ($p > 0.05$) in the blood. The increase observed can boost the immune system of the fish. Lymphocyte (LYM) volumes showed a steady increase as the concentration compare to the negative control, this disagree with the findings of Alkahem *et al.*, (1998), who confirm that there was a decline in the count of lymphocytes in pesticide treated O. Niloticus which they ascribing it to fall in the delivery of these cells to the circulation due to the low production or alternatively an increased rate of elimination from the blood and subsequent rapid devastation of cells. The study showed no significant increase or reduction in the white blood cells (WBC) of the six samples, this is in contrast with the work of Akinrotimi *et al.*, (2011), Gabriel *et al.*, (2010) who reported an increase in the white blood cell as the quantity of toxicant is increased. This may be due to release of WBC from the spleen to the blood stream to combat the stress or perceived enemy. These suggest that comparing both extracts they are not in any way harmful to the exposed fish and did not affect the fish adversely.

CONCLUSION

From the result we can conclusively say that increases observed in the red blood cell parameters may be an indication of the ethanol and aqueous leaf extract of papaya leaves having anti anemic properties, the slight duration effect observed also show the effect of the solvent used. The WBC insignificance in the result, means that the fish was not reacting to any changes that can cause harm to it., which is an indication of nontoxic effect of the extracts used. Also the two solvent of extractions where not in anyway of effect to the fish.

REFERENCE

Aguigwo, J.N., (2002). The Toxic Effect of Cymbush Pesticide on growth and survival of African catfish, Clarias gariepinus (Burchell 182 2). Journal of Aquatic Sciences, 17, (2) pg. 81-84.

Ajayi C.T., (2021) Genotoxicity, Hematological, Histopathological And Oxidative Stress Responses Of Heterobrancus Bidorsalis (Geoffroy Saint-Hilaire, 1809) Exposed To Ricin Active ingredients in Piscicidal plant Ricinus Communis (Castor Oil). MSc thesis submitted to the Department of Aquaculture and Fisheries management university of Ibadan, 125pp

Akinrotimi OA., Opara, J.Y., and Ibemere I. (2011) Effects of Handling stress on immune functions of

Blackjaw Tilapia Sarotherodon melanotheron. Nigerian J. of Fisheries Vol. 8(1) 154-158.

Alkahem, H.F., Ahmad, Z., Al-Akel, A.S. and Shamsi, M.J.K., 1998. Toxicity bioassay and changes in haematological parameters of Oreochromis niloticus induced by trichlorfon. Arab Gulf Journal of Scientific Research, vol. 16, pp. 581-593.

APHA (1985). American Public Health Association Standard methods for examination of water and waste water. 13th Edition. APHA Washington, D.C. USA. 1254pp.

Ayoola, S.O. and Ajani, E.K., 2008. Histopathological effect of cypermethrin on juvenile African catfish (Clarias gariepinus). World Journal of Biological Research, 1: 1-14.

Cyriac, P.J., Antony, A. and Nambisan, P.N., (1989). Hemoglobin and hematocrit values in the fish Oreochromis mossambicus (Peters) after short term exposure to copper and mercury. Bulletin of Environmental Contamination and Toxicology, vol. 43, no. 2, pp. 315-320

Fafioye, O.O., Adebisi, A.A. and Fagade, S.O. (2009). Toxicity of Parkia biglobosa and Raphia vinifera extracts on Clarias gariepinus juveniles. African Journal of Biotechnology 3(10)

FAO (Food and Agriculture Organisation of the United Nations) (2021) the state of food security and nutrition in the world building climate resilience for food p 3-5

Gabriel, U.U., Macauley, B.K., and Edori, O.S., (2010). Acute toxicity and behavioural responses of African cat fish Clarias gariepinus to Amine salt of 2,4-D. Chin J Appl Environ16:347-352

Gbem T.T; Balogun J.K; Lawal F.A and Annune P.A (2004) Sublethal Effects of Tannery effluent on some Haematological indices and growth of Clarias gariepinus (Teugels) Bullentin of environmental contamination and toxicology 71(6) 1200-6.

Ikele, C.B., Mgbenka, B.O. and Oluah, N.S., (2011). Histopathological effects of diethyl phthalate on Clarias gariepinus juveniles. Animal Research International, vol. 8, no. 3, pp. 1431-1438.

Majewski, H.S. and Gilles, M.A., (1981). Cardiovascular-respiratory responses of rainbow trout (salmo gairdneri) during chronic exposure to sub-lethal concentrations of cadmium. Water Research, vol. 15, no. 10, pp. 1211-1217.

OECD (2019). OECD Guideline for Testing of Chemicals. Draft Revised Version. Fish acute toxicity test. 11th version. July 2018.

Ofogba C.J. Agbomo FU, Abdul-m kareem, Abaelu, and A.M.,K. Alatishe (1998). Effect of Bridelia ferrugubea stembark on chemistryu

Omoniyi, I., Agbon, A.O. and Sodunke, S.A., (2002). Effect of lethal and Sub lethal concentration of tobacco (Nicotiana tobaccum) leaf dust extract on weight and haematological changes in Clarias gariepinus (Burchell). Journal of Applied Science & Environmental Management, vol. 6, no. 2, pp. 37-41.

Oparaku , F. N., M. Ukwueze , C. G. Nwosu *, F Andong , D. E, E. Okwuonu , N. Ezenwaji Effect of Carica papaya (paw-paw) aqueous leaf extract on the growth, haematological parameters and the liver enzymes of Clarias gariepinus juveniles. Published by Elsevier B.V. T Aquaculture Reports 34 (2024) 10187 ttps://doi.org/10.1016/ j.aqrep. 2023.101874

Oparaku , F. N., M. Ukwueze , C. G. Nwosu *, F Andong , D. E, E. Okwuonu , N. Ezenwaji (2024) Effect of Carica papaya (paw-paw) aqueous leaf extract on the growth, haematological parameters and the liver enzymes of Clarias gariepinus juveniles. Published by Elsevier B.V. T Aquaculture Reports 34 (2024) 10187 ttps://doi.org/10.1016/ j.aqrep. 2023.101874

Panday, N.B., Chanchal, A.K., Singh, S.B., Prasad, S. and Singh, M.P., (1979). Effect of some biocides on the blood and oxygen consumptiom of Channa punctatus (Bloch). In: Proceedings of the Symposium on Environmental Biology; Muzaffarnagar, India. Muzaffarnagar: Academy of Environmental Biology, 343-348.

Roche, H. and Boge, G., 1996. Fish blood parameters as a potential tool for identification of stress caused by environmental factors and chemical intoxication. Marine Environmental Research, vol. 41, no. 1, pp. 27-43.

Singh A, and Agarwal RA, (1988). Possibility of using latex of euphorbiales for snail control. Sci Total Environ; 77: 231-236.

Suleiman, B; Musa, S.P; and Bashir, AY. (2019) Effect of Castor (Ricinus communis) Seed Oil on the Haematological Parameters of Nile Tilapia Oreochromis niloticus (Linnaeus, 1758) The Journal of Agricultural Sciences - Sri Lanka Vol. 14,. (3), p165-171http://doi.org/10.4038/jas.v14i3.8600

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

IMPACTS OF FLOODING ON FISHERIES AND AQUACULTURAL PRODUCTION IN NIGERIA: A REVIEW

Gwari, B. M., Z.. Musa., M. Sabo., Y. A. Birnin-Yauri., N. D. Ago., P. Ifejika and A. O. Godfrey

National Institute for Freshwater Fisheries Research, P.M.B 6006, New Bussa, Niger State

E-mail: bitrusgwari54@gmail.com

ABSTRACT

Flooding is a peculiar meteorological occurrence associated with climate change. Global temperature rise is linked to this disastrous weather event, which results in severe downpours, an increase in sea level, and glacier melt. These occurrences cause coastal regions to be covered in ocean water. Floods have both positive and negative effects on the natural environment as a whole. Flooding not only destroys farms and houses, destroys people and towns, but also claims the lives of animals. Flood calamity has resulted in the sale of foodstuffs, including rice and other staple foods, at exorbitant prices, causing further suffering.Throughout the past three to four months, reports of these have come from both the southern and northern regions of Nigeria.The flood-affected areas also have a lot of long-term challenges. Flooding has a devastating effect that goes beyond property damage and casualties. A large number of people, especially those who reside in rural areas, rely on agriculture as their primary source of income. Their cattle, crops, and infrastructure—such as marketplaces—are all destroyed by floods. Two advantages of floods are the replenishment of groundwater and wetlands. Aquaculture increases the productivity of fisheries overall, which is extremely beneficial to humanity. This article addresses some of the significant concerns regarding potential damages and financial losses to persons and aquaculture operators, as well as preventive measures to lessen the effects of catastrophic floods on aquaculture.

KEYWORDS:
Aquaculture, Flood, Fisheries, Devastation, Foodstuff, Fish mortality

INTRODUCTION

The farming of aquatic life, including fish, molluscs, crustaceans, and aquatic plants, is known as aquaculture. Farming involves some form of rearing process intervention to increase yield, such as consistent feeding, stocking, predator protection, and general management. According to Nash (2011) this agricultural method has reportedly been used in China dating back to 4,000 years with the husbandry of common carp. At the household and national levels, the aquaculture sector is crucial to food security (Fisher et al, 2017). Production from aquaculture is now crucial to livelihoods, food security, and economic growth in many nations (Sangam, 2020). Production and earnings are already greatly impacted by the climate and extreme occurrences, such as high floods and seasonal droughts..Extreme floods caused by climate change are having an increasingly negative impact on agriculture in several regions of the world (Muller et al, 2023). Felix et al, (2010) cite a range of human activities that contribute to flooding, including increased urbanisation, deforestation to create residential communities, inadequate drainage systems, and a restricted quantity of dams and embankments.Sea levels increase as a result of global climate change related to land-ice melting and ocean waters expanding thermally (Cazenave and Llovel, 2010). Nonetheless, because they produce nutrient deposition and a suitable habitat for the majority of species, floods have some beneficial effects on aquatic life. Additionally, macro invertebrates—small insects which play a major part in the food chain of the ecosystem are affected by floods (Chanut, *et al*, 2019). Recharging wetlands, replenishing groundwater, and restoring soil fertility are some other benefits of floods (Toilbot, 2018).

A Substitute for Land-Based Agriculture: Aqaculture

Agriculture is a major source of income for many individuals, particularly those who live in rural areas. Floods brought about by river erosion, sedimentation, and inundation have washed away a large portion of arable land, leaving infertile areas and a decline in agricultural production. An excellent substitute for land-based agriculture is aquaculture, which is the process of harvesting food from aquatic habitats. Generally, aquaculture entails keeping a species (Table 1) enclosed in a safe environment where it can flourish. Production expansion also entails a rise in the population per unit area, which reduces the need for land and ocean space locally but increases the need for technology and fossil fuels, as well as for the usage and management of inputs and waste products. Troell *et al.*, (2013) define aquaculture as an industry that uses naturally available aquatic resources and transforms them into items that are desired by the general public. According to Chan *et al.* (2021), aquaculture provides people with significant employment opportunities as well as other sustainable, social, and economic benefits.

The Nutritional and Health Benefits Deravable from Aquaculture

Both the ecological and human health are improved by aquaculture. Farmers receive financial reward from it, while consumers benefit from nutrition. Protein is necessary for the body's growth and development, for maintaining and replacing damaged tissues, and for production. For around 950 million people globally, fish serves as their main protein source and is a significant component of the diets of many more. Additionally, fish is a good source of minerals and vital fatty acids and contributes approximately 16% of the animal protein consumed by humans worldwide. The main food source of omega-3 fatty acids for humans is fish. A fish-based diet is essential for reducing malnutrition, particularly in young infants (Conway, 2023). Fish is not just a source of protein; it also has other benefits for diets. Fish and other sea foods are good sources of minerals such iron, calcium, zinc, iodine, phosphorus, selenium, and fluorine. The term "highly bioavailable" refers to the ease with which the body can absorb these elements. Niacin (vitamins B1, B2, and B3), thiamin, riboflavin, and vitamins A and D are all abundant in fish. Bone growth and normal vision both depend on vitamin A. Because it is necessary for the absorption and metabolism of calcium, vitamin D, which is found in fish liver and oils, is important for the formation of bones. Thiamin, niacin, and riboflavin are necessary for energy metabolism. Red blood cell production of haemoglobin depends on iron. The movement of oxygen throughout the body depends on haemoglobin.

Table 1: Major Aquaculture Species Produced in the World

Finfish	**Crustaceans**
Grass carp (*Ctenopharyngodon idellus*)	Whiteleg shrimp (*Penaeus vannamei*)
Atlantic salmon (*Salmo salar*)	Red swamp crawfish (*Procambarus clarkia*)
Striped catfish (*Pangasianodon hypophthalmus*)	Chinese mitten crab (*Eriocheirsinensis*)
Roho labeo (*Labeo rohita*)	Giant tiger prawn (*Penaeusmonodon*)
Milkfish (*Chanos chanos*)	Oriental river prawn (*Macrobrachium nipponense*)
Torpedo-shaped catfishes (*Clarias spp*)	Giant river prawn (*Macrobrachium rosenbergii*)
Tilapia (*Oreochromis spp*).	
Rainbow trout (*Oncorhynchus mykiss*)	**Molluscs**
Wuchang bream (*Megalobramaamblycephala*).	Cupped oysters (*Crassostrea spp*)
	Japanese carpet shell (*Ruditapesphilippinarum*)
Marine fishes (Osteichthyes)	Scallops (*Pectinidae*)
Black carp (*Mylopharyngodon piceus*)	Sea mussels (*Mytilidae*)
Cyprinids (*Cyprinidae*)	Marine molluscs (*Mollusca*)
Yellow catfish (*Pelteobagrus fulvidraco*)	Constricted tagelus (*Sinonovacula constricta*)
Silver carp (*Hypophthalmichthys molitrix*)	Pacific cupped oyster (*Crassostrea gigas*)
tilapia (*Oreochromis niloticus*)	Blood cockle (*Anadara granosa*)
Common carp (*Cyprinus carpio*)	Chilean mussel (*Mytilus chilensis*)
Bighead carp (*Hypophthalmichthys nobilis*)	
Catla (*Carassiusspp*.)	

Source: FAO, 2020

Strong bone growth and mineralisation, as well as the proper operation of muscles and the neurological system, depend on calcium. It has a role in the process of blood coagulation as well. Its appropriate absorption is made easier by vitamin D. When smaller fish are consumed with their bones rather than having.In addition to being essential for good skin and immune system function, zinc is also crucial for growth and development. Seafood contains iodine, which is necessary for hormones that control metabolism. In youngsters, iodine is also necessary for growth and Strong bone growth and mineralisation, as well as the proper operation of muscles and the neurological system, depend on calcium. It has a role in the process of blood coagulation as well. Its appropriate absorption is made easier by vitamin D. For strong bones to develop and become mineralised, as well as for muscles and the nervous system to function normally, calcium is needed. It is also crucial for the process of blood coagulation. Proper absorption of it is aided by vitamin D. Eating smaller fish with their bones increases the intake of calcium, phosphorus, and fluorine compared to discarding the fish bones. Because zinc exists with proteins in vital enzymes needed for metabolism, it is necessary the fish bones thrown away, the intake of calcium, phosphorus, and fluorine is increased. The majority of bodily functions depend on zinc since it coexists with proteins in vital enzymes that are necessary for metabolism for the majority of bodily functions. In addition to its involvement in immune system function and good skin, zinc is essential for growth and development. Iodine, which can be found in seafood, is necessary for hormones that control metabolism. It is also necessary for children's growth and development (Conway *et al.*, 2023).

Causes and Types of Flooding

Recurrent floods are a risk to life along the water-soil boundary, especially during periods of seasonal rain and thawing, summer inundations, or other extreme weather conditions (Mashi *et al.*, 2018). Extreme floods are defined as situations in which the extremity and its anticipated consequence are unclear (Tamblay, 2021). Flooding is caused by various factors such as growing urbanisation, inadequate maintenance of wastewater and water infrastructure, poor solid waste management, and climate change. Climate variability reduces the predictability of the weather, particularly in underdeveloped nations like Nigeria where resources for weather forecasting and management are insufficient. According to MacLeod *et al.,* (2014) flooding is made worse by climate change indirectly by altering the pattern of flooding in the flood prone areas. According to Aldardasawi and Eren (2021) the following might be said about a flooding event: four types of flooding: coastal, urban, riverine, and areal. Areal flooding happens in these types of low-lying landscape settings. Floods in these low-profile places are mostly caused by heavy rainfall. In plain places like these, overly saturated soil will lose its ability to absorb water, resulting in flooding. Small rivers and streams can experience riverine flooding as a result of summertime glacier melting or severe monsoon rains. In reaction to periods of intense rainfall and other river releases, the river progressively rises destruction of metropolitan regions' livestock and infrastructure (Aldardasawi and Eren, 2021). Other types of flooding include dam spills, levee or dam breaches, and flash floods. Flash floods are defined as flood events in which the rise in water occurs during or shortly after the precipitation that causes the rise.

Numerous hydrological elements, including soil type, vegetation cover, human occupancy, slopes in the topography, and rainfall in the past, are relevant to the likelihood of a flash flood. In steep, rocky terrain or intensively urbanised areas, even a modest amount of rainfall might cause flash floods (Liudmila and Valinetin,2020). Because they happen so quickly, flash floods are extremely deadly and destructive because they can catch people unprepared. The majority of deaths are caused by drowning, while there may also be some traumatic injuries from being swept into standing objects by the debris-filled waters. Floods provide links between rivers and floodplains, bringing organic matter and nutrients to aquatic-terrestrial transition zones that promote habitat variability and biological productivity. The environment is altered by floods. Comparing these modifications to steady flow regimes, fish productivity can be increased along with species richness, diversity, evenness, and abundance.

Floods, however, might not have an impact on the structural indicators of some fish groups. Floods are influenced by changes in water levels that occur in terms of amplitude, frequency, length, timing, and rate of change. The effects of flooding can also differ according on fish age, shape, physiology (such as swimming strength, turbidity tolerance), behaviour (such as mobility, habitat utilisation), and community composition (species abundance, variety, etc.) (Sabina, 2023).Additionally, the effects of floods on native and exotic fish may differ. Both native and introduced fish species may benefit from river floodplain connectivity and become more common after floods, even if native fishes may be better adapted to flow regimes in their native area (Rupgam, *et al.,* 2023). Floods in some rivers favour introduced fish over native species in terms of recruitment, population growth, and reproduction. According to Bosso *et al.,* (2023), flooding modifies the flow regimes in streams and Tolbot, *et al.,* (2021) has reported on the inflow of nutrients and alterations in nutrient cycles. Massive volumes of silt, debris, and dangerous contaminants are carried into water bodies by flood waters; sediment buildup from flood floods lowers water depths. Contaminated sediments and floating debris are carried by viruses, bacteria, and other diseases and toxins (Suhr *et al.,* 2022). People who are directly exposed to these pathogens through swimming or eating seafood may experience symptoms of serious illness, including digestive irritation. Necrotising fasciitis and sepsis are two serious illnesses that can be brought on by other floodwater-borne organisms including Vibriovulnificus(Liang *et al.,* 2018). Floods have the potential to mobilise and deposit toxic chemicals such as pesticides, pathogens, and other materials into rivers, ponds, streams, and groundwater, rendering these resources unsuitable for human use and consumption by marine life. Flooding impacts the quality of water as well as the state of fishes due to the numerous deposition(Bull, *et al.,* 2023).Severe floods alter the rivers' geomorphology, which is totally dependent on the amount and quality of aquatic life. The aquatic system's geomorphology determines its nature, and any changes have an impact on the organisms that live there. They may be uprooted and lose their habitat as a result of the flood (Tolbot *et al.,* 2018).

Floods have a major negative influence on aquaculture and result in significant financial losses and harm to both individuals and aquaculture businesses. Following is a summary of some of the effects of flood disasters on aquaculture.

Fish assemblage disruption:

Fish assemblage disruption and population shifts in a variety of aquaculture species are brought on by flooding. Flooding leads to alterations in the populations of different aquaculture species as well as fish ensemble disruption. Fish in particular might suffer negative effects from the components in the flooding water, some of which are hazardous. Fish are said to be highly disposed to hazardous effects of ammonia, even at low quantities (Achieng, *et al.*, 2020).

Fish mortality:

Direct or indirect deaths from flooding are likely to happen. Both adult fish and baby fish die directly as a result of floods. Direct reasons could include pond dam failure, flood waves overflowing a dam, nearby areas being inundated with water, or abrupt environmental changes brought on by debris flow or poor water quality. The introduction of unwanted, invasive species, fish parasites into fish ponds for aquaculture, and an excessive amount of organic waste decomposition by natural processes are examples of indirect causes of fish mortality (Björnsson, *et al.*, 2022).A major cause for concern was the damage caused to aquaculture infrastructure after severe flooding and floods, which cost farmers an extimated billions of naira (Olutimise, 2023; Oyediran, *et al.*, 2020).

Reduction in dissolved oxygen (DO) level:

The presence of dissolved oxygen is crucial for aquatic systems. The global nitrogen and carbon cycles are significantly impacted by changes in their concentrations (Gu *et al,* 2023). When waste, particularly biological debris, is introduced into an aquaculture farm, the oxygen content of the fish pond is impacted. The dissolved oxygen is consumed by microbes during the degradation of the materials deposited, leaving little or no oxygen left for the aquaculture species. Because of the anoxic water, fish die (mortality) or go extinct as a result of oxygen deprivation.

Fish migration:

Fish migrations can occur in stream waters, lakes, reservoirs, and pond systems. Fish migrations are influenced by the specific species of fish involved, the time of year, the rate at which surface waters are replenished, and any adjustments made to the water level by human water management agencies. Different fish species react differently to flood circumstances depending on the species, age, and size of the fish. Most carp species have a very similar downstream migration pattern. On the other hand, hatchlings of peled (Coregonus peled), turbot, and catfish have a tendency to migrate whenever there is an opportunity, even in circumstances where there is little water flow. In these situations, the losses (downstream escapes) are typically close to 100% (Banet *et al.*, 2022).

Strategies for Prevention of fish loss

One of the primary criteria of prevention of fish stock losses is to use the natural conditions in places where fish are kept and to appropriately use the inundation. Each fish pond used for aquaculture needs to adhere to the safety and technical supervision principles as well as the technical requirements of water works.This lessens the chance of causing harm to waterworks and possible financial loss. The worst situations happen when floodwaters breach the pond dam, leaving the ponds totally fishless. Other management techniques include building embankments, early warning and emergency management systems, housing, and the retreat strategy.

Conclusion

Floods are typically seen as a serious natural danger that can lead to illness, destruction of property, infrastructure, and loss of life, as well as interruption of public services. Flooding, for instance, can result in hazardous landslides, the loss of crops and cattle, the disturbance of regular drainage systems, the leakage of raw sewage and animal waste, and the rapid release of toxic materials and nutrients into streams from urban and industrial areas. The impacts of floods on aquatic ecosystems are frequently perceived as detrimental due to their significant repercussions on people and infrastructure, although this is not always the case. Flooding can also have a lot of positive effects, such as replenishing wetlands, building floodplains, raising fish yields, enhancing wildlife habitat, and restoring soil fertility. Because flooding can have beneficial as well as detrimental impacts on aquatic environments, ecosystem benefits should likewise show a range of flood-related negative and positive consequences. Beyond merely flood intensity, a number of criteria can be used to forecast the effects of flooding on aquatic ecosystems and the services they provide.

References

Achieng, A.O.; Masese, F.O and Kaunda-Arara, B. (2020). Fish assemblages and size-spectra variation among rivers of Lake Victoria Basin, Kenya. Ecol. Indic., 118, 106745.

Banet, N.V., John, F and Peter, W.S. (2022). Migration, homing and spatial ecology of common carp in interconnected lakes Ecology of Fisheries, 31 (3).Pages 164-176.

Basso, S., Merz, R and Tarasova, L. (2023). Extreme flooding controlled by stream network organization and flow regime. Nat. Geosci.16, 339–343 (2023). https://doi.org/10.1038/s41561-023-01155-w

Berio, M and Jason, M. (2022). Analysis of the Sustainability, Vulnerability, and Challenges of Aquaculture Livelihood Projects,Technium Business and Management, Technium Science, 2(3), 38-62

Björn Björnsson, J. S and Pamela, J. W. (2022). Natural mortality in exploited fish stocks: annual variation estimated with data from trawl surveys, ICES Journal of Marine Science, Volume 79, Issue 5, July 2022, Pages 1569–1582.

Bull, O. S., Obunwo, C. C and Aghaeze, N. M. (2023). Flood and Post-flood Water Quality of Imonitea Freshwater Stream in Ndoni, Ogba Egbema Local Government Area, Rivers State, Nigeria. J. Appl. Sci. Environ. Manage. 27 (2) 197-201

Chan, C.Y., Tran, N., Cheong, K.C., Sulser, T.B., Cohen, P.J., Wiebe,K. and Nasr-Allah, A.M.(2021). The future of fish in Africa: Employment and investment opportunities. PLoS One. 22;16(12):e0261615. doi: 10.1371/journal.pone.0261615.

Conway, M.C., Yeates, A.J., Love, T.M., Weller, D., McSorley, E.M., Mulhern, M.S., Wesolowska, M., Watson, G.E., Myers, G.J., Shamlaye, C.F., Henderson, J., Davidson, PW., van Wijngaarden, E and Strain, J.J. (2023). Maternal fish consumption and child neurodevelopment in Nutrition 1 Cohort: Seychelles Child Development Study. Br J Nutrition;130(8):1366-1372

Chanut, P.C.M., Andre, R.S and Christopher, T.R. (2020). Flood disturbance affects macroinvertebrate food chain length in an alluvial river flood plain. Freshwater Biology. Volume 65, Issuue 3 pages 490-501

Djanibekov, U., Polyakov, M and Craig, H. (2024). Flood Impacts on Agriculture under Climate Change: The case of the Awanui Catchment, New Zealand. EconDisCliCha8, 283–316 https://doi.org/10.1007/s41885-024-00147-3

Durodola, O. (2019) The Impact of Climate Change Induced Extreme Events on Agriculture and Food Security: A Review on Nigeria. Agricultural Sciences, 10, 487-498. doi: 10.4236/as.2019.104038.

Felix, O., Mangodo, C., Ighodaro, U.B and Owombo, P.T. (2016) Climate Change and Food Production in Nigeria: Implication for Food Security in Nigeria. Journal of Agricultural Science, 8, 74-83. https://doi.org/10.5539/jas.v8n2p74

Fisher, B., Naidoo, R and Guernier, J. (2017). Integrating fisheries and agricultural programs for food security. Agric & Food Secur6, 1 (2017). https://doi.org/10.1186/s40066-016-0078-0

Gephart, J. A., Golden, C. D., Asche, F., Belton, B., Brugere, C., Froehlich, H. E. and Allison, E. H. (2020). Scenarios for Global Aquaculture and Its Role in Human Nutrition. Reviews in Fisheries Science & Aquaculture, 29(1), 122–138.

Liang, S.Y and Messenger, N. (2018). Infectious Diseases After Hydrologic Disasters. Emerg. MedClin. N. Am. 2018;36:835–851.

Liudmila, K and Valentin,G. (2020). Flash floods: formation, study and distribution. E3S Web of Conferences 163, 02005. https://doi.org/10.1051/e3sconf/202016302005

MacLeod, D.A.., Dankers, R., Graham, R., Guigma, K.., Jenkins, L., Todd, M.C., Kiptum, A., Kilavi, M., Njogu, A and Mwangi, E. (2021). Drivers and subseasonal predictability of heavy rainfall in equatorial East Africa and relationship with flood risk. Journal of Hydrometeorology22 (4), 887–903. doi: 10.1175/JHM-D-20-0211.1

Mashi, S.A., Oghenejabor, O.D and Inkani, A.I.(2019). Disaster risks and management policies and practices in Nigeria: A critical appraisal of the National Emergency Management Agency Act. International Journal of Disaster Risk Reduction 33, 253–265. doi:10.1016/j.ijdrr.2018.10.011

Max,T., Kautsky, N., Malcolm,B., Patrik,H., Jurgenne,P., Patrik, R, Carl, F. (2013). Aquaculture , Encyclopedia of Biodiversity, Second Edition , Pages 189-201

Müller, C., Ouédraogo, W.A., Schwarz, M., Barteit, S and Sauerborn, R. (2023). The effects of climate change-induced flooding on harvest failure in Burkina Faso: case study. Front Public Health. Aug 8;11:1166913. doi: 10.3389/fpubh.2023.1166913. PMID: 37614457; PMCID: PMC10442567.

Nash, C.E. (2011). The History of Aquaculture. Wiley Blackwell, Ames, Iowa. http://dx.doi.org/10.1002/9780470958971

Ngaravaa, S.,Leocadia, Z., Nyambo, P., Martin, M., Chari, B and Orlando, B. (2023). Aquaculture production, GHG emission and economic growth in Sub-Sahara Africa. Environmental Challenges 12, 100737

Olutumise, A. I. (2023). Impact of rexaing Flood policy interventions: Lessons from earthern based farmers in South Eastern Nigeria. Aquaculture International, 43(2).

Oyediran, O. O., Jackson, E and Augustine, E. F. (2020). Agriculture in the Face of Climate-Mediated Flooding in Tropical Africa: Technical Innovations of Fish Farmers in Southwestern Nigeria. Handbook of Climate Change Resilience. ISBN : 978-3-319-93335-1

Rupngam, T and Aimé, J. M. (2024). Unraveling the Interactions between Flooding Dynamics and Agricultural Productivity in a Changing Climate" Sustainability 16, no. 14: 6141.

Sabina, A. N. (2023). Fish Diversity in Extreme Flood in Epie Creek, Bayelsa State, Niger delta. Formosa Journal of Science and Technology (FJST) Vol.2, No.7, 2023: 1779-1788

Sangam, R. (2020). Impact of Small-Scale Aquaculture on Rural Livelihood: A study on how an aquaculture project affects the livelihood choices of poor people. Master's thesis in International Fisheries Management…FSK-391

Sochan, S., Susan, P and Watanabe, T. (2023) Effect of flood duration on water extractable dissolved organic matter in flood plain soils: A laboratory investigation,Geoderma, Volume 432, 116392.

Suhr, F and Steinert, J.I. (2022). Epidemiology of floods in sub-Saharan Africa: A systematic review of health outcomes. BMC Public Health. 2022;22:268. doi: 10.1186/s12889-022-12584-4.

Talbot, C.J., Bennett, E.M., Cassell, K., Hanes, D.M., Minor, E.C., Paerl, H., Raymond,PA, Vargas R, Vidon PG, Wollheim W, Xenopoulos MA.(2018), The impact of flooding on aquatic ecosystem services. Biogeochemistry;141(3):439-461.

Talbot,C.J., Paterson, M.J., Beaty, KG., Bodaly, R.A.D., and Xenopoulos, M. A. (2021). Nutrient budgets calculated in floodwaters using a whole-ecosystemreservoir creation and flooding experiment. Water Resources Research, 57. https://doi.org/10.1029/2020WR028786

Tramblay, Y., Villarini, G., El Khalki, E.M., Gründemann, G., and Hughes, D., (2021).Evaluation of the drivers responsible for flooding in Africa. Water Resources Research 57(6),. doi: 10.1029/2021WR029595

Umar, N and Gray, A. (2022). Flooding in Nigeria: a review of its occurrence and impacts and approaches to modelling flood data. International Journal of Environmental Studies, 80(3), 540–561. https://doi.org/10.1080/00207233.2022.2081471

PREVALENCE OF TRYPANOSOMES IN THE BLOOD OF THE AFRICAN CATFISH *(Clarias gariepinus)* FROM ZOBE RESERVIOR, DUTSIN-MA KATSINA STATE

[1]Umaru J., [1] M. A. Sadauki and [1] A. S. Nababa

[1]Department of Fisheries and Aquaculture, Federal University, Dutsin-Ma, Katsina state

Corresponding author:
umarujoel@gmail.com, +234 813 732 1106

ABSTRACT
A four (4) months study was conducted to assess the prevalence of Trypanosomes in the blood of *Clarias gariepinus* from Zobe reservoir, Katsina State, Nigeria. A total of 80 fish samples comprising males and females, from four major landing sites of the reservoir were randomly purchased June- September; 2022. The fish were transported alive to the fish biology laboratory, Federal University Dutsin -Ma, for the blood parasites determination. Fish were identified at each of the four landing sites of the reservoir. Sampled fish were measured for length and weighed. Prevalence and intensity of infection of the parasites were determined using standard procedure. Male fish had the high percentage of infestation (20.00%) than that of female fish (16.66%). The highest prevalence (25.00%) was recorded in fish samples from sample point A, while the lowest (15.00%) was recorded in sample points B and C. The results shows that *Clarias gariepinus* species from Zobe reservoir are moderately infected with Trypanosomes parasites.

Keywords:
Clarias gariepinus, Prevalence, Trypanosomes, Reservoir

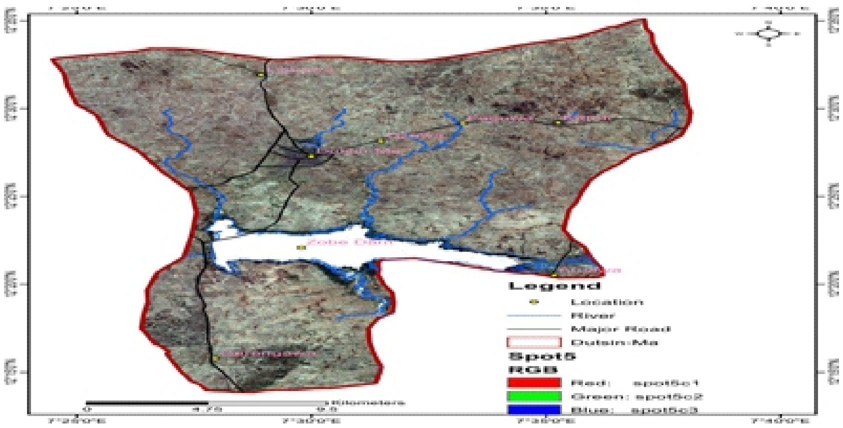
INTRODUCTION

Trypanosome hemoparasites of fish are flagellated parasitic protozoans that prey particularly on wild fish, and have recently been identified in farmed fish. Species of this genus are everywhere in both salt and freshwater fish species ((Fink *et al.*, 2015). Although most of the fish infected by Trypanosome spp are asymptomatic, the high number of parasites in the bloodstream can severely affect the health of the host, causing anemia, leukocytosis, hypoglycemia, splenomegaly, and a massive reduction of thrombocytes (Fink *et al.*, 2015).

Trypanosoma disease amongst wild fish species in Africa was spread from North to Southern sections, remarkably in Sudan (Samia et al., 2011). However, there is paucity of information on the prevalence of trypanosomes species of the African catfish *(Clarias gariepinus)* in Zobe reservoir. Consequently, the main aim of this research is to determine the occurrence of Trypanosomes in the blood of *Clarias gariepinus* in Zobe reservoir.

MATERIALS AND METHODS

The study was conducted in Zobe (Figure 1) with coordinates 12°23 '18” N (latitude) and 7°28'29” E (longitude) in Dutsin-Ma LGA of Katsina State. al., 2022).



Map of Zobe Reservoir

COLLECTION AND IDENTIFICATION OF EXPERIMENTAL FISH SAMPLES

A total of eighty (80) life experimental fish samples of African catfish were bought from artisanal fishermen from four major landing sites of the Zobe reservoir for the period of four months (June-September, 2022). The fish samples were identified according to Olasebikan and Raji (2013) and transported Live samples to Biology Laboratory, Federal University Dutsin-Ma in a plastic basin.

SEXING AND MEASUREMENT OF EXPERIMENTAL FISH SAMPLES

The urogenital papillae of fish samples were scrutinized by physical observation to confirm according to Sadauki et al., 2023. Body weight were recorded with a top loading sensitive weighing balance (GT4100 model) and the total and standard lengths of sampled fish were measured using meter rule (Sadauki et al,. 2023).

EXAMINATION OF BLOOD PARASITES

In the laboratory, the fish were immobilized in a wet fabric for blood sample collection. Blood samples were collected from the caudal vein behind the anal fins with a 21G hypodermic needle and plastic syringe. Thin blood smears were made from the blood samples collected. The blood smears were allowed to air dry and fixed in absolute methanol for five minutes. Slides were stained with phosphate buffered Geimsa and examined under100x objective oil immersion microscope. Images were captured by digital camera, in accordance with OIE (2013).

IDENTIFICATION OF BLOOD PARASITES

The parasites were identified based on their morphology (Smit et al., 2000). The Trypanosome were characterized by tapering anterior and posterior ends and faintly stained flagella.

PARASITE PREVALENCE AND INTENSITY ESTIMATION

The prevalence of parasitic infestation was calculated for sex, location, length and weight using the model described by Sadauki et al. (2023):

$$\text{Prevalence (\%)} = \frac{\text{No of fish host infected}}{\text{Total no. of fish host Examined}} \text{ x } 100$$

$$\text{Percentage (\%) of infection} = \frac{\text{Number of a specific parasite in the samples}}{\text{Total number of parasite in the samples}} \text{X}100$$

Data analysis

Occurrence and intensity of infestation was expressed in percentage (%). Data were presented using descriptive statistics; a simple percentage was used to present the prevalence and distributions of parasites. Chi-square was used to examine the association between infection and the risk parameters for the prevalence.

RESULTS

Out of 80 samples of *Clarias gariepinus*, collected from the reservoir, 50 were males and 30 were females. The result showed that male fish have a higher prevalence of trypanosome infection (20.00%) compared to the female fish with lower prevalence (16.66%) as shown in Table 1. Prevalence of trypanosomes among fish from the different sampling station showed that station A had the highest percentage of infestation (25.00%), while station B and D had the lowest percentage infestation of (15.00%) as presented in Table 2. Furthermore, African catfish samples with lengths range 20.1 to 25.0cm harboured more parasitic worms 5 (33.33%), while the lowest infection (20.00%) was recorded in samples with lengths ranging from 25.1 to 30.0cm as shown in table 3.

TABLE 1: Prevalence of Trypanosome species of *Clarias gariepinus* in relation to sex in Zobe reservoir.

SEX	No of examined	No of infected	% of infection
Male	50	10	20.00%
Female	30	5	16.66%
Total	**80**	**15**	**18.75%**

TABLE 2: Prevalence of Trypanosome sp of *Clarias* sp in relation to samples station.

Location	No of fish examined	No of fish Infected	% of Infection
Sample A	20	5	25.00%
Sample B	20	3	15.00%
Sample C	20	4	20.00%
Sample D	20	3	15.00%
TOTAL	**80**	**15**	**18.75%**

TABLE 3: Prevalence of Trypanosome species of *Clarias garipienus* in relation to the length

Fish length	No of examined	No of Infected	% of Infection
10.0-15.0	25	3	12.00%
15.1-20.0	30	5	16.66%
20.1-25.0	15	5	33.33%
25.1-30.0	10	2	20.00%
TOTAL	**80**	**15**	**18.75%**

DUSCUSION

The prevalence of trypanosome parasites for both male and female *Clarias gariepinnus* in the present study was 18.75%. This is less than the 50% prevalence in the Clarias gariepinus and Bagrus bayad (Silver catfish) from Lake Victoria recorded by Paperna (1996). Nico *et al.* (2004) also reported a high infection rate of trypanosome with 79% prevalence in Synodontis spp and 43% prevalence in *Clarias gareipinus*. The low prevalences of infection (18.75%) observed in the present study may probably be due to low population of the leeches in Zobe artificial lake. This assumption is based on Thomas (1973) submission that in the control of schistosomiasie the population density of the vector (Leech) must be at optimum and that below this critical threshold transmission may cease.

The high prevalence in male by blood parasitic worms in male African catfish *Clarias gariepinus* may similarly be attributed to random selection of due to larger number of males examined as compared with the females. The prevalence as recorded in this study, is an indication of high parasitic burden that could affect the performance of the fish species in the wild, and possibly predispose economically important species to extinction as perceived (Thompson *et al.*, 2013).

CONCLUSION

The outcome of this study indicated that C*larias gariepinus* spp frrom Zobe Reservoir are infected with blood parasites (Trypanosomes spp). This infection cut across sizes, sexes and age of the fish. Further research should be done on the strains of Trypanosomes spp that infect C*larias gariepinus*.

REFFRENCES

Fink, I.R., Ribeiro, C.M.S., Forlenza, M., Taverne-Thiele, A., Rombout, J.H.W.M.,Savelkoul, H.F.J. and Wiegertjes, G.F., (2015). Immune-relevant thrombocytes of common carp undergo parasite-induced nitric oxide-mediated apoptosis. Dev. Comp. Immunol. 50, 146–154.http://dx.doi.org/10.1016/j.dci.2015.02.008

Nico S.J, Van As J.G. and Davies A.J. (2004). Fish trypanosome from the Okavango Delta, Botswana. Folia Parasitologica 51 : 299-303

Olaosebikan, B.D. and Raji A. (2013). A Field guide to Nigerian freshwater fishes Revised edition Federal College of Freshwater fisheries technology, New Bussa, Niger State.144pp

OIE (2013).Office International des epizootics; World Organisation for Animal Health, Terrestrial Manual: Trypanosomosis (Tsetse transmitted);Version adopted by the 81st World Assembly of delecates of the OIE, 29thMay, 2013.Paris. Chapter 2.4.18 11p. www.fao.org/140318

Paperna, I. 1996. Parasites, infections and diseases of fishes of Africa. CIFA Technical Paper 31

Sadauki, M.A, Bichi, A.H and Timothy, A (2023). Comparative Survey of Parasites of African Catfish Clarias gariepinus inAjiwa and Zobe Reservoirs in North-Western Nigeria. Asian Journal of Fisheries and Aquatic Research 22 (2), 25-32.

Sadauki, M.A., Bichi, A.H., Dauda, A.B and Geidam, M.B. (2022). Assessment of Water Quality Parameters of Zobe and Ajiwa Reservoirs, Katsina State, Nigeria, African Scientist 23(1): 9-18, http://www.niseb.org/afs

Samia H, Ahmed H, Elsiddig MB (2011).Prevalence of Trypanosome infection in Oreochromis niloticusand Clarias lazera, from fish farms and Reservoir of Jebel Aulia Dam in Sudan: World's Vet. J. (1): 14 – 16.

Smit, N.J., Davies, A.J. and Van As, J.G. (2000). A Trypanosome from the Silver Catfish (Schilbe intermedius) in the Okavango Delta, Botswana. Bulleting of European Association of Fish Pathologists 20: 116-119.

Su,Y., Feng, J., Jiang, J., Guo, Z., Liu, G. and Xu, L., (2014).Trypanosoma epinephelin. sp.(Kinetoplastida) from a farmed marine fish in China, the brown-marbled grouper (Epinephelus fuscoguttatus). Parasitol. Res. 113, 11–18.http://dx.doi.org/10.1007/s00436-013-3626-6.

Thomas, J. D. (1973). Schistosomiais and the control of molluscan hosts of human schistosomiasis with particular refrence to possible self-regulation mechanism . Adv. Parasit. .II, 307-394.

Thompson, C.K., Adriana, B, Adrian, F.W., Stephanie, S.G., Alan, J.L.and Andrew T.C, (2013). Morphological polymorphism of T. Copmeniand description of genetically diverse T. vegarandis sp. From critically endangered Australian potoroid, bush tailed bettong (Bettonoga penicillata – Gray, 1837): Parasite and Vectors , 6 : 121.

BIOREMEDIATION OF SOME METALS IN BREWERY EFFLUENTS IN UYO METROPOLIS, AKWA IBOM STATE, NIGERIA

Udoh, J. P.[1,2], A. C. Okoko[3,4], and M. E. Udang[2]

[1]Department of Fisheries and Aquatic Environmental Management, University of Uyo, Akwa Ibom State, Nigeria; jamesudoh@uniuyo.edu.ng, jjamesphilip@gmail.com
[2]Center for Wetlands and Waste Management Studies, Faculty of Agriculture, University of Uyo, Uyo
[3]Fisheries Department, Ministry of Agriculture, Uyo, Nigeria; atimokoko@gmail.com.
[4]Technical Education Board, Ministry of Education, Uyo, Nigeria.

Corresponding Author:
jamesudoh@uniuyo.edu.ng, +234-802-3197962, 0000-0003-1153-0915

ABSTRACT
Untreated effluents generated from domestic and industrial activities constitute a major source of pollution to natural waters. Untreated effluents from an urban brewery facility located in Uyo metropolis southeast Nigeria were screened for useful autochthonous microbial flora. The potential of bioremediation to remove harmful heavy metals in the effluent was evaluated with a view for aquaculture and irrigation uses. The beneficial autochthonous fungi isolated included Aspergillus sp., Verticillium sp. and Mucor sp. Untreated effluents were inoculated with pure colonies of fungi isolates; control group were not inoculated; all were incubated for seven (7) days. Metal levels in the raw and remediated effluents were analysed for heavy metals and compared with National Environmental Standards, Regulations Enforcement Agency (NESREA) limits and aquaculture standards. Results confirmed bioremediation of some heavy metals like Fe, Zn, Pb and Cd in the brewery effluents; but the remediated effluents were not suitable for use in aquaculture or irrigation. Hence, the current practice of irrigating crops with such effluents should be discouraged.

Keywords:
Aquatic ecosystem, effluent toxicity, industrial pollution, waste recycling, urbanization

INTRODUCTION

Domestic and industrial activities generate effluents which serve as sources of elevated concentrations of phosphorus and nitrogen loads, ammonia and solids thereby reducing the quality and functional ability of the receiving waters (Isikhuemhen and Mikiashvili, 2009; Adebayo-Tayo *et al.*, 2011; Igboanugo and Chiejine, 2011; Egwuonwu *et al.*, 2012; Ezeonu *et al.*, 2012; Kenneth *et al.*, 2016; Adekanmbi and Falodun, 2017; Udoh and Adaka, 2018; Udoh *et al.*, 2020). They also bioaccumulate in fish and shellfish (Ajima *et al.*, 2015 Adaka *et al.*, 2017; Abiaobo *et al.*, 2020). Brewery effluents also contain pollutants, including heavy metals such as lead, chromium, and cadmium, which pose significant environmental risks when discharged untreated into water sources. Untreated effluents also pose economic costs in that they require recycling, management and conservation techniques to ensure ecosystem integrity and health. Such economic costs could limit water resources for public water supply, recreation, and tourism and can generate formidable conflict over the development of sites for other uses, including irrigated farming and aquaculture. Crop and animal farming and aquaculture are highly adopted forms of family entrepreneurship, economic wellbeing and for steady

income among urban dwellers in Uyo metropolis (Udoh and Adaka, 2018).
The assessment of quality of water sources in cities and environments confirm the leaching and spread of bacteria, viruses, heavy metals, and dissolved salts in surface and groundwater sources, owing largely to improper treatment and disposal of untreated domestic and industrial effluents to adjoining water bodies (Udoh and Adaka, 2018; Udoh *et al.*, 2020). Hence, several local, international and intergovernmental institutions have made water quality, sustainable development and environmental protection their concern, establishing pollution abatement policies (Udoh *et al.*, 2020). This study therefore investigates the ability of autochthonic and indigenous microbial community originating from the brewery effluents in removing or neutralizing in-situ pollutants in these effluents through their biological activities; thereby checking environmental deterioration of public water sources.

MATERIAL AND METHODS

Study site, sampling and sample preparation

A brewery facility in the city of Uyo situated at longitude 7° 55' 21" E and latitudes 4° 52' 35" N was chosen as study site. The area is typically a tropical rain forest zone with a luxuriant population and diversity of fauna. The mean annual temperature and rainfall of the area are: 26.4 °C (21 0C to 29 0C) and 2509 mm (300 mm to 3500 mm), respectively (Climate-Data, 2018). The dry season of the area spans April to December; and wet season, January to March.
Composite sub-samples of in-situ effluent were collected at the effluent discharge point within the brewery facility in sterile 10 litre plastic air-tight screw-capped containers to avoid contamination. The sample was labeled appropriately and transferred in ice box to the Microbiology Laboratory, University of Uyo, within 24 hours of analyses.

Microbiological analyses

Fungi isolation and characterization:

A 2 ml sample of raw effluents was aseptically inoculated on Potato Dextrose Agar (PDA) media for isolation of fungi; and 2 ml of streptomycin was added to the PDA media to inhibit bacterial growth. The PDA media was autoclaved at 121°C for 15 minutes, allowed to cool to obtain sterilized molten media aseptically poured into sterilized petri dishes. The inoculated media were incubated at 28 °C and observed for 7 days for fungal growth (Holt *et al.*, 1994). Fungal colonies growing on PDA were isolated, and purified through repeated sub culturing until pure colonies of fungi were obtained. Thereafter, the isolates were stained with lactophenol and observed under the microscopes for characteristic features such as colony colour, type of soma, nature of hyphae, special vegetative structure, conidia head, vesicle shape, and so on (Holt *et al.*, 1994).

Inoculation of effluent and bioremediation:
Pure colonies of different fungal isolates were subsequently seeded into slants in sterile McCartney bottles containing about 20 ml of molten medium. Extracts of the mycelia growth from these fungal isolates were inoculated aseptically into the Petri dishes containing 10 ml of raw effluent; incubated at 28 °C and observed for 7 days for fungal growth (Holt *et al.*, 1994).

Determination of heavy metal concentrations

The standard procedures of APHA (2005) were followed in determination of heavy metals. Each 100 ml of the sample was acidified with 5ml of concentrated nitric acid (HNO3) and heated to boil, until the volume is reduced to about 15 – 20 ml, and all residues completely digested. The mixture was cooled, transferred and made up to 100ml using metal-free distilled water. The digested samples were filtered to remove any particulates; and thereafter introduced into the atomic absorption spectrophotometer, AAS. Samples were diluted within their transmitting wave length proportional to the concentration of each metal, to avoid excess stray light. The specific wavelengths used were: 213.9nm (Zinc, Zn), 228.8nm (Cadmium, Cd), 232.0. (Nickel, Ni), 240.7 nm (Cobalt, Co), 248.3nm (Iron, Fe), 257 nm (Manganese, Mn), 283.3nm (Lead, Pb), 318.4nm (Vanadium, Vn), 324.7nm (Copper, Cu), and 357.9nm (Chromium, Cr).

Statistical analysis

Data obtained from the analysis of the parameters before and after remediation of effluent were subjected to paired sample t-Test and one-way analysis of variance (ANOVA) using SPSS software for Windows Version 13) to compare any significant differences arising from remediation experiment; valid inferences was put at the significance level ($P<0.05$).

RESULTS AND DISCUSSION

Three fungal isolates obtained from the raw effluent were identified based on physical structures (Table 1). Verticillium sp was identified as exhibiting cottony white to pale yellow colony, filamentous with septate hyphae, one-celled conidia head present and absence of Chlamydiospore. Aspergillus sp. was characterized by a compact white or yellow basal dark colony, filamentous with septate hypae; foot cells present with asexual reproductive conidiophores (smooth-walled and erect) and possessing a globose vesicle shape. Mucor sp displayed creamy yellow colony, filamentous with coenocytic hyphae; sympodial, branched sporangiophore and zygospores; no conidia head and vesicle shape present (Table 1). Microbiological analyses from this study confirm that raw untreated brewery effluent contain a host of fungal species including Aspergillus sp. and Verticillium sp (Akthar and Mohan, 1995; Ezeonu *et al.*, 2012; Nwogu *et al.*, 2014); as well as viruses, bacteria, fungi, protozoa and helminthes (Reinheimer, 1991). This occurrence could be attributed to organic matter present in the brewery effluent (Ogbeibu and Ezeunara, 2002; Igboanugo and Chiejine, 2011; Akpor and Muchie, 2011; Kenneth et al., 2016). Consequently, untreated wastewater rich in organic matter and essential nutrients introduce much variability into the microflora of the effluent and its associated water bodies.

Table 2 shows the heavy metal levels in raw and remedied effluents. Higher Fe concentrations were recorded in the raw (1.04 mg L-1) compared to remedied effluent (0.31 mg L-1); values were above the approved NESREA standard. Zinc content was not detected in the remedied effluent sample; but was 0.04 mg L-1recorded in the raw effluent. Lead (Pb) values were above the permissible standard of NESREA, 0.03 mg L-1and 0.01 mg L-1, for the raw and remedied effluents, respectively. Cadmium (Cd) levels were below the permissible limits in the raw and remedied effluents: 0.20 mg L-1and 0.04 mg L-1, respectively. Copper, (Cu), Manganese (Mn), Nickel (Ni), Chromium (Cr), Vanadium (Vn) and Cobalt (Co) contents were not detected in both raw and remedied effluents.

This study corroborates the capability of endemic microbial populations in biological sewage treatment. Traditionally, these microorganisms are used in either in fixed film systems, suspended film systems or lagoon systems, depending on the preference of the treatment plant. This is evident in this research that inoculation of microbes (Aspergillus sp., Verticillium sp. And Mucor sp.) and incubation of effluent over a 7-day period successfully manifested significant ($p = 0.05$) changes in heavy metal contents of inoculated effluent (Table 2).

Table 1. Characterization of fungal isolates

Isolates/ Colony colour	Soma Type	Nature of Hyphae	Special Vegetative Structure	Asexual spore	Special Reproductive structure	Conidial head	Vesicle shape	Probable organism
1.Cottony white to pale yellow	Filamentous	Septate	-	One celled conidia heads (cylindrical in shape)	Solitary Phialides chlamydiospores absent	-	-	*Verticillium* sp.
2.Compact white oryellow basal dark	Filamentous	Septate	Footcell	Globose conidia	Smooth walled erect conidiophores	Globose	Globose	*Aspergillus sp.*
3.Creamy yellow	Filamentous	Coenocytic		Sporangiophore	Sympodially branched sporangiophore Zygospores			*Mucor* sp

Source: Field Data

Table 2 Heavy metals concentrations of raw and remediated brewery effluents in comparison with NESREA and aquaculture Standards (mg L-1)

Parameters	Raw effluent	Remediated Effluent	NESREA Standard	Aquaculture Standard*	*t-Test*	*P*	Remarks
Iron, Fe	1.04^a	0.31^b	<0.001	<0.01	485	0.00106	Remediated, unsuitable
Cadmium, Cd	0.20^a	0.04^b	1	<0.005	14.120	0.00015	Remediated, unsuitable
Lead, Pb	0.03^a	0.01^b	0.005	<0.05	13.193	0.00019	Remediated, unsuitable
Zinc, Zn	0.04	BDL	2	<0.005	107.470	0.00000	Remediated, unsuitable
Copper, Cu	BDL	BDL	0.5	<0.02	-47.206	0.00000	Not detected
Manganese, Mn	BDL	BDL	0.2	<0.01	64.790	0.00000	Not detected
Nickel, Ni	BDL	BDL	0.2	<0.05	6.290	0.00326	Not detected
Chromium, Cr	BDL	BDL	<0.001	0.03	3.207	0.03268	Not detected
Vanadium, Vn	BDL	BDL	<0.001	<0.1	13.495	0.00017	Not detected
Cobalt, Co	BDL	BDL	<0.001	<0.05	-	-	Not detected

Source: Field data . Means with same superscript are not significantly different ($p<0.05$).
BDL – below detectable limit
Remediated, unsuitable = bi-remediated effluents were not suitable for use in aquaculture and irrigation operations.
* (FAO, 1989; Obot *et al.*, 2016)

This study confirm that the studied brewery effluent was rich in fungi with potentials to reduce and decrease toxic metallic compounds such as Fe, Zn, Pb and Cd to varying levels. These inoculated microbes employ diverse mechanisms in biologically degrading these effluents. These mechanisms include biosorption - passive binding of heavy metals to fungal cell walls, primarily via functional groups like carboxyl, amine, and phosphate, which are present in fungal polysaccharides (Akthar and Mohan, 1995; Isikhuemhen and Mikiashvili, 2009; Javanbakht *et al.*, 2014). Some fungi bioaccumulate and absorb heavy metals intracellularly through active transport of metal ions across the fungal membrane, where they may be stored in vacuoles or bound to proteins (Bai and Abraham, 2001; Adebayo-Tayo *et al.*, 2011). Certain fungi can detoxify heavy metals by biotransformation, altering their oxidation state, making them less bioavailable and less toxic. For example, chromium ($Cr6+$) can be reduced to the less toxic $Cr3+$ by fungal enzymes as demonstrated by Adekanmbi and Falodun

(2017) and reported by Aftab and Noorjahan (2006) for Aspergillus sp. Also, many fungi secrete exopolysaccharides that can bind to heavy metals and immobilize them. Studies by Ezeonu *et al.* (2012) suggest that Nigerian strains of Rhizopus and Trichoderma produce exopolysaccharides that can effectively remove zinc and lead from brewery effluents.

CONCLUSION

Brewery effluents contain metal-laden impurities which limit their beneficial use. They also contain strains of Aspergillus, Verticillium and Mucor which possess unique metabolic capabilities which make them suitable remediants and effluent modifiers. Such bioactive capabilities include biosorption, bioaccumulation, biotransformation, and the secretion of exopolysaccharides. Results from this study indicate that when such effluent modifiers are inoculated in effluent holding facilities for up to seven days prior to discharge, they could reduce heavy metal contents and environmental deterioration of receiving public water sources. However, a seven-day incubation did not sufficiently achieve remediation to permissible levels suitable for use of remediated effluent in aquaculture and irrigation operations. Further studies would require extending the incubation period to achieve this purpose.

REFERENCES

Abiaobo, N. A., Asuquo, I. E., and Akpabio, E. P. (2020). Heavy metal bioaccumulation in periwinkle (Tympanotonus fuscatus) and tilapia fish (Oreochromis niloticus) samples harvested from a perturbed tropical creek in the Niger Delta, Nigeria. Asian Journal of Environment and Ecology 12(1), 18-27.

Adaka, G., Ajima, M., Ezeafulugwe, C., Osuigwe, D. and Nlewadim, A. (2017). Assessment of heavy metals in fish tissues of some fish species in Oguta Lake, South-Eastern Nigeria. Futo Journal Series, 31,249–257.

Adebayo-Tayo, B. C., Adebayo, O. O., and Ezekiel, S. O. (2011). Heavy metal accumulation by fungi from brewery effluents in Nigeria. Journal of Microbiology and Biotechnology Research, 1(4), 96-103.

Adekanmbi, A. O. and Falodun, A. R. (2017). Biotransformation of Cr6+ to Cr3+ by Penicillium chrysogenum isolated from contaminated effluent sites in Nigeria. African Journal of Biotechnology, 16(22),1297-1305.

Aftab, S. Y. and Noorjahan, C. M. (2006). Biodegradation of fertilizer effluent. Asian Journal of Microbiology Biotechnology and Environmental Science,5(3),585-588.

Akpor, O. B. and Muchie, B. (2011). Environmental and public health implications of wastewater quality. African Journal of Biotechnology,10(13), 2379-87.

Akthar, N. M. and Mohan, P. M. (1995). Bioremediation of toxic metal ions from polluted lake waters and industrial effluents by fungal biosorbent. Current Science, 69(12),1028-1030.

American Public health association (APHA) (2005). Standard methods for the examination of water and waste water. (21st edition), American Public Health Association, Washington, DC, 2042p.

Bai, S. and Abraham, T. E., (2001). Biosorption of Cr (VI) from aqueous solution by Rhizopus nigricans. Bioresource Technology 79,73-81.

Climate-Data, 2018). Uyo climate: average temperature, weather by month. www.en.climate-data.org/africa/nigeria /akwa-ibom/ uyo-4733/ Accessed June 2018.

Egwuonwu, C. C., Uzoije, A. P., Okafor, V. C., Ezeanya, N. C. and Nwachukwu, M. U (2012). Evaluation of the effects of industrial wastewater discharge on surface water (A case study of Nigeria Breweries Plc, Enugu). Greener Journal of Physical Sciences, 2 (3),56-63.

Ekwu, A. O. (2010). Tissue distribution of heavy metals in fin fish from a tidal fish farm in Southeast Nigeria. In. Proceedings of the 36th Annual Conference of the Fisheries Society of Nigeria (FISON), ASCON, Badagry, Lagos, 25th -29th October 2010, pp. 215-219.

Ezeonu, C. S., Okafor, N. U., and Ogbonna, C. (2012). Exopolysaccharide production by Rhizopus and Trichoderma spp. for heavy metal removal in brewery effluents. Journal of Environmental Chemistry and Ecotoxicology, 4(9),144-152.

FAO (1989). Integrated Fish Farming in China. NACA Technical Manual No. 7.

Holt, G. J., Krieg, R. N., Sneath, A. H. P., Staley, T. J. and Williams, T. S. (1994). Bergey's Manual of Determinative Bacteriology. 9th International edition.

Igboanugo, A. C. and Chiejine, C. M. (2011). A mathematical analysis of brewery effluent distribution in Ikpoba River in Benin city, Nigeria. ARPN Journal of Engineering and Applied Science, 6 (9), 22-25.

Isikhuemhen, O. S., and Mikiashvili, N. A. (2009). Biosorption of heavy metals by Pleurotus tuber-regium cultivated on brewery waste. Environmental Monitoring and Assessment, 157(1-4), 547-558.

Javanbakht, V., Alavi, S. A. and Zilouei, H. (2014). Mechanisms of heavy metal removal using fungi as a biosorbent: a review. Journal of Environmental Health Science and Engineering, 12(1), 1-7.

Jonathan, B.Y., Maina, H. M. And Musa Y. M. (2010). Bioaccumulation of heavy metals in freshwater Clarias anguillaris and Parachanna africana from Lake Geriyo in Yola, Nigeria. In. Proceedings of the 36th Annual Conference of the Fisheries Society of Nigeria (FISON), ASCON, Badagry, Lagos, 25th-29th October 2010, pp. 185-188.

Kenneth, C., Ogbu, C., Ebenebe, I. and Abajue, C. (2016). Physico-chemical characteristics of Ama brewery effluent and its receiving Ajali River in Udi, Enugu State, Nigeria, Animal Research International Journal, 13 (2), 2392-2399.

NESREA (2006). NESREA Act 2006. National Environmental Protection (Effluent Limitation) Regulations National Environmental Standards and Regulations Enforcement Agency, NESREA, www.nesrea,gov.ng

Nwaka, S. U., and Udoh, J. P. (2022). Evaluation of nutritional profile of periwinkle (Tympanotonus fuscatus) from Ekeuku market, Owerri, Imo State. Journal of Aquatic Sciences, 37(1), 63-71.

Nwogu, N. A., Onunkwo, A. U., and Onianwa, P. C. (2014). Assessment of heavy metal content in brewery effluents and their impact on the environment. African Journal of Environmental Science and Technology, 8(5), 256-263.

Obot, O. I., Udoh. A. O., Otoh. A. J. and Udoh, J. P. (2016). Pond water quality management for tropical fish culture. In: Udoh, J. P. and Ekpo, I. E, eds., Efficient and Sustainable Tropical Aquaculture. Faculty of Agriculture, University of Uyo, Uyo, Nigeria, pp. 473 – 487.

Ogbeibu, A. E. and Ezeunara, P. U. (2002). Ecological impact of brewery effluent on Ikpoba River using the fish communities as bio indicators. Journal of Aquatic Research, 17 (1), 35-44.

Reinheimer, G. (1991). Aquatic Microbiology. 4th ed. John Wiley and Sons NY. 363p.

Udoh, J. P. and Adaka, G. S. (2018). Potentials of urban aquaculture and effluent in Uyo Metropolis, southeast Nigeria. Journal of Wetlands and Waste Management 2 (1), 20-47.

Udoh, J. P., Otoh A. J. and Udang, M. E. (2020). Biotreatment of brewery effluents for aquaculture use using autochthonous fungi. Tropical Freshwater Biology, 29 (2), 123 – 134. http://www.ajol.info/ index.php/tfb.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

EVALUATION OF HEAVY METAL LEVELS IN SEDIMENTS OF ESCRAVOS ESTUARY, NIGER DELTA, NIGERIA

[1]Ewutanure, S. J. and [2]O.A. Adeniyi

[1]Department of Fisheries and Aquaculture, Faculty of Environmental Management, Nigeria Maritime University, Okorenkoko, Delta State, Nigeria. Email: ewutanure@gmail.com, GSM: +2348101634482
2Ajayi Crother University Oyo. Nigeria

Corresponding author:
Osasadeniyi@gmail.com +2348035601425, 0032-0600-065

ABSRACT
Surface water contamination is linked to rising levels of both natural and human-made contaminants. There is, however, dearth of information regarding heavy metal (HM) concentrations in the Escravos Estuary (EE) and their effects on aquatic fauna species. This study investigated the levels of heavy metals in sediments of Escravos Estuary (EE), Niger Delta Nigeria. Spatially, Escravos Estuary was stratified into three stations (A1, A2, A3) based on predominant human activities, while monthly sampling covered February to May, 2024. Surface sediments samples were collected from the three stations, digested and analysed for heavy metals (Cu, Ni, Cd, Zn) mg/Kg using Atomic Absorption Spectrophotometer according to standard procedures. Data obtained were subjected to inferential statistics and ANOVA at a0.05 level of significance. Spatially, significantly highest (60.23±23.21) and least (49.17±16.24) levels of Cu occur in A3 and A1. Highest (36.52±11.36) and least (34.99±13.72) levels of Ni occurred A1 and A2, while it ranged from 29.92±19.54 to 35.02±1.02 in February and April, respectively. Level of Ni in the sediments of EE is relatively higher than recommended limits and this could threaten the survival of its benthic organisms.

Keywords:
Surface sediments, anthropogenic effluents, Aquatic pollutants.

INTRODUCTION

Surface water contamination is linked to rising levels of both natural and human-made contaminants (Adeniyi, 2024). Heavy metals are elements generally characterized by their high atomic mass and density (Ewutanure and Asogwa, 2024). They are considered as serious threat due to their environmental persistence, toxicity and ability to incorporate into food chains (FAO, 2018). Heavy metals enter the aquatic biota through geogenic and anthropogenic sources (Gijo and Alagoa, 2022). They may be bioaccumulated in aquatic fauna species thereby threatening their health and reproductive processes (Haynes, 2015). This knowledge can help identify pollution sources, develop effective mitigation strategies and monitor the success remediation effort.

While, sediments are originally formed by weathering processes and transported to the benthic environment, they are made up of particulate matter of various shapes, sizes and mineralogical constituents (FEPA, 2011). It has been reported that sediments act as a sink for pollutants due to the fact that pollutants are frequently discharged into surface water bodies (USEPA, 2009).

The Escravos Estuary is an important fishing area for the people living along its coast but the massive production of crude oil in the area has led to incessant oil spillages on the surface water (Ewutanure et al. 2022). Evaluating heavy metal level in the sediment of Escravos Estuary will provide an insight on the potential impacts of heavy metal on its sediments (Ewutanure and Olaifa, 2021). This research is therefore aimed at evaluating heavy metals (Nickel, Cadmium, Copper and Zinc) levels in the sediments of Escravos Estuary.

MATERIALS AND METHODS

Study area

Escravos Estuary is located on latitudes 5°35'42" N and 5°35'18" N of the equator and longitudes 5°33'59" E and 5°43'4" E of the Greenwich meridian, while the exact locations of all sampling stations were determined using Garmin GPSMAP eTrex10 type sensors. The Escravos Estuary flows along a distance of about 35 miles and transverse the zone of mangrove swamps. It passes through the Bight of Benin and the Gulf of Guinea where it eventually emptied into the Atlantic Ocean. It has been reported that the Escravos Estuary consistently experience relatively strong wave and tidal effects (Ewutanure and Binyotubo, 2021). It is located in a mangrove swamp forest with major identified mangrove species as Rhizophora racemose (red), Avicennia africana (white) mangroves (Ewutanure and Asogwa, 2024).

Sampling techniques

The Escravos Estuary was spatially stratified into three stations (A1, A2, A3) based on predominant human activities. Monthly stratification covered February – May, 2024. Intertidal sediment samples were collected by using van Ven bottom grab sampler (vanVen, 1979), placed in labeled polyethylene bags, sealed and transported to the laboratory for analysis. The samples were then air-dried at room temperature and homogenized for further study in the laboratory.

Sediment digestion and heavy metal analyses

Sediment sample was digested according to the method described by AOAC, (1990) as follows: One gramme (1g) of air – dried sediment sample was ground in a mortar and heated to reddish brown in a furnance and moistened using de – ionised water. 1 mL of 60% perchloric acid and 20 ml of 40% hydrofluoric acid were added. The content was heated to dryness in a sand bath at 180oC. It was cooled and 15 mL of 10% hydrochloric acid added. The mixture was heated in a crucible to dryness (APHA, 1992). The concentrations of the metals in the sediment were determined using Atomic Absorption Spectrophotometer according to standard procedures (ASTM, 2006).

Statistical analyses

Data from this study were analysed using descriptive (means and standard deviation) and inferential statistics (one-way ANOVA) by using SPSS (version, 22).

RESULTS

Results of heavy metal concentrations in the intertidal sediment of Escravos Estuary among stations and months are presented in Tables 1 and 2, respectively. Though, there were significant differences ($p<0.05$) in means of Cu, Cd and Zn among stations and months, their concentrations were within the acceptable limits by FEPA, (2011) and USEPA, (2009).

Table 1 Spatial heavy metal levels in intertidal sediment of Escravos Estuary

Heavy metals	Stations			FEPA, (2011)	USEPA, (2009)
	A1	A2	A3		
Cu (mg/Kg)	49.17 ± 16.24^c	54.71 ± 10.71^b	60.23 ± 23.21^a	65	73
Ni (mg/Kg)	36.52 ± 11.36	34.99 ± 13.72	35.67 ± 2.62	35	48
Cd (mg/Kg)	0.79 ± 0.20^c	0.86 ± 0.15^b	0.98 ± 0.16^a	1.2	1.2
Zn (mg/Kg)	65.61 ± 16.01^b	70.14 ± 19.15^a	59.99 ± 23.41^c	120	120

Note: Means values with same superscripts along the rows are not significantly different at $p > 0.05$.

Table 2 Monthly heavy metal levels in intertidal sediment of Escravos Estuary

Heavy metals	Months				FEPA, (2011)	USEPA, (2009)
	February	March	April	May		
Cu (mg/Kg)	56.49±15.13[b]	61.11±10.17[a]	45.78±14.68[d]	54.63±21.18[c]	65	73
Ni (mg/Kg)	29.92±19.54[b]	31.31±17.16[b]	35.02±1.20[a]	32.18±4.10[b]	35	48
Cd (mg/Kg)	0.81±0.19[b]	0.72±0.16[c]	1.09±0.13[a]	1.01±0.41[a]	1.2	1.2
Zn (mg/Kg)	43.44±17.35[c]	70.13±5.42[b]	70.64±11.14[a]	69.17±14.01[b]	120	120

Note:Means values with same superscripts along the rows are not significantly different at $p > 0.05$.

DISCUSSION

Though the values of Cu, Cd, Ni and Zn obtained among station and months in the intertidal sediment of Escravos Estuary were relatively high, they were lower when compared with FEPA, (2011) and USEPA, (2009) limits. This implies that the sediment quality is still within the acceptable limit of metal accumulation. It has been reported that sediment with lower concentrations of pollutants may not cause any harm to benthic invertebrates in the immediate but prolong contact with it could lead to accumulation of such toxicants in their body tissues (Ewutanure and Asogwa, 2024). Results from this study agreed with Ewutanure and Binyotubo, (2021) who recorded similar level of heavy metal in sediment within the study area and attributed it to the constant flow of water and upwelling along the Escravos Estuary that prevents excessive accumulation of heavy metals and other related pollutants.

CONCLUSION

Generally, results obtained from this study indicate that heavy metal concentrations monitored in the sediment of Escravos Estuary are still within the acceptable standards of FEPA, (2011) and USEPA, (2009) except Ni concentration which was relatively higher than FEPA, (2011) in A3 and April. This implies that Ni concentration measure during the study could cause harm to the aquatic fauna species and human that depend on them as sources of food.

RECOMMENDATION

Regular monitoring of the Escavos Estuary to assess its heavy metal levels and ecological health should be encouraged, while regulations reflecting current environmental management should be reviewed, updated and implemented.

REFERENCES

Adeniyi, A. O. (2024): Exploring Environmental Influences on Fish Abundance and Distribution in Nigeria: A Case Study of Lower River Niger, Agenebode, Nigeria 6th International Cappadocia Scientific Research Congress August 10-12, 2024, Goreme / TURKİYE; WEB: www.cappadociacongress.org Conference Proceedings Pg. 918-931 IKSAD Publications – 2024 © Issued: 02.09.2024 ISBN: 978-625-8254-57-0American Society for Testing and Materials (ASTM). 2006. Standard guide for conducting laboratory toxicity tests with freshwater mussels. E2455-06, Philadelphia. Annual Book of America Society for Testing and MaterialsStandards 11.6: 1393-1444.

APHA. 1992. Standard Methods for the Examination of Water and Waste Water. America Public Health Association, American Water Works Association, Water Environment Federation. Greenberg, A.E., Clesceri, L.S. and A.D. Eaton Eds. 18th Edition, Washington, D.C. 238 - 410.

Association of Official Analytical Chemists (AOAC), 1990: Methods of experimental analyses. Journal of Official Method of Analyses 8.1: 551 - 573.

Ewutanure, S.J. and Asogwa, V.I. (2024). Histopathological analyses of liver and gill of Coptodon zillii obtained from Okerenkoko Waterfront, Delta State, Nigeria. Animal research international, 21(1): 5249 - 5256.

Ewutanure, S.J. and Binyotubo, T.E. (2021). Impacts of Anthropogenic Activities on the Fish Compositions and Diversity of Okerenkoko Estuarine, Delta State, Nigeria. Proceedings of the Accra Bespoke Multidisciplinary Innovations Conference. University of Ghana/Academic City University College, Accra, Ghana. December 2021. Pp 9-8 www.isteams.net/ghanabespoke2021. DOI https://doi.org/ 10.22624/AIMS/ABMIC2021-V2-P2.

Ewutanure, S.J. and Olaifa, F.E. (2021). Effects of effluents from Gbalegbe River, Delta State, Nigeria on the breeding performance of Clarias gariepinus (Burchell, 1822). Proceedings of the Accra Bespoke Multidisciplinary Innovations Conference. University of Ghana/Academic City University College, Accra, Ghana. December 2021. pp 163-178 www.isteams.net/ghanabespoke2021. DOI https://doi.org/ 10.22624/AIMS/ABMIC2021P13.

Ewutanure, S.J., Eyo, V.O., Binyotubo, E.T. and Eriegha, O.J. (2022). Heavy metal and total petroleum hydrocarbon concentrations in water, sediment and fauna of Okerenkoko Estuarine, Delta State, Nigeria. Journal of Digital Innovations and Contemporary Research in Science, Engineering and Technology, 10(2): 1 - 12.

FEPA, (2011). National Environmental (Surface and ground water quality control) regulations. Printed and Published by The Federal Government Printer, Lagos, Nigeria j FGP 71/72011MOO (OL46). 35Pp.

Food and Agriculture Organization (FAO). (2018). "Heavy metal contamination in fisheries and aquaculture." [11:26, 17/09/2024] +234 810 753 7166: Duffus JH. Heavy metals. A meaningless term? International Union of Pure and Applied Chemistry (IUPAC). 2002; 74:793-807. DOI: 10.1351/pac2002740507.

Gijo, A. H and Alagoa, K. J (2022). The Concentration of Heavy Metals in the Sediments of the River Nun Estuary, Around 234 Akassa, Niger Delta, Nigeria. Haya Saudi J Life Sci, 7(8): 234-239.

Gupta, P. K. 2001. Methods in environmental analysis: Water, Soil and Air. AGROBIOS (India) Publisher. 1 - 408.

Haynes, W. M. (2015). Handbook of Chemistry and Physics, CRC Press/Taylor and Francis, Boca Raton, FL, 95th Edition, Internet Version 2015, accessed December 2014.

United States Environmental Protection Agency (USEPA) (2009). Exposure Factors Handbook, Final ed., (EPA/600/R-09/052F). Washington DC: U.S.

van Veen, J. 1979. Onderzoek near hetz and transport von rivierren. De Ingenieur 48: 151 - 159.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

ASSESSMENT OF THE PHYSICOCHEMICAL PARAMETERS AND FISH COMPOSITION OF OGBESE RIVER, ONDO STATE, NIGERIA.

Edward, J. B., R. O. Agunbiade and F. E. Ayeni

Department of Zoology and Environmental Biology, Ekiti State University, P.M.B. 5363, Ado Ekiti, Ekiti State, Nigeria.

Corresponding Author:
josephine.edward @eksu.edu.ng, +2347031045805, 000-0002-5404-6771

ABSTRACT
Physicochemical properties play essential roles in the maintenance of healthy aquatic ecosystems. This study aimed at assessing the physicochemical parameters and fish composition of Ogbese River in Ogbese, Ondo State, Nigeria. Water samples were collected following American Public Health Association, APHA (2005) standard, while fish samples were collected using baited local fish trap. Sixteen samples of water were collected fortnightly during the months of February to April, 2023. Physicochemical parameters determined include temperature (23.560C ± 2.03), alkalinity (96.8mg/L±10.4), pH (7.5±0.4), total hardness(105.3mg/L ± 26.7), total suspended solids (51.6mg/L ± 12.4), total dissolved solids (102.1mg/L), total solids (153.6 ± 12.4), DO (5.2mg/L±1.7), BOD (2.6mg/L±0.6), COD(4.0mg/L±1.4), acidity (65.5mg/L ± 9.2), sulphate (15.7±6.5), nitrate (9.5mg/L ± 4.8), and phosphate(18.4±3.7) respectively. Physicochemical parameters assessed were within the range of values recommended by WHO, NIS and FEPA with the exception of dissolved oxygen, phosphate and nitrate. Fish composition of this river includes two hundred and sixty-two (262) fishes belonging to seven different species. These species are Clarias gariepinus, Heterobranchus bidorsalis, Oreochromis niloticus, Tilapia zillii, Parachanna obscura, Malapterurus electricus, and Hepsetus odoe. Clarias gariepinus have the highest population abundance (34%) while the least abundant was Hepsetus odoe (2%). In conclusion, Ogbese River is of good quality fit for domestic and agricultural purposes except for the excessive lead, phosphate, nitrate and dissolved oxygen content that needed to be checked and controlled. However, further study is recommended on the source and quantification of heavy metals present in the river for timely intervention to public health advantage.

Keywords:
Physicochemical parameters,
Fish, Ogbese River,
Ondo State, Pollution.

INTRODUCTION

Water quality here is a term used to express the suitability of water to sustain various uses. Any particular use will have certain requirement for the physical, chemical or biological characteristics of water. Consequently, water quality can be defined by a range of variables which limit water use. Although many uses have some common requirements for certain variables, each use will have its own demands and influence on water quality. Water quality is determined by physical and chemical limnology of a reservoir (Okoye and Ogbebor, 2024) and includes all physical, chemical and biological factors of water that influence the beneficial use of water. Water quality is important in drinking water supply, irrigation, fish production, recreation and other purpose to which the water must have been important (Moshood, 2008). Therefore, water quality concerns are often the most important component for measuring access to improved water sources and it also dictates the type and quality of fish found in the river. Fish are rich sources of protein, essentially fatty acids, vitamins and minerals. Muhammed and Zeliha (2023) reported that fish flesh is about the best source of animal protein, better digested than beef and poultry, and it contains a good quality and quantity of mineral salts. Also, fish oil is poly-unsaturated fatty acids with anti-cholesterol factor. He concluded that regular consumption of fish is beneficial to human body. This study aimed at assessing the status of physicochemical parameters and fish composition of Ogbese river in Ondo State.

MATERIALS AND METHODS

Study Area: This study was carried out in Ogbese River located in Ayede-Ogbese along Akure-Benin expressway. Ayede Ogbese is under Akure North Local Government Area of Ondo State. The area lies within latitude E6°SE8° and longitude N4°N6°E. The river has its source from Ayede-Ekiti in Ekiti State and flows through Ogbese in Ondo State to Edo State. The Ogbese community is about 10 km east of Akure, the Ondo State capital. The river is surrounded by farmlands and it is a major discharge points for industries. Other major anthropogenic activities in the catchment area are automobile workshops, car wash and laundry.

Sample Collection and Analysis: Sampling was carried out fortnightly, between the month of February and April (hours of 6:00am to 7:00am) for physicochemical parameters and fish composition. Water sampling from the river were collected inside a clean plastic container of 1litre for the purpose of physical parameters assessment and the samples were taken to the laboratory in Federal University of Technology, Akure for analysis following standard laboratory procedures of (APHA (1995). The parameters analyzed include temperature (Celsius thermometer), pH (electronic buffered pH metre), Total dissolved solids (TDS), Total solids (TS) and Total Suspended Solids (TSS) (Gavimetry method), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) (Winkler Method). Nutrients measured include phosphate, sulphate and nitrate, and were determined spectrophotometrically. Acidity, alkalinity and hardness were determined using titration method.

Fish sampling was carried out on the river during the period of study using baited local fish traps. The traps were suspended in the river with a bait inside it to capture the fish available at 6p.m and the captured fishes were collected very early the next day latest by 9a.m. Fishes captured at a time were identified and named in accordance to the rule of taxonomy using Olaosebikan and Raji (2013) and the numbers of each species was recorded accordingly.

Data obtained were subjected to statistical analysis mainly descriptive statistics to determine the mean, standard error and correlation coefficients.

RESULTS AND DISCUSSION

The means and ranges of the physicochemical parameters are shown in Table 1, while Table 2 showed that of the fish composition obtained from Ogbese River during the period of study.

Table 1: mean and range of physicochemical parameters in four location on Ogbese River

Physicochemical parameters	Late February	Early March	Late March	Early April	Range	Mean ± STD	P Value	WHO	FEPA	NIS
Temperature (°C)	24	24.75	22.50	23.00	20.00-27.00	23.6 ± 2.03	0.00	35-40	<40	40
pH	7.10	7.09	7.98	7.74	6.90-8.30	7.5 ± 0.44	0.00	6.5-8.5	6.9	6.5-8.5
TSS (mg/L)	52.	42.00	42.85	68.60	31.50-74.70	51.6 ± 12.44	0.00	500	-	500
TDS (mg/L)	98.18	103.35	105.68	100.88	95.50-113.40	102.1 ± 4.86	0.00	500	2000	500
TS (mg/L)	150.88	145.55	148.53	169.48	134.30-181.20	153.6 ± 12.40	0.00	500	-	-
DO (mg/L)	3.63	5.83	5.30	6.00	3.20-8.30	5.2 ± 1.70	0.00	2.0	2.9	-
COD (mg/L)	2.56	3.50	4.75	5.20	1.90-6.20	4.0 ± 1.39	0.01	40	-	-
BOD (mg/L)	2.08	2.88	2.35	2.95	1.12-3.50	2.6 ± 0.59	0.01	10	30-50	-
Total Hardness (mg/L)	110.95	121.58	120.65	67.85	40.60-151.30	105.3 ± 26.65	0.06	100	-	100
Acidity (mg/L)	1.28	213.28	1.53	45.89	1.20-242.10	65.5 ± 9.15	0.00	-	-	-
Alkalinity (mg/L)	165.43	1.48	217.18	3.23	1.20-250.30	96.8 ± 10.14	0.02	150	-	150
Sulphate (mg/L)	21.28	15.65	19.88	5.84	4.50-22.30	15.7 ± 6.45	0.01	48-200	500-1000	500
Nitrate (mg/L)	6.75	6.73	7.70	16.88	5.20-20.30	9.5 ± 4.80	0.08	1.0	2.0	1.0
Phosphate (mg/L)	19.74	16.03	18.25	19.58	11.30-25.10	18.4 ± 3.67	0.00	10	-	-

Fish Composition of Ogbese River

Table 2: Check list for Fish Fauna in Ogbese River between February and April 2021

Fish Fauna	February	March	April	TOTAL	Percentage (%)
Clarias gariepinus	20	36	34	90	34
Heterobranchus dorsalis	11	11	22	44	17
Oreochromis niloticus	8	19	31	58	22
Tilapia zilli	3	6	8	17	7
Parachanna obscura	9	11	19	39	15
Malapterurus electricus	1	2	5	8	3
Hepsetus odoe	1	2	3	6	2
TOTAL	53	87	122	262	100

The results showed that all the measured parameters had mean values that are relatively within the allowable limits compared with the standard values of WHO, FEPA AND USEPA. Only dissolved oxygen, hardness, nitrate and phosphates exhibited mean values above the standard recommended limits. This might be due to surface runoff from nearby cultivated farmlands where fertilizer (especially NPK) has been washed into the river.

A total of two hundred and sixty-two fishes of seven different species were obtained from Ogbese River during the study period. Our findings on the icthyofauna of Ogbese River are quite similar to that of Adewumi et al. (2015) which was conducted on the ichtyofauna of an aspect of Ogbese River that flows through Ekiti State. The authors reported a total of 2,700 fishes between the months of October, 2010 - February, 2011. According to the authors, nine (9) species belonging to six (6) families were recorded. Six (6) species (Clarias gariepinus; (410), Heterobranchus bidorsalis (508), Oreochromis niloticus (508), Mormyrus rume (227), Mormyrus macrophythamus (221) and Malapterurus electricus (341). were dominant species, Hepsetus odoe and Parachanna obscura were sub-dominant, while Tilapia zillii was rare.

In conclusion, Ogbese River possessed good quality water fit for domestic and agricultural activities. However, further study is recommended on the source and quantification of heavy metals present in the river for timely intervention to public health advantage.

REFERENCES

Adewumi A.A., Idowu E.O., and Adeniji A.A. (2015). A survey of the Ichtyofauna of Ogbese River, South West, Nigeria. International Journal of Science. 4(5) http://www.ijsciences.com/pub/issue/2015-07/

APHA (1995). Standard Methods for the Examination of Water and Waste Water. 19th ed. American Public Health Association Inc., Washington, DC, 1467 pp.

Moshood M.K. (2008). Assessment of the water quality of Oyun Reservior, Offa, Nigeria, using selected physic-chemical parameters. Turkish Journal of Fisheries and Aquatic Science. 8:309-319. https://www.trjfas.org/uploads › pdf_626Mustapha, Y.N. and Zeliha, S. (2023). Fish as a significant source of nutrients. Journal of Public Health and Nutrition. Volume 6 Issue 4: 1-10. https://www.researchgate.net/publication/377853193

Okoye, G.U. and Ogbebor, J.U. (2024). Physicochemical Limnology and Water Quality Assessment of Ten Surface Water Bodies in Edo State, Nigeria. Journal of Applied Science and Environmental Management. Vol. 28 (9) 2927-2936. : https://dx.doi.org/10.4314/jasem.v28i9.39

Olaosebikan, B.D. and Raji, A. (2013) . Field guide to Nigerian Freshwater Fishes. Revised Edition. Federal College of Freshwater Fisheries Technology, New Bussa, Nigeria, pp144.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

BLUE BIOTECHNOLOGY AND GENETICS (BBG)

CHROMOSOME COMPOSITIONS OF *Gymnarchus niloticus* *(OSTEOGLOSSIFORMES: GYMNARCHIDAE)* FROM OLUWA RIVER, ONDO STATE, AND LEKKI LAGOON, LAGOS STATE, NIGERIA.

Jegede O. I.

Department of Fisheries and Aquaculture, Adamawa State University, Mubi, Nigeria.
E-mail: jegede264@adsu.edu.ng, +2347030651462, 0000-0001-6664-7710

ABSTRACT
Studying the metaphase chromosomes of *Gymnarchus niloticus* collected from the River and Lekki Lagoon in western Nigeria is crucial in understanding their chromosome composition. Chromosomes were extracted from the fish kidney after intraperitoneal injection with 0. 05% colchicine solution at 1 ml per 100g fish; the extracted kidney was homogenised and washed by centrifugation thrice consecutively in 3: 1 methanol acetic acid fixative. Slide preparation followed the standard Giemsa staining procedure; the prepared slides were examined for good metaphases, and the images were captured using a photomicroscope; metaphases were classified as metacentric, sub-metacentric, and acrocentric considering their centromeric position. The result revealed a significant difference in the chromosome composition of Gymnarchus species from the two locations, both in their numbers and features. The samples from the Oluwa River had a karyotype of 2n = 54, characterised by uni-armed and bi-armed chromosomes. In comparison, specimens from Lekki Lagoon exhibited a karyotype of 2n = 34 made up of only bi-armed chromosomes; this suggests that the species from the two sampled locations belong to different evolutionary lineages, underscoring the urgent need for further investigation into their species diversity.

Keywords:
Bonytongues, Mormyroidea, karyotypes, metaphase chromosome, strains

INTRODUCTION

The order Osteoglossiformes, commonly known as bonytongues, composed of about 250 species distributed in 31 genera and six families (Fricke *et al.*, 2022; Froese and Pauly, 2022) is an ancient fish order believed to have diverged early from the main Teleostean lineage (Bian *et al.*, 2016) Anatomically, fishes in this order bear a characteristic bone that resembles a tongue located on the floor of the mouth; this primitive feature distinguishes it from the remaining fish groups and from where it derives its common name (Helfman *et al.*, 2009) Although a relatively small fish order distributed in six families: Mormyridae, Pantodontidae, Gymnarchidae, Arapaimidae, Osteoglossidae and Notopteridae, the O*steoglossiformes* are found in the tropical regions of all the major continents in the southern hemisphere (Lavoue and Sullivan, 2004) Three of the Osteoglossiformes families; Mormyridae, Pantodontidae and, Gymnarchidae are endemic to Africa, while Arapaimidae and Notopteridae are represented in the African continent by at least one species (Bera, 2001; Olivera *et al.*, 2020).

The suborder, mormyroidea made up of the Mormyridae and the Gymnarchidae, possess electroreceptor cells which enable them to send and detect weak electrical signals, the nature of which are species specific and could be valuable in the taxonomy of the group (Arnegard and Carlson, 2005;) The large mormyroids cerebral are presumably used in coordinating these electrical signals (Helfman *et al.*, 2009).

Gymnarchus niloticus is the only species in the family Gymnarchidae (Nelson *et al.*, 2016; Jegede *et al.*, 2018; Hatanaka *et al.*, 2018) had separately reported chromosome compositions for G. *niloticus* in Lekki Lagoon and Oluwa River. In this study, chromosome compositions of G. *niloticus* from the two water bodies were compared to further elucidate chromosome characteristics of the fish and the implication of such chromosome diversities to speciation and evolution of karyotypes in the Gymnarchidae.

MATERIALS AND METHODS

Metaphase chromosome preparation

Five specimens of G. niloticus were collected from the Oluwa River and Lekki Lagoon in western Nigeria. Metaphase cells were obtained from the anterior portion of the kidney (Bertollo *et al.*, 2015) Protocol for metaphase cell and slide preparations were followed (Bertollo *et al.*, 2015), and Jegede et al. (2018) Dividing cells were arrested at the metaphase stage by injecting fish intraperitoneally with 0.01mlg-1 of 0.05% colchicine for 1 hr, after which the fish was sacrificed, the kidney isolated and placed in a hypotonic solution. Hypotonic treatment was performed using a 0.075 M potassium chloride solution lasting for 20 min. After hypotonic treatment, the kidney fragments were homogenised using a hypodermal syringe without a needle. The cell suspension was washed thrice consecutively in 3: 1 methanol: acetic acid fixative by centrifugation. After the last centrifugation, the precipitated cells were suspended in 1 ml fixative and stored in a freezer pending slide preparation. Two drops of the prepared metaphase cells were dispenced on different parts of the slides from a height of 12 cm to 20 cm.

The slides were stained for 30 minutes at 6% Giemsa solution and metaphase chromosomes, captured using GALENTM professional microscope model BA 120. The modal diploid chromosome number obtained from at least twenty spreads from specimens from each location was recorded as the diploid chromosome number. Chromosome arms were measured electronically using Adobe Photoshop CS5 version. Metaphases were classified as metacentric, sub-metacentric, and acrocentric considering centromeric position. Centromeric position and nomenclature followed the criteria of Levan et al. (1964). Karyotyping was done electronically using Adobe Photoshop CS5

RESULTS

Specimens of *Gymnarchus niloticus* from the two locations exhibited two different colour morphs (Figure 1) The samples from Oluwa River were grey, while those from Lekki Lagoon were blackish. In addition, the blackish specimens from Lekki Lagoon were hardier and survived longer in captivity. G. niloticus from Oluwa River exhibited a karyotype of 2n = 54 made up of uni and bi-armed chromosomes, 2n = 54 (26m+14sm+14sta), FN = 94 while those from Lekki Lagoon showed a karyotype of 2n = 34 composed of 26 metacentrics and, 8 submetacentrics: 2n = 34 (26m+8sm), FN = 68 (Figures 2 and 3).

For the Oluwa River samples, Chromosome 1 was a very large metacentric; Chromosomes 2 – 4 were medium metacentrics, while chromosomes 5 – 13 were small; the submetacentrics were composed of five large (chromosomes 14 – 18), one medium (chromosome 19) and a small (chromosome 20) chromosome; uni arm chromosomes were represented by seven subtelocentric, of which chromosome 21 was a large, chromosomes; 22 – 24 were medium, and chromosomes 25 – 27 were small (Figure 3) Chromosome composition of Lekki Lagoon specimens revealed that Chromosomes 1 – 7, and 8-13, were large and small metacentrics respectively, while chromosomes 14 – 17 were submetacentrics.

Figure 1: *Gymnarchus niloticus*, **A = Sampled, from Oluwa River, B = Sampled from Lekki Lagoon**

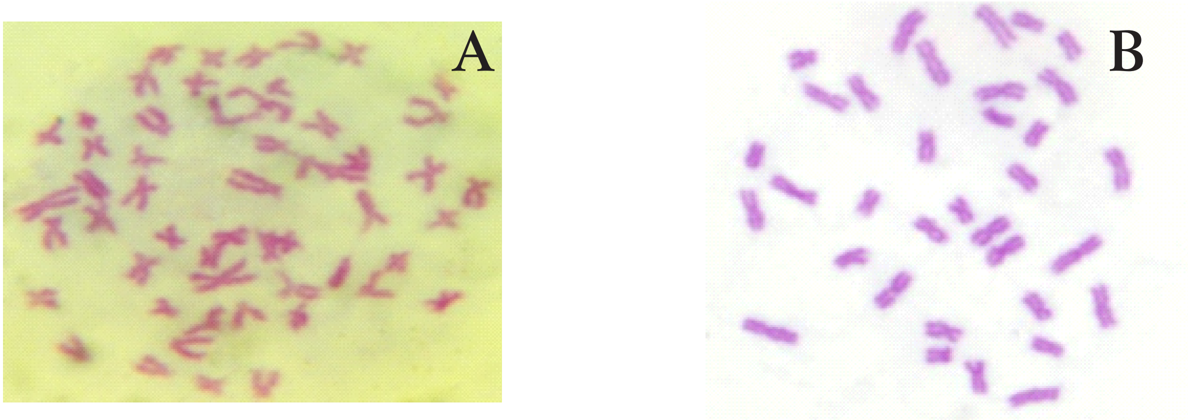


Figure 2: Metaphases of *Gymnarchus*. Niloticus: A: Metaphase chromosomes of G. *niloticus* from Oluwa River. 2n = 54 **B**: Metaphase chromosomes of G. *niloticus* from Lekki Lagoon 2n = 34

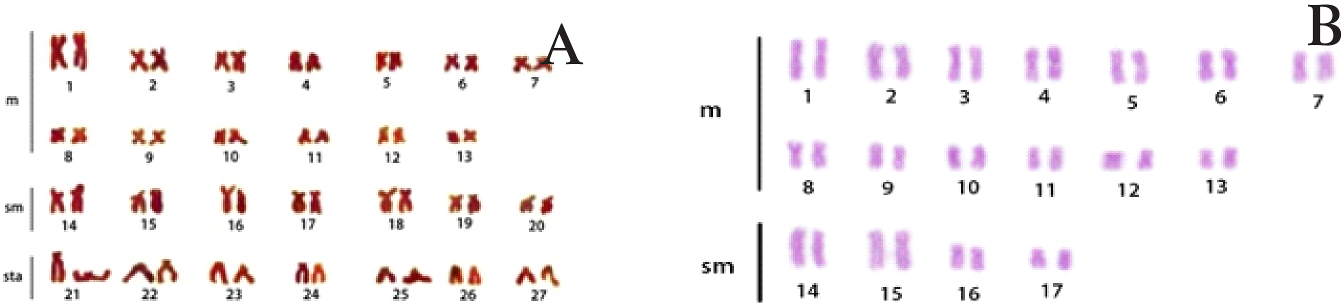


Figure 3: Karyotype of *Gymnarchus niloticus* A: Karyotype of G. *niloticus* in Oluwa River 2n = 54 (26m+14sm+14sta), FN = 94, B: Karyotype of G. niloticus in Lekki Lagoon. 2n = 34 (26m+8sm), FN = 68

DISCUSSION

The general concept among fisheries scientists is that the family *Gymnarchidae* is monotypic, consisting of a single species, *Gymnarchus niloticus*. Even though the local fishermen operating in Nigerian coastal waters know that *Gymnarchus* is composed of two colour morphs, black and grey types and that the black type is hardier and more elongated, the prevailing view among them is that both are the same. Since the black type is restricted to forested dark waters, the difference in body colour has been attributed to the difference in water colour. However, in addition to the observed differences in morphology, body colour and probably physiology, this study has shown that the two types show a wide gap in their chromosomal composition (Gray type: 2n = 54 (24m+20sm+10sta), FN = 94, Black type: 2n = 34 (26m+8sm), FN = 68. The restricted distribution of the black type to dark coastal waters and the general chromosome pattern in the superfamily mormyroidea (2n = 48 – 2n = 50) (Canitz *et al.*, 2017; Ozouf-Costaz *et al.*, 2015) suggests it harbour the evolved karyotype. Although Nigerian coastal lagoons and creeks are a continuum, the difference in the karyotypes of these types may have created reproductive isolation that could prevent gene flow between them. The concept that the family *Gymnarchidae* is monotypic needs more investigation. The study has shown that the family consists of two strains that are distinguishable morphologically and cytogenetically, belonging to two different evolutionary lineages. However, further studies are required to determine if the two strains represent different populations or species The findings obtained in this study are not only of great scientific interest, but are of high value in the management, and conservation of the natural population and also in artificial propagation and domestication of this highly valued fish.

REFERENCES

Arnegard, M. E. and Carlson, B. A. (2005). Electric organ discharge patterns during group hunting by a mormyrid fish. Proceedings of the Royal SocietyB: Biological Sciences 272, 1305–1314 doi:10.1098/rspb.2005.3101

Barby, F. F., Ráb, P., Lavoué, S., Ezaz, T., Bertollo, L. A. C., Andrzej, K., Sandra Regina Maruyama, S. R., Oliveira, E. A., Artoni, R. F., Santos, M. H., Jegede, O. I., Hatanaka, T, Tanomtong, A., Liehr., T., and Bello Cioffi, M. B. (2018). From chromosomes to genome: insights into the evolutionary relationships and biogeography of Old World knife fishes (Notopteridae; Osteoglossiformes). Genes 9, 306; doi:10.3390/genes9060306

Bera, T. M.(2001). Freshwater Fish Distribution. San Diego Academic Press. 607p.

Bertollo, L. A. C., Cioffi, M. B., Moreira-Filho, O. (2015). Direct chromosome preparation from freshwater teleost fishes. In: Ozouf-Costaz, C., Pisano, E., Foresti, F., Almeida Toledo, L. F. (eds). Fish Cytogenetic Techniques (Chondrichthyans and Teleosts). CRC Press: Enfield USA. pp 21 – 26.

Bian, C., Hu, Y., Ravi, V., Kuznetsova, I. S., Shen, X., Mu, X., Sun, Y., You, X., Li, J., Li, X., Qiu, Y., Tay, B., Thevasagayam, N. M., Komissarov, A. S., Trifonov, V., Kabilov, M., Tupikin, A., Luo, J, Liu, Y., Song, H., Liu, C.,Wang, X., Gu, D., Yang, Y., Li, W., Polgar, G., Fan, G.,Zeng, P., Zhang, H., Xiong, Z., Tang, Z., Peng, C., Ruan, Z., Yu, H., Chen, J., Fan, M., Huang, Y., Wang, M., Zhao, X., Hu, G., Yang, H., Wang, J., Wang, J., Xu, X., Song, L., Xu, G., Xu, P., Xu, J., O'Brien, S. J., Orbán, L., Venkatesh, B. and Shi, Q. (2016). The Asian arowana (Scleropages formosus) genome provides new insights into the evolution of an early lineage of teleosts. Scientific Reports 6:24501

Canitz, J. Kirschbaun, F. and Tiedermann, R. (2017). Karyotype description of the African weakly electric fish, Campylomormyrus compressirostris in the context of chromosome evolution in Osteoglossiformes. Journal of Physiology Paris. 110 (3PtB): 273 – 280 doi:10.1016/j.physparis.2017.01.002.

Fricke, R., Eschmeyer, W. N., & Fong, J. D. (2022). Species by family/subfamily [Online] Available http://researcharchive.calacademy.org/research/ichthyoloy/catalog/SpeciesByFamily.asp. (May 29, 2022)

Froese, R. & Pauly, D. (2022). FishBase. World Wide Web Electronic Publication. [Online] Available www.fishbase.org (May 29, 2022)

Hatanaka, T., Oliveira, E. A., Ráb, P., Yano, C. F., Bertollo, L. A. C., Ezaz, T., Jegede, O. I., Liehr, T., Olaleye, V. F., Marcelo de Bello Cioffi, M. B (2018). First Chromosomal Analysis in Gymnarchus niloticus (Gymnarchidae, Osteoglossiformes): Insights into the Karyotype Evolution of Osteoglossiform fishes. Biological Journal of the Linnean Society.

Helfman, G. S., Collette, R. B., Facey, D. E. and Bowen, R. B. (2009). The Diversity of Fishes: Biology, Evolution and Ecology. Wiley–Blackwell, a John Wiley and Sons, Ltd., publication. 738p.

Jegede, O. I., Akintoye, M. A. and Awopetu, J. I. (2018). Karyotype of the African weakly electric fish, Gymnarchus niloticus (Osteoglosiformes: Gymnarchidae) from Oluwa River, Nigeria. Ife Journal of Science 20 (3) 539-545.

Lavoue, S. and Sullivan, J. P. (2004). Simultaneous analysis of five molecular markers provides a well-supported phylogenetic hypothesis for the living bonytongue fishes (Osteoglossomorpha: Teleostei) Molecular Phylogeny and Evolution 33(1): 171-185.

Levan, A., Fredgaa, K. and Sandberg, A.A. (1964). Nomenclature for centromeric position on chromosomes. Hereditas 52: 201-220.

Oliveira, E. A; Bertollo, L. A. C; Ráb, P; Ezaz, T; Sandra Regina Maruyama; Yano, C. F; Andrzej, K; Jegede, O.I; Tanomtong, A; Liehr, T; Feldberg, E; Viana, P. F; Marcelo de Bello Cioffi (2020). Cytogenetics, genomics and historical biogeography of the South American and African Arapaimidae fish family (Teleostei, Osteoglossiformes) Reviews in Fish Biology and Fisheries,

Ozouf-Costaz, C., Coutanceau, J., Bonillo, C., Belkadi, L., Fermon, Y., Agnese. J., Guidi-Rontani, C. and Paugy, D. (2015). First insights into karyotype evolution within the family Mormyridae. Cybium 39(3): 227-236.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

PERFORMANCE ASSESSMENT OF INTRASPECIFIC HYBRIDS OF THAI *Oreochromis niloticus* STRAINS AND LOCAL *Oreochromis niloticus*

Ogbuebunu, K. E., M., Yisa, D. C., Nwangwu, M. I., Goni, E. A., Robert, J. O., Eze, R. Y., Atiribom, O. I., Binyontubo, G. R., Abubarkar, A., Abdullahi, M. M., Yahaya, G. Y., Khadijat, E. A., Gabriel, B. H., Okojie, C. C., Nworie, Y. S., Mohammed, A. S., Amina and H., Adamu.

[1]National Institute for Freshwater Fisheries Research, P.M.B. 6006, New Bussa, Niger State, Nigeria

Corresponding author:
kikaemmanuel@gmail.com, +234 7057905547, 0000-0003-3858-610X

ABSTRACT
This study investigated the growth performance of intraspecific hybrids of Thai *Oreochromis niloticus* strains and local *Oreochromis niloticus*. A total of 300 fingerlings were utilized for this 12-week study at the National Institute for Freshwater Fisheries Research (NIFFR) hatchery complex in New-Bussa, Niger state, Nigeria. A completely randomized design with four treatments (Hybrid 1 - TT1 x ON, Hybrid 2 - TT2 x ON, Control 1 - TT1 x TT1, and Control 2 - ON x ON) and three replicates was used. They were fed commercial fish feed and growth parameters (weight, length, feed conversion efficiency, and survival) were evaluated. Data analyses revealed significant differences in growth performance among the hybrids, providing valuable insights for sustainable aquaculture practices. The results showed that the hybrids (Hybrid 1 (TT1 x ON) and Hybrid 2 (TT2 x ON) exhibited superior growth performance and morphometric parameters compared to purebred controls (Control 1(TT1 x TT1) and Control 2 (ON x ON). The hybrids had faster growth rates, better feed efficiency, higher production capacity, and improved water quality. The study suggests that the hybrids can be a promising option for aquaculture production due to the heterosis effect. However, further research is needed to understand the cause of these differences and ensure wider applicability. The findings of this study can contribute to the development of more resilient and productive tilapia strains, supporting the long-term sustainability of global aquaculture.

Keywords:
Aquaculture, Tilapia Hybrids, Growth Performance, Intraspecific Hybridization, Water Quality Management, Sustainable Fisheries

INTRODUCTION

Intraspecific hybridization has emerged as a powerful tool in aquaculture, enabling the creation of superior strains with enhanced growth rate, disease resistance and adaptability to diverse environments (Mair et al., 2017; Mohammed *et al.*, 2021). Thai tilapia (Oreochromis spp.) and Nile tilapia *(Oreochromis niloticus)* are two of the most widely cultivated species in global aquaculture, with the latter being one of the most extensively farmed fish species worldwide (FAO, 2020). The production of intraspecific hybrids between these two species offers immense potential for improving tilapia aquaculture; leveraging the desirable traits of each parent species (Sarker *et al.*, 2024). Recent studies have demonstrated the feasibility and benefits of producing Thai *Oreochromis niloticus* strains × local *Oreochromis niloticus* hybrids, exhibiting improved growth performance, survival rate, and tolerance to environmental stressors (Ramli *et al.*, 2016; Vajargarh, 2021). However, further research is necessary to elucidate the genetic and phenotypic characteristics of these hybrids, ensure their optimal performance and sustainability in aquaculture systems.

This study aimed to investigate the intraspecific hybrids of Thai O*reochromis niloticus* strains and local O*reochromis niloticus*, focusing on their growth patterns, morphological characteristics, and genetic makeup. By exploring the potential of these hybrids, we can contribute to the development of more resilient and productive tilapia strains, ultimately supporting the long-term sustainability of global aquaculture.

MATERIALS AND METHODS

Study area: The study was carried out at the hatchery complex of National Institute for Freshwater Fisheries Research (NIFFR), New-Bussa, Niger State, Nigeria (longitude 9.881219 latitude 4.539907).

Broodstock selection: Healthy and mature broodstock (males and females) Thai O*reochromis niloticus* strains and local O*reochromis niloticus* were collected from the Tilapia hatchery Unit, at the hatchery complex of National Institute for Freshwater Fisheries Research, New-Bussa, Niger State

Source of water and quality management: The water source for this research was the Kigera dam, a reservoir located in NIFFR, New-Bussa, Niger State. Water quality parameters (temperature, pH, dissolved oxygen levels) were monitored using Winkler's method as documented by APHA (1985; 1990).

Experimental design: The experimental design employed in this study was a completely randomized design, with 4 treatments and 3 replicates.

Hybridization and breeding protocol: Using a ratio of 1 male to 3 females, Thai Oreochromis niloticus males with local O*reochromis niloticus* females (Thai O. *niloticus* ♂ x local O. *niloticus* ♀) were paired in happa nets, immersed in water, in 2 by 2 meters concrete tanks. Experimental hybrid combinations include:

- Treatment 1: TT1 x ON1 (Thai O. niloticus ♂ x local O. *niloticus* ♀) (Hybrid 1)
- Treatment 2: TT2 x ON2 (Thai O. *niloticus* ♀ x local O. *niloticus* ♂) (Hybrid 2)
- Treatment 3: TT1 x TT2 (Pure Thai O. *niloticus* 1, Control 1)
- Treatment 4: ON1 x ON2 (Pure local O. *niloticus*, Control 2)

Experimental units: 12 experimental units (each with a capacity of 1000 liters), comprising 4 treatments and 3 replicates were used. Each replicate contained 25 fingerlings.

Diets and feeding regimen: A commercial fish feed was used to feed the fish 3 to 4 times daily, while waste were regularly siphon from the tanks to maintain clean water conditions, thereby promoting optimal growth and development of the fish species.

Data collection and evaluation of Performance: Data was collected during bi-weekly random sampling of experimental fingerlings to monitor growth progression. The following parameters were evaluated: initial and final weight, weight gain, initial and final length, length gain, feed conversion efficiency and specific growth rate.

Statistical analysis: Data was analyzed using descriptive statistics, and one-way ANOVA was employed to determine significant differences between means. When significant differences were found, Duncan's Multiple Range Test was used to compare and identify specific means. Regression analysis was also performed

RESULTS

Table 1: Growth Performance Parameters of Interspecific Hybrids and Purebred Controls

Treatment	MIW (g)	MFW (g)	MWG (g)	SGR	FCR	FCE	PI	CF	Length Increase
Hybrid 1 (TT1 x ON1)	10.5 ± 0.3 [a]	51.2 ± 2.5 [a]	40.7 ± 2.2 [a]	3.5 ± 0.2 [a]	1.2 ± 0.1 [b]	82.1 ± 3.5 [a]	273.9± 15.6 [a]	1.9± 0.1 [a]	45.6± 2.8 [a]
Hybrid 2 (TT2 x ON2)	10.8 ± 0.4 [a]	48.5 ± 2.1 [b]	37.7 ± 1.9 [b]	3.2 ± 0.2 [b]	1.3 ± 0.1 [b]	78.5 ± 3.1 [b]	251.1± 12.9 [b]	1.8± 0.1 [b]	42.1± 2.5 [b]
Control 1 (TT1 x TT2)	10.2 ± 0.3 [a]	40.8 ± 1.9 [c]	30.6 ± 1.7 [c]	2.9 ± 0.2 [c]	1.4 ± 0.1 [a]	74.2 ± 2.9 [c]	219.8± 10.3 [c]	1.7± 0.1 [c]	38.5± 2.2 [c]
Control 2 (ON1 x ON2)	11.0 ± 0.4 [a]	38.2 ± 1.8 [d]	27.2 ± 1.5 [d]	2.5 ± 0.2 [d]	1.5 ± 0.1 [a]	70.3 ± 2.6 [d]	201.9± 9.5 [d]	1.6± 0.1 [d]	35.1± 2.0 [d]

Means in the same columns (for each section) with different superscript are statistically significant ($p<0.05$). MIW=Mean initial weight (g), MFW= mean final weight (g), MWG =weight gain (g), SGR = % specific growth rate, FCR=feed conversion ratio, FCE=feed conversion efficiency, PI= performance index, CF=condition factor, TT1 = Thai O. niloticus ♂, TT2 = Thai O. niloticus ♀, ON1 = local O. niloticus ♀ and ON2 = local O. niloticus ♂

Table 2: Length-weight relationship regression of intraspecific hybrids and purebred controls

Treatment	Intercept (a)	Growth Pattern (b)	Coefficient of Determination (R^2)
Hybrid 1 (TT1 x ON1)	4.23 ± 0.21 [a]	0.85 ± 0.04 [a]	0.95 ± 0.02 [a]
Hybrid 2 (TT2 x ON2)	4.15 ± 0.19 [b]	0.79 ± 0.03 [b]	0.92 ± 0.02 [b]
Control 1 (TT1 x TT2)	3.98 ± 0.18 [c]	0.73 ± 0.03 [c]	0.88 ± 0.02 [c]
Control 2 (ON1 x ON2)	3.85 ± 0.17 [d]	0.69 ± 0.03 [d]	0.85 ± 0.02 [d]

Table 3: Water quality parameters for intraspecific hybrids and purebred controls

Treatment	Temperature (°C)	Dissolved Oxygen (DO) mg/L	pH
Hybrid 1 (TT1 x ON1)	28.5 ± 0.5 [a]	5.8 ± 0.2 [b]	7.4 ± 0.1 [a]
Hybrid 2 (TT2 x ON2)	28.2 ± 0.4 [a]	5.5 ± 0.2 [b]	7.3 ± 0.1 [a]
Control 1 (TT1 x TT2)	28.0 ± 0.4 [b]	5.2 ± 0.2 [c]	7.2 ± 0.1 [b]
Control 2 (ON1 x ON2)	27.8 ± 0.4 [b]	5.0 ± 0.2 [c]	7.1 ± 0.1 [b]

Means in the same columns (for each section) with different superscript are statistically significant ($p<0.05$).

DISCUSSION

Growth Performance Parameters: Results of growth performance of interspecific hybrids and purebred controls (Table 1) show significant differences among the treatments. Hybrid 1 (TT1 x ON1) exhibited the best growth performance, followed by Hybrid 2 (TT2 x ON2), while the purebred controls (Control 1(TT1 x TT2) and Control 2 (ON1 x ON2) showed relatively lower growth performance (Table 1). The initial mean weight (MIW) was similar among all treatments, indicating that the fish started with similar weights. However, the final mean weight (MFW), mean weight gain (MWG), and specific growth rate (% SGR) were significantly higher in Hybrid 1(TT1 x ON1) and Hybrid 2 Hybrid 2 (TT2 x ON2) compared to the purebred controls (Control 1(TT1 x TT2) and Control 2 (ON1 x ON2). This suggests that the hybrids had a faster growth rate and better

growth performance than the purebred controls. Recent studies (Gjedrem *et al.*, 2019; Liu *et al.*, 2020; Nguyen et al., 2022) have also reported similar findings, highlighting the superior growth performance and feed efficiency of interspecific hybrids in aquaculture. These studies, along with the current study, demonstrate the consistent superiority of interspecific hybrids in terms of growth performance and feed efficiency, likely due to the *heterosis* effect. The results suggest that hybrids can be a promising option for aquaculture production, offering improved productivity and efficiency.
The feed conversion ratio (FCR) was significantly lower in Hybrid 1 (TT1 x ON1) and Hybrid 2 (TT2 x ON2) compared to the purebred controls (Table 1), indicating that the hybrids were more efficient in converting feed into biomass. The feed conversion efficiency (FCE) was also significantly higher in Hybrid 1 and Hybrid 2 (Table 1), further supporting the superior growth performance of the hybrids. The performance index (PI) was significantly higher in Hybrid 1 and Hybrid 2, indicating that the hybrids had a higher production capacity than the purebred controls. The condition factor (CF) (Table 1) was also significantly higher in Hybrid 1 and Hybrid 2, suggesting that the hybrids had better body condition and health status. The length increase was significantly higher in Hybrid 1 and Hybrid 2, indicating that the hybrids had a faster growth rate in length.

Length-weight relationship: The intercept (a) represents the initial length of the fish, and the results indicate that Hybrid 1 (TT1 x ON1) had the highest initial length (4.23 cm), followed by Hybrid 2 (TT2 x ON2) (4.15 cm), Control 1 (TT1 x TT2) (3.98 cm), and Control 2 (ON1 x ON2) (3.85 cm). These differences in initial length may be due to genetic differences among the treatments. The growth pattern (b) represents the slope of the length growth curve, and the results indicate that Hybrid 1 had the steepest growth curve (0.85), followed by Hybrid 2 (0.79), Control 1 (0.73), and Control 2 (0.69). This suggests that the hybrids had a faster growth rate than the purebred controls. The coefficient of determination (R^2) represents the goodness of fit of the growth model, and the results indicate that Hybrid 1 had the best fit (0.95), followed by Hybrid 2 (0.92), Control 1 (0.88), and Control 2 (0.85). This suggests that the growth model was more accurate for the hybrids than for the purebred controls. Overall, the results indicate that the interspecific hybrids (Hybrid 1 and Hybrid 2) exhibited better length growth performance compared to the purebred controls (Control 1 and Control 2).

Water Quality Parameters: The results of the water parameters for interspecific hybrids and purebred controls show that the hybrids and purebred controls were reared in similar water conditions, with some significant differences. Temperature (°C) was similar among all treatments, ranging from 27.8°C to 28.5°C, which is within the optimal range for tilapia growth. Dissolved Oxygen (DO) levels were significantly higher in Hybrid 1 (5.8 mg/L) and Hybrid 2 (5.5 mg/L) compared to Control 1 (5.2 mg/L) and Control 2 (5.0 mg/L). This suggests that the hybrids were able to maintain better water quality in terms of oxygen levels. pH levels were significantly higher in Hybrid 1 (7.4) and Hybrid 2 (7.3) compared to Control 1 (7.2) and Control 2 (7.1). This indicates that the hybrids were able to maintain a more stable and optimal pH range. The hybrids' superior water quality is attributed to a combination of biological (improved feeding efficiency and enhanced digestion), physiological (efficient gill function and better osmoregulation) and environmental factors (efficient stocking density, improved water circulation and efficient water quality maintenance).

CONCLUSION

The differences in growth performance among the treatments may have important implications for aquaculture production. Therefore, it can be concluded that the hybrids' faster growth rate and improved growth performance can make them a more suitable option for farmers, potentially leading to increased productivity and profitability. However, further research is needed to fully understand the causes of these differences and to determine the long-term effects of hybridization on growth performance and other important traits. Additionally, the results of this study should be verified in other environments and with other species to ensure their wider applicability.

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REFERENCES

American Public Health Association (APHA). (1985). Standard methods for the examination of water and wastewater. APHA

American Public Health Association (APHA). (1990). Standard methods for the examination of water and wastewater. APHA

Food and Agriculture Organization (FAO) of the United Nations. (2020). The state of the world's fisheries and aquaculture

Gjedrem, T., Robinson, N., and Rye, M. (2019). The importance of selective breeding in aquaculture. Reviews in Aquaculture, 11(2), 247-257.

Liu, Y., Li, S., and Qin, J. G. (2020). Genetic improvement of tilapia: A review. Aquaculture, 522, 735-242.

Mair, G. C., Abucay, J. S., Skibinski, D. O. F., and Beardmore, J. A. (2017). Genetic improvement of farmed tilapias: Genetic parameters for growth and survival. Aquaculture, 468, 157-166.

Mohammed, A. A., Ahmed, A. M., and Hassan, A. A. (2021). Growth performance and feed utilization of Nile tilapia (Oreochromis niloticus) and Thai tilapia (Oreochromis spp.) hybrids. Journal of Aquaculture Research and Development, 12(3), 1-8.

Nguyen, N. H., Ponzoni, R. W., & Hampton, J. (2022). Genetic improvement of tilapia: A review of recent progress. Reviews in Aquaculture, 14(1), 1-18.

Ramli, N. S., Dan, S. K., and Hashim, R. (2016). Growth performance and survival rate of Thai tilapia (Oreochromis spp.) and Nile tilapia (Oreochromis niloticus) hybrids. Journal of Aquaculture and Fisheries, 1(1), 1-8.

Sarker, A. K., Islam, M. M., and Hossain, M. A. (2024). Hybridization between Thai tilapia (Oreochromis spp.) and Nile tilapia (Oreochromis niloticus): A review. Journal of Fisheries and Aquatic Science, 19(1), 1-12.

Vajargarh, H. R. (2021). Comparative study on growth performance and feed efficiency of Thai tilapia (Oreochromis spp.) and Nile tilapia (Oreochromis niloticus) hybrids. Journal of Aquatic Science and Technology, 9(2), 1-10

COMPARATIVE STUDY OF THE EFFECTIVENESS OF COCONUT WATER AND SALINE SOLUTION IN BREEDING OF *Clarias gariepinus*

[1]Isaac, M. K., [1]A. T. Yisa, [2]T. M. Jibril, [2]L. U Onyia and [1]S. A. Olayimika

[1]Department of Water Resources Aquaculture and Fisheries Technology Federal University of Technology P. M. B. 65 , Minna, Niger State
[2]Modibbo Adama University, Yola

Correspondence author:
kwalamicah@gmail.com Phone: +234706506493

ABSTRACT
Comparative study of the effectiveness of Coconut water and saline solution in breeding of *Clarias gariepinus* fingerlings. Was carried in a farm hatchery within Abuja environment. With the aim of evaluating the fecundity, percentage fertilization, hatchability and growth performance and Survival of the hatchlings. Pair of broodstock was obtained in a commercial fish farm in Abuja. The eggs were spawned into six treatment with three replication each, thereafter at fry stage at the second phase of the study thirty fry from each treatment were randomly selected and stock in labelled 20litre plastic bowls T1, T2, T3, T4,T5 and T6 in three replicate each for determination of growth performance. Hatchlings were reared for the period of eight weeks. The result indicates that higher percentage fertilization was recorded in T2 (2:5ml) each of coconut water and saline solution at (98%) with the least been recorded in T3 (3:2ml) of coconut water and saline solution at (92%). Meanwhile higher hatchability was recorded in T3 (3:2ml) of coconut water and saline solution at (92.4%) and lower was experienced in T1the control at (80.0%) Specific growth rate was higher in T3 (5.30000±0.360555a) than in T4 with mean growth being (4.36667±0.202759b). Higher survival was achieved in both T2 (72.5667±5.88907a) and T6 (72.1667±6.36614a) and lower in T4 (62.6333±3.41874a) during the period of the study at fingerling stage. In addition, the cost of using coconut water and saline was also compared.

Keywords:
coconut water,
saline ,fecundity

INTRODUCTION

Artificial propagation of fish is a most promising and reliable way of ensuring availability of good quality fish seeds all year round and sustainability of the Aquaculture industry.

It involves the use of natural (hypophysation) or synthetic hormones to induce ovulation and spawning in farmed fishes (Olumuji *et al.*, 2012). It is a method used for fishes that do not normally breed in captivity. The fish farming industry has been more focused towards the quality of eggs and larvae rather than that of spermatozoa, even though the spermatozoa quality of male brood stock also affects the production of healthy larvae (Rurangwa *et al.*, 2004). Artificial fish propagation is the most effective and reliable way of ensuring the availability of high-quality fish seed throughout the year and the sustainability of the aquaculture industry. Normal saline which is the commonly used form of saline solution is prepared by dissolution of 9 g of NaCl in 1 litre of water (Madu 1989). Saline solution is used not only as a carrier of homogenate but also as a preservative for the milt. (Orji *et al.* 1997) reported that the success of induced spawning is as a result of the application of saline solution. Saline solution has been used for storing and preserving animal cells. The quantity or rate of application differs among researchers (Adebayo and Popoola, 2008). The quantity of saline mixed with milt before it is used to fertilized stripped eggs is suspected to have an effect on the fertilization rate, hatchability rate and survival rate of the eggs (Okunsebor *et al.*, 2014). Coconut water is rich in low levels of fat, carbohydrates, and electrolytes such as potassium, sodium, calcium, and magnesium (Saat *et al.*, 2002). The concentrations of these electrolytes in coconut water produce an osmotic pressure which is similar to that observed in blood (Fernandes *et al.*, 2000). Coconut water also contains B vitamins which are required as co-enzymes for enzymatic reactions for cellular function (Depeint et al., 2006). Coconuts are of different sizes and varieties among which are: Malayan green dwarf, Malayan yellow dwarf, Malayan orange dwarf, West African tall coconut and the hybrid varieties (Odewale et al., 2013). Coconut fruits are said to be mature when they are 12 months and above, while the ones between 6 and 8 months are considered immature coconut fruits. The use of coconut water in aquaculture is gradually gaining attention as observed in Nwachi and Yuzine, 2015, who used coconut water in the hypophysation of C. *gariepinus*. Coconut water was also realised to contain sugars such as: sucrose, glucose and fructose however, saline solution was discovered to contain no sugar, protein, and other parameters found in the coconut water. The pH value of mature coconut water was also observed to be relatively similar to that of saline solution.(Akanmu and Ipinmoroti *et al.*, 2019). The objectives of this study are to evaluate the efficacy of using different dilutions of saline water and coconut water in reproductive performance of C. *gariepinus* as well as the growth of hatchlings under hatchery conditions.

MATERIALS AND METHOD

Experimental sites

The study was conducted at a fish farm hatchery located at Gidan mangoro, by Loyola Jesuit College, Karu-Karshi Express Road, FCT, Abuja. The FCT covers an area of approximately 7315 square km having a population of 3,564,126 (2016 estimates) in the north central part of Nigeria between latitude 8°25' N and 9° 25' and longitudes 6° 45' and 7° 45' E (National Population commission (NPC), 2006).

The Farm is located within Latitude 8.997o and Longitude 7.599o with an Altitude of 388.3 meters above sea level.

Experimental design

A Completely Random Design (CRD) was used for this experiment in which six (6) spawning trials was carried out with three replicates each. The six treatments were based on the different volumes of Coconut water and saline solution used, different ratio of saline solution and coconut water represented as T1, T2, T3, T4, T5, T6 respectively and each treatment has three replicates with stocking density of 30 pieces of fry. The respective volumes of different ratio of coconut water and saline solution in millimeters that was used are as follows:

Treatment T1 (control without saline and coconut water)

Treatm ent T2 (coconut water 2.5ml and saline solution 2.5ml).

Treatment T3 (coconut water 2ml saline solution 3ml)

Treatment T4 (coconut water 3ml saline solution 2ml)

Treatment T5 (coconut water 5:0 mil only)

Treatment T6 (saline solution 5:0 mil only)

Fertilization and incubation

In each incubation tank of six twenty-five liter filled with clean and well-oxygenated water, free of plankton organisms, the fertilized eggs were placed on the spawning net (Kakaban) (Delince et al., 1987). After 10 hours of fertilization, the dead eggs were observed to be white and opaque in appearance. As soon as the fertilized eggs were spread across the spawning net (kakaban) inside the incubation tanks, the incubation period began. All treatments undergo an incubation period of 20-24 hours during the experiment. Hatching started after 24 hours of incubation during the investigation and lasted for 2-3 hours, after which the kakaban were removed with the unhatched eggs. The broken fry shells and dead unfertilized eggs were siphoned out of the incubation tank, then flow-through system was run to refresh the water completely.

Water Quality Parameters

Water quality parameters such as dissolved Oxygen; pH and temperature required for growth and other biological processes was monitored weekly.

Dissolved Oxygen (DO) was determined directly by using DO meter and temperature was determined weekly using mercury in-glass thermometer and reading will be recorded.

Data Analysis

Data obtained from fertilization, hatchability, survival, growth, water quality parameters, of the treated bowl and the control was subjected to statistical analysis. One way analysis of variance (one way ANOVA) was used. The difference between the means was determined using Least Significant Difference (LSD) at 95% while means was compared for significant differences ($p<0.05$).

RESULTS AND DISCUSSION

The highest fertility and hatchability percentages recorded in T2 the fertilized eggs mixed with coconut water and saline solution at the same dilution ratio of 2.5ml each at (98%) is in agreement with the results of Muchlisin et al., (2010) who reported coconut water at dilution level of 1:20 as best extender for C. gariepinus spermatozoa. The better results recorded in treatment T2 with same dilution ratio of 2.5ml each of both coconut water and saline solution is among the natural extenders could be attributed to the fact that extender is a buffer solution which contains inorganic compounds that determine the longevity, success, or failure of spermatozoa (Omitogunet al., 2012).

Highest hatchability was recorded in T3 treated with different dilution of coconut water and saline solution 3:2ml at (92.40%) this agrees with the findings of Rasowoet al. (2007) who reported that physiological saline solution provides a conducive environment for egg hatching. In addition, it has been reported that both freshwater and brackish water fish species possess hatching enzymes with salt-dependent characteristics (Kawaguchi, 2013).

Survival rate of the fingerlings was recorded higher in T2 same dilution ratio of coconut water and saline solution 2.5ml each at (72.5667±5.88907 a) and T6 with 5ml of saline solution only at (72.1667±6.36614 a) when compared to T4 with different dilution ratio of coconut water and saline solution at 2:3ml which is similar to the findings of Dokuboba et al. (2018) who reported low survival rate in the hatchlings of C. gariepinus produced using physiological solutions of different concentrations. The results of water quality parameters monitored during the study revealed that the values obtained in each water quality parameters monitored were in the optimum range for fish production as reported by Boyd (1998).

CONCLUSION AND RECOMMENDATION

The study revealed that matured coconut water might be a good substitute for saline solution in breeding of C. gariepinus at same dilution ratio of 2.5ml each. It was also discovered that mixing mature coconut water with saline solution at ratio 2.5ml each enhanced better fertilization, hatchability and hatchlings survival rate of C. gariepinus.

REFERENCE

Adebayo, O.T. and Popoola, O.M. (2018). Comparative evaluation of efficacy and cost of synthetic and non synthetic hormones for artificial breeding of African catfish (clarias gariepinus, burchell 1822). Journal of fisheris and aquatic science, 3(1);66-71

Adewolu, M. A., Adeniji, C. A., and Adejobi, A. B. (2008). Feed utilization, growth and survival of Clarias gariepinus (Burchell 1822)

Akankali, J.A., Seiyaboh, E.L. and Abowei, J.F.N. (2011). Fish hatchery and management in Nigeria. Advance Journal of Food Science and Technology, 3(2):144-154, 2011.

Anne, M.H. (2016). How to make saline solution at home.Retrieved on 17th may, 2016 from http: // chemistry. about.com |od| lab recipes |a| How-To-make-saline- solution. HTML

Atse, C.B., Audet, C. and De La Noue, J. (2002). Effects of temperature and salinity on the reproductive success of Arctic charr, Salvelinus alpinus L.: Egg composition, milt characteristics and fry survival. Aquaculture Resources, 33: 299-309

Awad S, Allison SP, Lobo DN (April 2008). "The history of 0.9% saline". Clinical Nutrition. 27 (2): 179–188. doi:10.1016/j.clnu.2008.01.008. PMID 18313809.

Billiard, R. and Cosson, M.P. (1992). Some problems related to the assessment of sperm motility in fresh water fish. Journal of Experimental Zoology, 261:122-131.

Charo, H and Oirere, W. (2000). River-based artificial propagation of the African catfish, Clarias gariepinus: An option for the small fish farmer. NAGA:The International Center for Living Aquatic Resources Management Quarterly. January -March, 2 (1):14-16

Dada, A. A.and A. E. Fagbohun (2018). Effects of Dietary Supplementation of Date palm (Phoenix dactyliferaL.) Seed on Milt Quality of African Catfish (Clarias gariepinus) Broodstocks. The Journal of Agricultural Sciences13 (2): 153-161.

Dalton C (31 March 2018). "Why Did Sterile Salt Water Become The IV Fluid Of Choice?". NPR.org.

Fagbenro, O.A., salami, A.A and Sydenhan, H.J. (1991).“Induced Ovulation and Spawning in the Catfish (Clarias isheriensis) using Pituitary Extract from Non- piscine sources”.Journal of Applied Aquaculture 1: 15-20

FAO, (1996).“Artificial Reproduction and pond rearing of the African Catfish (Clarias gariepinus). Food and Agricultural Organization of the United Nations. Fisheries and Aquaculture Department, Rome, 4:38-48

Froese, Rainer and Pauly, Daniel, eds. (2014).”Clarias gariepinus" in FishBase. March 2014 version

Olumuji O.K., Mustapha M.K. (2012) “Induced breeding of African Mud catfsh,Clarias gariepinus (Burchell 1822), using different doses of normal saline diluted ovaprim.” Journal of Aquaculture Research Development 3: 133

ENHANCING GENE EXPRESSION STUDIES IN FISHERY MOLECULAR BIOLOGY THROUGH PRIMER UTILIZATION

Joseph J. B. [1], O. R. Oguntade [2] and O. R. Osoniyi [1]

[a] Department of Biochemistry and Molecular Biology, Obafemi Awolowo University, Ile-Ife, Nigeria.
[b] Department of Biotechnology, Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos, Nigeria

Correspondence: japhetbawa@gmail.com

ABSTRACT

The current study delves into the significance of primer selection in the PCR and sequencing of the TNF-*a* gene in two tilapia species, focusing on the physiological features indicated in specific gene areas. Fish samples were obtained from the Badore Jetty, Lagos, Nigeria, with specific coordinates provided. The research involved RNA extraction, cDNA synthesis, and PCR amplification, followed by sequencing using two sets of specific primers. The amplified products were analysed using agarose gel electrophoresis, and the specificity of the primers was verified through Sanger sequencing. The findings revealed that both TNF*a*-1 and TNF*a*-2 primers effectively amplified and expressed the target gene of interest, resulting in amplicons of 160 bp and 565 bp, respectively. Notably, TNF*a*-2, targeting the more extended gene region, provided a more comprehensive nucleotide sequence offering a greater depth of expression information than TNF*a*-1. The study underscores the critical role of primer selection in conducting precise and insightful gene expression studies within fishery science. The implications of these results are significant, as they extend to applications in fishery genetics research, aquaculture, and species conservation, highlighting the pivotal importance of accurate primer selection in advancing molecular biology investigations within fish populations.

Keywords:
Gene expression,
Primers, TNF-*a*,
Tilapia, PCR,
Sanger sequencing,
Fishery molecular biology.

INTRODUCTION

Primers are fundamental tools in gene expression studies, especially in fishery molecular biology (Maduna et al., 2020), where precise genetic analysis is essential for understanding species biology, population dynamics, and conservation needs. These short nucleotide sequences (Primers) initiate DNA synthesis during Polymerase Chain Reaction (PCR), which is crucial for amplifying specific regions of interest in a gene (Karunanathie et al., 2022). The accuracy and effectiveness of PCR-based gene expression studies depend heavily on the careful design and selection of primers, which directly influence amplification, ensuring specificity and fidelity in detecting gene expression levels (Blay et al., 2022). Accurately targeting gene regions is pivotal for generating reliable genetic data to inform critical ecological and evolutionary insights.

In the context of fishery research, primers are frequently designed to amplify critical genes involved in physiological responses, such as those encoding innate immune-related proteins or metabolic enzymes. These genes provide valuable information for understanding how fish populations adapt to environmental changes, pathogens, or aquaculture practices. However, given the genetic variability across species, the primer design must be optimized to ensure specificity and avoid off-target amplification while targeting significant regions with comprehensive genetic information about a particular gene (Cermakova et al., 2023). For example, primers designed to amplify a shorter gene region might not have reasonable information about a gene study; also, nuclear or mitochondrial genes are essential for tracking species-specific gene expression patterns and detecting variations that may indicate a physiological feature in fish species.

The emergence of next-generation sequencing (NGS) technologies has heightened the importance of precise primer design in gene expression studies in Fishery research (Rather et al., 2023). Even slight mismatches in primer sequences can introduce biases, leading to inaccurate quantification of gene expression levels, especially when dealing with complex or mixed-species samples (Bruce et al., 2021). This study aims to investigate the impact of primer design on the accuracy and reliability of gene expression analysis in fishery molecular biology. By optimizing primer selection, researchers can ensure the amplification of specific target gene regions having important information, leading to more accurate assessments of gene expression and ultimately advancing the understanding of fish populations and their ecological roles.

MATERIALS AND METHODS

Sample collection, identification, and storage

The selection of fish species, especially tilapia and the sampling sites: Adore Jetty geographical coordinates include the following: latitude 06° 3023.1" N and Longitude 003°3415.8" E) is based on some factors that surround aquaculture. Correctly identifying the captured tilapia species was crucial for the subsequent molecular analyses. This identification was made by using morphometric characters, which helped in accurate identification at the time of capture by fishermen during this research.

In the laboratory, the researchers quickly took approximately 1 g fillet tissue samples from each of the identified tilapias, as earlier reported by Joseph et al. (2023). Some of these samples were immediately plunged into 1 ml RNA Later buffer within 2 ml Eppendorf tubes for future RNA analysis. This methodical approach ensures the preservation of RNA integrity, which is crucial for reliable molecular investigations.

The prepared samples were immediately placed in a freezer at -20 °C to prevent degradation of the molecules in the samples through enzymatic and chemical reactions. This strict storage protocol was followed to preserve the RNA integrity, which is crucial in molecular biology.

RNA extraction, quantification, and cDNA synthesis

RNA extraction was done using the JENA mini kit by following the instructions in the manufacturer's book from Jena Bioscience, Germany. The quality of the extracted RNA was determined from the absorbance spectra obtained from a NanoDrop 2000 UV spectrophotometer (Thermo Fischer Scientific, Waltham MA, USA) by calculating the absorbance ratio at 260 nm to that at 280 nm wavelengths. To make cDNA, Reverse Transcription Polymerase Chain Reaction (RT-PCR) was conducted with FireScript RT cDNA synthesis kits, a product of FIREScript®, Estonia, and prepared per the standard protocols provided by the manufacturers. The reaction utilized oligo-dT primers and adhered to the following thermal profile: The reverse transcription step was done at 65 °C for 5 min, annealing of the primers at 25 ˚C for 10 min, and the inactivation of the reverse transcriptase enzyme at 85 °C for 5 min.

Table 1 Oligonucleotide primers used in experiments

Name	Nucleotide sequence(5′→3′)	Base pair
GAPDH-F	GCCCTCTGGTAAAATGTGGA	450
GAPDH-R	ATTCCCTTCATGGGTCCTTC	
TNF α1 - F	GTCGTCGCTATTCCCGCAGATCA	875
TNF α1 - R	GGTTAGTTGAGAAGAAATCACCTGCA	
TNF α2 - F	CAGGATCTGGCGCTACTCAG	180
TNF α2 - R	TAGCTGGTTGGTTTCCGTCC	

The housekeeping gene used to quantify cDNA was Glyceraldehyde-3-Phosphate Dehydrogenase (GAPDH), with the primer sequence shown in Table 1.0. The amplification process started with an initial denaturation at 94 °C for 2 minutes. It was further proceeded by 30 cycles of denaturation at 94 °C for 30 seconds, annealing at 54 °C for 30 seconds, and extension at 72°C for 30 seconds.

Tumor necrosis factor gene amplification and Sequencing

The primer set detailed in Table 1 was utilized to amplify the TNF-*a* genes of the two primers from the quantified cDNA. The thermal cycling conditions consisted of an initial denaturation step at 94 °C for 2 minutes, followed by 25 cycles comprising denaturation at 94 °C for 30 seconds, annealing at 57 °C for 30 seconds, and extension at 72 °C for 30 seconds.

After amplification, the PCR products were resolved and visualized on a 2% agarose gel. The bands, stained with ethidium bromide, were quantified using a UV transilluminator (Kodak E3000). Sanger sequencing—recognized as the gold standard in DNA sequencing—was employed to ensure high accuracy. The resulting sequences were exported in FASTA format for further bioinformatics analysis. This thorough sequencing protocol guarantees the reliability of the sequences obtained. The FASTA sequences underwent extensive bioinformatics analysis to identify potential variants and relevant genetic information related to the amplified TNF-*a* gene. This robust approach facilitates a reliable evaluation of TNF-*a* amplification and preserves the sequences' accuracy and integrity for subsequent bioinformatics assessments.

RESULTS AND DISCUSSION

Distribution of Fish Species in Sampled Regions

Along with other fish species, 54 tilapia species were collected by fishermen during the sampling time. Sarotherodon melanotheron and Coptodon guineensis were identified and consequently chosen for further studies. These species have ecological significance and are frequently used as model organisms in studies of fishery molecular biology because of their genetic diversity and adaptive characteristics (Lalèyè et al., 2021). They establish the fact that the biodiversity of the sampled areas is diverse, and call for further molecular studies in order to unravel more of the genetic factors that underpin such living organisms' capability to adapt.

RNA Extraction, Quantification, and cDNA Synthesis

The RNA extraction from the above identified species gave good concentration above the optimum concentration of 10 ng/μl with a A260/A280 ratio greater than 1.8 indicating the quality of RNA required for further analysis (Ruiz-Ojeda, 2020). PCR amplification of the synthesized cDNA and subsequent gel electrophoresis on 2% agarose gel further suggests the quality of syn5hesized cDNA, gel reveals bands of GAPDH presented in lane 1-9.

The absence of non-specific bands or primer dimers underscores the high fidelity of the synthesis process. These results are in concordance with routine practices in molecular biology where RNA purity and integrity of cDNA synthesis are cardinal steps in gene expression analysis. GAPDH amplicons provided further evidence for the reproducibility of the method and its applicability for further steps, including target gene amplification and sequencing (Kuzan et al., 2023).

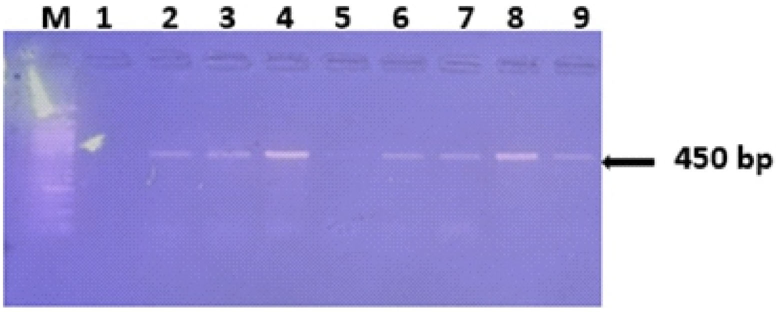

Figure 1. Agarose Gel Electrophoresis of Quantified cDNA Samples.

Tumour necrosis factor gene amplification and Sequencing

Consequently, two regions of interest of TNF-*a* gene were successfully amplified from cDNA of interested tilapia species in this study and these were 150 bp and 875 bp as determined by DNA ladder makers in PCR gel (Figures 2 and 3) confirming Joseph et al. (2023). The appearance of only distinct bands in all the PCR products affirm the specificity of the chosen primers in line with Ye et al. (2012); hence, they do not amplify non-specified DNA sequences or form primer-dimers confirming Karunanathie et al. (2022).

These results further confirms the stable expression of TNF-*a* gene in all Sarotherodon melanotheron and Coptodon guineensis tested, which may support the TNF-*a* gene as a candidate biomarker for stress or immune response investigation(Xiong et al., 2012).

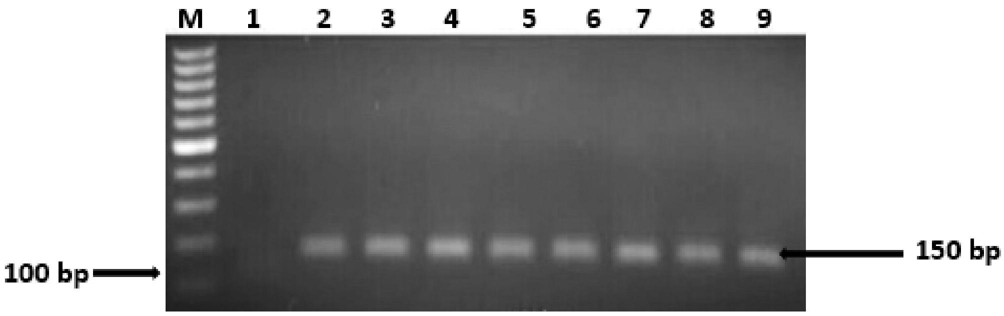

Figure 2. Agarose Gel Electrophoresis of TNF*a*-1 primers Amplicons Samples.

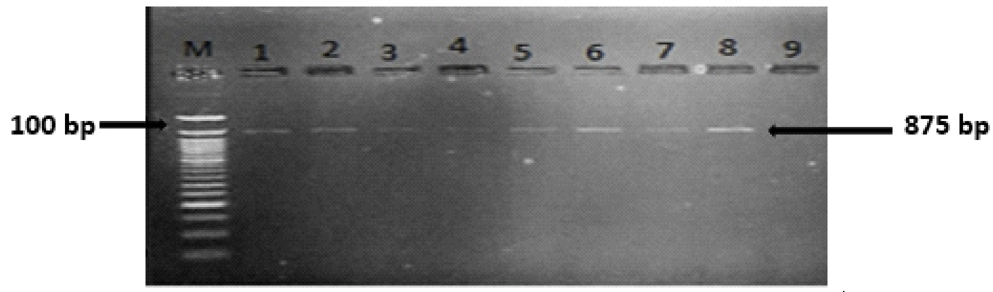

Figure 3. Agarose Gel Electrophoresis of TNF*a*-2 Amplicons.

High-quality chromatograms were produced by sequencing TNF-*a* amplicons with forward primers; TNF*a*-1 and TNF*a*-2 generated FASTA sequences of 160 and 565 base pairs, respectively. The sequences were analyzed using BLAST against the NCBI database as stipulated by De Cario et al. (2022) revealing notable variations in sequence length and targeted regions (Tables 2 and 3). These variations demonstrate the importance of primer design in obtaining particular genetic information of same gene of interest and illustrate the elaborate nature of tilapia species gene expression research. The observed variances highlight the significance of precise primer design in molecular biology research and may be explained by species-specific genetic diversity or changes in primer-binding sites (Zha ng et al., 2020).

Table 2: A typical NCBI Hit Table for TNF*a*-1 Primer used for Sanger Sequencing

S/n	Scientific Name	Accession	Query Cover	E value	Per. ident	Acc. Len
1	*Oreochromis aureus*	XM_031754288.2	90%	2E-63	98.61	1287
2	*Cyprinus carpio*	JF957372.1	90%	2E-63	98.61	352
3	*Astatotilapia calliptera*	XM_026183917.1	90%	1E-61	97.92	1268
4	*Pundamilia nyererei*	XM_005750958.1	90%	1E-61	97.92	1264
5	*Haplochromis burtoni*	XM_005923630.2	90%	1E-61	97.92	1403

Table 3: A Typical NCBI Hit Table for Second TNF*a*-2 Primer used for Sanger Sequencing

S/n	**Scientific Name**	**Accession**	**Query Cover**	**E value**	**Per. ident**	**Acc. Len**
1	*Oreochromis aureus*	XM_031754288.2	52%	4E-96	94.51	1287
2	*Oreochromis niloticus*	NM_001279533.1	52%	4E-96	94.51	1306
3	*Simochromis diagramma*	XM_040030873.1	52%	9E-88	92.41	2488
4	*Neolamprologus brichardi*	XM_006801812.2	41%	9E-88	92.41	1239
5	*Astatotilapia calliptera*	XM_026183917.1	52%	4E-86	91.98	1268

Implications for Fishery Molecular Biology

The TNF-*a* gene was successfully amplified and sequenced, proving the validity of the experimental procedure for examining fish species' gene expression. In order to efficiently target particular genomic areas, primer optimisation is crucial, as demonstrated by the observed sequence variations. These kinds of results are crucial in fishery molecular biology, where genetic research informs conservation plans and aquaculture enhancements. The development of genetic markers to track fish health and resilience under environmental stressors is made possible by them, in addition to offering insights into the molecular basis of adaptive features.

CONCLUSION

This study underscores the pivotal role of primer design in advancing gene expression studies within fishery molecular biology. The successful amplification of TNF-*a* from tilapia samples using well-designed primers illustrates the critical importance of targeting precise gene regions to obtain reliable genetic data. Primers are not only essential tools for amplifying specific gene segments, but their design and selection are instrumental in ensuring the accuracy and specificity of gene expression analyses.

The findings highlight that even slight variations in primer sequences, as demonstrated by the TNF*a*-1 and TNF*a*-2 primers used in this study, can result in significant differences in the information obtained from gene expression profiles. TNF*a*-2, targeting a more extended gene segment, provided more comprehensive genetic data than TNF*a*-1, which amplified a shorter and less informative sequence. This variation emphasizes the need to select primers that capture extensive and biologically relevant gene regions, particularly in complex molecular studies like fishery biology. Moreover, the successful application of Sanger sequencing in this study confirmed the specificity and integrity of the amplified gene sequences, contributing valuable genetic resources for fishery research. Overall, this research offers significant contributions to fishery molecular biology by demonstrating how optimized primers enhance the specificity and accuracy of gene expression studies. The findings will serve as a valuable resource for future research, guiding the development of more effective primers for fisheries science and ultimately supporting species conservation, management, and sustainable aquaculture practices.

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REFERENCES

Amoussou, T.O., Karim, I.Y.A., Dayo, G.K., Kareem, N., Toko, I.I., Chikou, A. and Toguyéni, A., (2019). An insight into advances in fisheries biology, genetics, and genomics of African tilapia species of interest in aquaculture. Aquaculture Reports, 14, p.100188.

Blay, E., Hardyman, E. and Morovic, W., (2023). PCR-based analytics of gene therapies using adeno-associated virus vectors: Considerations for cGMP method development. Molecular Therapy-Methods & Clinical Development, p. 31.

Bruce, K., Blackman, R.C., Bourlat, S.J., Hellström, M., Bakker, J., Bista, I., Bohmann, K., Bouchez, A., Brys, R., Clark, K. and Elbrecht, V., 2021. A practical guide to DNA-based methods for biodiversity assessment. Pensoft Advanced Books.

Cermakova, E., Lencova, S., Mukherjee, S., Horka, P., Vobruba, S., Demnerova, K. and Zdenkova, K., (2023). Identification of fish species and targeted genetic modifications based on DNA analysis: State of the art. Foods, 12(1), p.228.

De Cario, R., Rega, M., Pippucci, T., & Romeo, G. (2020). 'Sanger Validation of High-Throughput Sequencing in Genetic Diagnosis: Still the best practice?' Frontiers in Genetics, p. 11. https://doi.org/10.3389/fgene.2020.592588.

Joseph J. B., I. Megbowon, O. R. Oguntade, M. M. A. Akinwale, C. I. Ayo-Olalusi, E. A. Ukenye, B. Edah, T. Mojekwu, A. B. Usman, R. O. Adeleke, G. E. Olagunju, J. Ayokhai, C. Omatah and C. Igwe (2023). Comparison of the efficacy of RNA later preserved and fresh tissue in gene expression study of fish. Nigerian Journal of Fisheries Vol. 20, No. 2; pg 2685-2690. https://drive.google.com/drive/u/6/folders/1m8vMLGRQYv9oo_INn3zDt_nxrqYoReke

Karunanathie, H., Kee, P.S., Ng, S.F., Kennedy, M.A. and Chua, E.W., (2022). PCR enhancers: Types, mechanisms, and applications in long-range PCR. Biochimie, 197, pp.130-143.

Kuzan, A., Tabakov, I., Madej, L., Mucha, A. and Fulawka, L., (2023). What should be done if the qPCR Test for SARS-CoV-2 or other pathogens lacks endogenous internal control? A Simple Test on Housekeeping Genes. Biomedicines, 11(5), p.1337.

Lalèyè, P., Olaosebikan, D.B., Dankwa, H., Schmidt, R.C., Diallo, I. and Darwall, W.R.T., (2021). The status and distribution of freshwater fishes in western Africa. Identification and Validation of Western African Freshwater Key Biodiversity Areas. T. Starnes and WRT Darwall (eds.). IUCN, Gland, Switzerland, pp.22-36.

Maduna, S.N., Vivian-Smith, A., Jónsdóttir, Ó.D.B., Imsland, A.K., Klütsch, C.F., Nyman, T., Eiken, H.G. and Hagen, S.B., (2020). Genome-and transcriptome-derived microsatellite loci in lumpfish Cyclopterus lumpus: molecular tools for aquaculture, conservation, and fisheries management. Scientific Reports, 10(1), p.559.

Rather, M.A., Agarwal, D., Bhat, T.A., Khan, I.A., Zafar, I., Kumar, S., Amin, A., Sundaray, J.K. and Qadri, T., (2023). Bioinformatics approaches and big data analytics opportunities in improving fisheries and aquaculture. International Journal of Biological Macromolecules, 233, p.123549.

Ruiz-Ojeda, F.J., Plaza-Diaz, J. and Gil, A., (2020). RNA Analyses. In Principles of Nutrigenetics and Nutrigenomics (pp. 41–48). Academic Press.

Xiong, F., Shu, L., Zeng, H., Gan, X., He, S. and Peng, Z., (2022). Methodology for fish biodiversity monitoring with environmental DNA metabarcoding: The primers, databases, and bioinformatic pipelines. Water Biology and Security, 1(1), p.100007.

Ye, J. et al. (2012). 'Primer-BLAST: A tool to design target-specific primers for polymerase chain reaction,' BMC Bioinformatics, 13(1). https://doi.org/10.1186/1471-2105-13-134.
Zhang, S., Zhao, J. & Yao, M. (2020). 'A comprehensive and comparative evaluation of primers for metabarcoding eDNA from fish,' Methods in Ecology and Evolution, 11(12), pp. 1609–1625. https://doi.org/10.1111/2041-210x.13485.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

GENETIC CHARACTERIZATION STUDIES OF PARENT STOCKS AND PROGENIES OF *Clarias gariepinus* AND *Heterobranchus longifilis*

[1]ROBERT, E.A., [2]A.T. YISA, ., [2] S.M. TSADU AND [2]S.A. OLAYIMIKA.

[1]National Institute for Freshwater Fisheries Research (NIFFR), P.M.B 6006, New Bussa, Niger State, Nigeria.
[2]Federal University of Technology (FUTMINNA), P.M.B 65, Minna, Niger State, Nigeria.
*Corresponding author: ememrobert@gmail.com, +234 8051251464, 0009-0006-1853-4483

ABSTRACT

Eleven samples of parent stocks and progenies of *Clarias gariepinus* and *Heterobranchus longifilis* were used for gene characterization studies after induced breeding using thirty parent stocks to produce first filial generation progenies. Progenies were then fed with the hormones 17*a*-methyltestosterone (MT) and 17ß-estradiol (E2) in two treatments for both species; while the rest were fed without the hormones in another treatment. Experimental duration was three hundred and sixty-five (365)days. Annealing temperature values obtained in this study were 510C, 500 C, 480 C and 550 C; for which four primers CGA01, CGA02C, CGA03 and CGA05 were used. Microsatellite DNA further reported more observed genotype counts at loci 1,2,3 and 4 in the sample population in this study but at lower sequence repeats. This means that the progenies were observed to be of the same genotypes, with their parent stocks. There was evidence of high DNA results on all the samples used in this study as the DNA results showed the recommended DNA Purity range of 1.80 to 2.00nm. The mean range for genetic heterozygosity in this study stated ranges of 0.7863 to 0.839 indicating a higher proportion of heterozygous genotypes. Pairwise relatedness showed ranges of 0.070 to 0.092, useful in testing for genetic diversity in populations. The Hardy-Weinberg Equilibrium (HWE) in this study reported significant effects of the hormones on the DNA of the progenies. This research aimed to document the comparative studies for parent stocks and progenies of C. *gariepinus* and *H. longifilis*.

Keywords:
genotyping, DNA Transcriptome Sequencing, parent stocks, progenies, hormones

INTRODUCTION

Genetic characterization is carried out using genetic markers. A genetic marker is a DNA sequence used to mark a location on a gene e.g. chromosome (Karki, 2020). Genetic markers are used for genetic identification of the fish species and are aimed at viability of the fish stock population (Oladimeji et al., 2022), species improvement and fishery management for the ultimate conservation of genetic resources (Amoussou, 2019). A gene is detected by analyzing identifiable DNA sequence bringing about the study of the inheritance of the gene at the particular location (Karki, 2020). Markers build the reliability to be able to see the phenotype aforehand (Hassan et al., 2021). New horizons in fisheries have advanced to the gene level, hence this study (Xi et al., 2014 and Martinez et al., 2014).Therefore, this study will serve to document, educate and inform on comparative studies for parent stocks and progenies of *Clarias gariepinus* and *Heterobranchus longifilis*.

MATERIALS AND METHODS

The study area was New Bussa. New Bussa, the headquarters of the Borgu Emirate and Borgu Local Government Area. It is located at 9°53'10``N and 4°31' 30``E coordinates (NIFFR Archives, 2023). Kigera Dam, a dam in Borgu Emirate was the foremost source of water for this study. Experimental fish were sourced from Fish Breeding and Culture Program of the National Institute for Freshwater Fisheries Research, Borgu Kingdom, New Bussa. Feeding with 17*a*-methyltestosterone and 17ß-estradiol for C. *gariepinus* and *H. longifilis* respectively. After one week, fry progenies were transferred to the outdoor concrete tanks and stocked in thirty six tanks i.e. thirty fry in three tanks for treatment 0mg/kg for C. *gariepinus*, *H. longifilis*, thirty fry in three tanks for treatment 50mg/kg for C. *gariepinus*, *H. longifilis* and thirty fry in three tanks for treatment 100mg/kg for C. *gariepinus*, *H. longifilis*. Treatments were triplicated. As the progenies grew, Ecofloat feed in varying feed sizes was introduced from first month till end of the experiment. After the experimental duration of 365 days, eleven parent stock and progeny samples were taken for gene characterization, to test for similarity in parent stocks and offsprings (see Table 2). Afterwards, two more samples of parent stocks and two samples of progenies were also taken for DNA Transcriptome sequencing to compare the genes in both parent stocks and progenies and to identify them one by one (Table 3 and Table 4). Therefore, the procedures carried out during gene characterization and comparison of the parent gene and progeny gene characterization of C. *gariepinus* and *H. longifilis* of the first generation, fed with the hormones 17*a*-methyltestosterone (MT) and 17ß-estradiol (E2) and the ones fed without the hormones were as follows: Primer Digestion and PCR: Four Microsatellite primers (Cga01, Cga02, Cga03 and Cga05) (Ogbuebunu et al., 2021), as isolated by Ola-Oladimeji, (2021) for catfish were used. They were digested, vortexed and their annealing temperature ascertained using a Tm calculator (version 1.16.5). Polymerase chain reaction (PCR) amplification (FIREPol®): The extracted DNA was amplified using a PCR machine (GeneAmp® 9700) following standard procedures of FIREPol Gel Electrophoresis and Ethidium Bromide Staining:Gel Electrophoresis (BIO-RAD®) was conducted on 2% Agarose gel at 100 volts and 250 MA for 20 to 60 minutes. Furthermore, the polymorphic bands were scored by comparison to a 100 bp standard DNA ladder with the aid of gel analyzer according to Ola-Oladimeji (2021). Quantitative Real-Time (Qrt)-PCR Analysis to collect gene bank data:A gene called *a*-tubulin was used (Zhang et al., 2020). The Qrt-PCR reaction system contained 12.5 μL of SYBR green (Takara Dalian, China), 1 μL of gene specific primer RT-PCR and RACE (1.0 μM), 1 μL of CDNA, 8.5 μL of DEPC water. DNA Transcriptome Sequencing: Transcriptome sequencing was achieved by obtaining the concentration of sample (molecules/μL) using QuantifluorTM- ST fluorimeter, while the titration of emPCR (emulsion PCR) was done with GS FLX Titanium SV em PCR kit (Lib-L), which is used for transcriptome analysis in fish (Qian et al., 2014; Finotello and Camillo, 2014). Gene Identification comparison: Gene identification was done using the BLAST search program. DNA of the parent stock fish samples selected (PC2 , PH3) were isolated using RNeasy mini kit and subjected to reverse transcription experiment using PrimeScriptTM. Eleven (11) random samples (CMT50, CMT100, CE501, CE1001, HMT1001, HE501, HE1001, PC1, PH1, CMT0, HE0) of blood and fins collected for the brood parent stocks, and for the progenies of *Clarias gariepinus* and *Heterobranchus longifilis* in this study had their results compared after laboratory analysis of gene characterization had been carried out. Four extra samples (2 parent stocks and 2 progenies-PC2, PH3, CMT502,) were also collected and their ovaries and testes extracted for gene identification comparison. Experimental design: Experimental design was the Super-factorial design. Data analyses: Data collected were subjected to statistical analysis using a one-way analysis of variance (ANOVA) (Shweta and Mishra, 2022). T-test was used to compare growth in the culture systems and between the species, in all the treatments under study (Ziliak, 2019). Duncan Multiple Range Test (DMRT) was used for mean separation and the differences were determined at level of significance ($p < 0.05$) (Nwachi et al., 2020); alongside the use of Microsoft Office Excel 2023 and IBM SPSS statistics software Version

2020 (Ola-Oladimeji, 2021) for detailed computational analysis. Data was further, subjected to analysis for regression (Ojuwoni et al., 2019). Data generated from gene characterization was analysed using Microsatellite DNA derived from transcriptome sequencing (Finotello and Camillo, 2014; Qian et al., 2014); while analysis of molecular variance (AMOVA) was used to detect population differentiation using molecular markers (Jorge et al., 2018).

RESULTS

Table 1: Characteristics of the microsatellite markers used in this study.

Locus	Repeat array	Forward and Reverse Primer sequence (5'- 3' and 3'-5')	Annealing temperature (°C)	Gene bank accession number
Cga01	$(GT)_{15}$	GGCTAAAAGAACCCTGTCTG TACAGCGTCGATAAGCCAGG	51	U30862
Cga02	$(GT)_{10}N_2(GT)_8$	GCTAGTGTGAACGCAAGGC ACCTCTGAGATAAAACACAGC	50	U30863
Cga03	$(GT)_{21}$	CACTTCTTACATTTGTGCCC ACCTGTATTGATTTCTTGCC	48	U30864
Cga05	$(GT)_{11}N_2(GT)_2$	TCCACATTAAGGACAACCACCG TTTGCAGTTCACGACTGCCG	55	U30866

G – Guanine, C- Cytosine, T-Thymine, A- Adenine, (Tm) -melting temperature

Table 2: DNA Concentration and Purity measured at absorbance ratio of 260/280 nm (nanodrop ND -1000) using Gel Electrophoresis via UV Spectrophotometric method.

S/N	Sample ID	DNA Concentration (ng/µl)	DNA Purity measured at 260/280 nm
1	**CMT50**	62.98	2.00
2	**CMT100**	102.62	1.86
3	**CE50**	83.82	2.00
4	**CE100**	140.49	1.81
5	**HE50**	59.50	1.89
6	**HE100**	96.13	1.99
7	**HMT100**	74.42	1.92
8	**PH_1**	139.07	2.00
9	**PC_1**	78.17	2.00
10	**CMT_0**	102.11	1.93
11	**HE_0**	68.20	2.00

nm- nanometer, ng/ul – nanogram per microlitre

CMT50 - C*larias gariepinus* progenies in the 50mg/kg-1 17*a*- methyltestosterone treatments.
CMT100 - C*larias gariepinus* progenies in the 100mg/kg-1 17*a*- methyltestosterone treatments.
CE50 - C*larias gariepinus* progenies in the 50mg/kg-117ß-estradiol treatments.
CE100 - C*larias gariepinus* progenies in the 100mg/kg-1 17ß-estradiol treatments.
HE50 - *Heterobranchus longifilis* progenies in the 50mg/kg-117ß-estradiol treatments.
HE100 - *Heterobranchus longifilis* progenies in the 100mg/kg-1 17ß-estradiol treatments.
PH1 - *Heterobranchus longifilis* parent stocks in the control treatments.

PC1 - *Clarias gariepinus* parent stocks in the control treatments.
CMT0 - *Clarias gariepinus* progenies in the control treatments.
HE0 – *Heterobranchus longifilis* progenies in the control treatments.

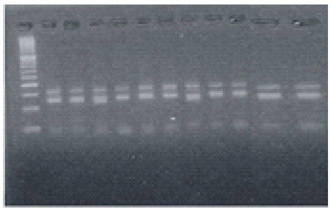

Fig. 1

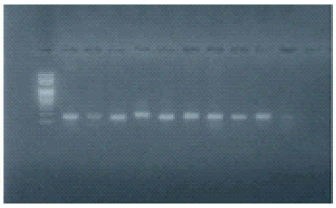

Fig. 2

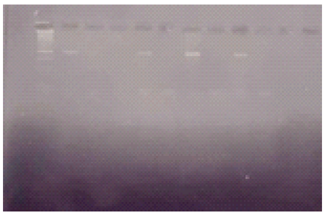

Fig. 3

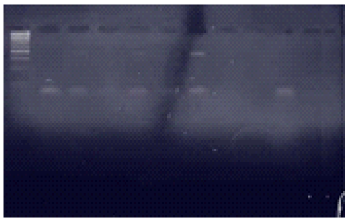

Fig. 4

Fig. 1: Gel Electrophoresis image of Primer CGA01 the Gel Analyzer using 100 bp standard ladder.
Fig. 2: Gel Electrophoresis image of Primer CGA02 from the Gel Analyzer using 100 bp standard ladder.
Fig. 3: Gel Electrophoresis image of Primer CGA03 from the Gel Analyzer using 100 bp standard ladder.
Fig. 4: Gel Electrophoresis image of Primer CGA05 from the Gel Analyzer using 100 bp standard ladder.

Table 3: Transcriptome sequence of identified genes for *Clarias gariepinus* and *Heterobranchus longifilis* parent stocks and their progenies treated with and without the hormone 17*a*- methyltestosterone

Gene	Forward and Reverse Primer sequence (5'- 3' and 3'-5')	Gene bank ID
Dmrt1	GAAGCACGAGGCCGCGCAGAG GTTGGTATACTCTCTGAGACTT	Unigene51662
dmrt1a	ATGCCGAAGTGCTCCCGGTGCs AGCGGCTCCCAGAGGCAGC	FJ596554
dmrt1b	AAGGATGAGCACCAGGGGACA TTACTTAGCCAGCTCCCTCTAT	FJ596555
dmrt1c	CCAGGGCCAGGTGGCTCTGCG TTACTTAGCAGCTCCTCTAT	FJ596556

G – Guanine, C- Cytosine, T-Thymine, A- Adenine

Table 4: Transcriptome sequence of identified genes for *Clarias gariepinus* and *Heterobranchus longifilis* parent stocks and their progenies treated with and without the hormone 17ß-estradiol (E2).

Gene	Forward and Reverse Primer sequence (5'- 3' and 3'-5')	Gene bank ID
dmc1	CTCCACCACCAGGATCAGTT CCGGTAGAGATGGCAAATGT	XM_003961352
ckd2	CGTCGCTAGCCAAGCAATCA ATCTCGGATGGCAGTGCT	XM_003973094
ckd4	GGTCACCAGCGGAGGACAGATC ACAGCGTCACCACCACAGAGG	XM_003973099
cdk6	GCAGTCCAGTTACGCCACACC CCTCCTCTGAAGGCAAGCCAATG	XM_003969394
ccna2	ACAAGCCAGCCACTGTGAATGAG TCCAACCTCCACCAGCCAGTC	XM_011610984
ccnd2	GAGCGTCGATGTCGTCAAGAGTAG CCGCACGGAAATCGCAGTATAGC	XM_003972778
cdkn1b	ATGCATGGCATAAGGCGTCC TCGGGCTCCCGTTTGATATAGT	XM_003967486
cdkn2c	GGGTCGACGTCAAAGGGAAC AGGTATTGGACCGTGTCCGT	XR_965382

G – Guanine, C- Cytosine, T-Thymine, A- Adenine

DISCUSSION

There was no heterozgote deficiency (FIS) (HWE deficiency ($p<0.001$)) noticed at any of the loci in the sampled population which was New Bussa, Niger state of Nigeria. Gene characterization and genetic variability analysis showed different transcriptomic responses for these fishes fed with 17*a*-methyltestosterone (MT). Also, transcripts of three different forms of dmrt1 were seen. They were: dmrt1a, dmrt1b and dmrt1c. These transcripts were revealed using PCR amplification with microsatellite primers. For C. gariepinus and H. longifilis administered with 17 -estradiol (E2) in varying inclusion levels of 0mg/kg, 50mg/kg and 100mg/kg respectively, according to the motif and gene functionality after DNA extractions, amplification performed by polymerase chain reaction (PCR) showed the presence of the following genes: dmc1, ckd2, ckd4, cdk6, ccna2, ccnd2, cdkn1b and cdkn2c.

CONCLUSION AND RECOMMENDATION

It is concluded that, the hormones 17ß-methyltestosterone and 17ß-estradiol, used in this study, had a significant effect on the genes of the progenies of C. *gariepinus* and *H. longifilis*. There were high DNA results on all fish samples used in this study; for parent stock and progenies of C. *gariepinus* and *H. longifilis*. It is recommended that, further studies on RNA-Transcriptome Sequencing in *Clarias gariepinus* and *Heterobranchus longifilis* be carried out, comparing across multiple events using High Next Generation Throughput Sequencing; while testing for the presence of proteins, amino acids and their interactive network analyses.

REFERENCES

Amoussou, T. O., Karim, I. Y. A., Dayo, G-K., Kareem, N., Toko, I. I., Chikou, A. and Toguyeni, A. (2019). An insight into advances in fisheries biology, genetics and genomics of African tilapia species of interest in aquaculture. Aquaculture Reports, 14, (2019), 100188.

Finotello, F. and Camillo, B. D. (2014). Measuring differential gene expression with RNA-Seq: Challenges and Strategies for data analysis. Briefings in functional genomics, 14 (2), 130-142. doi: 10.1093/bfgp/elu035

Hassan, N., Choudhary, S., Naaz, N., Sharma, N. and Laskar, R. A. (2021). Recent advancements in molecular marker-assisted selection and applications in plant breeding programmes. Journal of Genetic Engineering and Biotechnology, 19, 128. doi: 10.1186/s43141-021-00231-1

Jorge, P. H., Mastrochirico-Filho, V. A., Hata, M. E., Ariede, R. B., Vieira de Frietas, M., Vera, M., Porto-Foresti, F. and Hashimoto, D. T. (2018). Genetic characterization of the fish Piaractus brachypomus by microsatellites derived from transcriptome sequencing. Frontiers in Genetics. 9, 46. Retrieved from https://doi.org/10.3389/fgene.2018.00046

Karki, G. (2020). Molecular markers - types and applications. Retrieved from onlinebiologynotes.com

Martinez, A. H., Avila, L. C., Pilido, M. A., Ardila, Y. A., Akle, V.and Bloch, N. I. (2022). Age-Dependent Effects of Chronic Stress on Zebrafish Behavior and Regeneration. Frontiers in Physiology, 13, 856778. doi: 10.3389/fphys.2022.856778

National Institute for Freshwater Fisheries Research (NIFFR) (2023). Archives, with researcher's modification. 2023-10-19.

Nwachi, O. F., Zelibe, S. A. A. and Kelly-Igumbor, S. (2020). Culture of catfish (Clarias gariepinus) fed wit diet containing 17-ß-methyltestosterone. Nigerian Journal of Fisheries, 17 (2), 2017-2021.

Ojuwoni, A. A., Akinwole, A. O. and Faturoti, E. O. (2019). Growth performance and Nutrients Utilization of Oreochromis niloticus fed maggot meal-based diets. Proceedings of the 34th Annual Conference of Fisheries Society of Nigeria (FISON), held on the 28th October-1st November at the Law Auditorium, Ebonyi State University, Abakaliki. pp.130-133.

Ola-Oladimeji, F. A. (2021). Population genetics of fast-and slow-growing strains of Clarias gariepinus (Osteichthyes: Clariidae) as revealed by microsatellite markers. Egyptian Journal of Aquatic Biology and Fisheries, 25 (2), 21-35.

Oladimeji, T. E., Caballero, I. C., Mateos, M., Awodiran, M. O., Winemiller, K. O., Adite, A. and Hurtado, L. A.(2022). Genetic identification and diversity of stocks of the African bonytongue, Heterotis niloticus (Osteoglossiformes: Arapaiminae), in Nigeria, West Africa. Scientific Reports, 12, 8417. Retrieved from https://doi.org/10.1038/s41598-022-12428-6

Ogbuebunu, K. E., Awodiran, M. O., Yisa, M., Nwangwu, D. C., Goni, I. M., Abubakar, G. R., Yahaya, M., Eze, J. O. and Atubo, M. P. (2021). Studies of genetic variation and population structure in Lates niloticus populations from Lake Kainji and River Benue using single sequence repeats. Proceedings of the 36th Annual General Meeting and Conference of FISON (GARDEN CITY 2021) Held at Ebitimi Banigo Auditorium, Port-Harcourt. 24th – 29th October. pp.867-870.

Qian, X., Ba, Y., Zhuang, Q. and Zhong, G. (2014). RNA-Seq Technology and Its Application in Fish Transcriptomics. OMICS: A Journal of Integrative Biology, 18 (2), 98-110. Retrieved from https://doi.org/10.1089/omi.2013.0110

Xi, Q., Yi, B., Qianfeng, Z. and Guofang, Z. (2014). RNA-Seq Technology and its application in fish transcriptomics. OMICS: A Journal of Integrative Biology, 18 (2), 98-110. Retrieved from http://doi.org/10.1089/omi.2013.0110

Zhang, W., Wang, H., Brandt, D. Y. C., Hu, B., Sheng, J., Wang, M., Luo, H., Li, Y., Guo, S., Sheng, B., Zeng, Q., Peng, K., Zhao, D., Jian, S.,Wu, D.,Wang, J., Zhao, G., Ren, J., Shi, W., Van Esch, J. H. M., Klingunga, S., Nielsen, R. and Hong, Y. (2022). The genetic architecture of phenotypic diversity in the Betta fish (Betta splendens). Science Advances, 8 (38), 4955. doi: 10.1126/sciadv.abm4955

Ziliak, S. T. (2019). Statistical Inference in the 21st Century: A world beyond p<0.05. How large are your G-Values? Try Gosset's Guinessometrics when a little 'p' is not Enough (Gosset 1908). The American Statistician. 73, 281-290. Retrieved from https://doi.org/10.1080/0031305.2018.1514325

EFFECT OF THE MALE SEX HORMONE (TESTOSTERONE PROPIONATE) ON SIAMSESE FIGHTER *(Betta splenden)* FRY

Alum-Udensi, O, J. C Ikwuemesi, P. Ikechukwu and B. C. Onukaire

Department of Fisheries and Aquatic Resources Management. Michael Okpara University of Agriculture, Umudike Abia State, Nigeria.

okeyalum@gmail.com

ABSTRACT
The effects of different levels of testosterone propionate administered by inclusion in feed on growth, survival and sex-ratio of *Betta splenden* was studied. Four (4) treatments of experimental diets and a control with 3 replicates for each was set up and the hormone was administered to the fry from day 2 for a period of 8 weeks. The results indicated that synthetic androgen testosterone propionate administered by inclusion in feed influenced the sex in B. splendens. Highest percentages of males (80% and 75%) were found at dose 0.75 and 1.0mg/L. At a dosage of 0.25mg/L a high percentage of female was observed. Higher doses of the hormone showed lower survival compared to lower doses. The frequency of male fish in all the hormone treated groups except the 100mg/kg group were significantly higher than that of the expected frequency of male fish in a normal population.

KEYWORDS:
Fish breeding;
Ornamental fish;
Sex reversal;
Mono-sex populations

INTRODUCTION

The entire aquarium industry, including ornamental fish, aquarium accessories, aquarium fish feed, aquarium construction and public aquariums is estimated to be worth more than the US $20 billion annually with much contribution in the export trade by South East Asia (Pal, 2015; Yadav and Sharma, 2017; Alum-Udensi and Orji, 2019). Freshwater tropical aquarium fishes are of great economic importance due to their attractive colour, shape, finnage, and behavior (Mekdaeng, 2015; Alum-Udensi et al., 2019a; Bardhan *et al*, 2021). Sex reversal in fish can occur as a result of disturbances in natural conditions or laboratory manipulations (Smith, 2005).

The maintenance and breeding of male populations have generated a great amount of interest in commercial ornamental fish production (Singh et al., 2019). Different method such as manual sorting, hybridization hormonal sex reversal and super male production has been applied to monosex population (Soumokil *et al.*, 2020) These techniques have been applied to some fish species exhibiting sexual dimorphism with preference of male to females including guppy *(Poecilia reticulata)*, balloon molly *(P. latipinna)*, sailfin molly, *(P. velifera)*, sunset platy *(Xiphophorus variatus)*, dwarf gourami *(Colisa lalia)*, fighting fish *(Betta splendens)*, rosy barb *(Barbus conchonius)*, Convict cichlid *(Cichlasoma nigrofasciatum)*, and red Australian rainbow, *(Glossolepis incisus)* Muniasamy, et al., (2019). The male of these species may command up to four times the price of females encouraging the culture of all-male monosex populations with significant economic advantage (Mousavi-Sabet 2011).

Manual sorting was the first method to be used in the early days as it required little or no technology besides simple sort, cull and discard the unwanted sex. This method is wasteful, inefficient (Hafeez-ur-Rehman *et al.*, 2008), stressful to fish, results in relatively high mortality (Dunham, 2004), requires experienced labour and the fish must be grown to size of sexual dimorphism before commencement of manual sorting. Hybridization has also been used to produce monosex populations (Bartley et al., 2001; Bardhan *et al.*, 2021). Hybridization however has some setbacks, including skewed sex ratios, production of infertile F1 generation (sterile offspring) and the need to maintain two separate pure brood lines (Mubarik *et al.*, 2011; Bartley *et al.*, 2001)

Hormonal sex reversal involves use of hormones to effect sex reversal in fish. The treatment of sexually undifferentiated fry by administration of hormones has been shown to work well in a wide range of species (Pandian and Kirankumar, 2003; Bardhan *et al*, 2021). Badura and Friedman (1998) reported transformation of the anatomical features/characteristic of females fish injected with testosterone to males expressed by changes in fin length, body coloration, and gonadal morphology.

17*a*-methyltestosterone is the most preferred and widely used hormone for induction of masculinization in fish like *Betta splendens* (Amiri-Moghaddam *et al.*, 2010; Balasubraman, 2010).

Testosterone Propionate has a faster rate of release than other esterified testosterones and it is also a locally available steroids. Different methods have been used to administer steroids, including immersion (Pandian and Kirankumar, 2003, Mekdaeng, 2015) however, oral administration of feed incorporated with methyltestosterone is the most effective and practical method for the production of all male populations. Oral administration of the synthetic androgen 17*a*-methyltestosterone (MT) has been effective for all male populations in carp (Damstra *et al.*, 2002; Mubarik *et al.*, 2011) Bharadwaj and Sharma (2000) studied the effect of methyltestosterone (tablets) in sterilization and masculinization of common carp, C. carpio var. communis (L). Wassermann and Afonso (2003) investigated the efficacy of three androgens, (17*a*-methyltestosterone, 17*a*-methyl dihydrotestosterone and 17*a*-ethynyltestosterone) through immersion treatment on the sex ratio of Nile tilapia (0. niloticus) fry. In undifferentiated fry, 50mg Trenbolone Acetate/ kg feed or immersion in TBA induced 100% male populations in both channel catfish, Ictalurus Punctatus, and blue tilapia, Oreochromis aurea (Fitzpatrick et al. 2000). Amiri-Moghaddam *et al.*, (2010) used 17-*a*-methyltestosterone to achieve male secondary sexual characteristics in the adult female green swordtail (Xiphophorus hellerii). Numerous attempts has been made to optimize the methods of hormonal sex reversal by varying parameters such as hormone dose, treatment start time, duration of treatment and stocking density (Kirankumar and Pandian, 2002; Mubarik *et al.*, 2011; Bardhan *et al*, 2021).

The Siamese fighting fish *(Betta splendens)* is a popular freshwater ornamental species that have been selectively bred to display a vibrant array of colour and tail types over the years (Alum-Udensi *et al.*, 2019a). The fish is sexually dimorphic with males being more brightly colored with extravagant finnage than females.

We investigated the use of testosterone propionate in hormonal sex reversal by incorporating it in the diet of B. splendens.

MATERIALS AND METHODS

This study was carried out in the Department of Fisheries and Aquatic Resources Management, Michael Okpara University of Aquaculture, Umudike, Umuahia, Abia State for a period of 56 days (8 weeks). Three pairs of broodstock Siamese fighter were procured from Nature Nurture - an ornamental fish breeder in Abuja, Nigeria and transported to Umudike. Spawning was done to obtain fry. A total of 225 fry of *B. splendens* at two (2) days old was carefully collected in two transparent plastic tanks before separation into the various treatment and replicates. Transparent plastic tanks of (40 x 30x 40) cm each was set up for five (5) treatments representing experimental diets with 3 replicates for each. The tanks were filled with water to about 10cm, and twelve (15) B. splendens fry was transferred into each experimental tank for the feeding trials. The fry was fed with fry food containing various levels of testosterone propionate. Partial water change in the experimental tanks was carefully done once a week; however 1liter of fresh water was added to each tank daily after feeding. Water parameters (temperature, pH, nitrate, nitrite and ammonia) was monitored weekly.

Commercial fry feed containing 65% crude protein was procured and the hormone was incorporated at

four different rates: 0(T1), 25(T2), 50(T3), 75(T4), and 100(T5) mg.kg-1. T1 served as the control diet without hormone to the food.
The stock solution of testosterone propionate was prepared in absolute ethanol at a concentration of 1mg testosterone propionate/ml ethanol. The treatment was diluted appropriately to the finial steroid concentration for each treatment diet and sprayed over the powdered fry food and left open at room temperature for 24 hours for the ethanol to evaporate leaving behind hormone incorporated feed.
Fry weight was determined using sensitive weighing balance to the nearest 0.1g. Mortality was counted and recorded; Sex of experimental fish was determined at about 2.5 cm body length by the external examination of the dorsal, anal, and caudal fins following Kirankumar and Pandian, (2002). Growth, survival and percentage weight gain were computed. Growth and survival were compared between the treatments using analysis of variance (ANOVA).

RESULTS AND DISCUSSION

The percentage survival of B. splendens after inclusion of the hormone in feed during the first 4weeks for each Treatment is given in figure1. The survival of B. splendens was 100% in week 1and 2 but reduced to 80% after 8 weeks in T2 (0.25mg). The percentage survival rate was also 100% for all the treatment (0.25mg, 50mg, 75mg, and 100mg) in week 1. After 8weeks, the survival rates went down to 80%, 66.7%, and 53.3% in 0.50, 0.75, 1.00mg respectively. This change in the percentage survival was also observed in the control suggesting non hormone influence. The effect of testosterone propionate on sex ratio of B. splendens was also studied and the results were presented in Table 2. The sex ratio in the treatments 0.25mg/L, 0.50mg/L, 0.75mg/L and 1.00mg/L were 1:0.71, 1:0.5, 1:0.25 and 1:0.22 respectively. The sex ratios in the control groups did not differ much (1.086) from the expected 1:1 distribution. At 0.25mg/L, the sex reversal was not significantly different from the control and could be considered as an insufficient dosage. Pongthana and Tangthongpairoj (1999) reported that lower dosage of 20μgl[1] of 17*a* methyltestosterone influenced higher female sex ratio 85.43± 9.06% in three week old hatchlings of C. *garienpinus*. Also, treatment 4(1.00mg/L) showed the lowest number of sexed fish(24). The highest percentage of male (80%) and lowest percentage of female 20% were observed in a dose of 0.75mg/L with a male to female ratio of 1:0.25. When the dose of the hormone was 0.50mg/L, the sex ratio was 0.05. The production of high number of males in the 0.75mg and 0.50mg is an indication of the positive impact of the hormone in the production of male B. splendens.
Table 1 presents the effect of testosterone propionate on the growth and survival of B. splendens was also studied for the four doses viz 0.25mg, 0.50mg, 0.75mg and 1.0mg and control for the control groups. The first treatment 0.25mg had a mean weight of 0.032±0.41, 0.131±1.04, and 0.189±1.21 after 7days, 21day and 8weeks respectively. The second treatment had a mean weight of 0.038± 0.72 and 0.204±0.41 after 1 week and 8 weeks 0f monitoring. In 1 week, treatment 3(0.75mg) showed a mean weight of 0.031±0.34 and the mean weight to 0.157±0.82 and 0.192±1.14 after 21days and 8weeks respectively. However the treatment 4(1.0g) had a mean weight of 0.031±0.21 and 0.202±0.84 after 1 week and 3weeks respectively while the control was 0.034±0.92 after 1 week and 0.188±1.09 after 8weeks.

Table1: Effect of testosterone propionate on ***B. splendens***

	TREATMENT									
Weeks	T1 (0.25mg/kg)		T2 (0.50mg/kg)		T3 (0.75mg/kg)		T4 (1mg/kg)		T5 (control)	
	Wt (g)	Survival (%)	Wt (g)	Survival %	Wt (g)	Survival %	Wt (g)	Survival %	Wt (g)	Survival %
2	0.032	45(100%)	0.038	45(100%)	0.031	45(100%)	0.037	45(100%)	0.034	45(100%)
4	0.084	45(100%)	0.076	42(93%)	0.087	42(93%)	0.091	45(100%)	0.088	45(100%)
6	0.131	36(80%)	0.154	36(80%)	0.157	39(86.7%)	0.177	36(80%)	0.062	39(86.7%)
8	0.189	36(80%)	0.204	36(80%)	0.192	30(66.7%)	0.207	24(53.3%)	0.188	39(86.7%)

Table 2: Effect of testosterone propionate on the sex ratio of *B. splendens.*

Treatment	No of sexed fish	Males	Females	Sex ratio
.25	36	21(58.3%)	15(41.7%)	1:0.73
.50	36	24(66.7%)	12(33.3%)	1:0.5
.75	30	24(80%)	6(20.0%)	1:0.25
1.0	24	18(75%)	6(20.0%)	1:0.33
Control	39	21(53.8%)	18(46.2%)	1:0.86

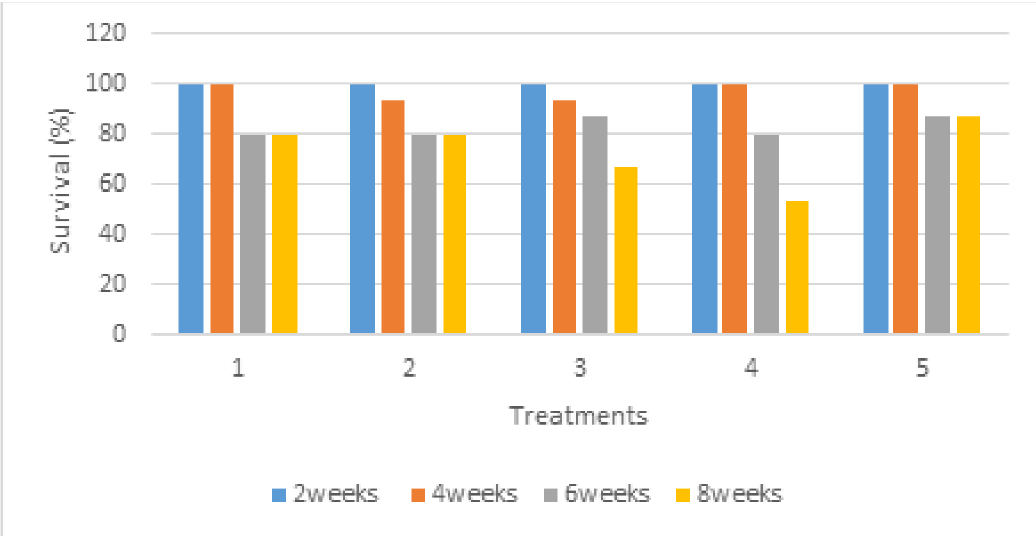

Figure 1: Survival and growth of *Betta splenden* treated with testosterone propionate

Our observations agree with Yamakazi, (2006) revelation that androgens sex reversal effect depends on the dosage, method of stimulation, age or size of fish to which the treatment was applied and the species of fish. The present study indicated that synthetic androgen testosterone propionate administered by inclusion in feed effectively influenced the sex in B. splendens. Highest percentages of males (80% and 75%) were found at dose 0.75 and 1.0mg/L (Table 2). At the dose of 0.25mg/L a high percentage of female were observed. Similar to the observations by Demska–zakes and Zakes (1997) in pikeperch - Stizosterdion luciperrca using methyltestosterone at different doses of 30, 60 and 90mg/kg diet; total sex reversal was not observed for any of the administered dosage. Fish mortality was recorded in the different treatments of this present study. There were no significant variations in the effect of the hormone on weight of the fish during the study period.

CONCLUSION

Testosterone propionate influenced the sex of *B. splendens* males at the optimal dose but did not contribute to the enhancement of the growth of the hormone treated fish. All male population could not be achieved in this study. There is need for further studies to determine the correct dose of hormone, duration and the best route of administration of the hormonal for the species.

REFERENCES

Alum-Udensi, O. and Orji, N. (2019). Ornamental Fish and Aquarium Design as an Enterprise for a Recovering Economy. In: Agripreneurship: Roadmap to food security and wealth creation in Nigeria Ekwe, K. C., Ogbe, S. E.and Obasi. R. O. (Eds). Centre for Entrepreneurship Development, Michael Okpara

University of Agriculture, Umudike Nigeria. (printed by Naphtali Prints Nig. Ltd). p 227-234.

Alum-Udensi, O. Egesi, O. C. and Awa, C. (2019a). Ornamental Fish Industry: Potentials for Nigeria's National Economic Development. Journal of Science of Agriculture, Food Technology and the Environment, 17(18): 69-75.

Alum-Udensi, O. Ikechukwu, P. and Agwu, P. I. (2019b). Performance of Betta splendens (Regan 1910) Fed Different Fry Foods. Journal of Science of Agriculture, Food Technology and the Environment 17(18): 55-60.

Amiri-Moghaddam, J., Maniei, F., Mahboobi-Soofiani, N. and Asadolla, S. (2010). Use of 17-*a*-methyltestosterone for production of male secondary sexual characteristics in the adult female green swordtail (Xiphophorus hellerii). AACL Bioflux, Vol. 3/1.

Badura, L. L and Friedman, H. (1998) Sex reversal in female Betta splendens as a function of testosterone manipulation and social influence. J Comp Psychol;102(3):262-8.

Balasubraman A. (2010). Effect of Norethindrone AcetateSZe on Masculinization, Growth and Reproduction in Zebrafish Danio rerio. Asian Fisheries Science 23:44-59

Bardhan, A., Sau, S., Khatua, S., Bera, M., & Paul, B. (2021). A review on the production and culture techniques of mono sex tilapia. International Journal of Current Microbiology and Applied Sciences, 10(1), 565-577.

Bharadwaj, R., Sharma, L.L. (2000). Effect of methyltestosterone (tablets) in sterilization and masculinization of common carp, Cyprinus carpio cominunis (L). Indian J. Fish. 47(4): 377-381.

Bharadwaj, R., Sharma, L.L.(2002). Experimental manipulation of sex in Cyprinus carpio var. communis by oral administration of testosterone undecanoate. J. Aqua.Trop. 17(1): 7-13.

Damstra, T., S. Barlow, A. Bergman, R. Kavlock and G.V.D. Kraak, 2002. WHO Report on Global Assessment of the State-of-the-Science of Endocrine Disruptors.

Fitzpatrick, M.S., Contreras-Snchez, W. M. and Schreck, C. B. (2000). Effect of Treatment Timing and Dose on Masculinization with Trenbolone Acetate. In: McElwee K, Burke D, Niles M, Cummings X, Egna H (Editors). Seventeenth Annual Technical Report: Pond Dynamics/Aquaculture CRSP, Oregon State University. Corvallis, Oregon. p 63-68.

Hafeez-ur-Rehman, M., I. Ahmed, M. Ashraf, N. Khan and F. Rasool, 2008. The culture performance of mono-sex and mixed- sex tilapia in fertilized ponds. Int. J. Agric. Biol., 10: 352–354

Kirankumar, S., and Pandian, T. J. (2002). Effect on growth and reproduction of hormone immersed and masculinized fighting fish Betta splendens. Journal of Experimental Zoology, 293(6), 606-616.

Mekdaeng, N. (2015). Appropriate concentration and frequency of 17*a*-methyltestosterone immersion on Guppy (Poecillia reticulate) sex inversion to male. SWU Science Journal, 31(1), 159-174.

Mubarik, S. M.,Ahmed, I., Mateen, A. and Iqbal, T. (2011). 17*a*-Methyltestosterone Induced Masculinization and its Effect on Growth and Meat Quality of Cyprinus carpio. International Journal of Agriculture & Biology. 13:6. 971–975.

Muniasamy, S., Benziger, P. A., Kumar, Y. A., Haniffa, M., Paray, B. A., Albeshr, M. F., and Al-Umri, S. (2019). Effect of 17*a*-methyl testosterone incorporated diets on growth of spotted snakehead, Channa punctatus and white carp, Cirrhinus mrigala. Saudi Journal of Biological Sciences, 26(3), 541-546.

Pandian, T.J and Kirankumar S. (2003). Recent advances in hormonal induction of sex reversal in fish, App Aquac. 13 ,205-230.

Singh, R., Chauhan, R. S., and Singh, T. P. P. (2019). Comparative efficacy of 17-*a* methyl testosterone on swordtail (Xiphophorus helleri) fry via oral feed administration. Journal of Entomology and Zoology Studies, 7(2), 505-508.

Smith, T. S. (2005). Primary Sex Reversal in Female Betta splendens following Treatments with Temperature and Trenbolone Acetate. An MSc thesis presented to the Department of Biology, East Tennessee State University. p 65

Soumokil, A., Lumamuly, J., and Laimeheriwa, B. (2020). Masculinization of betta fish (Betta splendens) through natural honey immersion with different concentration. the IOP Conference Series: Earth and Environmental Science. IOP Publishing.

Van den Hurk and R.C.,Richter, J.J and Janssen Dommerholt (2001). Effects of 17*a* methyltestosterone and 11ß hydroxyandrotenedione on gonad differentiation on the african catfish, Clarias gariepinus. Aquaculture 83:179-191.

Wassermann, G.J., and Afonso, L.O. (2003). Sex reversal in Nile tilapia (Oreochromis Niloticus Linnaeus) by androgen immersion. Aquacult. Res. 34(1): 65-71.

Yamakazi, F. (2006). Application of hormones in Fish culture- J. Fish. Res. Board Can. 33: 948-958.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

OVULATION, STRIPPING AND HATCHING IN *Clarias Gariepinus* INDUCED WITH COMBINATION OF DILUTED OVATIDE AND SUPRECUR

[1]Ataguba, G. A., [2]F. U. Inya and [1]D. Iliya

[1]Department of Fisheries and Aquaculture, College of Forestry and Fisheries, Joseph Sarwuan Tarka University, Makurdi Benue State, Nigeria.
[2]Department of Fisheries and Aquatic Science, Faculty of Agriculture and Forestry
University of Cross River State, Obubra Campus.

Corresponding author:
gabriel.ataguba@uam.edu.ng

ABSTRACT
This study was designed to determine the effects of using serially diluted Ovatide® supplemented with Buserelin acetate (Suprecur®), a luteinizing hormone-releasing hormone analogue (LHRHa) in African catfish. Treatments administered include are 0.2ml/kg Ovatide® (T1), 0.15ml/kg Ovatide® + 50ug/kg Suprecur® (T2), 0.10ml/kg Ovatide + 50ug/kg Suprecur® (T3), 0.05ml/kg Ovatide® + 50ug/kg Suprecur® (T4) and 50ug/kg Suprecur® (T5). Egg counts, latency, fertilization, hatching, and survival to first feeding are determined. Diluted Ovatide® + Suprecur® together successfully induced ovulation. No significant difference ($p>0.05$) in egg weights stripped. T1, T2, and T3 resulted in earlier synchronization of ovulation (Latency period; 11 hours). Treatment 5 did not cause ovulation. Results of the fertilization percentage indicated that decrease in dose of Ovatide® via dilution but supplemented with Suprecur® did not significantly affect fertilization rate ($p>0.05$) in treated groups (89.91%, 93.21%, 83.84% and 86.02% for T1 to T4 respectively) and hatching rate ($p>0.05$) with rates of 27.24%, 38.58%, 33.91% and 29.23% for T1 to T4 respectively. However, hormonal administration affected survival rate to first feeding ($p<0.05$) with normal dose Ovatide® producing the best survival rate (86.79%). Therefore, decreased doses of Ovatide® and Suprecur® can yield similar reproductive success, but post-hatching treatment may be needed for optimal survival.

Keywords:
Ovulation, latency, hormone, fertilization, hatching

INTRODUCTION

The use of different forms of exogenous Gonadotropin Releasing Hormone agonists (GnRHa) that are responsible for stimulating secretion of endogenous gonadotropins (GTH) have been reported (Anderson *et al.*, 2017; Mylonas and Zohar, 2000; Zohar and Mylonas, 2001). A plethora of varieties of synthetic formulations containing GnRH are now available with various degrees of success in stimulating ovulation process in different fish species (Marimuthu et al., 2009). Ovatide is a variant of the analogue of salmon gonadotropin releasing hormone (sGnRHa) bundled together with a dopamine blocker (Anderson *et al.*, 2013). Whereas GnRH analogs stimulates the pituitary to release gonadotropins and trigger the process of reproduction, the dopamine antagonist inhibits the release of dopamine and make sure that the secretion of gonadotropin is not inhibited. The use of Ovatide and other GnRHa's have been reported to induce ovulation in cyprinids (Hill et al., 2005), catfish (Sharma *et al.*, 2010) and other species (Marimuthu *et al.*, 2007). The objective of induced spawning is the acquisition of a large supply of good quality eggs on demand. Egg quality can be determined using fertilization and hatching rates (Marx *et al.*, 2020; Snow and Phelps, 2020). A single dose of ovatide given intramuscularly to the broodstock leads to the massive ovulation of eggs through complete spawning with high fertilization and hatching percentage (Rashid *et al.*, 2015). Therefore, the current research sought to determine latency period, fecundity, fertilization and hatching rates of Clarias gariepinus induced with combined hormones.

MATERIALS AND METHOD

The study was carried out at the fishery Hatchery of the Department of Fisheries and Aquaculture, Joseph Sarwuan Tarka University Makurdi. A total number of fifteen [15] fish comprising ten [10] females and five [5] males were used. All broodstock were selected following the external morphological characteristics using the method of Ayinla *et al.* (1994). The broodstock were acclimatized for two [2] days.

Ovatide® was acquired from J-Climax Agro Limited Ado U-turn Nasarawa State. Suprecur® a brand of Buserelin acetate meant for females was obtained from www.drugstore.ng #29 Ayangbure road, Ikorodu, Lagos State.

Suprecur® obtained was manufactured with a concentration of 1mg/ml of solution (Sanofi-Aventis 2022). A stock solution containing 0.4ml (400μg) of the original Suprecur® made up to 10ml using normal saline (9.6ml) was made to obtain a concentration of 50μg/ml of solution. A dosage range of 10 to 100μg of buserelin acetate per kilogram body weight of fish was recommended by Chatakondi et al. (2018). The current trial utilized four different dosages of Ovatide®: 0.20ml/kg, 0.15ml/kg, 0.10ml//kg, and 0.05ml//kg. The dose of Suprecur® was fixed at 50μg/kg of bodyweight. From the foregoing, the following volumes were used in the dose combination in all cases:

Table 1: Dose of Hormones (Ovatide and Suprecur®) administered to female *C. gariepinus*

TREATMENT	DOSES OF HORMONES	
	Ovatide® (ml/kg)	Suprecur® (ml/kg)
T1	0.20	–
T2	0.15	1.25
T3	0.10	1.25
T4	0.05	1.25
T5	–	1.25

Injected female broodstock were removed from plastic tank after 10-12 hours and stripped in dry bowl by holding the fish at the head and tail by an assistant. The ovulated eggs oozed out on slight pressure by thumb into the dry plastic bowl and 10g of eggs were collected from each sample into a petri-dish for counting so as to know the total number of eggs produced from each of the female brood stock. The male broodstock were removed after dissecting them and the milt was collected by laceration of the testes with a clean razor blade. The sperm was then used to fertilize each treatment.

Incubation of the fertilized eggs was carried out in 60 litres plastic bowl containing 40 litres of clean water which was equipped with water aerators. Nylon mesh size (1mm) was suspended above the floor in the plastic bowl for spreading of fertilized eggs. The fertilized eggs were spread in a single layer on the suspended nylon meshed net for incubation. Upon hatching (about 24 hours after incubation), the nylon meshed net was removed with the egg shells while the hatched larvae clustered at the bottom of the incubation tank.

Fertilization rate was determined using 750 eggs from each cross. The eggs were covered in the dry, labelled Petri dish and were kept with labels. The number of eggs were estimated using the gravimetric method (number of eggs/g). The translucent eggs containing embryonic eyes at the time of polar cap formation 10 - 20 minutes after fertilization were considered fertilized and counted to estimate fertilization rate (De Graaf et al.) . Percentage hatchability was estimated 24 hours after hatching was completed. This was estimated using the volumetric method. To do this, the incubation bowl was stirred gently to disperse the larvae evenly in the water. A beaker (100ml) was used to collect water from the bowl with the dispersed larvae swimming freely inside. The number of larvae in the volume of water was counted. This was repeated three times and the average number was taken. The value was then estimated to cover 40 litres water volume using mathematical relationship. The hatching rate was determined using a modified version of formula provided by Adebayo and Popoola (2008) as:

$$\text{Hatching Rate} = \frac{\text{Total Number of Hatched Eggs}}{\text{Total Number of Incubated Eggs}} \times 100$$

The survival rate of larvae was estimated four days after hatching i.e. post yolk sac absorption. The volumetric method was employed in determining survival rate. Here water in the holding tanks was stirred to ensure even dispersion of fry using a glass rod. After this, a representative sample of the water (100ml) was taken in a beaker and fry within the water volume were counted. This was repeated three times and the average was taken. The population was then estimated to cover the entire water volume (40,000ml). Therefore, the following equations were used:

$$A_{100} = \frac{\sum \textit{No. of fry in three samples}}{3}$$

$$\text{Survival rate} = \frac{A_{100} \times 40000ml/_{100ml}}{\text{No. hatched}} \times 100$$

Water quality parameters such as pH, Electrical Conductivity, Total Dissolved Solids (TDS) and Dissolved Oxygen of the water were monitored using Hanna Multiparameter Water Quality Probe Model HI-98129. A mercury in glass thermometer was used to take temperature readings. Differences in the measured parameters across the treatments were determined using one-way ANOVA in R (R-Core_Team, 2020). Mean separation was done using the Tukey HSD.

RESULTS AND DISCUSSION

Fecundity of female broodstock induced with a combination of Ovatide® and Suprecur® (Figure 1) shows that broodstock used for the 0.1ml/kg Ovatide® + 50µg/kg dose of Suprecur® (T3) had the highest fecundity followed closely by broodstock allotted to the 0.2ml/kg dose of Ovatide® alone (T1) while broodstock administered only 50µg/kg dose of Suprecur® had the least fecundity. There was an undulating pattern of fecundity at various hormonal treatments in the current study. This pattern was also observed by Sahoo et al., (2005) when they induced C. batrachus with doses of Ovatide® between 0.5 and 2.0ml/kg.

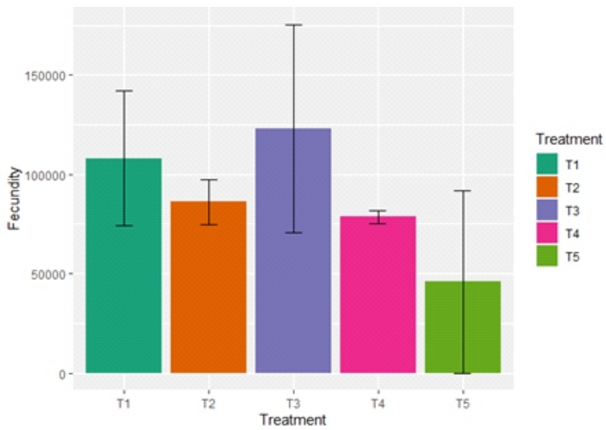

Figure 1: Fecundity of Female Broodstock of C. *gariepinus* stripped under each treatment

Parameters that were determined to understand the effect of each dose administered (Table 2) shows that the weight of eggs stripped from each female for each treatment was not significantly different ($p>0.05$) and also reflective of the fecundity (Figure 1). There was no fertilization and hatching in T5. Fertilization rates did not differ across the treatments ($p>0.05$). Reports of serial dilution of Ovatide® have shown differences in fertilization rate with positive linear relationship according to dilution. According to Maradun *et al.* (2019), fertilization rate of Clarias sp. ranged from 0% to 93.33% following dilution of 100% down to 0% dilution. Latency period differed significantly ($p<0.05$) among the treatments with the least period of 11 hours being recorded for fish treated with 0.2ml//kg of Ovatide® alone as well as 0.15 and 0.1ml/kg Ovatide® and 50μg/kg of Suprecur®. A report on the use of Ovatide® to induce C. *gariepinus* by Shinkafi and Ilesanmi (2014) indicates that the fish were ready for stripping earlier than those in the current report by at most a 3-hour margin. Hatchability also did not differ significantly across the treatments ($p>0.05$). The rate of hatching of eggs produced using diluted Ovatide® and Suprecur® was undulating between the treatments. However, it was not significantly different. Shinkafi and Ilesanmi (2014) also reported an undulating pattern of hatchability in C. *gariepinus* treated with serially diluted Ovatide®. Survival at yolk sac absorption was significantly different among the treatments ($p<0.05$) with T1 having the highest survival rate of 86.79% and T4 having the least survival rate of 52.40%. Survival rate differed according to hormonal treatment used to produce the fry in the current report. In a previous trial using the same species but with only dilution of Ovatide® without supplementation with Buserelin, Maradun *et al.* (2019) also reported the dependence of fry survival on the dose of hormone used to produce them.

Table 2: Egg and breeding parameters of C. *gariepinus* **induced using serially diluted Ovatide® supplemented with Suprecur®**

Treatment	Egg Wt (g)	Latency (Hours)	Fertilization (%)	Hatchability (%)	Survival (%)
T1	144.85 ± 52.4	11.0 ± 0.0^{b}	89.91 ± 0.99	27.24 ± 10.1	86.79 ± 6.67^{b}
T2	128.75 ± 15.6	11.0 ± 0.0^{b}	93.21 ± 1.90	38.58 ± 1.77	72.22 ± 1.91^{ab}
T3	194.15 ± 56.2	11.0 ± 0.0^{b}	83.84 ± 2.28	33.91 ± 15.2	63.59 ± 1.71^{ab}
T4	126.75 ± 2.65	12.0 ± 0.0^{a}	86.02 ± 2.14	29.23 ± 1.54	52.40 ± 8.90^{a}
T5	64.22 ± 64.22	–	–	–	–
p-value	0.465	$<2.0\times10^{-16}$	0.082	0.823	0.049

Means in the same column followed by different superscripts differ significantly ($p<0.05$)

Water quality in the incubation tanks reveals means of pH (7.53), EC (130.6 μS/cm), TDS (63.4 mg/l), Temperature (26.34°C), and DO (4.21 mg/l).

CONCLUSION

The commercial seed production of C. *gariepinus* can be achieved in captivity through induced breeding using diluted Ovatide® boosted with Suprecur®. However, the success rate of induced spawning will depend on the dose of inducement. The use of 0.15ml/kg of Ovatide® + 50ug/kg of Suprecur® can produce fertilization and hatching rates (93.21% and 38.58%) that is as good as 0.2ml/kg of Ovatide® alone (89.91% and 27.24% respectively). The breeding protocol is simple and can be adopted by small scale hatcheries. Possibility of diluting Ovatide® and supplementing with Suprecur® can be helpful in increasing availability of commercial seed required by the expanding catfish aquaculture industry.

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REFERENCES

Adebayo, O. T., and Popoola, O. M. (2008). Comparative evaluation of efficacy and cost of synthetic and non-synthetic hormones for artificial breeding of African catfish (Clarias gariepinus Burchell, 1822). Journal of Fisheries and Aquatic Science, 3(1), 66-71. https://doi.org/https://dx.doi.org/10.3923/jfas.2008.66.71

Anderson, G. W., Genz, J., and McDougall, C. (2013). Using Ovaprim™ as a conservation tool for lake sturgeon, Acipenser fulvescens: The short and long term effects of endocrine manipulation during the reproductive cycle. Winnipeg.

Anderson, K., Pankhurst, N., King, H., and Elizur, A. (2017). Effects of GnRHa treatment during vitellogenesis on the reproductive physiology of thermally challenged female Atlantic salmon (Salmo salar). PeerJ, 5, e3898.

Ayinla, O. K., Kayode, O., Idoniboyeobu, O. I. E., Oresegun, A., and Adindu, V. E. (1994). Use of tadpole meal as substitute for fishmeal in diet of Heterobranchus bidorsalis. . Journal of Aquaculture In the Tropics, 9, 25-33.

Chatakondi, N. G., Butts, I. A. E., and Dunham, R. A. (2018). Hormone Preparation, Dosage Calculation, and Injection Techniques for Induced Spawning of Foodfish. Southern Regional Aquaculture Centre (SRAC Publication) No. 0405, 6 pages

De Graaf, G. J., Galemoni, F., and Banzoussi, B. (1995). Artificial reproduction and fingerling production of the African catfish, Clarias gariepinus (Burchell 1822), in protected and unprotected ponds. Aquaculture Research, 26(4), 233-242.

Hill, J. E., Baldwin, J. D., Graves, J. S., Leonard, R., Powell, J. F. F., and Watson, C. A. (2005). Preliminary observations of topical gill application of reproductive hormones for induced spawning of a tropical ornamental fish. North American Journal of Aquaculture, 67(1), 7-9.

Maradun, H. F., Ovie, S. O., Argungu, L. A., Ahmad, M., Kasim, L. I., Nasiru, S. S., and Sahabi, A. M. (2019). Effect of Different Doses of Saline-diluted Ovatide on the Breeding Performance of Clarias anguillaris and Clarias gariepinus. Open Science Journal of Bioscience and Bioengineering, 6(1), 9-14. http://www.openscienceonline.com/journal/bio

Marimuthu, K., Haniffa, M. A., and Rahman, M. A. (2009). Spawning performance of native threatened spotted snakehead fish, Channa punctatus (Actinopterygii: Channidae: Perciformes), induced with ovatide. Acta Ichthyologica et Piscatoria, 39(1), 1-5 doi: 10.3750/AIP2009.39.1.01

Marimuthu, K., Kumar, D., and Haniffa, M. A. (2007). Induced spawning of striped snakehead, Channa striatus, using Ovatide. Journal of Applied aquaculture, 19(4), 95-103.

Marx, K. K., Rathipriya, A., Sundaray, J. K., and Abishag, M. M. (2020). Broodstock Management and Fish Seed Production. CRC Press London, United Kingdom.

Mylonas, C. C., and Zohar, Y. (2000). Use of GnRHa-delivery systems for the control of reproduction in fish. Reviews in Fish Biology and Fisheries, 10(4), 463-491.

Rashid, M., Naiko, A., and Ahamad, T. (2015). Induced breeding of grass carp (Ctenopharyngodon idella) and silver carp (Hypophthalmichthys molitrix) using ovatide as synthetic hormone at national fish seed farm (Nfsf) manasbal, Kashmir, J&K. Fisheries and Aquaculture Journal, 5, 1-4 doi: 10.4172/2150-3508.1000110

Sahoo, S. K., Giri, S. S., and Sahu, A. K. (2005). Effect on breeding performance and egg quality of Clarias batrachus (Linn.) at various doses of Ovatide during spawning induction. Asian Fisheries Science, 18(1/2), 77-83.

Sharma, K., Yadava, N. K., and Jindal, M. (2010). Effect of different doses of ovatide on the breeding performance of Clarias batrachus (Linn.). Livestock Research for Rural Development, 22 Article #69.

Retrieved January 4, 2022, from http://www.lrrd.org/lrrd22/4/shar22069.htm

Shinkafi, B. A., and Ilesanmi, B. D. (2014). Effect of varying doses of ovatide on the breeding performance of African catfish (Clarias gariepinus Burchell, 1822) in Sokoto, North-western Nigeria. Asian Journal of Animal Sciences, 8(2), 56-64.

Snow, J. R., and Phelps, R. P. (2020). Practical Hatchery Management of Warmwater Fishes. American Fisheries Society. Bethesda, MD 20814 USA, 402pp.

Zohar, Y., and Mylonas, C. C. (2001). Endocrine manipulations of spawning in cultured fish: from hormones to genes. Aquaculture, 197(1), 99-136. https://doi.org/https://doi.org/10.1016/S0044-8486(01)00584-1.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

TAIL MEAT YIELD OF INVASIVE TIGER SHRIMP *(Penaeus monodon)* AND *Farfentepenaeus notialis:* IMPLICATIONS FOR SELECTIVE BREEDING

Nwafili S.A. and D.C. Olumati

Department of fisheries, University of Port Harcourt, P.M.B. 5323 Choba, Port Harcourt, Rivers State

Corresponding author:
sylvanus.nwafili@uniport.edu.ng

ABSTRACT

Among the principal traits for consideration by investors in prawn production is the tail weight. In this study we assessed the tail weight of the two candidate aquaculture species in the coastal waters of Nigeria. We compare the percentage of the total body weight of *Penaeus monodon* and *Farfentepenaeus notialis* that were available for consumption. A total of 257 individuals of *P. monodon* and *F. notialis* were obtained from three locations – New Calabar River, Andoni River System and Bille Creek in the Niger Delta Area of Rivers State. The total body weight and tail weight (weight of abdomen severed along the carapace posterior) of each individual were subjected to analysis. The tail weight was 64 – 67% and 58 – 65% in *P. monodon* and *F. notialis*, respectively of the body weight. The tail weight of female *F. notialis* was meatier than in males which suggest the profitability of monosex culture. There was strong positive correlation between body weight and tail weight, implying that selection for body weight will profoundly influence tail weight.

Keywords:
Tail weight, Penaeus monodon, Farfentepenaeus notialis, Niger Delta, selective breeding

INTRODUCTION

The idea of culturing shrimp is relatively new in Nigeria, being born out of the evidence that it may be difficult to increase sustainably the shrimp catches from Nigerian coastal waters due to the collapse of the pink shrimp fishery in 1990s from over-exploitation, water pollution, habitat degradation, and poor management. (Ansa, 2009; Ansa *et al.*, 2010; Zabbey *et al.*, 2010). The collapse of pink shrimp *(Farfentepenaeus notialis)* fishery coincided with the appearance of the invasive Asia tiger prawn, *Penaeus monodon* in Nigerian Coastal waters (Zabbey et al., 2010). *P. monodon* has since become a major commercial species as the population and size of *F. notialis* continue to decrease. Attention has, therefore, been directed towards the development of shrimp culture as a means to increase shrimp production in the country. This shift towards shrimp aquaculture as an alternative to supply from wild capture in Nigeria is, therefore, a significant development that could open up opportunities for investors and it has the potentials of creating jobs.

However, the choice of candidate shrimp species for culture depends on well-defined characteristics such as high economic value and high market demand, ease of culture, and fast growth. Of the penaeid shrimp in Nigerian waters, the Asia tiger prawn, *P. monodon* and the pink shrimp, *F. notialis* satisfy the conditions of culturable species (Anyanwu *et al.*, 2011). Tail weight is a major trait for selection of shrimp because it is the main marketing component in the industry. The tail weight is a measure used in the shrimp processing industry to estimate the meatiness or yield of the individual or population. It is the ratio of the weight of the tail meat to the total weight of the whole shrimp. The phenotypic and genetic correlation of tail weight to body weight is very high (Chandra *et al.*, 1997). According to

Chandra *et al.* (1997) tail weight is highly variable, implying that it can be exploited through selection. Producers are interested in processing characteristics, such as fillet yield, amount of tail meat, or percentage of edible muscle in relation to body weight of aquaculture species (Thompson *et al.*, 2004). The low tail yield, for example, in freshwater prawns such as Macrobachium species which ranges from 28 to 51 % only (Lin and Boonyaratpalin 1988) makes their culture disadvantageous.

The production of *P. monodon* has already commenced in Badagry by Atlantic shrimpers Limited. Despite the importance of pink shrimp as native species, baseline studies on important economic traits are either lacking or inadequate, particularly those relating metric traits. The objective of this research was to determine the yield characteristics (shell-in tail weight) of two candidate aquaculture species, *P. monodon* and *F. notialis* in the coastal waters of Nigeria. The result will guide potential investors and farmers in the choice of species for farming. The study will provide fresh insight on the potential yield and efficiency of culturing each species.

MATERIALS AND METHODS

Study area

The study was carried out in three locations in the Niger Delta axis of River State namely; New Calabar River, Andoni River system, and Bille Creek. The New Calabar River is located between longitude 7060'E and latitude 5045'N in the coastal area of the Niger Delta (Dienye and Woke, 2015). The Andoni River is located between latitudes 4028' to 4045'N and longitudes 7045'E in the coastal region of the Niger Delta (Komi and Sikoki, 2013). The Bille Creek is tributary of the Sombriero River located between latitude 4036'0" N and longitude 6055'60" E (Wikepedia, 2020).

Sample collection

Penaeus monodon and Farfantepenaeus notialis were collected from local fishermen fishing with cast net (from January – July, 2023). The samples were transported in ice box to the laboratories where they were identified and sorted using appropriate keys (Powell, 1982).

Laboratory Procedures

Each individual of P. monodon and F. notialis were sexed. The petasma in the first pleopod was used to identify the males, while the thelycum in between the fourth and fifth pereopods in females. They were then preserved in 96% alcohol.

The total body weight and tail weight of each individual were obtained using a weighing scale (0.01g). The tail weight (TW) refers to weight of abdomen severed along the carapace posterior.

Data handling and Analysis

The software "Past326b" was used to obtain the means, standard error, linear regression between the total body weight and tail weight as well as the coefficient of correlation (R2), which was used to determine the degree of relationships that exist between the total body weight and tail weight.

The tail weight as percentage of the body weight was derived using this formula:

$$\frac{\text{Total weight of whole shrimp}}{\text{Weight of tail}} \text{ x } 100$$

RESULTS AND DISCUSSION

Total body weight – Tail weight relationship

A total of 257 specimens of penaeid shrimps *(Penaeus monodon* and *Farfantepenaeus notialis)* were obtained from three different locations. However, no specimen of *P. monodon* was collected from Bille Creek. This may be due to low salinity and inability of the invasive species to adapt to prevailing conditions in the Creek. The correlation and coefficient of determination between total body weight and tail weight of *P. monodon* and *F. notialis* are shown in Table 1. In both species the correlation (0.7576 - 99183) and coefficient of determination (0.574 - 98372) were high. The result showed that both species displayed positive linear relationship for the sexes.

Table 1: Total body weight and tail weight relationship of *Penaeus monodon* and *Farfantepenaeus notialis*

Species	Location of Sampling	Sex	r	R^2
Penaeus monodon	New Calabar River	M	0.9858	0.9718
		F	0.99183	0.98372
	Andoni River	M	0.9752	0.95117
		F	0.9891	0.97835
Farfentepenaeus notialis	New Calabar River	M	0.9830	0.96643
		F	0.9319	0.8685
	Andoni River	M	0.9658	0.9329
		F	0.9569	0.91567
	Bille	M	0.8680	0.75389
		F	0.7576	0.574

Where r = correlation value, R2 = coefficient of determination

The yield (Tail weight) characteristics of *Penaeus monodon* and *Farfentepenaeus notialis*

The tail yield characteristics of *P. monodon* and *F. notialis* are presented in Table 2. The tail weight yield ranged from 64 - 67% in *P. monodon* and 58 - 68% in *F. notialis*. For *P. monodon*, the tail weight occupied more than 60% of their total body weight, ranging from 64% to 67% in female and 66 – 67% in males. The tail weight of *F. notialis* occupied some 60% of the total weight with a range of 61 – 65 % and 58 – 61% respectively for females and males.

Table 2: Tail weight of *Penaeus monodon* and *Farfentpenaeus notialis* as percentage of total body weight

Species	Location	Sex	$\bar{X}\pm$SE		% TW of TBW
			TBW	**TW**	
Penaeus monodon	New Calabar River	Male	26.51±1.24	17.72±0.85	67
		Female	37.32±3.02	24.86±1.97	67
	Andoni River	Male	63.5±1.9	41.76±1.26	66
		Female	90.12±7.25	57.83±4.50	64
Farfentepenaeus notialis	New Calabar River	Male	2.35±0.15	1.38±0.14	59
		Female	2.65±0.22	1.72±0.19	65
	Andoni River	Male	7.17±0.57	4.39±0.37	61
		Female	10.56±0.92	6.5±0.6	62
	Bille Creek	Male	1.96±0.19	1.14±0.12	58
		Female	1.89±0.15	1.14±0.09	61

Where X= mean, SE= Standard error, TBW= total body weight, TW= tail weight.

The tail weight is about the most important metric trait in shrimps. It is the edible portion of the shrimp. The percentage tail weight of shrimp is a measure used in the shrimp processing industry to estimate the meatiness or yield of the shrimp. A higher percentage tail weight indicates that a larger portion of the shrimp's weight consists of meat, making it more desirable for consumers and potentially commanding a higher price in the market. In this study, the percentage meat yield was in the range of a previous report (Chemonics, 2002; Campos-Montes *et al.*, 2017). This study reveals that the mean tail weight of the penaeid shrimps examined were more than 60% (pooled) of their mean total body weights. This is in agreement with the report of Chemonics (2002) and Durand *et al.* (2003) that, in the penaeid species, the tail makes up approximately 60 percent of the total weight and higher than those reported for freshwater species which ranges from 28 to 51 % (Lin and Boonyaratpalin 1988)). For *F. notialis,* the percentage tail weight was skewed towards a higher value in females suggesting that all-female culture of the species may be more profitable to farmers. It was not observed whether the females carried eggs or not.

Furthermore, the high positive correlation between body weight and tail weight implies that selecting for body weight will indirectly improve tail weight simultaneously. Genetically, both traits are influenced by the same genes.

CONCLUSION

This study has revealed sexual dimorphism in tail weight of *F. notialis*. This situation can encourage monosex production of *F. notialis*. Secondly, tail weight or tail yield is higher in *P. monodon* suggesting that it is meatier than *F. notialis,* a characteristic that will favour farmers and investors choice of the species. There is strong correlation between body weight and tail weight.

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REFERENCES

Ansa, E.J. (2009). Opportunities for shrimp farming in the Niger Delta: dilemma of sustainable production in the absence of regulatory framework. Book of Proceedings 24th Annual Conference of the Fisheries Society of Nigeria (FISON), Akure, held between 25th and 28th October 2009 at Federal University of Technology, Akure, Ondo State, pp. 138–142.

Ansa, E.J., Davies, O.A. and Akinrotimi, O.A. (2010). Sustainability of Shrimp Farming in the Niger Delta. Paper presented at Aquaculture 2010, Triennial Conference of the World Aquaculture Society held in San Diego, California, USA, 1 – 5 March. 2010. 2pp.

Anyanwu, P.E., Ayinla, O.A., Ebonwu, B.I., Ayaobu-Cookey, I.K., Hamzat, M.B., Ihimekpen, A.F., Matanmi, M.A., Afolabi, E.S., Ajijo, M.R. and Olaluwoye, B.L. (2011). Culture Possibilities of Penaeus monodon in Nigeria. Journal of Fisheries and Aquatic Science, 6: 499-505.

Campos-Montes, GR., Montaldo, H.H., Armenta-Córdova, M., Martínez-Ortega, A., Caballero-Zamora, A., and Castillo-Juárez, H. (2017). Incorporation of tail weight and tail percentage at harvest size in selection programs for the Pacific white shrimp Penaeus (Litopenaeus vannamei). Aquaculture, 468(1): 293-296

Chandra, P.K., Rajendran, K.V., Santiago, T.C., Vijayan, K.K. and Rao, L.H. (1997). Reliable criteria for the selection of broodstock of Penaeus monodon Fabricius in genetic improvement programmes. Indian Journal of Fisheries, 44(4): 331-336.

Chemonics (2002). Subsector Assessment of the Nigerian Shrimp and Prawn Industry. CII (Chemonics International Incorporated). 1133 20th Street, NW, Suite 600 Washington, DC 20036 (202) 955-3300. 85p.

Dienye, H.E. and Woke, G.N. (2015). Physico-chemical parameters of the upper and lower reach of the New Calabar River Niger Delta. Journal of Fisheries and livestock production, 3(154): Dio:10.4172/2332-2608.1000154.

Durand, S., Redman, R., Mohney, L., Tang-Nelson, K., Bonami, J. and Lightner, D. (2003). Qualitative and quantitative studies on the relative virus load of tails and heads of shrimp acutely infected with WSSV. Aquaculture, 216, 9–18.

Komi, G.W. and Sikoki, F.D. (2013). Physico-chemical characteristics of the Andoni River and its potential for production of the Giant Tiger Prawn (Penaeus monodon) in Nigeria. Journal of Natural Science Research, 3(12): 83-89.

Lin, C.K. and Boonyaratpalin, M. (1988). An analysis of biological characteristics of Macrobrachium rosenbergii (de Man) in relation to pond production and marketing in Thailand. Aquaculture, 74:205–215.

Powell, C.B. (1982). Fresh and Brackish water Shrimps of Economic Importance in the Niger Delta. Presented to the 2nd Conference of Fisheries Society of Nigeria held at Calabar, pp 254-284.

Thompson, K.R, Muzinic, L.A, Yancey, D.H, Webster, C.D., Rouse, D.B. and Xiong, Y. (2004). Growth, processing measurements, tail meat yield, and tail meat proximate composition of male and female Australian red claw Crayfish, Cherax quadricarinatus, stocked into earthen ponds. Journal of Applied Aquaculture, 16:117–129.

Wikepedia (2020) Bille tribe. Retrieved from: https://en.google-info.org/20489982/1/bille-trbe.html.

Zabbey, N., Erondu, E.S. and Hart, A.I. (2010). Nigeria and the prospect of shrimp farming: critical issues. Livestock Research for Rural Development, 22 (11): 1-12.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

BLUE ECONOMY EMPLOYMENT AND LIVELIHOOD OPPORTUNITIES IN FISHERIES MANAGEMENT (BELF)

BLUE ECONOMY: CHALLENGES AND CONTRIBUTIONS OF THE FISHERIES AND AQUACULTURE SUB-SECTOR IN BOOSTING THE NIGERIAN ECONOMY

[1]Ukagwu, J.I, [2]S. O. Ohaturonye, and [3]G.S Adaka,

[1]Agricultural Science Department, Alvan Ikoku Federal University of Education, Owerri, Imo State Nigeria
[2]Fisheries and Aquaculture Department, Nnamdi Azikiwe University, Awka, Anambra State Nigeria
[3]Department of Fisheries and Aquaculture Technology, Federal University of Technology, Owerri, Imo State Nigeria

Corresponding Author:
ukagwujohn@yahoo.com, +234-803-764-8878, 0009-0002-0145-7849

ABSTRACT
The concept of the blue economy encapsulates the sustainable use of ocean resources for economic growth, improved livelihoods, and job creation, while preserving the health of ocean ecosystems. Nigeria, with its vast aquatic resources, stands to benefit immensely from the blue economy, particularly through its fisheries and aquaculture sectors. Despite the recognized potential of Nigeria's fisheries and aquaculture sectors, their contributions to the economy are below expectations. The country is yet to fully optimize its marine and inland water resources, resulting in continued dependence on fish imports to meet domestic consumption needs. This paper adopts a qualitative approach, drawing from a range of secondary data sources, including reports from the Food and Agriculture Organization (FAO), World Bank, and Nigerian Federal Ministry of Agriculture. Therefore, this paper examines the contributions of these sectors to Nigeria's economy, including their roles in food security, employment, and poverty reduction. It also discusses challenges such as overfishing, environmental degradation, and policy constraints that hamper optimal performance. Recommendations are made for leveraging these sectors to promote sustainable development within the blue economy framework such as development of national plan of action for capture fisheries and aquaculture, strengthening regulatory framework among others.

Keywords:
Capture fisheries, Aquaculture, Gross Domestic Product, Nigeria.

INTRODUCTION

The term "blue economy" refers to the sustainable use of ocean and marine resources for economic growth, improved livelihoods, and preservation of the ocean ecosystem. They include, Fisheries and aquaculture, maritime transport, coastal tourism and hospitality, offshore renewable energy, marine biotechnology, marine and coastal infrastructure, shipping and ports, ocean exploration and research, underwater mining, marine conservation and biodiversity, water sport and recreation, desalination and water management. Nigeria, with a coastline spanning over 853 km and access to major inland water bodies, is well-positioned to harness the blue economy. In 2020, the fisheries sector contributed approximately 3.4% to Nigeria's Gross Domestic Product (GDP), generating over N1 trillion annually and employing more than 6 million people (FAO, 2021). In spite of this, Nigeria remains a net importer of fish, with over 1.2 million metric tons of fish imported annually to meet local demand. Aquaculture is expanding at a growth rate of 12% annually, yet it only accounts for 0.8 million metric tons of fish production (Nigerian Bureau of Statistics, 2022). The blue economy has emerged as a critical element in the global pursuit of sustainable development, emphasizing the balance between economic growth and environmental conservation in ocean and water-related industries. The fisheries and aquaculture sectors are key pillars of this economy, especially in coastal nations like Nigeria. Nigeria have an exclusive economic zone (EEZ) covering approximately 217,313 square kilometers, with significant potential for harnessing aquatic resources to support economic growth. However, despite the vast resources, Nigeria's fisheries and aquaculture sectors remain underdeveloped and face numerous challenges. In recent years, the Nigerian government has shown increasing interest in the blue economy as a strategy to diversify its oil-dependent economy and boost sectors like fisheries and aquaculture. Despite the recognized potential of Nigeria's fisheries and aquaculture sectors, their contributions to the economy are below expectations. The country is yet to fully optimize its marine and inland water resources, resulting in continued dependence on fish imports to meet domestic consumption needs. For instance, Nigeria imported 2.4 million metric tonnes of fish in 2020, valued at over $1 billion (FAO, 2021). Additionally, overfishing, illegal fishing practices, and environmental pollution have contributed to declining fish stocks, especially in marine waters. This paper is motivated by the need to explore how the blue economy, particularly through fisheries and aquaculture, can contribute to diversifying Nigeria's economy, ensuring food security, and creating sustainable livelihoods. The potential for fisheries and aquaculture to boost Nigeria's economy has been widely recognized, but the sector's full potential remains untapped.

CONCEPTUAL FRAMEWORK

Overview of Nigeria's Fisheries and Aquaculture Sector

Nigeria's fisheries sector is comprised of two main components: capture fisheries and aquaculture. Capture fisheries dominate production, with 60% of domestic fish production, primarily from artisanal fisheries. Aquaculture on the other hand is growing rapidly, with Nigeria ranked as the largest aquaculture producer in sub-Saharan Africa. Yet, the country faces several challenges, including overfishing, climate change, lack of adequate infrastructure, and inefficient policies.The blue economy encompasses a wide range of economic activities that rely on the sustainable use of ocean, coastal, and freshwater resources. Key sectors include fisheries, aquaculture, marine tourism, renewable energy, and maritime transport (World Bank, 2017). In this context, the blue economy in Nigeria is viewed as a strategy for diversifying the economy away from oil dependency and tapping into the sustainable use of aquatic resources. The fisheries and aquaculture sectors are integral to this process, contributing to food security, employment, and trade.The blue economy operates on the principle of sustainability, emphasizing the need to balance the economic benefits derived from aquatic resources with the long-term preservation of the marine environment (World Bank, 2021). In Nigeria, the fisheries and aquaculture sectors offer an avenue for wealth creation, employment, and food security, directly contributing to the nation's development goals, including the Sustainable Development Goals SDGs.The concept of the blue economy in fisheries is closely linked with the "triple bottom line" approach—economic, social, and environmental sustainability. According to Béné et al. (2016), sustainable fisheries ensure that future generations will continue to benefit from ocean resources. However, overfishing, poor governance, and environmental degradation pose significant risks to these goals in Nigeria.

Statistical Overview of Fisheries and Aquaculture in Nigeria

- Fish production: Nigeria's annual fish production stands at approximately 1.1 million metric tons, far below the national demand of 3.5 million metric tons (FAO, 2021). This has led to an annual import of 1.2 million metric tons of fish, costing the country over N300 billion (Nigerian Bureau of

Statistics, 2022).

- Employment: The sector supports over 6 million livelihoods, with a higher concentration of artisanal fishers in the Niger Delta region. Aquaculture is primarily located in southern and central Nigeria (Ezenwa, 2020).
- Export potential: The global fish trade is valued at over $150 billion, and Nigeria has the potential to increase exports of fisheries products, especially from aquaculture, if challenges like poor infrastructure and weak regulatory frameworks are addressed (WorldFish, 2021).

Overview of Global Blue Economy

The global blue economy is estimated to be worth $1.5 trillion annually, contributing 3% of global GDP (OECD, 2020). Fisheries and aquaculture are major components, providing food for over 3 billion people and employing more than 200 million worldwide (FAO, 2021). The sector's importance is growing as the global population increases and demand for sustainable food sources rises. Aquaculture, in particular, has grown rapidly, accounting for nearly 50% of the world's fish supply (World Bank, 2017). In contrast, Nigeria, despite having significant water resources, has not fully integrated into this global movement, due in part to policy and regulatory gaps.

THEORETICAL FRAMEWORK

The theory of sustainable development underpins the concept of the blue economy, which seeks to meet present needs without compromising the ability of future generations to meet their own. Within fisheries and aquaculture, this involves the sustainable management of fish stocks and aquatic ecosystems to prevent over-exploitation. The 'Tragedy of the Commons' theory also applies, highlighting the challenges associated with the overuse of common pool resources, such as fisheries (Hardin, 1968). This theory is relevant to Nigeria, where weak regulation and enforcement have led to overfishing in marine and inland waters.

This study is also anchored on the resource-based view (RBV) theory, which posits that the sustainable use of natural resources leads to competitive advantages and economic growth (Barney, 1991). In Nigeria, marine and inland water bodies represent significant natural capital that, if properly managed, can contribute to economic diversification beyond oil dependence. This aligns with the theory of Sustainable Livelihoods (Chambers and Conway, 1992), which emphasizes that the exploitation of natural resources should simultaneously improve livelihoods while ensuring ecological balance.

EMPIRICAL FRAMEWORK

Fisheries and aquaculture contribute significantly to food security, providing nearly 50% of Nigeria's animal protein intake (FAO, 2020). The sector employs about 10 million people, either directly or indirectly (Federal Ministry of Agriculture, 2022). Aquaculture production, particularly Catfish farming, has been growing at an average rate of 12% annually over the last decade, but the sector still falls short of meeting domestic fish demand (FAO, 2021). Despite these gains, challenges such as poor infrastructure, inadequate funding, and limited access to technology have constrained sectoral growth.

METHODOLOGY

This paper adopts a qualitative approach, drawing from a range of secondary data sources, including reports from the Food and Agriculture Organization (FAO), World Bank, and Nigerian Federal Ministry of Agriculture. Key data on fisheries and aquaculture production, employment, and trade were reviewed to assess the sector's contribution to the Nigerian economy. Additionally, interviews with stakeholders in the fisheries and aquaculture sectors were conducted to identify challenges and potential solutions. Statistical data on fisheries production, trade, and environmental degradation were analyzed to provide a comprehensive view of the sector's current status and future prospects.

PROSPECTS AND CHALLENGES

Prospects of Blue Economy in Nigeria's Fisheries and Aquaculture Sector

- Sustainable Economic Growth: The blue economy, with its emphasis on sustainable use of marine and aquatic resources, holds great potential for Nigeria's fisheries and aquaculture sector. The country has access to rich marine resources in the Gulf of Guinea and vast inland water bodies that can support expanded fish production, processing, and export. Nigeria's potential to become a global hub for aquaculture is growing due to increasing local and international demand for fish.
- Job Creation and Livelihoods: Nigeria's fisheries and aquaculture industry can provide significant employment opportunities. Small-scale fish farmers, artisanal fishermen, and those involved in fish processing and distribution stand to benefit from enhanced access to resources and markets, promoting improved livelihoods in rural and coastal communities.
- Food Security and Nutrition: Fisheries and aquaculture contribute significantly to food security in Nigeria, providing affordable protein sources. Expanding the sector under a blue economy framework can increase fish production, address nutritional deficiencies, and reduce reliance on imported fish. The use of new technologies, such as floating-cage aquaculture and improved fish farming techniques, can boost local production.
- Marine and Coastal Tourism Development: The blue economy offers prospects for developing eco-friendly marine and coastal tourism that can complement fisheries. Sustainable tourism activities could be integrated with aquaculture projects to provide additional revenue streams for coastal communities while promoting conservation efforts.
- Technological Advancements: The adoption of modern technologies such as solar-powered cold storage, floating-cage aquaculture, and advanced breeding techniques can significantly improve the efficiency and productivity of Nigeria's fisheries and aquaculture sector. Information and communication technologies (ICTs) also play an important role in monitoring and managing fish stocks, facilitating sustainable fishing practices.

Challenges of Blue Economy in Nigeria's Fisheries and Aquaculture Sector

- Overfishing and Illegal, Unreported, and Unregulated (IUU) Fishing: One of the major challenges facing Nigeria's fisheries sector is the problem of overfishing and IUU fishing, which threatens fish stocks and marine biodiversity. This undermines the sustainability goals of the blue economy and poses a threat to the long-term viability of fishery resources.
- Pollution and Environmental Degradation: Aquatic ecosystems in Nigeria are increasingly impacted by pollution from oil spills, industrial waste, and agricultural runoff, particularly in the Niger Delta region. Such environmental degradation negatively affects marine habitats and reduces fish productivity, posing a serious threat to fisheries and aquaculture.
- Inadequate Infrastructure and Technology: The fisheries and aquaculture sector in Nigeria suffers from insufficient infrastructure, including inadequate cold storage, poor transportation networks, and limited access to modern aquaculture technologies. This restricts the ability of fish farmers and coastal communities to scale up production and access larger markets.
- Climate Change and Rising Sea Levels: Climate change poses a significant risk to Nigeria's coastal fisheries and aquaculture sector. Rising sea levels, coastal erosion, and ocean acidification affect marine biodiversity, breeding grounds, and aquaculture facilities. Furthermore, changes in temperature and precipitation patterns impact freshwater systems, reducing the availability of resources for inland fisheries.
- Limited Access to Finance: Many small-scale fish farmers and artisanal fishers in Nigeria lack access to credit and investment opportunities. This limits their capacity to adopt new technologies, expand operations, and improve productivity. The absence of financial support mechanisms impedes the development of a vibrant and inclusive blue economy.
- Weak Governance and Regulatory Framework: The governance of Nigeria's fisheries and marine

resources is often characterized by weak enforcement of policies and regulations, leading to unsustainable fishing practices. Corruption and lack of institutional coordination hinders the effective management of marine ecosystems. Stronger governance and policy reforms are needed to ensure sustainable management of aquatic resources.

- Insecurity in Coastal Areas: Coastal communities involved in fishing face security challenges due to piracy, kidnapping, and conflicts over resources. Insecurity undermines investment in fisheries and aquaculture, disrupting operations and discouraging local and foreign investment.

CONCLUSION AND RECOMMENDATIONS

Fisheries and aquaculture are critical components of Nigeria's blue economy and have significant potential to contribute to economic diversification, food security, and sustainable livelihoods. However, to fully realize this potential, Nigeria must address the challenges of overfishing, environmental degradation, and weak policy implementation.

Recommendations

- Development of a National Plan of Action (NPOA) on capture fisheries and Aquaculture.
- Strengthening regulatory frameworks to ensure sustainable fishing practices.
- Investing in aquaculture infrastructure and technologies to increase domestic fish production.
- Promoting public-private partnerships to improve access to finance and market opportunities for fish farmers.
- Enhancing environmental protection measures to mitigate pollution and restore degraded ecosystems.

REFERENCES

Béné, C., Hersoug, B., and Allison, E. H. (2016). Not by rent alone: Analysing the pro-poor functions of small-scale fisheries in developing countries. Marine Policy, 20, 83-96.

Barney, J. (1991). Firm resources and sustained competitive advantage. Journal of Management, 17(1), 99-120.

Chambers, R., and Conway, G. (1992). Sustainable rural livelihoods: Practical concepts for the 21st century. IDS Discussion Paper, 296, 1-29.

Ezenwa, B. (2020). Current status of aquaculture in Nigeria. Journal of Fisheries Research, 15(2), 145-160.

FAO (2021). Fishery and Aquaculture Country Profiles: Nigeria. Food and Agriculture Organization report.

Federal Ministry of Agriculture (2022). Annual Fisheries Report. Government of Nigeria.

Hardin, G. (1968). "The Tragedy of the Commons." Science, 162(3859), 1243-1248.

OECD (2020). The Ocean Economy in 2030. Organisation for Economic Co-operation and Development report.

Nigerian Bureau of Statistics. (2022). Annual fisheries report. Abuja: NBS.

Nigerian Institute for Oceanography and Marine Research (2021). State of Nigeria's Marine Fisheries Resources.

World Bank (2017). The Potential of the Blue Economy: Increasing Long-term Benefits of the Sustainable Use of Marine Resources for Small Island Developing States.

WorldFish. (2021). Unlocking the potential of aquaculture in Africa. WorldFish Report.

POVERTY STATUS OF ARTISANAL FISHER FOLKS IN OLUWO FISH MARKET, EPE, LAGOS STATE, NIGERIA

[1]Oyetade O. P., [1]N. A. Bamidele, [2]W. G. Ojebiyi, [1]C. J. Okolie, [1]T. O. Akintade, [3]A. O. Fakeye and [1] M. C. Ifeakanwa

[1]Department of Aquaculture and Fisheries Management, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria
[2]Department of Agricultural Extension and Rural Development, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria
[3]Department of Fisheries Technology, Federal College of Fisheries and Marine Technology, Victoria Island, Lagos State, Nigeria

Corresponding Author:
oyetadeop@funaab.edu.ng, +2347031849361, 0000000189874916

ABSTRACT
The study analyzed the poverty status and economic analysis of artisanal fisher folks in Oluwo fish market Epe, Lagos State. A total of 106 fisherfolk's were selected using multistage sampling techniques with a focus on socio-economic and fishing characteristics, economic analysis, and household expenditure. The socio-economic analysis revealed that 74.5% were female and 25.5% were male, with a mean age of 44.4±10.10 and 49.1% having secondary education. The highest income earning members were 62.3%, with an estimated monthly income of 34.9%. The most spent on food and non-food items were N90,000-10,000 (33.0%), and 40,000 and above (30.2%). The level of poverty was 80% poor, with 20% being non-poor. Linear regression analysis showed that education level, household size, and estimated monthly income were significantly related to poverty. The study concluded that fishing households in Epe fish market experience high levels of poverty, with limited access to education, income, and credit. It recommended training and capacity building programs for artisanal fishers to enhance their skills and knowledge in fishing, processing, and marketing.

Keywords:
Economic analysis, household expenditure, artisanal fisher folks, poverty and capacity building programs

INTRODUCTION

Poverty encompasses deprivation in various forms that impact human capacities including consumption, food security, health, education, rights, etc. Literatures in fisheries has long perpetuated the myth that 'artisanal' fishermen are poor, illiterate, and impoverished individuals who are forced to pursue fishing as a means of subsistence because they lack other options. Also, in their work, several challenges including seasonality, environmental risks, climate change, economic instability, social and gender dynamics, political influences, and health issues are some of the variables that affect their very fluctuating incomes (FAO, 2022), Poorly-managed coping strategies, such as dragging children out of school, taking out high-interest loans, liquidating valuables, or illegal fishing, can jeopardize the sustainability of the environment and the well-being of households (FAO, 2023). In Nigeria, artisanal inland fisheries generate 10.77% of the country's GDP (FAO, 2023), but poverty persists among fishermen due to lack of resources, access to clean water, poor sanitation and healthcare, and lack of education. High rates of poverty affect the livelihoods, well-being, and social standing of fishermen and women in Epe Lagoon, Lagos State, Nigeria, affecting their overall well-being and social standing (Akinbode, 2018).

Objectives of the study

The main objective of the study is to determine the poverty status of artisanal fisherfolks in Epe lagoon while the specific objectives are:

i. Determine the socioeconomic characteristics of the artisanal fisher folks
ii. Evaluate the artisanal fisher folk's expenditure and income.
iii. Determine the artisanal fisher folk's poverty status.

Materials and Methods

The study was carried out around Epe Lagoon, which is a coastal lagoon located in the Epe Local Government Area of Lagos State, Nigeria. It is a vital fishing ground and a significant source of livelihood for the surrounding communities (Olawunmi, 2019). The Lagoon is approximately 30 kilometers long and 5 kilometers wide, covering an area of about 150 square meters (Nwosu, 2017). Epe Lagoon is situated in the Southwestern part of Nigeria, bordered by Atlantic Ocean to the south and Lekki Lagoon to the east (Ajayi, 2020).

Data collection and Sampling Techniques

This study used a validated interview guide to gather data on socio-economic characteristics of artisanal fishers, fishing characteristics, economic variables, and household consumption. The targeted populations were fishers in the Epe community and, especially women fisher folks. A stratified random sampling method was used to ensure representation across various fishing operations scales, with a sample size of 106 fisher folks.

Analytical techniques

The data was analysed using Descriptive statistics, Mean Expenditure Threshold Model, Linear Regression Model, and Cost-Return Analysis. The Mean Expenditure Threshold Model was used to determine the poverty status of the fishing community, classifying households into poor and non-poor based on per capita expenditure. Households with less than the mean per capita expenditure were considered poor, while those with above the mean were non-poor. This method was used by Ademola and Abang (2015).

$$\text{Per Capital Expenditure} = \frac{\textit{Total Household Expenditure}}{\textit{Number of household members}} \cdots\cdots\cdots (1)$$

$$\text{Mean per Capital Expenditure} = \frac{\textit{Sum of all respondents' per capita expenditures}}{\textit{Total number of respondents}} \cdots\cdots\cdots (1)$$

Linear Regression Model was used to identify the socio-economic factors that contribute to the fishers poverty status. The model is specified as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_n X_n + \epsilon \ldots\ldots\ldots (3)$$

Where:
- Y = Poverty status
- β_0 = Constant
- $\beta_1, \beta_2, \ldots\ldots, \beta_n$ = Coefficient that measure the effect of each independent variable
- $X_1, X_2 \ldots\ldots X_n$ = Independent variables (e.g., age, household size)
- ε = Error (Captures unexplained variability)

Cost Return analysis was used to assess the economic performance of the fishers by evaluating their costs and returns. The key metrics were the Gross Margin (GM), Net Profit (NET).

RESULTS AND DISCUSSION

Summary Statistics of the Socio-Demographic Characteristics of Respondents used in the Study

Table 1 summarizes the demographic and financial characteristics of the Epe lagoon fishing community. The community is predominantly of female population with a mean age of 44.4 years. Most residents have a Secondary education and are identified as Christian. Households are relatively large, with an average of 7.9 members. Most households have multiple income-earning members, but income levels are generally low. Expenditure on food and non-food items is significant, reflecting the community's reliance on fishing and related activities.

Table 1: Respondents' Socio-economic Characteristics

Variables	Minimum	Maximum	Mean	Std.Dev	Majority
Age	25	65	44.43	10.01	>50years (32.1%)
Gender	-	-	-	-	Female (74.5%)
Marital status	-	-	-	-	Married (84%)
Highest level of Education	-	-	-	-	Secondary (49.1%)
Religion	-	-	-	-	Christianity (68.9%)
Household size	2	30	7.92	5.10	4 - 8 (58.5%)
Number of dependent	1	20	4.04	3.10	3 - 5 (62.5%)
Number of incomes earning members	0	10	3.26	1.893	2 - 3 (50.9%)
Estimated monthly income	20000	750000	131386.79	102088.06	N50000-90000 (34.9%)
Monthly expenditure on food items	15000	150000	81084.91	32805.38	N90000 - N100000 (33%)
Monthly expenditure on non-food items	7500	100000	28811.32	13439.01	>N40000 (30.1%)

Economic Analysis of Fishers in Epe

Table 2 presents an economic analysis of fishers in Epe, revealing high variability in monthly and annual revenue. Major costs include gear, craft, labour, and fuel, with significant deviations among fishers. The Gross Margin (GM) averages N1,505,344.34, indicating the ability of fishers to cover fixed costs. The Net Profit (NET) stands at N253,268.87, reflecting actual profitability after accounting for both fixed and variable costs. The high standard deviation of net profit (N170,579.30) indicates significant differences in profitability among fishers, with some generating higher returns while others struggle with lower profits.

Table 2: Economic Analysis of Fishers in Epe (n = 106)

	Mean	Std. Deviation
Monthly Revenue	131386.7925	102088.0638
Annual Revenue	1576641.51	1225056.766
Cost of gear	529056.6038	442167.8809
Cost of craft	723018.8679	558438.1618
Cost of labor	12250	8246.28343
Cost of fuel	29650.9434	17766.76536
Cost of repair	29396.2264	27858.37627
TFC	1252075.472	1000606.043
TVC	71297.1698	53871.42506
TC	1323372.642	1054477.468
GM	1505344.34	1171185.341
NET	253268.8685	170579.2982

Poverty Status of Epe Lagoon Artisanal Fishing Community

Based on the Mean Expenditure Threshold model used, 19.8% of the respondents are categorized as poor i.e., earn below the Mean per Capita Expenditure while 80.2% are categorized as non-poor (Figure 1). The result implies that 80.2% of the respondents earn below N109896.2 on a monthly basis, they are therefore considered poor indicating that income for most households could cannot meet their basic needs particularly food and non-food expenditures. The findings of this study align with Olutumise and Ajibefun (2019) whose findings revealed that over 60% of fishing household are poor.

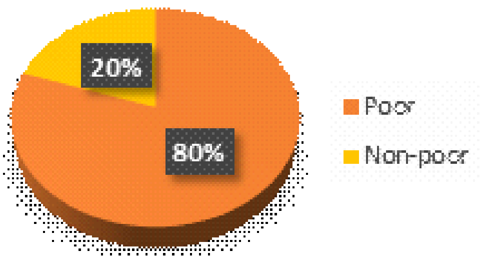

Figure 1: Poverty Status of Epe Lagoon Artisanal Fishing Community

Socio-economic Determinant of the Fishing Community Poverty Status

The study identified the factors influencing poverty status in the Epe Lagoon fishing community. Results showed that age has a significant negative effect on poverty status, with younger fisherfolks being more likely to be poorer than older ones as shown in table 3. The β indicates that for every 1-year increase in age, poverty status decreases by 0.199 units. Gender is not statistically significant, suggesting that both men and women are equally vulnerable to poverty within the fishing sector. Marital status is also not a significant determinant of poverty. Education has a positive impact on reducing poverty, as higher levels of education equip individuals with better skills and opportunities to diversify their income, increasing economic stability. Household size has a significant negative impact on poverty, with larger households more likely to experience worsened poverty status. The number of dependents is also a significant determinant, with larger households struggling to meet the needs of all members, leading to a higher risk of poverty. The β being -0.05 indicates that odds of a fisher folk being poor changed by a factor of 0.05 with every unit increase in household size. This justifies the study of Jatto *et al.*, (2021) and Oyetade *et al.* (2023) that reported the same. The number of income-earning members in the household does not have a significant impact on poverty status, possibly because their incomes are insufficient or irregular. Estimated monthly income has a highly significant positive effect on reducing poverty, with higher earners being more financially secure. This agrees with Olutumise and Ajibefun (2019). Food spending and Non-food expenditures do not have a significant impact on poverty status, potentially indicating that non-food expenditures are not substantial enough to determine whether a household is poor or non-poor.

Table 3: Socio-economic Determinant of fishing households' poverty Status

	β	Std. Error	t-value	p-value
(Constant)	1.689	0.208	8.133	0
Age	-0.199	0.063	-3.152	0.002
Gender	-0.022	0.044	-0.501	0.618
Marital status	0	0.032	0.013	0.99
Highest level of Education	0.013	0.003	4.135	0
Household size	0.05	0.014	-3.653	0
Number of dependent	-0.057	0.021	-2.71	0.008
Number of incomes earning members	5.49E-08	0	0.197	0.844
Estimated monthly income	6.16E-06	0	5.122	0
Monthly expenditure on food items	1.97E-06	0	0.785	0.435
Monthly expenditure on non-food items	-1.00E-02	0.061	-0.169	0.866

CONCLUSION AND RECOMMENDATIONS

The study reveals that fishing households in Epe Lagoon experience high levels of poverty, with limited access to education, income and credit. The findings suggest that low education levels, low income, high expenditure and limited access to credit are significant determinants of fishing household poverty status. To help alleviate the poverty in the system, training and capacity building programs for fishers and women fisher folk to enhance their skills and knowledge in fishing, processing and marketing is advocated. Socio-economic status of the fishing community should be improved by providing basic infrastructure that could help ease their expenses.

REFERENCES

Ademola, A. A. and Abang, S. O. (2015). Analysis of poverty status of rural farm families in Akwa Ibom State, Nigeria. Global Journal of Agricultural Sciences, 14(1), 45-50.

Ajayi, O. T. (2020). Socio Economic Characteristics of Fisher folk in Epe Lagoon, Lagos State. Journal of Fisheries and Aquatic Sciences, 15(1), 53-63.

Akinbode, O. (2018). Poverty and Livelihoods of Fisher folk in Epe Lagoon, Lagos State. Journal of Sustainable Development, 11(2), 1-12.FAO. (2022). Strengthening coherence between social protection and fisheries policies – Framework for analysis and action. FAO Fisheries and Aquaculture Technical Paper No. 671/1. Rome.

FAO. 2023. International Year of Artisanal Fisheries and Aquaculture 2022 – Final report. Rome.

Jatto, K. A., Akanni, O. F., Olatunji, B. T., Arowolo, O. V., Abegunrin, O. O., Kareem, A. T. and Olayemi, O. O. (2021). Poverty status of arable farm households in Akinyele local government area of Oyo State, Nigeria. Journal of Agriculture and Food Sciences, 19(2), 43-50.

Nwosu, J. (2017). Poverty and Access to Social Services among Fisher folk in Epe Lagoon, Lagos State. Journal of Sustainable Development, 10(2), 1-12.

Olawunmi, S. O. (2019). Women's Livelihoods in Aquatic Communities in Nigeria: A Case Study of Epe Lagoon. Journal of Women's Studies, 30(1), 34-47.

Olutumıse, A. I., and Ajıbefun, I. A. (2019). Evaluation of poverty status and time-taken to exit poverty among food crop farmers in Nigeria. Journal of Agricultural Faculty of Gaziosmanpaşa University

(JAFAG), 36(2), 97-106.

Oyetade. O. P., Bamidele, N. A., Ojebiyi, W. G., Oyebamiji, B. A., Olaitan, K. A., Olaoye, O. J., Akinde, A. O. and Ale, O. A. (2023). Economics, Analysis and Poverty Status of Artisanal Fishing Household in Ogun Waterside Local Government Area of Ogun State. AKSU Journal of Agriculture and Food Science, 7(3) 115-127.

CLIMATE CHANGE AND ITS IMPACT ON FISHERIES RESOURCES (CCFR)

A REVIEW ON CLIMATE CHANGE AND IT'S IMPACT ON FISHERY PRODUCTION IN KAINJI LAKE NIGERIA

Manuwuike, Q. M., Ifejika P.I., Nwabeze, G. O., Esther, O. A. and Ekundayo, O. W.

National Institute For Freshwater Fishery Research (NIFFR), P.M.B 6006 New Bussa Nigeria.

Corresponding Author:
queenmercy123@gmail.com, +2348034494087

ABSTRACT

This review aims at determining the impact of Climate Change on fish production in the Kainji Lake basin of Nigeria. This study was conducted based on information from secondary sources. The fishery subsector in Nigeria contributes about 3 to 4 percent to the country's annual GDP. The declining trend in the fishery yield especially that of Lake Kainji calls for a review on whether this decline is associated with Climate change. Climate change has been known as a global externality, resulting from rapid industrial development and associated human induce changes in the natural environment. The estimate of lake' s fish yield production in 1996 was 38,246 metric ton by 1997 there had been a sharp decline to about 25 percent recorded, and since then reserch shows that there has been a drastic decline in fish yield at about 4500mt. This decline could be attributed to beach seine that ended up affecting the Clupeid resources in the lake. Also the study review that a continuous rise in the temperature of surface level water due to the changes of climate conditions may change the stability of the water quality and hinder the penetration of nutrients from lower depths into the water surface, this could lead to fall in productivity of fishery. This review also indicates that rainfall seems to have a negative impact and an undefined link to the declining fish yield in the lake, thus a well structured and adaptive as well an effective communicative component be put in check towards the fisher folks and stakeholders in relation to climate change.

Keywords:
Climate Change, Fishery, Production, Lake Kainji.

INTRODUCTION

In Nigeria, the fisheries sub-sector contributes 3-4 per cent to the country's annual GDP. Fish is an important contributor to the population's nutritional requirements, constituting about 50 per cent of the animal protein intake (FAO, 2016).A recent study estimated that Nigeria ranks third globally for the number of people dependent on coastal fisheries for food and nutrition security, and the demand for fish is growing, alongside growth in population and incomes. However, household fish consumption in Nigeria—measured at 13.3 kg/capita/year—is low compared with the world's average of 20.3 kg/capita/year (FAO 2018). which indicates a situation of undernutrition.

In the African diet, fish has always been important, providing protein to 200 million individuals and providing employment for up to 10 million individuals in Africa (Adebo & Ayelari, 2011), including in Nigeria. The fishery production in Nigeria originates from three sources; artisanal fisheries (inland water, lakes, coastal and salty water),aquaculture (fish cultivation) and mechanized fishing (Otubusin, 2011). A declining trend in Nigerian fishery production and a growing demand for fish as food highlights, the need for better understanding of the sources of this decline and for the establishment of measures to support local production is paramount.

A primary cause of overfishing is "open access" to fisheries, where no one takes responsibility for sustaining the resource, but everyone seeks to maximize individual gains. The deterioration of fisheries in Nigerian lakes because of overfishing has been widely reported (Tafida, *et al.*, 2013). At Lake Kainji, studies indicate that there has been a decline in the mean size of fish species (i.e. mean length and weight) and changes in reproduction rates due to both environmental factors and community overfishing (Seisay & du Feu, 1997).

Destructive/obnoxious fishing practices: The use of destructive fishing methods, such as beach seine, has threatened the sustainability of fishery resources in Nigerian lakes, such as the Kainji and Jebba Lakes (Nwabeze, Erie, & Erie, 2012). The use of toxic substances, which was banned for fishing in Nigeria (Hobday, & Hudson 2015), could be another factor causing harm to fish production in lakes
The absence of government controls is not left out as this is another factor cited in literature has been non effective and inefficient in the sense that administrative measures designed for exclusive control of fishing efforts have been unsuccessful (Hoguane, Lopes & Lopes, 2002). Other than the above factors that influence fishery production, recent literature highlights that climate change significantly affect fishery productivity worldwide (Ficke, Myrick & Hansen, 2012).

Climate change is a global externality, resulting from rapid industrial development and associated human-induced changes in the natural environment. Inferences on climate variation are drawn from an assemblage of observations of temperature, rainfall and other forms of precipitation, wind, sunlight and humidity drawn from historical records and other meteorological estimates (IPCC, 2007)

Scientists have established that disturbances to regular cycles of weather can influence biological systems, including agriculture, and affect the stability of food supply and water availability threatening the sustainability of fisheries systems. For instance, estimates suggest that agricultural yield could fall by as much as 50% between 2000 to 2020 in some parts of Africa owing to accelerated soil erosion, which is attributed to climate change (Apata *et. al.*, 2009; IPCC, 2007). Climate change can be both a biophysical and economic driver in fishery management to safeguard fish supplies, particularly in the presence of various other factors that affect fisheries productivity, as discussed earlier.

Climate change impacts may be felt over the entire earth or can be limited to a specific location (UNFCCC, 2011), requiring a range of adaptation measures to mitigate the consequences. It is well-known that the vulnerability to climate change and the capacity to adapt to ongoing changes results in a varied net impact of climate change across locations. The socio-economic setting and the existing natural regenerating capacity of the natural resource systems – such as fisheries – have an impact on the outcome.
Broadly, climate adaptation measures in the fisheries sector would include increased diversification into non-fishing activity, and the devising of appropriate fishing access and use regimes for fishing communities, including indigenous access limits, and assisting communities to learn and practice new measures to adapt to a more variable climate (Huq, *et al.*, 2007).

IMPACT OF CLIMATE CHANGE ON FISHERY PRODUCTION

Global climate change, as highlighted in a number of reviews, involves long-term shifts in weather patterns, usually around 30 years. Such shifts have accompanied increased variation in weather variables including an increase in temperature, evaluated at almost 0.2 °C every decade since 1980

(Osborn, 2010), increasing precipitation in some regions and reduction in others, and a rise in global sea level (Cunningham & Cunningham 2004). These changes are associated with heightened changes and may be linked to ongoing accumulation of greenhouse gasses in the atmosphere (IPCC, 2007). Scientific observations suggest that climatic variability, particularly at the medium term or at the decadal scale, may have influenced global fisheries production (Garcia and Rosenberg, 2010). Such changes are attributed to worldwide changes in temperature, rainfall, humidity and water salinity.

There are several aquatic habitats in Nigeria including freshwater and marine environments,man-made Lakes such as Kainji Lake, reservoirs and floodplain systems such as the river Benue (Tohan *et al.*, 2006), all of which provide habitat for distinct species of fish and react in diverse ways to the effects of climate change, prompting changes in stocks of fish. This could have economic implications since it is most likely to affect the level of extraction, particularly impacting on the poor and the vulnerable who depend on fishing as their source of livelihood. The impact of climate change on fishery productivity can be classified as physical, economic and biological.

PHYSICAL IMPACT OF CLIMATE CHANGE ON FISHERY PRODUCTION.

Worldwide climate change is likely to influence aquatic frameworks through changes in the hydrologic cycle: dissipation, changes in temperature and precipitation (Kling *et al.* 2013). Even though historical evidence does not link increased evaporation with lower water levels in low temperature lakes. The inherent trend in climate change tends to put an extra stressor into the suite that already incorporates pollution, overfishing, water redirection and across-the-board presentation of non-local fish species (Goudswaard *et al.* 2002). On these grounds, it is useful to consider the influence of various climatic factors on fishery production.

TEMPERATURE

An increase in water temperature may influence fish physiology, changing the spawning patterns and the survival of juveniles, and ultimately the annual recruitment and the exploitable catch size (Grego, 2014). In particular, high temperature during stages of juvenile growth can have a huge impact on the sexual maturation of new spawns.. The rates of feeding, digestion and development are also influenced by the water temperature because when the temperature is lower than ideal, feeding behavior is diminished (Chitmanat & Traichaiyapon, 2010).

This provides ample evidence that temperature is the most noteworthy element affecting fishery production as it has a profound effect on the water's salinity and fish productivity. Changes in the temperature of the water level could prompt changes in the movement of fish, leading to a decrease in fish yield, particularly where sea water meets fresh water ecosystems (African Action, 2007).

Rainfall

Kainji Lake lies near 9°30'N and 10°35'N latitudes and 4°25'E and 4°45'E longitudes. The district is a zone of Guinea Savannah kept up by yearly burning. The geology is of low alleviation, lying between 150 m to 300 m above sea level. The rainfall is altogether restricted to a period starting about mid-April and stretching out to mid-October. In a study of the impact of rainfall on estuarine fisheries in Queensland, Australia, Meynecke *et al.* (2006) found approximately 30 percent of the variation of the total catch was associated with rainfall variability. The literature also identified a positive relationship between freshwater inflows (rainfall) and fishery productivity based on an exportation of sediment from the inputs. The inflows bring increases in nourishment in the water, providing food and shelter for the fish species in the habitat, especially during their development stage and thereby increasing their rate of survival and grow (Ayub, 2010). The incremental change in rainfall and water level supports the multiplication, recruitment and migration of fish in the lakes (FAO, 2014). However, when the rainfall is too heavy, it may significantly reduce the level of the fish catch and the catch per unit effort (CPUE).

Biological impact of climate change.

Fish are known to react to ecological change, for instance, the presence of warmer water. The species can change through migration to another habitat in search of water of a more suitable temperature, resulting in an increasing yield in a higher latitude. However, when the latitude is relatively low, it is likely there will be loss in fish, resulting in a decline in the fish stock (Mohammed & Uraguch, 2013). Changes in the water level can fluctuate from 30 to 70 percent in higher latitudes, and this may pose a serious threat to fisher folk who may not be able to follow the fish stock at such a high level. .Subsequent changes in fish stock appropriation and distribution will affect the profitability of fisheries and may influence the production of a fish resource provided by fishing communities, with likely effects on the livelihoods of the fisher folk in fishing communities. For example, the supply of an adequate protein, market availability and social welfare (OECD, 2010) will be affected in the fishing communities.

Economic Impact of Climate Change

Failure to recognise the importance of balancing human and ecological needs has brought about a worldwide temperature alteration and climate change with their related devastating impacts (Eliam 2015). to land surface (vegetation) and water resources through to the biological and physical properties of soil are particularly important for the sustainability of fisheries and providing for human life on earth (Badjeck *et al.,* 2017). Environmental externalities can influence fishery profitability in several ways such as modifying recruitment, development rates and normal mortality, but these are negative externalities that may lessen the efficiency of fishery yield (Richard, *et al.*, 2015).

Climate change may have a physical, biological and economic effect on the sustainability of fishery resources. The required inputs for fishery production are complex and may incorporate the fish stock as well as fishing gear, vessel sort and size and the fuel expended. As the fishing resource population falls, the exertion expected to make the same catch goes up, influencing the cost of the effort used and creating a higher plane of competition among fisher folk, which then alters the price stability of the resource and the fishery sub-sector of the economy at large. However, the threat of climate change interactions notwithstanding, it could also be possible that other factors may be interacting to threaten the productivity pattern of the natural resources in the fishing community, which may contribute to the dwindling of these resources in the Kanji Lake Basin.

Fishery adaptation to climate change

Fisheries adaptation to climate change reveals the need for the safeguarding fish stock through resource protection or conservation measures and harvest restrictions (Terry, 2012). Adaptation to climate incorporates receptive activities by people or, by public institutions, which range from forsaking fisheries for other occupations to creating protection frameworks and changing fishing operations (Daw, *et al.,* 2009). Adaptation may include modifying fishing weights to sustainable levels, setting catch limits in the light of changes in recruitment, development, survival and reproductive achievement should be possible using versatile administration, checks and preparatory standards (FAO, 2018). For instance, in the Kainji Lake, the fisher folks seem to be aware that the precipitation level brought about by climate change is beyond their control. Prior knowledge of this could lead to their ability to embark on livelihood diversification plans.

CONCLUSION

It has been demonstrated theoretically that various factors play a role when it comes to climate change, both in the short- and long-term, because it tends to reflect changes in fish prices, declines in fish yield and the effect on the long-term sustainability of fish yields, fish marketing structure, the cost of fishing and the income and profit made by fisher folks. Thus, the awareness of climate change and other related human activities becomes important with regards to the economic adaptation of fisheries-dependent people by way of livelihood diversification, which might be an alternative measure for sustenance by the fisher folk, so that less attention will be paid to the fish stock to allow for the recovery of proper reproductive rates by the juveniles.

REFERENCES

Adebo, G. M., & Ayelari, T. A. 2011,. Climate change and vunerability of fish farmers in Southwestern Nigeria. African Journal of Agricultural Research, 16(18), 4230-4238.

Apata T. G. Samuel, K. D. & Adeola, A. O. 2009,. Analysis of Climate change perception and Adaptation among Arable Food Crop Farmers in south Western Nigeria paper presented at the conference of International Association of Agricultural Economics pp. 2-9

Ayub, Z. 2010,. Effect of Temperature and Rainfall as a Component of Climate Change on Fish and Shrimp Catch in Pakistan. The Journal of Transdisciplinary Environmental Studies, ISSN 1602-229. http://www.journal-tes.dk/

Badjeck M.C, Allison E. H, Halls A. S, Dulvy N.K. 2017,. Impacts of climate variability and change on fishery-based livelihoods. Marine Policy. 34:375–383. doi: 10.1016/j.marpol.2009.08.007.

Cunningham, W. P., & Cunningham , M. A. 2004,. Principles of Environmental Science, Inquiry and Applications. 2, 303.

Elias, P., & Omojola, A. 2015,. Case study: The challenges of climate change for Lagos, Nigeria. Current Opinion in Environmental Sustainability, 13, 74-78. doi:http://dx.doi.org/10.1016/j.cosust.2015.02.008

FAO. 2016,. The State of the World Fisheries and Aquaculture. Contributing to food security and nutrition for all. Retrieved from Rome: March 2016 Ficke, A. D., Myrick, C. A., & Hansen, L. J. 2007,.

FAO. 2018,. The State of the World Fisheries and Aquaculture 2018- meetingt the sustainable development goal. Rome

Ficke, A. D., Myrick, C. A., & Hansen, L. J. 2012,. Potential impacts of global climate change on freshwater fisheries. Reviews in Fish Biology and Fisheries, 17(4), 581-613.

Gregory,J.P and Smith,P.(2013) Climate Change and Sustainable Food Production. The Proceedings of the Nutrition Society, 72, 21-28. https:// doi.org/10.1017/S0029665112002832

Huq, S. A. Rahman, M. Konate, Y. Sokona and H. Reid 2003,. Mainstreaming Adaptation to Climate Change in Least Developed Countries (LDCs), IIED, London.

IPCC. 2007,. Climate change: Synthesis report. Contribution of working groups I, II and III to the fourth assessment report of the Intergovernmental Panel on Climate Change.

Meynecke, J. O., Lee, S. Y., Duke, N. C., Warnken, J. 2006,. Effects of rainfall as a component of climate change on estuarine fish production in Queensland, Australia. Estuarine Coastal and Shelf Science 69: 491-504.

Mohammed1, Y,E & Uraguchi Z.B. 2013.,Impacts of Climate Change On Fisheries: Implications For FoodSecurity In Sub-Saharan Africa. Nova Science Publishers, Inc. ISBN: 978-1-62618-192-2.

Nwabeze, G. O., Erie, A. P., and, & Erie, G. O. 2012.,. Fishers' Adaptation to ClimateChange in the Jebba Lake Basin, Nigeria Socio Economics and Extension Services Division, National Institute for Freshwater Fisheries Research (NIFFR), P.M.B 6006, New Bussa. Niger State. African Journal Online.

Otubusin, S. O. 2011,. Inaugural lecture: Fiah! Fish!! Fish!!!. Department of Aquaculture and Fisheries Management, College of Environmental Resources Management. University of Agriculture, Abeokuta, Nigeria.

Seisay, M. D., & du Feu, T. A. 1997,.. The effect of long term exploitation by gill net fishery on the multi-species fish stocks in Kainji Lake. Nigerian.

Tafida, A. A., S.I., O., Jimme, M. A., & K.O, A. 2013,. Understanding Poverty and Vulnerability for Fisheries Resource Management in Nigeria: A review. 5(5), 28-36

Richards, R. G., Davidson, A. T., Meynecke, J.-O., Hernaman, V., Lynam, T. and Putten I. E. 2015,. Effects and mitigations of ocean acidification on wild and aquaculture scallop and prawn fisheries in Queensland, Australia. Fisheries Research, 161, 42-56.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

CLIMATE CHANGE AND SUSTAINABLE FISHERIES DEVELOPMENT IN NIGERIA

Aderemi Olasupo Abioye

Nigerian Defence Academy, Kaduna (Ph.D Defence and Security Studies Scholar)

Correspondence : remyemi2@yahoo.com

ABSTRACT
This paper aims to critically examine the relationship between climate change and sustainable fisheries development in Nigeria in a descriptive form through the use of secondary sources of data from printed and online materials. Climate change is caused mainly by greenhouse gases, principally carbon dioxide (CO2), and the depletion of the ozone layer in the atmosphere leading to the overall rise of global temperature and the disruption of natural climate patterns. Its impact on sustainable fisheries development has become more critical in sub-Saharan Africa, especially in Nigeria, over the past decades. Mitigation measures help to reduce greenhouse gas emissions, while adaptation measures help to reduce the effects on the environment and allow people and communities to adapt to predicted changes and the realities imposed by climate change. Increased climate activity endangers human life and ecosystems, hinders growth and societal development, threatens to exacerbate existing vulnerabilities, and creates new ones for the poor The domestication of the relevant United Nations Sustainable Development Goals (SDGs) and the implementation of other relevant policies would help to reduce the negative impacts of climate change on sustainable fisheries development in Nigeria. Lastly, innovations in science, technology, business, and education are needed for social, environmental, and economic benefits which contribute to sustainable development globally.

Keywords:
Climate change,
sustainable development,
mitigation measures,
sustainable livelihoods.

INTRODUCTION

The social effects of climate change have gained global importance in recent time. The Intergovernmental Panel on Climate Change (IPCC, 2011) defines "climate change" as "a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties and that which persists for an extended period, typically decades or longer. The fisheries and aquaculture sector has not been spared of climate change effects over the past decades (Mabe and Asase, 2020; IPCC, 2007).

Climate change will redraw our coastlines, alter where we can grow food, change where we can find water, expose us to fiercer storms or more severe droughts and promote forced migration, and stress existing mechanisms for sharing resources like transboundary rivers and migratory fish stocks (IPCC, 2007).

Discussions

Causes of Climate Change

Climate change could be referred to as an increase in average global temperature caused by natural and human activities including the burning of fossil fuels (coals, oil and natural gas) releasing CO2 in the atmosphere at an ever-increasing rate (WWF, 2013).

- Natural Causes of Climate Change: The earth's climate is influenced and changed through natural causes like volcanic eruptions, ocean current, earth's orbital changes and solar variations. The sun is the source of constant energy for the earth's climate system. However, small changes over an extended period can lead to climate change. (Hanson *et al*, 2012).
- Human Causes of Climate Change: The largest known contribution comes from the burning of fossil fuels which releases carbon dioxide gas to the atmosphere. Other human activities that contribute to climate change include bush burning, cutting down of trees, use of generator, gas flaring from oil companies and burning of fossil fuels from vehicles, gases released from industries; excess use of chemicals and crude oil spillage (Solomon *et al*, 2007).

The Relationship between Climate Change and Sustainable Development

Climate change is a threat multiplier with the potential to worsen some of humanity's greatest challenges, including health, poverty and hunger (UN Climate Change News, 19 July 2019).

Sustainable development is the practice of maintaining productivity by replacing used resources with resources of equal or greater value without degrading or endangering natural biotic systems. There is an emphasis on the present generations' responsibility to regenerate, maintain and improve planetary resources for use by future generations (UNESCO, 2015).

Sustainable fisheries development is defined by FAO as fisheries development that integrates bio-ecological, technological, economic and social dimensions to sustainably improve the well-being of all the people engaged directly or indirectly in the fisheries sector as well as the natural productive system.

There is a dual relationship between sustainable development and climate change. On the one hand, climate change influences key natural and human living conditions and thereby also the basis for social and economic development, while on the other hand, society's priorities on sustainable development influence both the greenhouse gas (GHG) emissions that are causing climate change and the vulnerability. Climate Change will compound existing poverty in the developing nations because of their dependence on natural resources, and their limited capacity to adapt to a changing climate.

Climate Change and Sustainable Development in Nigeria

According to El-ladan (2014) Nigeria has a vast space of land spanning 923,768 sq. km. across different climatic regions and is understood to be highly vulnerable to climate change. There are desert encroachment and extreme droughts in the northern states as well as serious problems of flooding and erosion in the littoral southern states which combine to threaten Nigeria with shrinkage and collapse. The migratory pattern of fish stocks has changed markedly, just as the catch has declined.

Climate Mitigation and Climate Adaptation Measures

Responses can be categorized into mitigation and adaptation measures. Mitigation measures help to reduce greenhouse gas emissions, while adaptation measures help to reduce the effects on the environment and to allow people and communities to adapt to predicted changes and the realities imposed by global climate change. However, because effects of climate change are unavoidable in the near and medium-term, adaptation strategies that will make societies more resilient in the face of impending change are essential to sustainability (SL&CCA, February 2004).

Climate Mitigation Strategies

Climate mitigation is any action taken to permanently eliminate or reduce the long-term risk and hazards of climate change to human life, and property. The International Panel on Climate Change (IPCC) defines mitigation as: "An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases." (IPCC, 2007).

Climate Adaptation Strategies

These measures/strategies include using scarce water resources more efficiently; adapting building codes to future climate conditions and extreme weather events; building flood defenses and raising the levels of dykes; developing drought-tolerant crops; choosing tree species and forestry practices less vulnerable to storms and fires and setting aside land corridors to help threatened species migrate.

(IPCC, 2007). It refers to the ability of a system to adjust to climate change (including climate variability and extremes), moderate potential damage, take advantage of opportunities, or cope with the consequences (IPCC, 2007).

Adaptation Strategies for Climate Change in Fisheries

The climate change adaptation strategies used by fishers are increasing daily fishing time, increasing fishing efforts, changing fishing time, intensive aquaculture production, migrating to another fishing area, fishing further away or deep inside the water, catching smaller fish, participation in alternative livelihoods.

Floods/Erosion in Coastal and Riverine Areas (Fishing Communities)

Multiple pressures, including habitat loss and degradation, pollution, overexploitation of fish stocks climate change and natural hazards- affect the coastal ecosystems. The effects of climate change could be devastating to vulnerable coastal and marine areas as well as to the function and structure of their ecosystems. Increasing sea level (1.7 mm/year) changes the shape of coastlines, contributes to coastal erosion and leads to flooding and more underground salt-water intrusion. Building up resilience to increasing climate variability is the most significant climate challenge facing all countries, including Nigeria. Countries will need to factor climate risks and climate change adaptation into their development planning, and consider the range of interventions that will increase their resilience to climate change (Eboh, 2009).

Climate Change and Water Bodies in Nigeria

The global climate change has brought about the drying up of some water bodies in Nigeria including the Lake Chad, the Komadugu-Yobe River Basin and the Hadejia-Jamaare River Basin among others. These wetlands have suffered from drought-like conditions in the past decade. Communities living along the courses or banks of the feeder rivers are hindering the rivers from supplying the water into Lake Chad by building dams along them in their quest for water for irrigation activities and other relevant activities. This situation has resulted in the drastic reduction of the water of the lake causing increasing drop in fishing activities in the lake as well as reduction in water supply for pastoral and irrigation farming activities. The secondary impacts include increased rural/urban migration, job losses and user conflicts (Abubakar, 2008).

Climate Change Opportunities

There are some identified opportunities for countries to boost food production and to promote food security. These include the introduction of climate-smart agricultural and fisheries and aquacultural practices, integrated landscape management, sustainable production intensification, etc. Climate Smart Agriculture brings about increased land for agricultural practices and the introduction of new varieties / species of hardy crops, animals and fish (Lipper *et al.* 2014).

Climate-induced water scarcity from changes in temporal and spatial distribution of rainfall could lead to increased competition within the agriculture sector and with other sectors. Moreover, addressing this and other challenges would require modifying physical infrastructure, such as irrigation systems and altering the design and location of storage facilities. Increased risk from flood and droughts poses additional threats to agricultural and fisheries production.

CONCLUSION AND RECOMMENDATIONS

The paper reviewed the impact of climate change on sustainable fisheries development in Nigeria and concludes that necessary adaptation strategies and mitigation strategies should be adopted by stakeholders in the fisheries and aquaculture sector to ensure sustainable development.

In order to attain sustainable fisheries development in Nigeria, it is recommended that:

- The Federal Ministry of Marine and Blue Economy should bring on board relevant stakeholders from the Public Sector and the Private Sector to manage the impact of climate change on sustainable fisheries development.
- Mitigation and adaptation strategies to reduce sectoral vulnerability to climate change should be

prioritized for implementation at reasonable costs.

- The adoption of global best practices on climate change, including the aspects of adaptation, mitigation and carbon credit support policy to reduce the production of greenhouse gases and promote the use of renewable/alternative/sustainable energy.
- The domestication of the relevant United Nations Sustainable Development Goals (SDGs) and the implementation of other relevant policies.
- Lastly, innovations in science, technology, business, and education are needed for social, environmental, and economic benefits which contribute to sustainable development globally.

REFERENCE

Abubakar, B. (2008). The Impacts of Global Climate Change in Africa: the Lake Chad, Adaptation and Vulnerability. IJNA 37-2,

Eboh, E. (2009), Implications of Climate Change for Economic Growth and Sustainable Development in Nigeria. Enugu Forum Policy Paper 10. African Institute for Applied Economics, Nigeria.

El-ladan, I. (2014). Climate Change and Food security in Nigeria. Conference Paper at the International Conference on Possible Impacts of Climate Change on Africa at the Institute of African Research and Studies, Cairo University, Cairo, Egypt.

Hansen, James, Makiko Sato, and Reto Ruedy. August 6, 2012 109 (37). E2415-E2423. https://doi.org/10.1073/pnas.1205276109.

IPCC (2011). Renewable Energy Sources and Climate Change Mitigation. Special Report of the Intergovernmental Panel on Climate Change (IPCC), Summary for Policymakers and Technical Summary, WMO, UNEP, 220-246.

IPCC Fourth Assessment Report: Climate Change 2007: Working Group III: Mitigation of Climate Change.

Lipper, L., Thornton, P., Campbell, B. et al. Climate-smart agriculture for food security. Nature Clim Change 4, 1068–1072 (2014). https://doi.org/10.1038/nclimate2437 D

Mabe and Asase (2020). Climate change adaptation strategies and fish catchability: The case of inland artisanal fishers along the Volta Basin in Ghana. https://doi.org/10.1016/j.fishres.2020.105675

Prajapati, R. (2019), Climate Change and Sustainable Development, International Journal of Science and Research (IJSR), https://www.ijsr.net/get_abstract.php, Volume 8 Issue 9, September 2019, 816-818.

Solomon, S., et al. (2007) Climate Change 2007: The Physical Science Basis. Working Group I Contribution to the Fourth Assessment Report of the IPCC. Vol. 4, Cambridge University Press, Cambridge and New York. https://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm

Sustainable Development Goals (United Nations, 2015)

Sustainable Livelihoods & Climate Change Adaptation - A Review of Phase One Activities for the Project on, "Climate Change, Vulnerable Communities and Adaptation" February, 2004. Prepared by: IUCN—The World Conservation Union International Institute for Sustainable Development (IISD) Stockholm Environment Institute – Boston Center (SEI-B) Swiss Organisation for Development and Cooperation (Intercooperation).

Sustainable Livelihoods and Climate Change Adaptation (February, 2004)

UNESCO, 2015. UNESCO, Climate Change and COP 21.

WWF, 2013. Climate Change and WWF. Address at opening ceremony of UN Secretary-General's Climate Summit, Sept 23, 2013.

FISHERIES EXTENSION AND COMMUNITY DEVELOPMENT (FECD)

ASSESSMENT OF FISH FARMING MANAGEMENT PRACTICES AND ITS CONTRIBUTION TO LIVELIHOOD IN NASARAWA STATE, NIGERIA

[1]Danwali, I. M., [2]F. K. Abubakar, [2]I.O. Hafsat, [2]H.D. Mudi, [3]U.G. Ibrahim, [4]U.P. Yakubu, [5]A. S. Ibrahim. and [5]A. J. Bunu

[1]Department of Aquaculture and Fisheries Management, Faculty of Agriculture (Shabu-Lafia Campus), Nasarawa State University Keffi, Nigeria.
[2]Department of Fisheries, College of Agriculture, Science and Technology,
Lafia, Nasarawa State, Nigeria.
[3]Department of Natural Sciences, College of Education Billiri, Gombe State, Nigeria.
[4]Department of Water Resources, Aquaculture and Fisheries Technology, Federal University of Technology, Minna, Niger State, Nigeria.
[5]Department of Fisheries and Aquaculture Technology, Federal University of Technology Owerri, Imo State, Nigeria.

Corresponding Author:
danwaliismail@gmail.com, +2348033847329, 0009-0005-8783-2073

ABSTRACT
This study was conducted in Nasarawa State to assess fish farming management practices and its contribution to livelihood among fish farmers. A total of 210 respondents were chosen at random out of the 464 identified registered fish farmers for the study. A validated structured questionnaire was administered to the respondents to elicit information. Both descriptive and inferential (regression) statistics were employed to analyze the data. The results revealed that the level of management practices in fish farming operations by the fish farmers was high with four (4) of the operations topping the participation index which include feeding of fish (1.89***), stocking of fish seed (1.59***), sorting (1.51***) and cropping of fish (1.39***). There was significant difference ($P \leq 0.05$) among the selected socio-economic variables on the factors influencing fish farmers' management practices in fish farming operations. Fish farming contributed immensely to fish farmers' livelihood as main source of income (1.87***), food security (1.69***), job opportunity (1.68***) and source of protein (1.55***). The major constraints facing fish production in the study area are high cost of feed (1.96***), insufficient fund (1.55***) and disease outbreak (1.41***). The study, thus recommend that fish farmers should have reasonable access to conventional food and financing facilities.

Keywords;
Fish farmers,
Fish farming,
Management practices,
Livelihood.

INTRODUCTION

Fish is considered more favourably when compared to both white and red meat. It is a high-quality excellent protein food and the fast-growing in fisheries industry (Kari et al., 2020). It has no cultural and religious barrier to its consumption, unlike beef and pork. Fish is one of the cheapest quality protein sources, with macronutrients such as selenium, calcium, zinc, iron, vitamin A and essential fatty acids. It constitutes an important diet on the table of Nigerians, especially those people around riverine areas and Atlantic coast (Adeogun et al., 2014).

Fish farming plays an important role in income generation and employment creation (Mulokozi et al., 2020). This is mostly applicable to socioeconomic status of rural communities who depend on fishing for livelihood. Half of the fish consumed in the nation is imported while there is still a significant need for domestic fish production (Subasinghe et al., 2021). According to Onyekuru et al. (2019), Nigeria's current fish demand is 1.4 million metric tons, whereas the country's total annual fish supply from all sources (culture and capture fisheries) is less than 0.7 million metric tons. Nigeria must import almost $500 million worth of fish year, or 0.7 million metric tons, to make up for the shortfall (Issa et al., 2022). More fish farming is needed to meet this demand, because fish supply is not keeping up with the enormous demand, making Nigeria one of the world's biggest importers of fish. The objective of this study is to assess the fish farming management practices and its effect on fish farmers' livelihood in Nasarawa State, Nigeria.

MATERIALS AND METHOD

Study Area

The study was conducted in six (6) Local Government Areas of Nasarawa State, which are predominantly involved in fishing.

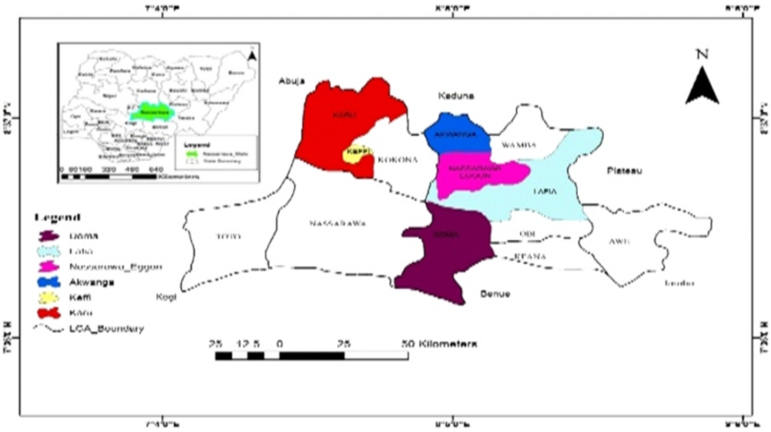

Figure 1: Map of Nasarawa State showing the study area
Source: Nasarawa State Ministry of Lands and Survey (2019)

Sampling technique and Sample Size

Target respondents for the research were registered fish farmers in Nasarawa State. Respondents' selection was achieved using multi-stage sampling technique.

Stage 1: Six (6) out of the thirteen (13) Local Government Areas in the State were selected purposively due to their predominant participation in fish farming. The selected Local Government Areas were: Doma, Lafia, Nassarawa Eggon, Akwanga, Keffi and Karu.

Stage 2: Four (4) districts were randomly selected from the six (6) selected Local Government Areas making twenty-four (24) selected districts.

Stage 3: At this stage, 45% of fish farmers from each of the selected districts were picked randomly using available sample frame, making the total of two hundred and ten (210) registered fish farmers as respondents for this study.

Analytical Technique

Data obtained from structured questionnaire were subjected to simple descriptive statistics using SPSS statistical package, 20.0 version. Factors influencing fish farmers' management practices in the study area was analyzed using multiple linear regression.

RESULTS AND DISCUSSION

Table 1. Level of management practices by fish farmers in the study area

	Never		Occasionally		Always				
Variables	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Weighted Score	Mean Value	Rank
Spawning	100	47.62	86	40.95	24	11.43	134	0.64*	11 th
Sorting	14	6.67	114	54.29	102	48.57	318	1.51***	3rd
Stocking of fish seed	12	5.71	94	44.76	120	57.14	334	1.59***	2nd
Feeding of fish	04	1.90	16	7.62	190	90.48	396	1.89***	1st
Cropping of fish	10	4.76	107	50.95	93	44.29	293	1.39***	4th
Treatment of water	37	19.05	130	61.90	43	19.05	216	1.03**	7th
Checking of water quality parameters	70	33.33	90	42.86	50	23.81	190	0.90*	8th
Removal of waste matter from water	32	15.24	130	61.90	48	22.86	226	1.08**	6th
Use of chemical to control diseases	64	30.48	136	64.76	10	4.76	156	0.74*	10 th
Changing of water	16	7.62	116	55.24	78	37.14	272	1.29**	5th
Pond fertilization	60	28.57	112	53.33	38	18.09	188	0.89*	9th

*** Highly participated in fish farming management practices * Low participation in fish farming management practices ** Moderately participated in fish farming management practices
Note: Multiple responses were considered

Level of Management Practices by Fish Farmers in the Study Area

Results in Table 1 shows the mean values of the respondents' level of management practices such as feeding of fish (1.90), stocking of fish seed (1.52), sorting (1.45), cropping of fish (1.41) and changing of water (1.30). Conversely, respondents were not much participated in spawning, use of chemicals and pond fertilization (0.68, 0.73 and 0.91, respectively). This result corresponds with the findings of Ayeloja et al. (2021). It implied that nearly all the fish farmers in the surveyed area fed their fish routinely, while majority carried out sorting and changing of water as part of their management practices as also reported by Akalonu et al. (2019).

Factors Influencing Participation in Fish Farming Management Practices in the Study Area

Results in Table 2 shows the regression of the factors influencing participation in fish farming management practices. There was a significant difference (P≤0.05) between the chosen socio-economic variables at the 1, 5, and 10% probability levels regarding the factors impacting fish farmers' participation in fish farming management practices. The result showed that the respondents' involvement in fish farming management practices was negatively correlated with criteria such as gender, educational attainment, and access to finance facilities. This is consistent with Mafura's reports (2020).

Table 2. Factors influencing fish farming management practices in the study area

Variables	Coefficients	Std. Error	t- value
Constant	10.553	2.701	3.664
Age of respondents	0.109	0.021	3.382***
Gender	-1.038	0.864	-1.161 NS
Household size	0.277	0.093	2.889***
Educational level	-0.067	0.070	-0.898 NS
Membership of association	0.210	0.073	2.611***
Years of aquaculture experience	0.725	0.031	18.290***
Pond stocking capacity	0.011	0.008	2.021***
Number of ponds	0.334	0.116	2.490**
Average monthly farm income	9.004	0.001	1.620*
Climate change	3.195	2.214	1.405 NS
Access to credit facilities	-0.882	1.596	-0.487 NS

$R^2 = 0.648$
F- statistics= 4.6212

NS= Not significant ** Significant at 5%
*** Significant at 1% * Significant at 10 %

Contribution of Fish Farming to Fish Farmers' Livelihood in the Study Area

Table 3 shows the contribution of fish farming to farmers' livelihood. Fish farming made a substantial contribution to the respondents' livelihood in terms of income, employment opportunities, food security, and protein sources respectively. The implication of the significant contribution of fish farming to the livelihood of the respondents is that fishing brings an improvement in the livelihood of the respondents. This finding is corroborated by Ayeloja et al. (2021) which stated the role played by fish farming in bettering farmers' livelihood.

Table 3. Contribution of fish farming to fish farmers' livelihood in the study area

Variables	No Benefit	Slight Benefit	High Benefit	Weighted Score	Mean Value	Rank
Main source of income	06	16	188	392	1.87***	1st
Source of protein	08	78	124	326	1.55***	4th
Job opportunity	-	68	142	352	1.68***	3rd
Food security	14	36	160	356	1.69***	2nd
Increase in knowledge	06	118	86	290	1.38**	6th
Water conservation	138	22	50	122	0.58*	9th
Alternate source of income	56	96	58	212	1.01**	7th
Ornamental/Recreational purpose	106	10	94	198	0.94*	8th
Source of manure to plants	24	74	112	298	1.42**	5th

*** Highly contributed to fish farmers' livelihood
**Moderately contributed to fish farmers' livelihood
*Low contribution to fish farmers' livelihood
Note: Multiple responses were considered

Constraints to Fish Farming in the Study Area

Table 4 shows the constraints facing fish farming in the study area. This study has revealed the constraints affecting fish production in Nasarawa State which considered high cost of feed, insufficient fund, poor access to credit facilities and theft as major challenges. This align with the study outcome of Ogunremi et al. (2018). It implies that among the listed constraints, the above mentioned are the ones with higher adverse effects on fish farming in the study areas.

Table 4. Constraints to fish farming in the study area

Constraints	No Constraints	Minor Constraints	Major Constraints	Weighted Score	Mean Value	Rank
Insufficient fund	36	22	152	326	1.55***	2nd
Land acquisition	70	92	48	188	0.89*	6th
Theft	44	88	78	244	1.16**	5th
Disease outbreak	20	84	106	296	1.41***	3rd
Quality fish seed	86	96	28	152	0.72*	7th
Poor extension services	148	38	24	86	0.41*	10 th
Poor access to credit facilities	28	112	70	252	1.20**	4th
Reliable/Quality water source	102	74	34	142	0.68*	8th
High cost of feed	-	08	202	412	1.96***	1st
Unskilled personnel	90	102	18	138	0.66*	9th

***Highly challenging to fish production
**Moderately challenging to fish production
* Low challenging to fish production
Note: Multiple responses were considered

CONCLUSION

It can be concluded that Feeding of fish was ranked highest as the major management practice adopted by the fish farmers. The study also revealed significant differences among the socioeconomic variables set to determine factors influencing fish farmers' engagement in fish farming management practices in the area. The fish farmers' livelihood was positively impacted by fish farming since it provided a steady source of income. The primary obstacle to fish farming in the area was the high cost of feed, which made the fish farmers' participation in the management practices so discouraging since it affects the level of production.

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REFERENCES

Adeogun, O.A., Alimi, T. and Adeyemo, R. (2014). Comparative analysis of profitability and technical efficiency of fish farming using different rearing techniques in Nigeria. Asian Journal of Agricultural Extension, Economics and Sociology. , 3(5): 405-418.

Akalonu, G.C., Akinyoade, O.F., Nwakuche, E.I., Oyelade, O.A. and Opowoye, I.O. (2019). Management Practices Involved in Fish Farming Operation in Four Local Government Areas of Kwara State. Continental Journal of Agricultural Science. , 13(2): 26-37

Ayeloja, A.A., Adebisi, G.L. and Oyebode, L.A. (2021). Contribution of fish farming to the socio-economic status of fish farmers in Oyo State, Nigeria. Ghana Journal of Agricultural Sciences. , 56(2): 75 – 84.

Issa, F.O., Aderinoye-AbdulWahab, S., Kagbu, J.H. and Adisa, R.A. (2022). Assessment of Aquaculture Development Programmes in Nigeria. Journal of Agricultural Extension. , 26(1): 18.

Kari, Z.A., Kabir, M.A., Razab, M.K.A.A., Munir, M.B., Lim, P.T. and Wei, L.S. (2020). A replacement of plant protein sources as an alternative of fish meal ingredient for African catfish, Clarias gariepinus: A review. Journal of Tropical Resources and Sustainable Science. , 8. , 47-59.

Mafura, L. (2020). Analysis of factors influencing participation in bee keeping enterprises in southern Lesotho. Lesotho Journal of Agricultural Sciences, 1(2): 74-88.

Mulokozi, D.P., Mmanda, F.P., Onyango, P., Torbjörn, L., Tamatamah, R. and Berg, H. (2020). Rural aquaculture: Assessment of its contribution to household income and farmers' perception in selected districts, Tanzania, Aquaculture Economics and Management, 24:4, 387-405, DOI: 10.1080/13657305.20 20.1725687

Ogunremi, J.B., Dauda, A.K. and Akor, F.O. (2018). Methods of improving the quality of fish seed supply to fish farmers in Benue State, Nigeria. Nigerian Journal of Animal Production. , 45(1): 99-105.

Onyekuru, N.A., Ihemezie, E.J. and Chima, C.C. (2019). Socio-economic and profitability analysis of catfish production: A case study of Nsukka Local Government Area of Enugu State, Nigeria. Journal of Tropical Agriculture, Food, Environment and Extension. , 8(2): 51-58.

Subasinghe, R., Siriwardena, S.N., Byrd, K., Chan, C.Y., Dizyee, K., Shikuku, K., Tran, N., Adegoke, A., Adel eke, M., Anastasiou, K., Beveridge, M., Bogard, J., Chu, L., Fregene, B.T., Ene-Obong, H., Cheong, K.C., Nukpezah, J., Olagunju, O., Powell, A., Steensma, J., Williams, G., Shelley, C. and Phillips, M. (2021). Nigeria fish futures. Aquaculture in Nigeria: Increasing Income, Diversifying Diets and Empowering Women. Report of the scoping study. Penang, Malaysia: WorldFish. Program Report: 2021-16.

THE ROLE OF WEST AFRICA AGRICULTURAL PRODUCTIVITY PROGRAMME (WAAPP) IN SUSTAINABLE FISHERIES IN KAINJI LAKE BASIN, NIGERIA: A REVIEW

[1]Faleke, S.A., [1]G.O. Nwabeze, [2]H. A. Buhari, [1]J.Z. Abdullahi, [1]A. Bello and [1]M. Najaka

[1]Extension Programme, National Institute for Freshwater Fisheries Research (NIFFR), P.M.B. 6006, New Bussa, Nigeria, ,
[2] Basic Science Department, Federal College for Freshwater Fisheries Technology, P.M.B. 1500, New Bussa, Nigeria.

Corresponding Author's e-mail:
falekesunday12@gmail.com; Phone: +2347066419500: +2349057501986

ABSTRACT
This paper examines the role of West Africa Agricultural Productivity Programme (WAAPP) in sustainable fisheries in Kainji Lake Basin, Nigeria. The study highlighted activities of WAAPP in Kainji Lake Basin, and their challenges. West Africa Agricultural Productivity Programme (WAAPP) played in fisheries development programme in Kainji Lake Basin which had projects with proven positive impacts. This study reveals that introduction of WAAPP has yielded positive result by encouraging increase fish production through pond culture technology dissemination, adoption and promotion of other component of fish value chain. The paper concludes that WAAPP has contributed significantly to sustainability of fishery sector in so many ways. Moreover, attention should be given to implementation process stable, policies and improved funding to ensure continuity. The challenges faced by the WAAPP could be traced to poor implementation process.

Keywords:
Fisheries, Programme and Kainji Lake Basin

INTRODUCTION

In Nigeria, several attempts have been made by government, non-governmental organization, programme implementers, agricultural extensionists and researchers to develop appropriate fishery development programmes that will eliminate hunger, poverty and improve standard of living of people through increase productivity. Fishery is recognised as one of the important sectors of agriculture that has significant contribution to the livelihood of people and country GDP in the last few decades. This is confirmed Odioko and Becer, (2022) that fisheries sector is an essential aspect of the world economy sector in terms of employment, food security, enterprise development, foreign exchange earnings, livelihoods of many rural people and nutrition.

West Africa Agricultural Productivity Programme (WAAPP–Nigeria) became effective on 12th January, 2012 after approval by the World Bank. It was implemented by Agricultural Research Council of Nigeria of the Federal Ministry of Agriculture and Rural Development (FMA&RD) through a Project Coordination Office (PCO). In Kainji Lake Basin, NIFFR-WAAPP activities was implemented through outreach department centre on demonstrating proven aquaculture technologies to farmers in adopted villages and facilitating rural micro-economic development through the promotion of livelihood activities. There have been a number of activities in the following adopted villages: Musawa,

Cover dam, Dukia, and Correctional centre, New Bussa among others.
Thus, it is of interest to review roles of WAAPP in terms of achievements and challenges directed at implementing and maintaining various policies and projects for development and sustainability of fisheries productivity. It is also with a view to making recommendations to key players in the fisheries development programmes in planning effective programme that will enhance productivity.

METHODOLOGY

The study relied on available literature to describe the role of West Africa Agricultural Productivity Programme (WAAPP) in sustainable fisheries in Kainji Lake Basin, Nigeria and from this review, gaps was drawn with recommendations for improvement.

RESULTS AND DISCUSSION

Activities of WAAPP adopted villages in 2014

The activities in adopted villages such as, Musawa, Cover dam, Dukia and Correctional centre were shown in Table 1. In Musawa community activities such as site selection, land clearing for pond construction, pond preparation and stocking of 1000 fingerlings of Clarias species were carried from April 2014 to first week of July 2014. Other activities that follow include distribution of improved seeds of Faro 44 rice, sorghum and maize to farmers. Also, the participants' names were collated for allocation of e-wallet fertilizer to promote their other livelihood activities outside fishing business. Further, the activities in Cover dam village under group one was started from March 2014 to July 2014. It begins with stakeholders meeting with NIFFR staff to sensitize participating community members on the activities to be carried out in 2014. These activities include site selection for demonstration ponds, digging of earthen ponds, pumping out of contaminated water from new ponds, fertilization and liming of ponds, distribution of improved rice seeds (Faro 44), sorghum, maize and collation of farmers names for fertilizer distribution. Also, in Dukia village under group one, activities commenced from May 2014 to July 2014 with distribution of improved rice seeds (Faro 44), sorghum and maize, and collation of farmers' names for e-wallet fertilizer distribution to assist them improving their crop farming activities for more income generation for better standard of living. In Correctional centre, the same activities in Dukia village were carried out at the same period.

Table 1. WAAPP activities in adopted villages

Table 1. WAAPP activities in adopted villages

S/No	Adopted Village	Activities	Date
1	Musawa	Land clearing/weeding of pond area	April 2014
		Pond preparation for stocking	April 2014
		Stocking of pond with 1000 fingerlings of *Clarias species* by community fish farmers under the supervision of NIFFR staff.	May 2014
		Given of 6 bags of 2mm and 4 bags of 4mm NIFFR fish feed	May 2014
		Improved seeds of faro 44 rice, sorghum and maize distributed to farmers	April 2014
		Collation of farmers names for proposed e -wallet fertilizer allocation	1st week of July 2014
2	Cover dam	Community /NIFFR stakeholders meeting to sensitize participating community members for 2014 activities	March 2014
		Selection of site between Community /NIFFR stakeholders for a conducive site for demonstration pond	April 2014
		Youth supervised to dig a new 12MX 6m fish pond (earthen)	6th-12th April 2014
		Pumping out of contaminated ditch water off the new pond	19th of April 2014
		Pond fertilization and salting	
		Invitation of farmers to NIFFR headquarters for seed distribution	May 2014
		Distribution of improved seeds of Rice (Farro 44) sorghum and Maize	May 2014
		Collation of farmers names for fertilizer distribution	July 2014
3	Dukia	Invitation of fish farmers representatives to NIFFR headquarters for seed collection/distribution to members	May 2014
		Distribution of improved seeds of Rice (Farro 44) sorghum and maize to farmers to support fish farming	May 2014
		Collation of farmers names for fertilizer allocation	July 2014
4	Correctional centre	Invitation of farmers to NIFFR headquarters for seed collection	May 2014
		Distribution of improved seeds of Rice (Farro 44) sorghum and Maize	May 2014
		Collation of farmers names for fertilizer distribution	July 2014

Adapted from Sule, (2014).

THE ROLE OF WAAPP IN KAINJI LAKE BASIN, NIGERIA

The contribution of WAAPP to sustainable economic development in Nigeria cannot be over emphasize. Today, fishery activities have been the major occupation of many people especially in Kainji Lake Basin which could be traced to the contribution of WAAPP in the area. Since many communities appreciate the value of fish as an important source of income, food and rich protein source, vitamins, minerals and fats. WAAPP-Nigeria as a development programme work through adopted villages to ensure sustainable fish farming (Daniel, 2015).

It is evident that the introduction of WAAPP in Nigeria to promote rural development and productivity in the sub-component of agriculture-fisheries is yielding positive results (Olowosegun, Tanko, Idris, and Ndakotsu, 2015). The programme aim to encourage increase fish production through aquaculture technology dissemination, adoption and promotion of value chain. It was implemented in some villages and secondary schools in Nigeria, in which NIFFR adopted villages and agricultural research outreach centres are not excluded. To achieve the aim of technology dissemination under WAAPP programme, WAAPP-NCoS-NIFFR used quiz competition strategy to stimulate students' interest in fish farming enterprise. To keep the students abreast and involved in the WAAPP activities in fisheries aquaculture, workshops were organised for all the schools that participated in the quiz competition to sensitise and teach the students on the subject for the quiz. They were exposed to some areas in aquaculture such as, fisheries extension, feed formulation, fish biology and water quality management. Furthermore, in fulfilling the mandate of WAAPP in technology dissemination and adoption, the National Centre of Specialisation (NCoS) organised field trip to modern fish farm in New-Bussa, Niger state, Nigeria, for adopted villages of Monai and Musawa. The trip was to stimulate interest, exchange knowledge, share experiences to support adoption and establish linkages for quick access to inputs and advisory services (WAAPP-NCoS-NIFFR, 2013). In NIFFR, the programme established a number of fishery projects such as, demonstrative fish ponds, distribution of improved crop and fish seeds and establishment of fish processing centres among others. It was discovered that each of these projects are self-sustainable, by generating income and improving the standard of living of the participating communities and schools. WAAPP also helps to addresses grass root problems faced by fish farmers that is associated with productivity, poverty and supporting them to proffer solution to those problems.

CHALLENGES OF WAAPP SUSTAINABILITY

Despite the contribution of the WAAPP towards fishery development in Kainji Lake Basin, the programme experience low participation which was based on belief that there are no meaningful results from programmes due to bad experience from most of the past government programmes. Furthermore, the programme experienced setbacks due to poor implementation process such as incompatibility of some technologies with the existing knowledge of the farmers, lack of technical know-how, inadequate credit facilities to farmers, inadequate extension agent and poor monitoring and evaluation. Vincent and Mustapha, (2015) also reported that challenges of the programme include how to maintain productivity gains, while supporting technological innovations for agricultural diversification, and to add value through processing so that farmers can capture a large share of the gains.

CONCLUSION AND RECOMMENDATION

From the discussion above, we have highlighted activities of WAAPP in some adopted villages with the roles in fishery development and the challenges. This programme contributed significantly to development of fishery sector in so many ways. Despite its contribution to fisheries development there are shortcomings which include: poor funding, poor maintenance and sustainability problem. Others are lack of continuity in government policies, inadequate extension agent and poor monitoring and evaluation. For sustainability, more attention should be given to programme implementation by involving target group in the development process of the programme. Moreover, lessons learnt from previous programmes should serve as guide for future fishery policies and programmes inventions.

REFERENCES

Daniel, E. (2015). Adopted villages: the journey so far. In agriculture. Nation newspaper. https://thenationonlineng.net.

Odioko, E and Becer, Z. (2022). The Economic Analysis of The Nigerian Fisheries Sector: A Review. Journal of Anatolian Environmental and Animal Sciences.7(2),216-226. https://www.researchgate.net/10.35229/jaes.1008836.

Olowosegun, T., Tanko, A., Idris, H. and Ndakotsu, S.S. (2015). Establishment of demonstration ponds in NIFFR Adopted villages and agricultural research outreach centres (AROCs) 2013/2014NIFFR Annual report.

Sule, A.M. (2014). Mid-year report on NIFFR WAAPP-Nigeria activities (Monitoring & Evaluation,

NCoS, WAAPP Nigeria). Unpublished report NIFFR WAAPP-Nigeria.
Vincent, Y. and Mustapha S. (2015). Why WAAPP wants research council restructured. Daily trust https://dailytrust.com/why-waapp-wants-research-council-restructured

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

FISHERIES GOVERNANCE POLICY AND MARINE PROTECTED AREA (FGPM)

PROMOTING CLIMATE-SMART AQUACULTURE POLICY IN OYO STATE: AN INTEGRATIVE APPROACH

Agbeja, Y. E.

Department of Aquaculture and Fisheries Management. University of Ibadan

Corresponding email:
eniolagbeja@yahoo.com

ABSTRACT
Aquaculture is recognized as a vital alternative for meeting global demand for dietary protein, especially in West Africa, where it contributes between 5.9% and 7.1% to fish production. However, climate extremes threaten production and exacerbate livelihood vulnerabilities. This paper explores the need for climate-smart aquaculture (CSA) policies in Nigeria, focusing on Oyo State, to enhance resilience, reduce environmental impact, and ensure sustainable growth in the sector. CSA practices, such as water recirculation systems, efficient feed management, and renewable energy-powered systems, are vital in enhancing productivity, improving resilience to climate change, and minimizing environmental footprints. However, Oyo State's current policy framework is fragmented, lacking coherence and strategic integration of aquaculture into its climate resilience plans. The paper identifies key policy challenges, including poor governance, inconsistent policy implementation, and infrastructure gaps, which limit the development of sustainable aquaculture. To address these gaps, an integrative policy framework is proposed, emphasizing cross-sector collaboration, climate adaptation measures, inclusive stakeholder engagement, and sustainable resource management. This framework calls for the institutional strengthening of aquaculture-focused organizations, increased investment in climate-resilient technologies, and regulatory incentives to encourage the adoption of CSA practices. Furthermore, the paper highlights the importance of participatory policymaking and the development of localized regulations that reflect the socio-economic realities of smallholder farmers. By institutionalizing CSA, Oyo State can enhance food security, reduce poverty, and promote sustainable economic growth while aligning with national and international climate adaptation goals. This integrative approach also provides a strategic pathway to advancing climate-smart aquaculture in Nigeria.

Keywords:
Climate-smart, policies, aquaculture, Oyo state

INTRODUCTION
Aquaculture is increasingly recognized as a vital alternative source of fish to meet the growing global demand for dietary protein (Subasinghe et al., 2009). In West Africa, it contributes between 5.9% and 7.1% to total fish production, with significant potential for expansion (Nhuong Tran et al., 2022).
Despite this, the sector faces significant challenges, particularly climate extremes, which pose risks to

production and further exacerbate livelihood vulnerabilities. Addressing these challenges requires a strategic shift toward environmentally sustainable and climate-smart aquaculture. This proactive approach—focusing on adaptation rather than reaction—offers the most promising pathway to ensure the long-term sustainability of both the environment and the fisheries sector in the face of climate change.

To achieve this, there is an urgent need for policies that reduce aquaculture's carbon footprint, enhance its environmental benefits, and build resilience against climate change, while also expanding aquaculture's role as a market mechanism. Such policies should position aquaculture as an adaptive tool for sustainable development, for instance, by utilizing marginal lands degraded by declining soil fertility.

Oyo State plays a crucial role in Nigeria's aquaculture production, contributing significantly to food security and the state's GDP (Oyo State Ministry of Agriculture, 2020). Effective climate action and production efficiency are essential to meeting the high demand for fish, which helps substitute imports. This research, therefore, seeks to develop an integrative policy framework that can enhance the climate resilience of aquaculture in Nigeria, with a particular focus on Oyo State.

This paper aims to identify and explore the climate-smart practices and policy measures necessary to build resilience in Oyo State's aquaculture sector. By advocating for the institutionalization of CSA, this paper will offer recommendations that can enhance fish farmers' livelihoods while aligning with national and international climate mitigation and adaptation goals.

Study Area- Oyo State

Oyo State, situated in the southwestern geopolitical zone of Nigeria, presents an array of opportunities for the development of aquaculture due to its abundant water resources and favorable climate.

The capital city is Ibadan. Oyo State has 33 local government areas with four agricultural development (ADP) zones under Oyo State Agricultural Development Programme (OYSADEP). These are Ibadan/Ibarapa, Ogbomoso, Oyo and Saki agricultural zones (Figure 1). The state is endowed with numerous rivers, lakes, and streams, which can support diverse aquaculture practices. With a growing population and increasing demand for protein sources, aquaculture emerges as a viable alternative to traditional fishing, promising sustainable livelihoods for local communities. Moreover, the integration of modern techniques and technologies in aquaculture can enhance productivity levels, ensuring food security and economic resilience.

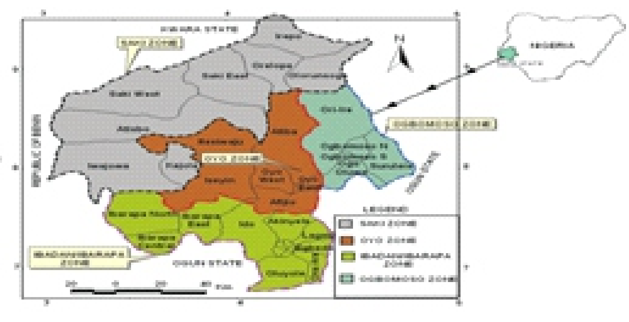


Figure 1: Map of Oyo State showing the ADP zones
Source: Adapted from Ashley-Dejo et.al., 2020

Climate-Smart Strategies for Aquaculture

Climate-Smart Aquaculture Practices involve techniques that:

a) enhance productivity, such as the use of (i) water recirculation systems (RAS). This improves water use efficiency, allowing for higher stocking densities and better control of the aquaculture environment, (ii) efficient feed management, to reduce feed waste, improve feed conversion ratios, and enhance fish growth rates, contributing to better farm productivity. (iii) selective breeding for resilience and growth, this involves breeding species for faster growth rates and higher yields under

various climate conditions and (iv) polyculture systems, to integrate multiple species in the same environment to optimize space and resources, leading to increased overall productivity.
b) improve resilience to climate change such; (i) as deploying integrated multi-trophic aquaculture (IMTA), a system where multiple species are farmed together in a way that mimics natural ecosystems. For example, fish can be grown alongside seaweed and shellfish, which help absorb excess nutrients, improving water quality and reducing environmental impacts. (ii) designing climate-resilient pond design to withstand extreme weather, such as floods or droughts, ensuring continuous production. (iii) Using advanced disease and pest monitoring systems i.e. implementing early warning systems for harmful algal blooms, temperature fluctuations to detect climate-related stressors, thereby preventing losses from disease outbreaks linked to temperature or water quality changes.
c)reduce environmental impact by; (i) engaging solar-powered aquaculture systems, that is utilizing renewable energy to power aquaculture operations, reducing carbon emissions. (ii) using algae-based carbon sequestration, this involves cultivating algae to absorb excess carbon dioxide from the atmosphere, mitigating the carbon footprint of the farm. (iii) using sustainable feed alternatives i.e. eco-friendly feed sources (e.g., insect meal, algae-based feeds) to reduce the environmental impact of feed production and reduce reliance on wild fish stocks. (iv) managing waste, this involves recycling waste materials into biogas or compost to minimize pollution and generate renewable energy. (v) Reducing dependency on freshwater resources by using harvested rainwater, preventing over-extraction of groundwater.

Challenges and Gaps in Current Policies

Nigeria lacks a specific legislation for aquaculture at the national and state levels even as the country has been recognized as the second biggest Aquaculture producer in Africa (Agbeja, 2011; Ogunji and Wuertz, 2023). Despite this recognition, aquaculture remains insufficiently acknowledged in Oyo State's development strategies and current policy frameworks, particularly in the Oyo State Roadmap for Sustainable Development 2023 – 2027 (Oyo State, 2023). This lack of recognition reflects a significant gap in policy coherence and coordination, especially in light of climate change. Oyo State's policies regarding aquaculture are indeed subject to contradictions that hinder sustainable growth in this critical sector. The following are examples of areas where this inconsistency is evident:

- **Inconsistent Policy Implementation:** National and regional policies often emphasize increasing fish production and fostering climate resilience. However, the lack of effective governance and fragmented policy efforts at the state level create bottlenecks, such as poor disease management protocols and inadequate support for small-scale fish farmers, undermining their ability to expand production. Additionally, the sector suffers from a reliance on imported fish, reflecting weak domestic policy support that could otherwise bolster local production (Oladimeji *et al.*, 2019)
- **Infrastructure Gaps:** infrastructure support in Oyo State is insufficient. For example, the state's policies do not adequately address the need for modernized aquaculture systems or improved access to quality inputs like feed. This leaves small-scale farmers struggling with outdated methods that limit their productivity, despite government promises of investment in infrastructure (Oladimeji *et al.*, 2019 and Ajagbe *et al.* 2020).
- **Sustainability and Environmental Issues:** Policies aimed at environmental protection and sustainable resource management often conflict with the on-ground realities. One of the limiting aquacultures in Nigeria and Oyo State include a lack of proper policy that can regulate the overuse of agro-allied and industrial wastes, and based on the existing official policy, it is difficult to determine the rights of aquaculturists (Ogunji and Wuertz, 2023).
- **incoherent strategy:** Oyo state's lack of coherent strategy for integrating climate resilience into aquaculture exacerbates risks, such as overfishing and environmental degradation, which further threaten food security and economic stability.

These contradictions and inefficiencies point to the need for a more harmonized policy approach that bridges the gap between planning and execution, fostering long-term sustainability in Oyo State's aquaculture sector.

Integrative Approaches to Climate-Smart Aquaculture Policy in Oyo State

An integrative approach to climate-smart aquaculture policy in Oyo State should focus on creating synergies across different sectors, institutions, and stakeholder groups to foster resilience and sustainability in the face of climate change.

By incorporating these integrative approaches, Oyo State can build a climate-resilient aquaculture sector that supports food security, economic development, and environmental sustainability.

The following are the proposed components of such an approach:

1. Cross-Sector Collaboration

ii) Agriculture, Water, and Environment: Climate-smart aquaculture requires collaboration between the ministries responsible for agriculture, water resources, and environmental protection. Integrated water management systems, such as watershed management and irrigation, can help ensure sustainable water use while protecting aquatic ecosystems

ii) Education and Training: Intentional partnerships with educational institution and research organizations can improve the knowledge base on sustainable practices and innovation in aquaculture. Climate-adaptation strategies, such as selecting resilient fish species, must be informed by scientific research and disseminated through extension services

2. Incorporation of Climate-Resilience Measures

I) Climate Adaptation: Oyo State's policies on aquaculture should promote adaptive measures, such as the use of climate-resilient species, temperature regulation technologies, and sustainable feed sources. Incentives for farmers to adopt these technologies, such as subsidies or low-interest loans, can accelerate the transition to climate-smart practices

ii)Disaster Risk Management: As climate change increases the frequency of extreme weather events, policies must incorporate disaster risk reduction strategies to mitigate impacts on aquaculture, such as establishing early warning systems and climate insurance created by the State for fish farmers.

3. Inclusive Stakeholder Engagement

i) Smallholder Farmers: Ensuring that smallholder fish farmers have access to training, financial support, and markets is critical for equitable development. Policies should prioritize inclusivity by providing access to resources and support systems for small and marginalized farmers

ii) Community-Based Management: Encouraging local governance structures, such as cooperatives, to manage resources collectively can foster ownership and ensure that climate-smart aquaculture practices are locally adapted and sustainable

4. Sustainable Resource Management

Innovative Technologies and Practices: An integrative approach to promoting climate-smart aquaculture policy involves complementary and supportive policy and institutional changes, making use of the best available smart technologies. Example is the integrated aquaculture systems. Promoting and providing incentives for integrated systems, such as rice-fish farming or aquaponics, would diversify production and enhances resource efficiency, reducing the environmental impact of aquaculture.

Biodiversity Conservation: Policies must ensure that agriculture and aquaculture practices do not lead to habitat destruction or biodiversity loss. This involves regulating the use of harmful chemicals and protecting natural water bodies from pollution and over-exploitation.

5. Monitoring and Evaluation

Data-Driven Policy Adjustments: Establishing a robust monitoring and evaluation framework is key to ensuring that climate-smart aquaculture policies are effective. Presently, the state does not have a clear or concise mechanism for data regarding aquacultural activities. Regular assessments of fish stocks, water quality, and the socio-economic impact on farmers can help adjust policies to respond to evolving climate conditions.

CONCLUSION AND RECOMMENDATIONS

The scarcity of aquaculture-related climate policies and the fragmented regulatory frameworks in Oyo State, which fail to adequately address adaptation, production, and ecosystem-based approaches, underscore the need for a cohesive, integrative policy response. To bridge this gap, it is recommended that a new policy framework be developed—one that provides a versatile pathway to climate-smart aquaculture. Instead of enforcing prescriptive regulations and standards-based solutions, this framework should focus on offering broad regulatory guidance for proactive agencies to pursue. It should empower authorities to develop localized regulations that incorporate the best standards, including recommendations on complementary tools and strategies.

For state and local governments, a standardized offtake framework should be established, focusing on local content adoption. These guidelines should center on outcomes, tools, and successful programs, emphasizing targets, trading schemes, best practices, and performance benchmarks. These components will facilitate the adaptation of local policies to the broader climate-smart aquaculture agenda.

Moreover, to achieve farm-level adaptation and contribute to sustainable development in the state, participatory policy-making is crucial.

In recognition of the multi-functional nature of climate-smart aquaculture, there is a need to design and adopt an integrative approach to policy and implementation in Oyo State, Nigeria. This approach could enable the State to set higher regulatory standards while maintaining a healthy aquaculture industry in Oyo State in particular and Nigeria as a whole. The goals, however, are easier suggested than implemented, given that all initiatives require complex decision-making, immediate adaptation measures, and a diverse range of policy measures. Policymakers also need to be realistic, considering that policies are but one of the climate change drivers. The pursuit of or prevention from change seems implausible if the model in mind that depicts climate-smart aquaculture is that of providing environmental and social benefits.

REFERENCES

Ajagbe, R. O., Ajagbe, S. O., Ariwoola, O. S., Abdulazeez, F. I., Oloba, O. G., Oyewole, O. O., Kareem, A. T., Ojubolamo, M. T., Olomola, A. O. and Oke, O. S. (2020) Ife Journal of Agriculture, 1, 67-75.

Ashley-Dejo, S., Olaoye, J. and Adelaja,O. (2020) Comparative evaluation of economic bene ts of adopters and non-adopters of improved sh production technologies in Oyo State, Nigeria Nigerian Journal of Animal Production Vol. 44 i2994

Nhuong Tran a, Long Chu b, Chin Yee Chan a, Jeffrey Peart a, Ahmed M. Nasr-Allah c, Harrison Charo-Karisa (2022) Prospects of fish supply-demand and its implications for food and nutrition security in Egypt. Marine Policy, 146. 10pp

Ogunji, J. and Wuertz, S. (2023) Aquaculture Development in Nigeria: The Second Biggest Aquaculture Producer in Afric Water 15, no. 24: 4224. https://doi.org/10.3390/w15244224

Oladimeji, Y.U., Galadima, S.A., Hassan, A.A, Sanni, A.A, Abdulrahman, S., Egwuma, H., Ojeleye, A.O. and Yakubu, A. (2019) Risk Analysis in Fish Farming Systems in Oyo and Kwara States,
Nigeria: A Prospect Towards Improving Fish Production. Animal Research International 16(1): 3226 – 3237

Oyo State (2023) Oyo State Roadmap for Sustainable Development 2023 – 2027. https://seyimakinde.com/wp-content/uploads/2023/02/Roadmap-To-Sustainable-Development-2023-2027.pdf

Oyo State Ministry of Agriculture. (2020). Oyo State Aquaculture Development Policy.

Subasinghe, R., Soto,D. and Jia, J.(2009) Global aquaculture and its role in sustainable development. Reviews in Aquaculture, 1(1): 2-9

The World Bank Group (2021). Climate Risk Profile: Nigeria. 28pp https://climateknowledgeportal.worldbank.org/sites/default/files/2021-07/15918-WB_Nigeria%20Country%20Profile-WEB.pdf

FISH NUTRITION AND ALTERNATIVE FEED DEVELOPMENT (FNAD)

GROWTH RESPONSE AND FEED UTILIZATION OF *Oreochromis* (LINNAEUS, 1758) FINGERLINGS FED DOUM PALM PULP *(Hyphaene thebaica)* MEAL AS REPLACEMENT FOR MAIZE

[1]Hussaini, I., [1]M.G Yakubu, and [2]D.G Wase

[1]Department of Fisheries, Yobe State College of Agriculture Science and Technology, Gujba.
[2]Akperan Orshi Polytechnic Yandev, Gboko Benue State

Corresponding author:
hussainiisa25@gmail.com +23408032818354/08022686796

ABSTRACT

The effect of Doum Palm (Hyphaene thebaica) pulp meal (DPPM) in the diet of Oreochromis niloticus as replacement for Maize was investigated. The diet was control diet 0%DPPM, 25%DPPM, 50%DPPM, 75%DPPM and 100%DPPM respectively. The feeds were fed to O. niloticus fingerlings at 5% body weight twice daily for the period of 90 days in an indoor partial follow-through system. Initial bulk weight and initial standard length of O. niloticus fingerlings and water quality parameters were monitored biweekly. Inclusion level at 0 and 25% of DPPM meal has higher (MWG) 4.03±0.03 and 3.91±0.20g, (SGR) 0.57±0.01 and 0.58±0.02, (FCR) 1.15±0.01 and 1.17±0.01 respectively. The lowest growth and feed utilization were observed in fish fed 100% inclusion level. The weight gain of fish decreases with increase inclusion level above 25%. However, there was no significant difference between control diet and 25% inclusion level ($p>0.05$). Carcass proximate composition revealed significant difference ($p\leq0.05$) among the various inclusion level of DPP meal. Crude protein and (NFE) recorded the highest value of 39.91±0.55 and 8.44±0.39 respectively at DPPM 25% inclusion level when compared with control. Conclusively, the fruit of H. thybaica meal is a source of Carbohydrate and a good replacement for maize meal at 25% (4 g/100g) inclusion level for optimal growth and lower cost of feed production.

Keywords:
Doum palm Pulp meal, Oreochromis niloticus fingerlings, Growth

INTRODUCTION

Doum palm *(Hyphaene thebaica L.)* is a desert palm tree with edible oval fruit, native to Egypt, sub-Saharan Africa and West India. It is rich in antioxidants, B-complex, essential minerals and are good source of monosaccharides such as glucose and fructose (Aboshora *et al.*, 2014). Originally native of the Nile valley but grows well in the Northern part of Nigeria. It is a member of the palm family, Arecaceae and it is dichotomous and arborescent in nature. *H. thebaica* is listed as one of the useful plants of the world (Fletcher, 1997; Datti *et al.*, 2020). It has a brown outer fibrous flesh normally chewed and spewed out. *H. thebaica* fruit has several applications in the food industry, such as in manufacturing sweetmeats, cakes, and nutritious drinks (Aboshora *et al.*, 2014). It is edible when it is unripe but hard when it is ripe. Previous reports have documented the effect of dietary Date palm fruit extracts, Phoenix dactylifera, a plant in the same family with *H. thebaica* in augmenting growth rate, immune parameters, and antioxidant enzyme activity of common carp, Cyprinus carpio (Hosseinifar *et al.*, 2017; Hosseinifar *et al.*, 2015). Aquaculture play a significant role in animal protein production which can meet the increasing worldwide demand for protein sources, perhaps one of the most significant fish species bridging this gap are the Tilapias groups of freshwater omnivorous cichlids that are native to Africa and subsequently have been introduced, either deliberately or accidentally, throughout the world (Eknath and Hulata 2009). The Nile Tilapia, *Oreochormis niloticus*, is the target species of this study; is highly favored for aquaculture due to its relatively fast growth, hardiness, easy reproduction and high market acceptance (Ernzen *et al.*, 2021).

MATERIALS AND METHODS

Table 1: Gross composition and proximate analysis (g/100g) of the five experimental diets fed to *Oreochromis niloticus* **fingerlings**

Ingredients	0% DPPM	25% DPPM	50% DPPM	75% DPPM	100% DPPM
DPPM	0.00	3.89	7.79	11.69	15.58
Yellow maize	15.58	11.69	7.79	3.89	0.00
Rice brand	13.33	13.33	13.33	13.33	13.33
Fish meal	35.71	35.71	35.71	35.71	35.71
Soybean	25.38	25.38	25.38	25.38	25.38
Bone meal	1	1	1	1	1
Palm Oil	3.5	3.5	3.5	3.5	3.5
Salt	0.8	0.8	0.8	0.8	0.8
Min/vit premix	0.7	0.7	0.7	0.7	0.7
Methionine	2	2	2	2	2
Lysine	2	2	2	2	2
Total	100	100	100	100	100
Moisture	4.69±0.09	4.79±0.01	4.50±0.00	4.69±0.01	4.55±0.00
Ash	18.90±0.01	18.80±0.35	18.73±0.37	18.33±0.33	18.10±0.30
Ether extract	13.33±0.33	13.53±0.33	13.46±0.33	13.46±0.33	13.13±0.09
Crude Protein	34.75±0.03	34.85±0.58	35.13±0.01	34.75±0.00	34.68±0.37
Crude fiber	7.25±0.00	7.96±0.01	8.45±0.00	8.45±0.00	10.34±0.00
NFE	13.19±0.33	11.19±0.00	10.98.0±0.00	12.65±0.01	11.22±0.01

Table 2: Proximate composition of *H. thebaica* **pulp and yellow maize (mg/100g)**

Proximate content	Doum Palm pulp	Yellow Maize
Moisture	4.05±0.01	8.03±0.21
Ash	11.35±0.13	2.32±0.13
Crude lipid	7.80±0.23	5.42±0.02
Crude protein	6.25±0.02	9.60±0.07
Crude fiber	10.15±0.13	4.64±0.07
% NFE	70.55±0.46	74.63±0.32

NFE= Nitrogen free extract

Feed Formulation and experimental fish: Five diets contain 35% crude protein were formulated with DPPM replacing maize at 0% (control), (25DPPM), (50DPPM), (75DPPM), and (100DPPM) inclusion level of *Hyphaene thebaica* pulp meal using the Pearson's Square method (Table 1).
Two hundred and fifty (250) *Oreochromis niloticus* fingerlings mixed sex with an average weight of (5.74±0.02 g) were obtained from Kuka Farm, Gabasawa Local Government Kano State, Nigeria. The

fish were transported in an airtight polythene with oxygen to the Fisheries Laboratory of the Department of Biology, Ahmadu Bello University Zaria. Fish were left in the water bath (150x50x40 cm) for two weeks for acclimatization.

Fifteen (15) plastic aquaria with dimension of 50×45×35 cm was used (three aquaria/ experimental diet), each containing borehole water. Ten (10) fingerlings of O. niloticus were stocked randomly in each aquarium. The set up was covered with net to avoid fish from jumping out. Water was changed every three (3) days using a semi flow through system to eliminate fecal matter and unutilized feed in the tank. At the start of the feeding trial, fish were starved for 24 hours to empty the gut and prepare them for the experiment. The fish were fed twice daily (8:00-8:30am and 4:00-4:30pm) for a period of twelve weeks (Aderolu et al., 2018).

Growth Parameters and Feed Utilization Determination

At the end of the experiment, the data obtained were analyzed to determine growth response and feed utilization parameters such as mean weight gain, mean standard length gain, daily weight gain, relative weight gain, mean growth rate, specific growth rate, survival rate, performance index, protein index, protein efficiency ratio, feed consumed, feed conversion ratio, feed conversion efficiency, and net protein utilization.

Data analyses: Data were analyzed using one-way analyses of variance (ANOVA) and Duncan's multiple range test (DMRT) was used to rank means where significant at ($P \leq 0.05$) using IMB-SPSS version 25 software package.

RESULTS AND DISCUSSION

The results for the proximate composition of the Doum palm fruits pulp studied revealed the presence of some amounts of protein (5.25±0.02%), lipid (7.80±0.23%), ash (11.35±0.13%), crude fiber (10.15±0.13%), moisture content (4.05±0.01%) and NFE (71.56±0.46 %). These results were found to be very close to that reported by Datti *et al.*, (2020). However, some researchers reported higher parameters in some instances. Bonde et al., (1990) reported higher protein content of 9.26%. Similarly, the value of crude fiber (10.15%) is higher than that reported by Nwosu et al., (2008) who reported (8.1%) and Abdel-rahman *et al.*, (2014) who reported (7.17%).

The growth performance of O. niloticus fed varying inclusion levels Doum palm pulp meal indicates the mean initial bulk weight (81.33-81.66g) was not significantly different ($p>0.05$) among the experimental treatments, showing uniformity in size at onset of the experiment as recommended by previous studies (Jegede and Fagbenro, 2008).

Growth of fish fed diet containing DPPM 0% (122g) and DPPM 25% (120.5g) significantly ($p \leq 0.05$) increased steadily from initial to the final week following a typical growth curve while, Growth in fish fed diets 50%DPPM, 75%DPPM and 100%DPPM followed in descending order Table 3. The best performance was obtained in the control DPPM0% and DPPM 50% respectively, followed by fish fed DPPM50% and DPF75% while the lowest value was recorded in fish fed on the control (DPPM 0%).

Similarly, the specific growth rate (SGR) also displayed decreasing trend with increasing levels of DPPM in the diets. DPPM was better utilized at 0% and 25% level of substitution compared to other inclusion. The good utilization of H. thebaica meal, with relatively high fiber content might be due to the acidic nature of Tilapia stomach ($pH<2$) and presence of cellulase in the gut that facilitate the rupture of the cell wall of the vegetative matter (Fagbenro *et al.*, 2005).

Bashir and Suleiman (2018) reported similar results, decline in the growth parameters with inclusion level of Tamarindus indica L. seed in the diet of O*reochromis niloticus*. The general slow gain in weight might be since fish were fed exclusively the formulated feeds with no access to natural feed as may be found in pond or riverine condition (Amisah *et al.*, 2009) and reared under laboratory condition. The high values recorded for FCR suggests indigestibility of the diet and can be attributed to high crude fiber in the diet (Zaid and Sogbesan, 2010). According to De-Silva (2001) feed conversion ratio is

between 1.2 - 1.8 for fish fed carefully prepared diets, and the results from the present study are within this range. Several studies opined that low level of FCR is an indicator of feed utilization efficiency of formulated feed (Kader et al., 2003; Khan, et al., 2013; Shipton and Hecht, 2013).
However, minerals found in doum plants boost hormones and enzymes, and they activate enzyme, as reported by Zai-jie (2007) this may also lead to the increased and better growth performance recorded with DPPM25% increasing inclusion levels of doum palm fruit in the diets. Similar results were reported by (Hanan *et al.*, 2020) who established the beneficial effect of doum palm fruit on growth performance of O. niloticus significantly increased all growth parameters. Findings in the study were also in accordance with the results of (Hoseinifer et al., 2015) on common carp. They asserted that consumption of the dietary date palm fruit extract of 200 mL/kg for eight weeks could induce growth-related gene expression and improve fish weight by 34.6% and feed utilization by 17.53% whish are of the same family with DPP.

Table 3: Growth response and feed utilization of O. *niloticus* **fed different inclusion level of** *H. thabaica* **pulp meal**

Parameters	0% DPPM	25% DPPM	50% DPPM	75% DPPM	100% DPPM	P-value
MIBW (g)	81.66 ± 0.33^{a}	81.33 ± 0.33^{a}	81.66 ± 0.88^{a}	81.33 ± 0.88^{a}	81.33 ± 0.33^{a}	0.984
MIL (cm)	5.13 ± 0.22	5.32 ± 0.23	5.33 ± 0.12	5.14 ± 0.33	5.03 ± 0.32	
MFBW (g)	122.0 ± 0.57^{a}	120.5 ± 1.85^{a}	118.6 ± 1.85^{c}	116.66 ± 0.66^{c}	116.0 ± 1.52^{c}	0.000
MFL (cm)	8.50±0.23a	8.60±0.24a	7.60±0.32b	7.50±0.43b	7.30±0.22b	0.000
MWG (g)	4.03 ± 0.03^{a}	3.91 ± 0.20^{a}	3.49 ± 0.23^{b}	3.43 ± 0.12^{c}	3.46 ± 0.16^{c}	0.000
ADWG (g)	0.04 ± 0.00^{b}	0.05 ± 0.00^{a}	0.03 ± 0.00^{bc}	0.02 ± 0.00^{d}	0.03 ± 0.00^{c}	0.000
SGR	0.58 ± 0.00^{a}	0.57 ± 0.02^{a}	0.48 ± 0.03^{c}	0.46 ± 0.02^{c}	0.42 ± 0.02^{c}	0.000
FI	180.4 ± 0.00	201.6 ± 0.00	178.8 ± 0.00	188.3 ± 0.00	227.6 ± 0.00	
FCR	1.15 ± 0.00^{c}	1.17 ± 0.01^{c}	1.29 ± 0.01^{b}	2.34 ± 0.01^{a}	2.37 ± 0.01^{a}	0.000
PI	79.63 ± 0.05^{c}	87.59 ± 1.16^{b}	80.67 ± 0.01^{c}	81.62 ± 0.01^{c}	101.0 ± 0.85^{a}	0.000
PER	0.25 ± 0.00^{b}	0.45 ± 0.02^{a}	0.32 ± 0.03^{b}	0.16 ± 0.01^{d}	0.24 ± 0.02^{c}	0.000
CF	1.25 ± 0.01^{d}	1.27 ± 0.02^{c}	1.40 ± 0.04^{b}	1.42 ± 0.02^{a}	1.39 ± 0.03^{a}	0.000
SR (%)	80.0 ± 0.00^{b}	86.33 ± 3.33^{b}	90.33 ± 6.66^{b}	93.00 ± 0.00^{e}	93.00 ± 0.00^{a}	0.000

Means with the same superscript across rows were not significantly different (P≥0.05)

Key: T= treatment, NFE= Nitrogen free extract, DPPM= Doum palm pulp meal, IBW= Initial bulk weight, FBW= Final bulk weight, WG= Weight gain, ADWG= Average daily weight gain, SGR= Specific growth rate, FI= Feed intake, DFI= Daily feed intake, FCR= Feed conversion ratio, PI= Protein intake, API= Average protein intake, PER= Feed efficiency ratio, CF= Condition factor, SR= Survival rate
The carcass crude protein in this experiment increased significantly (p≤0.05) after the feeding trial Fig 1. Generally, fish carcass had more protein retained in the body at the end of the experiment. Obaroh *et al.* (2015) reported that protein, lipids and moisture contents are the major constituents when evaluating nutritive value of fish. All experimental diets significantly increased the protein and lipid contents of experimental fish. This result implies that there was synthesis and increased tissue protein production as reported by (Fuller, 1961 and Yusuf *et al.*, 2016).
The mean initial crude protein (29.16%) was significantly lower than the values obtained after the

feeding trial. High value (37.31% and 39.99%) was recorded in fish fed DPPM25% and the control respectively. A similar increase in body protein content has been documented in African catfish fed on diets enriched with doum palm pulp meal (Hanan *et al.*, 2020). There was no significant difference in the ash content of the fish fed (50% and 75%) DPPM but it differed with the other treatments and the control. Ash ranged from 13.38% to 19.04% and moisture ranged from 4.15% to 4.85%. Moisture content, Crude lipid and Soluble carbohydrate (nitrogen free extract) differs significantly (p≤0.05) in the all treatment and control. Increase inclusion level of doum palm pulp meal increases the parameters mentioned above. Enhanced feed efficiency and utilization by DPPM, as well as improved digestibility, might be held responsible for these findings as the carcass composition has been demonstrated to be influenced by the diet (Orire, 2010). Various factors, including culture conditions, feed composition, environment factor, fish size, stress, and geographical location can affect the carcass composition of fish (Roques *et al.*, 2020).

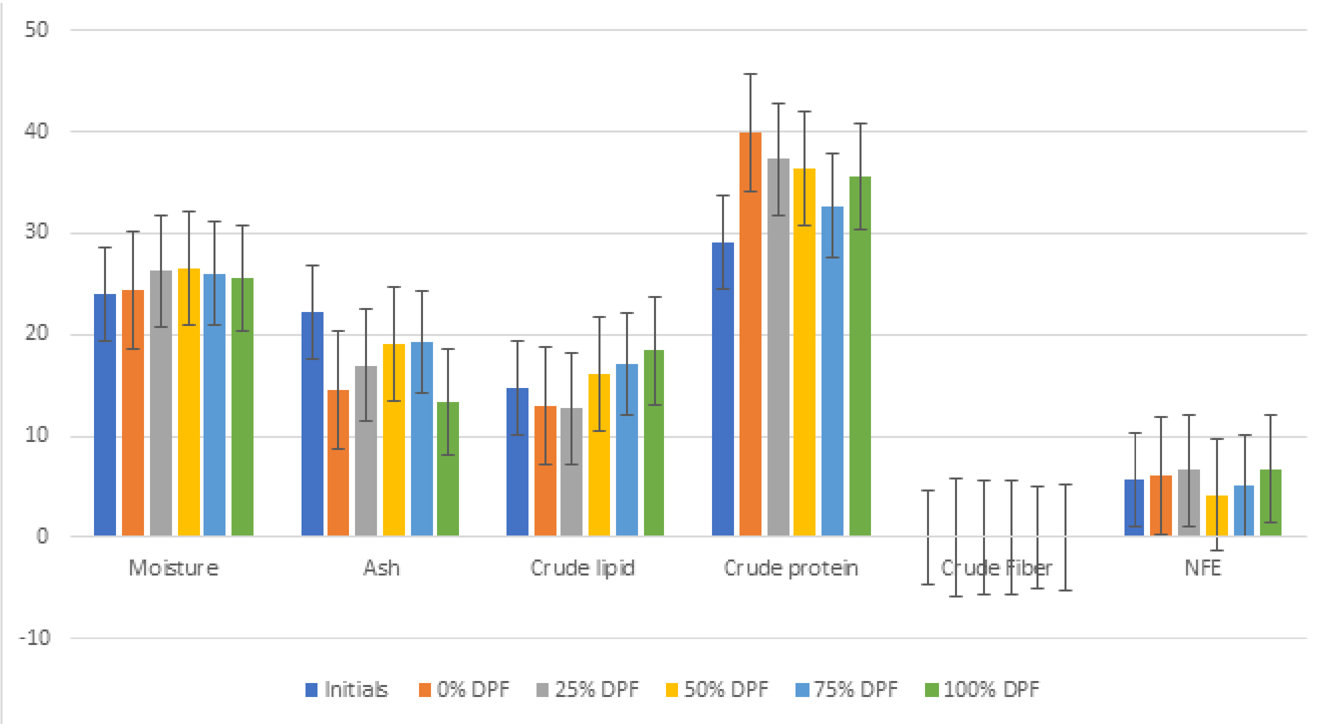


Fig 1: Carcass composition of *O. niloticus* fed different inclusion level of *H. thabaica* pulp meal before and after feeding with the experimental diet (g/100g DM)

CONCLUSION

Oreochromis niloticus fed DPPM meal at 25% inclusion level exhibited highest growth and nutrients utilization MWG, SGR and FCR at (4.03±0.03, 0.85±0.00 and 1.15±0.00) respectively compared to the control diet. Carcass proximate composition revealed significance difference among the various inclusion level of DPP meal. Crude protein and NFE recorded the highest value of (39.91±0.55 and 8.44±0.39 respectively) at DPPM 25% (4 g/100g) inclusion level when compared to control.

REFERENCES

Abdel-Rahman N, Awad I. and Elshafe'a B. (2014). Characterization of some Sudanese edible forest fruits. Journal of Agri-Food and Applied Sciences. 2:39-44.

Aboshora, W., Lianfu, Z., Dahir, M., Gasmalla, M.A., Musa, A., Omer, E. and Thapa, M. (2014). Physicochemical, nutritional and functional properties of the epicarp, flesh and pitted sample of doum fruit (Hyphaene thebaica). Journal of Food Nutritional Resources. 2,180 -186.

Aderolu, A.Z., Lawal, M.O., Awobajo, F.O., Olaniyan, S. and Bello, Y. (2018). Dietary energy requirement of clarias gariepinus juvenile at Fixed crude protein and its effects on growth, nutrient Performance, haematology and biochemical indices. Animal Research International. 15(3): 3090 – 3100.

Amisah, S., Oteng, M.A. and Ofori, J.K. (2009). Growth performance of the African catfish Clarias gariepinus, fed varying inclusion levels of Leucaena leucocephala leaf meal. Journal of Applied Sciences and Environmental Management, 13(1), 21-26.

Bashir, A.Y and Suleimam, B. (2018). Growth and Feed Utilization Value of Fermented Tamarindus indica L. Seed in the Diet of Oreochromis niloticus(Linnaeus, 1758). Turkish Journal of Fisheries and Aquatic Sciences. 18: 905-911 (2018).

Bonde, S. D., Agate, V. V. and Kulkarni, D. K. (1990). Nutritional composition of the fruits of doum palms (Hyphaene) from the west coast of India. Principes, 34 (1), 21-23.

Datti, Y., Ibrahim, M., Salihu, I., Abdulhadi, M., Muhammad, S.M., Abubakar, S.A., Halima S., Ahmad U.U., and Nura, T. (2020). Mineral Content, Proximate Composition and the Antioxidant Properties of the Ethanol Extract of Hyphaene thebaica L. from Gezawa Town, Kano State, Nigeria. Asian Journal of Applied Chemistry Research. 6(2), 33-40.

Eknath, A.E. and Hulata, G. (2009). Use and exchange of genetic resources of Nile tilapia (Oreochromis niloticus). Reviews in Aquaculture 1: 197–213.

Ernzen, P. J., Daitx, O. V., Souza, S. L., Pedreira, M. J. L., Pettigrew, J., and Machado, F. D. (2021). Dietary supplementation of Viligen to Nile tilapia improves growth and gut morphology. Aquaculture Nutrition. 1–12. https://doi.org/10.1111/anu.13247

Fagbenro, O. A., Nwanna, L. C., Adepanusi, E. O., Adebayo, O. T., and Fapohunda, O.O. (2005). An overview of animal feed industry and dietary substitution of feedstuffs for farmed fish in Nigeria. In: Dris R. editor, Crops: growth, quality and biotechnology (current status and future prospects). Finland: WFL Publisher. 91-107.

Fletcher R. (1997). Listing of useful plants of the world. Australian New Crops. Available from: http://www.newcrops.uq.edu.au/listing/hyphaenethebaica

Hanan, S. A., Khalil, A., Shima, A., Shimaa, I., Shalaby, H. A., Badr, M. Farag, M. L., Altohamy D. A. and Afaf, A. R. (2020). Effects of Dietary Doum Palm Fruit Powder on Growth, Antioxidant Capacity, Immune Response, and Disease Resistance of African Catfish, Clarias gariepinus (B.) Animals, 10, 1407

Hoseinifar, S. H., Dadar, M., Khalili, M., Cerezuela, R., and Esteban, M. Á. (2017). Effect of dietary supplementation of palm fruit extracts on the transcriptomes of growth, antioxidant enzyme and immune-related genes in common carp (Cyprinus carpio) fingerlings. Aquaculture Resources. 48:3684-3692.

Hoseinifar, S. H., Khalili, M., Rufchaei, R., Raeisi, M., Attar, M., Cordero, H., and Esteban, M.Á. (2015). Effects of date palm fruit extracts on skin mucosal immunity, immune related genes expression and growth performance of common carp (Cyprinus carpio) fry. Fish Shellfish Immunology. 47:706-711.

Hussein, A. M., Salah, Z. A. and Hegazy, N. A. (2010). Physicochemical, sensory and functional properties of wheat-doum fruit flour composite cakes. Journal of Food Nutritional Science. 60, 237–242.

Jegede, T. And Fagbenro, O. (2008) Histology Of Gonads In Tilapia Zillii (Gervais) Fed Neem (Azadirachta Indica) Leaf Meal Diets. 8th International Symposium on Tilapia in Aquaculture

Nwosu, F. O., Dosumu, O. O. and Okocha, J. O. C. (2008). The potential of Terminalia catappa (Almond) and Hyphaene thebaica (Dum palm) fruits as raw materials for livestock feed. African Journal of Biotechnology Vol. 7 (24), pp. 4576-4580.

Obaroh, I.O., Haruna, M.A. and Ojibo, A. (2015). Comparative study of proximate and mineral element composition of Clarias gariepinus from the cultured and wild sources. European Journal of Basic and Applied Sciences, 2(2), 19-26.

Orire, A. (2010). Protein Sparing Effects of Carbohydrate and Lipid in the Practical Diets of Catfish (Clarias gariepinus) and Tilapia (Oreochromis niloticus) Production. Ph.D. Thesis, Federal

University of Technology, Minna, Nigeria.

Roques, S., Deborde, C., Richard, N., Skiba‐Cassy, S., Moing, A., and Fauconneau, B. (2020). Metabolomics and fish nutrition: a review in the context of sustainable feed development. Reviews in Aquaculture, 12(1), 261-282.

Siddique, A.B. and Wright, D. (2003). Effects of different seed drying methods on moisture percentage and seed quality (Viability and Vigour) of pea seeds (Pisum sativum L.). Journal of Agronomy: 2:201-208.

Sweilum, M. A., Abdella, M. M. Salah, E. l. and Din, S. A. (2005). Effect of dietary protein-energy levels and fish initial sizes on growth rate, development and production of Nile tilapia, Oreochromis niloticus L. Aquaculture Research, 36(14): 1414 – 1421

Yusuf A, Umar R, Micah DA and Akpotu JO (2016). Growth response and feed utilization of Clarias gariepinus (Burchell, 1822) juveniles fed graded levels of boiled Senna obtusifolia l. seed meal as a replacement for soybean meal. Journal of Advanced Veterinary and Animal Research, 3(4): 345-352.

Zaid, A. A. and Sogbesan, O. A. (2010). Evaluation and potential of cocoyam as carbohydrate source in catfish, (Clarias gariepinus [Burchell, 1822]) juvenile diets. African Journal of Agricultural Research, 5(6), 453-457.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

RECOVERY PERIODS AFTER INDUCEMENT OF FEMALE CLARIAS GARIEPINUS BROODSTOCKS FED DIETS INCLUDED WITH VITAMINS C AND E.

Robert, E. A., S. O. Ovie., O. I. Binyotubo., I. Y. Yem., N. D. Ago., B. M. Gwari., J. O. Eze., H. F. Maradun., K. E. Ogbuebunu., Z. J. Ibrahim., U. B. Abdullahi., E. A. Gabriel., I. U. Ibrahim., M. M. Logodi., C. C. Offor., U. B. Mohammed and H. M. Goni

National Institute for Freshwater Fisheries Research, P.M.B 6006, New Bussa, Niger State, Nigeria.

Corresponding author:
ememrobert@gmail.com, +2348051251464, 0009-0006-1853-4483

ABSTRACT

The recovery period after induced breeding, for thirty female *Clarias gariepinus* broodstocks stocked in nine 2x2x1m2 concrete tanks, were observed for six months. Ten females per treatment T1, T2 and Tc were stocked. Treatments were in triplicates. Broodstocks were fed experimental feed containing 40% Crude Protein. Vitamin C and Vitamin E were added in the experimental feed for treatments T1 and T2. Treatment Tc served as the control, without Vitamin C and Vitamin E. *Clarias gariepinus* were fed at 2% of their body weight. Mean initial weight (MIW) varied from 1027.14±140.00g to 1029.00±105.00g. Mean final weight (MFW) recorded values 1137.00±100.01g to 1644.00±254.06g. Broodstock recovery began from month four to month six; more for the broodstocks in T2 treatment with more egg releases due to the presence of Vitamin C and E in higher amounts. Broodstock re-use time is recommended from the fourth month after being used once, for induced breeding. Percentage fecundity reported 69.78% for T1 , 75.51% for T2 , and 24.00% for TC. Mean dissolved oxygen of the treatments ranged from 5.06-5.80mg/L. Temperature ranged from 27.00-27.03 0C while PH was between 6.2-6.33. Lowest Survival rate was 90.80% in treatment TC. This was closely followed by high survival of 91.58% in treatment T1. Treatment T2 maintained the highest survival in the study with value 95.20%. This study aimed to enlighten aquaculturists on the recovery period and re-use time of female *Clarias broodstocks* after induced breeding, using well-formulated local feeds. Experimental duration was one hundred and eighty-two (182) days.

Keywords:
recovery rate, fecundity, locally formulated feeds, Clarias gariepinus, vitamin C, vitamin E

INTRODUCTION

Sustainable aquaculture involves using adequate and time-tested techniques, steps and procedures to enhance profound productivity (Dickson and Omoregbee, 2021). The development of the fish industry will promote increased production and foreign exchange earnings (Alfred et al., 2021). Despite recent technologies to boost induced breeding practices and aid successful fish production, the challenge of quick recovery of female broodstocks used for induced breeding remains a challenge in the sector. This is why the utilization of quality fish feeds that enhance recovery of broodstock after induced breeding is important to the sustainability of the fish production process. The current study aimed to assess the recovery periods after inducement and fecundity of female *Clarias gariepinus* broodstocks fed diets included with vitamins C and E.

MATERIALS AND METHODS

This study was carried out using the outdoor concrete tanks of the Fish breeding and Culture program, Research Operations Department, National Institute for Freshwater Fisheries Research (NIFFR), New Bussa, Niger state. New Bussa is located at 9°53'N 4°31'E coordinates (Robert et al., 2024). Broodstocks were also obtained from the Fish Breeding and Culture unit of NIFFR, New Bussa. Source of water for this research was from NIFFR's Kigera Dam. Experimental design for this study was a factorial design. Fish selection were from nine 2X2X1m2 concrete tanks containing ten female broodstocks each, and five male broodstocks all labelled per three treatments T1, T2, T3, totaling thirty female broodstocks and fifteen male broodstocks. These fifteen *Clarias gariepinus* broodstocks (five males and ten females) from treatment 1 (T1), treatment 2 (T2) and treatment 3 (TC- control treatment) were selected and used for induced breeding. The female fishes selected per treatment, were weighed and injected with 0.5ml ovaprim dosage with regards to their body weight in readiness for fertilization. After the injection, they were placed back in the holding vats for twelve hours. In twelve hours, the female fishes ovulated and were ready to release their eggs. The male *Clarias gariepinus* broodstocks selected per treatment were sacrificed, the testes collected, and cleaned with dry tissue paper and further cleaned using saline solution. The injected female fishes were then stripped, and the milt from the dissected testes of the sacrificed males were used to fertilize the stripped eggs from the females. Female *Clarias gariepinus* broodstocks used for induced breeding were weighed again using a manual HANA 50KG weighing balance before they were returned to nine concrete 2X2X1m2 tanks for recovery. In the recovery tanks, broodstocks were fed with Vitamins C and E locally formulated diet in varying amounts as seen on Table 1. Data were taken, documenting their recovery period and fecundity, monthly. Cases of mortality due to stress and handling were minimal. Female *Clarias gariepinus* broodstocks in recovery were continuously fed with locally formulated feeds made up of 40% crude protein; which contained Vitamins C and E for two treatments (treatments T1 and T2) in varying amounts: with 0.030kg of Vitamin C and 0.005kg of Vitamin E for Treatment T1 , 0.300kg of Vitamin C and 0.005kg of Vitamin E for Treatment T2 and 0.00kg of Vitamin C , 0.00kg of Vitamin E for the control treatment (TC) as also seen on Table 1. Feeding was carried out twice a day-morning and evening. The female *Clarias gariepinus* broodstocks used in this study were sampled monthly, using drag nets, scoop nets, big bowls to carry the broodstocks and a manual weighing balance for body weight measurements. Fish' readiness to release eggs for subsequent induced breeding was ascertained by gently pressing the female abdomen. Once pressed monthly, if the eggs are released with little pressure, then the female broodstocks are deemed ready. Determination of fecundity by female *Clarias gariepinus* broodstocks monthly, was carried out using a XPS series 500X microscope. Eggs released were manually counted and estimated (Robert et al., 2021). Total lengths and standard lengths were measured using a ruler to the nearest 0.1cm (Robert et al., 2019). Growth of fish were monitored using the following indices below:

Mean Initial Weight (MIW) = $\frac{TW}{TN}$

Where: TW = Total Weight of fish
TN = Total number of fish (Ovie *et al.*, 2014; Robert *et al.*, 2021).

Mean Weight Gain (MWG) = MFW - MIW
Where: MFW = Mean Final Weight
MIW = Mean Initial Weight (Bake et al., 2014; Robert *et al.*, 2021).

Percentage Mortality (% mortality) $\frac{CM}{Tns} \quad x\ 100$

Where: CM=Cumulative Mortality
TnS=Total Number Stocked
(Okomoda *et al.*, 2017; Robert *et al.*, 2021).

Percentage Survival (% survival) $\frac{cs}{Tns} \quad x\ 100$

Where: CS= Cumulative Survival
TnS= TotalNumber Stocked (Okomoda *et al.*, 2017; Robert *et al.*, 2024).
Survival Rate (SR) = *NS-NM*
Where: NS= number of fish stocked
NM= number of mortalities (Okomoda *et al.*, 2017; Robert *et al.*, 2024).

Specific Growth Rate % day (SGR)= $\log_{,n}$FW-$\log_n$IW x 100
D

Where: $\log_n$FW=$\log_n$ final weight
$\log_n IW$ = $\log_n$ initial weight
D=Feedings Period in days (Bake *et al.* 2014)

Feed Conversion Efficiency (FCE)= $\frac{FW}{WF}$ x 100

Where: *FW*= Final weight of experimental fish
WF= Weight of feed given during experimental duration (Abaho *et al.*, 2020).

Fecundity (F)= $\frac{oW}{SsW}\ x\ Ne$

Where; OW-Ovary Weight
SsW= Subsample weight
Ne-Number of eggs in subsample (Jan and Ahmed, 2016; Robert *et al.*, 2024)

Performance Index (PI) = $\frac{SR\ x\ FMW - IMW}{D}$ x 100

Where: SR= Survival Rate
FMW = Final mean weight
IMW= Initial mean weight
D=Rearing duration in days (Yakubu *et al.*, 2014)

Data were subjected to one way analysis of variance (ANOVA) (Ojuwoni et al., 2019). Duncan Multiple range test was used to compare means (Yakubu et al., 2014). Analysis for regression was also computed (Nwachi et al., 2020).

RESULTS

Table 1: Feed Composition with varying amounts of Vitamin C and E

Ingredients	T_C (Kg)	T_1 (Kg)	T_2 (Kg)
Fish meal	15.00	15.00	15.00
Soyabean meal	20.00	20.00	20.00
Groundnut cake	27.00	27.23	27.23
Wheat offal	11.00	11.735	11.465
Maize	20.00	20.00	20.00
Oil	2.00	2.00	2.00
Bone meal	1.00	1.00	1.00
Starch	2.00	2.00	2.00
Premix	2.00	1.00	1.00
Vitamin C	0.00	0.030	0.300
Vitamin E	0.00	0.005	0.005

Table 2: Fecundity rates of *Clarias gariepinus* broodstocks at the end of six months

Treatments	Fecundity	% Fecundity
T_1	34168.17± 61 40.11^{b}	69.7 8%
T_2	38209.03 ±5 23.00 ^{c}	75.51%
T_C	15046.00± 978 12 ^{a}	2400%

Values in the same columns with different superscript are significantly different ($p<0.05$).

Table 3: Growth performance of female *Clarias gariepinus* broodstocks during recovery

Treatments	T_1	T_2	T_C
MIW (g)	1028.00±150.01	1027.^{a}14±140.00a	1029.00±105.00^{a}
MFW(g)	1380.00±100.00^{a}	1644.00±254.06^{b}	1137.00±100.01^{a}
MWG (g)	352.00±50.01^{b}	437.11±41.00^{c}	216.00±0.50^{a}
% SGR	3.14±0.00^{b}	3.22±0.00^{c}	3.06±0.00^{a}
FCR	1.420±0.00^{b}	1.144±0.00^{c}	2.315±0.00^{a}
FCE	2.76±0.00^{a}	3.28±0.00^{a}	2.27±0.00^{a}
PI	126.37±751.64^{a}	182.50±168.13^{b}	103.23±539.56^{a}
PI	6.9±0.00^{a}	6.9±0.00^{a}	6.9±0.00^{a}

Values in the same columns with different superscript are significantly different ($p<0.05$).

MIW=Mean initial weight (g), MFW= mean final weight (g), WG =weight gain (g), SR= survival rate, %SR =%survival rate, %SGR = %specific growth rate, FCR=feed conversion ratio, FCE=feed conversion efficiency, PI= performance index and CF=condition factor

Table 4: WATER QUALITY PARAMETERS

Treatments	Temperature (°C)	DO (mg/L)	ρH
T_1	27.00 ± 0.00^a	5.06 ± 0.0^a	6.2 ± 0.28^a
T_2	27.03 ± 0.01^a	5.21 ± 0.0^a	6.3 ± 0.04^a
T_C	27.02 ± 0.00^a	5.80 ± 0.01^a	6.33 ± 0.00^a

Values in the same columns with different superscript are significantly different ($p<0.05$).

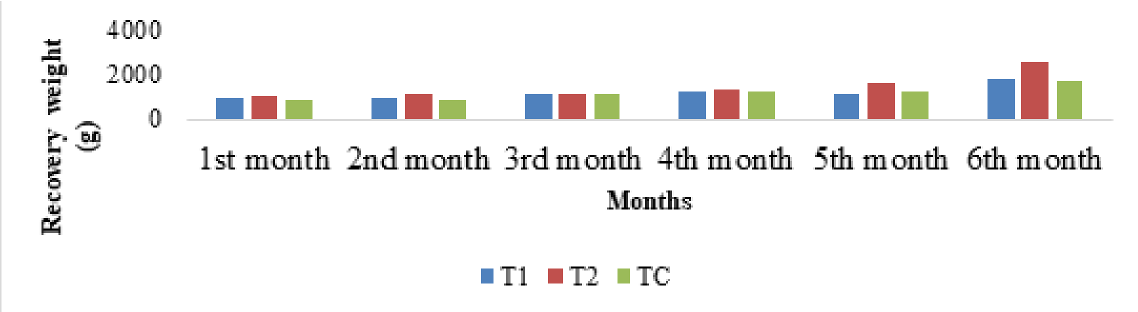


Figure 1: Weight gain of Thirty (30) female Clarias gariepinus broodstocks during recovery Month One-December, Month Two-January, Month Three -February, Month Four-March, Month Five -April, Month Six-May

Table 5: Proximate Analysis of the local formulated 6mm diet with varying amounts of Vitamins C and E

Treatments	%Moisture content	% Ash content	% Crude fibre	%Crude protein	% Crude fat	%NFE
T_1	3.42 ± 0.07^b	7.29 ± 0.07^c	4.04 ± 0.21^b	40.05 ± 0.50^b	5.00 ± 0.00^a	30.00 ± 0.00^c
T_2	3.21 ± 0.10^a	7.52 ± 0.06^b	4.17 ± 0.01^c	40.09 ± 0.44^c	5.01 ± 0.03^b	30.29 ± 0.13^a
T_C	3.60 ± 0.33^c	6.66 ± 0.00^a	3.87 ± 0.15^a	40.01 ± 0.36^a	5.01 ± 0.11^b	30.34 ± 0.07^b

DISCUSSION

At the end of the experimental period, the highest feed conversion efficiency (FCE) (3.28±0.00) was observed in Treatment T2 with 0.300kg of Vitamin C and 0.005kg of Vitamin E. The highest feed conversion ratio (FCR) (2.315±0.00) were observed in Treatment Tc with 0.00kg of Vitamins C and E. The highest Condition factor (CF) recorded 7.18±0.00 as observed in Treatment T2 . In the month of February-the third month of the study, female *Clarias gariepinus* broodstocks stopped releasing eggs due to the dry weather conditions in New Bussa, Niger state of Nigeria where this study was carried out. It was also observed during the study that the female broodstocks in Treatment T2 showed high fecundity in December even though it was the beginning of the harmattan season. This success could be attributed to the presence of 0.300kg of Vitamin C and 0. 005kg of Vitamin E in the diet of the female broodstocks as seen in Treatment T2 (see Table 1). Female *Clarias gariepinus* broodstocks stopped releasing their eggs in the dry season–(late January to late March). At the onset of the rainy season, as was seen in the months of April/May, the fifth and sixth months, more eggs were released by the female broodstocks fed with Vitamins C and E. Treatment T2 however, did release a few eggs by March, the 4th month. Summarily therefore, fish in Treatment (T2) showed highest fecundity of 75.51% and fish in Treatment (T1) showed higher fecundity of 69.78%. Fish in Treatment C (TC) showed a fecundity of 24.00%. This report was in agreement with Robert et al. (2021) whose earlier study documented high fecundity of 37,105 eggs. There was a significant difference (p>0.05) in the fecundity rates in this study. The recovery period was more noticeable from the fourth month (one hundred and twenty days). A previous report stated recovery rates were faster at forty-five days for male Clariids were experimented upon in Bosso Local Government, Minna, Niger state of Nigeria. These male Clariids were reported to show possibilities of being used up to six times for induced breeding in a year after abdominal incision. Furthermore, the spent male C. *gariepinus* could be sold live. There were however, no stated seasonal conditions in Nigeria for which their study could be carried out (Yisa *et al.*, 2014).

CONCLUSION AND RECOMMENDATION

It is concluded that recovery period and re-use time for *Clarias gariepinus* broodstocks is from the fourth month after being used for induced breeding, given the special formulated feed of Vitamin C and Vitamin E in their diet. Feeds with Vitamins C and E, are hereby recommended in diets of fish because they aid growth, quick recovery and foster faster re-use time.

REFERENCES

Abaho, I., Thaddeus, Z., Arinaitwe, I.Z.A., Howard, K., Norman, M., Gilbert, S.B., Mujibu, N., Sylvester, D.B., David, H. and Jackson, E. (2020). Effect of stocking density on growth and survival of Nile Tilapia (Oreochromis niloticus, Linnaeus 1758) under cage culture in Lake Albert, Uganda. International Journal of Fisheries and Aquaculture, 12, 26-35. doi: 10.5897/IJFA2018.0671

Alfred, O., Egwenomhe, M., Shaahu,A., Jibung, G.G., Amon, T.E., Msaakpa,T.S. and Orban, D.A. (2021). Survey of Feeding Practice of Fish Farmers in Bida Local Government Area, Niger State, Nigeria. Proceedings of the 3rd Conference of Association of Nigerian Fisheries Scientist (ANIFS) held at the Faculty of Agriculture, Cooperative Secretariat, University of Benin, Benin City, Edo State, Nigeria on the 28th July-30th July. pp:75- 82.

Bake, G.G., Martins, E.I. and Suleiman, S.O.E. (2014). Nutritional evaluation of varying levels of cooked flamboyant seed meal (Delonix regia) on the growth performance and body composition of Nile Tilapia (Orechromis niloticus) fingerlings. Agricukture, Forestry and Fisheries 3(4): 233-239.

Dauda, A.B., Adamu, H.M. and Abubakar, S.H. (2023). Influence of Culture Tank Colurs on the Water Quality, Growth Performance and Feed Utilization of Oreochromis niloticus (Linnaeus, 1758) Juveniles. UMYU Scientifica, 2(2), 016-22.

Dickson, A.A. and Omoregbee, F.E. (2021). Comparative Analysis of Adoption Rate of Fish Production Practices in Akwa Ibom state, Nigeria. Proceedings of the 3rd Conference of Association of Nigerian Fisheries Scientist (ANIFS) held at the Faculty of Agriculture, Cooperative Secretariat, University of Benin, Benin City, Edo State, Nigeria on the 28th July-30th July. pp:43-52.

Nwachi, O.F., Zelibe, S.A.A. and Kelly-Igumbor, S. (2020). Culture of catfish (Clarias gariepinus) fed with diet containing 17-*a*-methyltestosterone. Nigerian Journal of Fisheries, 17(2), 2017-2021.

Ojuwoni,A.A., Akinwole, A.O. and Faturoti, E.O. (2019). Growth performance and Nutrients Utilization of Oreochromis niloticus fed maggot meal-based diets. Proceedings of the 34th Annual Conference of Fisheries Society of Nigeria (FISON), held on the 28th October-1st November at the Law Auditorium, Ebonyi State University, Abakiliki. pp.130-133.

Onada, O.A. and Ogunlola, O.S. (2017). Effects of Catfish (Clarias gariepinus) broodstocks egg combination on hatchability and survival of fish larvae. Journal of Aquaculture Research Development 2, 014. doi: 10.4172/2156-9546

Ovie, S.O., Ovie, S.I., Wonah,C., Ekundayo, T., Offor, C.C., Maradun, H. F., Ibrahim, J. Z., Robert, E.A. and Abdullahi, U.B. (2014). The effect of fertilization on the growth of Heteroclarias fry in outdoor concrete tanks. Best Journal 11(2): 141-146.

Robert, E.A., Yisa, A.T. and Tsadu, S.M. (2019). Growth performance and survival of monosex cultured

Heterobranchus longifilis juveniles in concrete flow-through and stagnant water systems. Scientific Research Journal (SCIRJ). 7(2), 43-65. doi:10.31364/SCIRJ/v7.i2.2019.P0219615

Robert, E.A., Ovie, S.O. and Onyeche, V.O. (2021). Fecundity and Recovery Rates of Female Clarias gariepinus Broodstocks used for Induced Breeding and Fed with Feed containing and Vitamin C. Proceedings of the 3rd Conference of Association of Nigerian Fisheries Scientist (ANIFS) held at the Faculty of Agriculture, Cooperative Secretariat, University of Benin, Benin City, Edo State, Nigeria on the 28th July-30th July. pp:69 -74.

Robert, E.A., Binyotubo, O.I., Ogbuebunu, K.E. and Eze, J. (2024). Ovulation stimulation and fecundity of Clarias gariepinus and Heterobranchus longifilis given Ovaprim doses. Nigerian Journal of Fisheries Science and Technology, 3(1), 10-16.

Robert, E.A., Yisa. A.T., Tsadu, S.M. and Olayimika, S.A. (2024). Fecundity studies on Clarias gariepinus and Heterobranchus longifilis parent stocks. Global Journal of Fisheries Science (GJFS),6 (4), 112-118. Article number: 7738760C4. Retrieved from https://doi.org/10.31348/GJFS2024.063

Yakubu, A.F., Nwogu, N.A., Olaji, E.D., Ajiboye, O.O., Apochi, J.O., Adams, T.E., Obule, E.E. and Eke, M. (2014). A comparative study on growth performance and survival rate of Clarias gariepinus Burchell 1822 and Heterobranchus longifilis Valenciesnnes, 1840 under water recirculation system Agriculture, Forestry and Fisheries, 3(1), 30-33.

Yisa, T. A., Lamai, S. L., Tsadu, S. M. and Kolo, R. J. (2014). Induced breeding of Clarias gariepinus using non-conventional method of abdominal incision. International Journal of Biochemistry and Biotechnology, 2 (7), 484-489.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

GROWTH AND ECONOMIC PERFORMANCE OF *Clarias gariepinus* JUVENILES FED THREE DIFFERENT COMMERCIAL FEEDS IN SEMI-ARID REGION, NIGERIA

Olanrewaju A. N., * A. Nasir and A. Umara

[1]Department of Fisheries Technology, Federal College of Freshwater Fisheries Technology, Baga, P.M.B. 1060, Maiduguri, Nigeria

Corresponding
aanasir10@gmail.com; Phone no.: +234706 600 2455, 0009-0004-8881-4072

ABSTRACT
This study investigates economic and growth performance of Clarias gariepinus juveniles fed three different commercial feeds. Triplicate groups of 30 fingerlings (4.29±0.31 g) were assigned each to plastic aquaria (2.9 m3) representing different commercial feeds as treatments CP, AQ and BC. Fish were fed twice daily at 5% body weight for 84 days. Growth parameters such as Mean Weight Gain (MWG), Specific Growth Rate (SGR) and Feed Conversion Ratio (FCR) were calculated using standard formula. Survival rate, incidence cost and profit index were determined following standard formula. Significantly highest MWG ($p<0.05$) was recorded in fingerlings fed on BC (65.90±2.45 g) and CP (60.03±2.29 g) feeds. The SGR (1.44±0.07 %) and FCR (1.21±0.01 %) of C. gariepinus were best in fish fed BC. Survival rate was slightly higher with AQ feed (100 %) than treatments CP and BC with the same value (96.12 %). Profit index and incidence of cost highly favoured BC feed. This study suggests that BC feed is the best in terms of growth and economic performance. It is therefore, recommended that further studies be conducted to compare cost of feeding to adult stage.

Keywords:
Fish culture, commercial feeds, growth indices, survival rate, water quality, Maiduguri

INTRODUCTION

Catfish aquaculture industry is a formidable economic business in Nigeria, but its future development is still been hampered by availability of affordable and high-quality feed (Olanrewaju *et al.*, 2015). This implies that for aquaculture to be highly successful and meet the nation's goal for self-sufficiency in fish production, there is need for good quality and inexpensive feed to encourage investors. Dwyer *et al.*, (2002) asserts that good quality feed at optimum feeding frequency enhance utilization of diets resulting in good growth rate and feed utilization in African catfish. Poor quality fish feed, however, leads to leaching of nutrients, reduction in feed conversion ratio and increase in input list (Yakubu *et al.*, 2013). More so, low-quality feed give rise to accumulation of wastes that adversely affect the water quality and fish well-being. This has continued to drive interest in research and technology to address the problems and bring forth efficient and effective use of fish feed.

Culture of fish in pond is receiving a lot of attention in Borno State, Nigeria (Olanrewaju *et al.*, 2009) and it require adequate quality feed to support the growing production phases. Meanwhile, the effective production of *Clarias gariepinus* in the area has been inhibited by the high cost of imported feed and the non-availability of affordable locally made high-quality fish feeds. However, the quest to provide adequate feed have been high and, there are many brands of fish feed available in the market. These feeds vary in nutrient composition, price, and efficacy, and many could not meet the expectations of good growth in fish. Therefore, fish farmers with this situation are in serious conundrum, hoping for intervention in research. It is against this backdrop, that this study was carried out to compare the growth performance and survival of C. *gariepinus* fingerlings fed three different commercial feed in Maiduguri, Nigeria. The results from this study will provide baseline information that will assist farmers, regulatory agencies, and other stakeholders in the aquaculture business in the State, and Nigeria as a whole.

MATERIALS AND METHODS

The experiment was conducted in 2021 inside the Fish Hatchery Complex of Federal College of Freshwater Fisheries Technology, Baga, Borno State, and the feeding trial lasted for 84 days. Two hundred and seventy fingerlings of C. gariepinus (4.29±0.31 g) were obtained from the College hatchery facility. The fish were fasted for 24hrs before distributed into experimental tanks filled with freshwater from hatchery. Nine rectangular plastic aquaria (2.9 m3) were supplied with dechlorinated freshwater and changed every 72 hours to ensure good water quality and prevent ammonia build-up. Thirty (30) fish were randomly stocked into each tank, which were covered with a net of 2 mm mesh size to protect the fish from jumping out of the tank. Prior to starting the experiment, the fish were starved for 24 hours before they were individually weighed to obtain the initial weight. The research design was 3 x 3 Completely Randomized Design (CRD). The feeds were assigned to triplicate groups of fish. Three aquaria for each treatment of feed with diets CP, AQ and BC were used. The macronutrient composition of the three commercial feeds used is shown in Table 1. The fish were fed with 2mm size of various treatment feed (Table 1) at 5% of total body weight per day, as recommended by Adewolu and Olakunle (2009), with half daily ration fed to the fish at 0800 h and the other half at 1700 h. Feeding was generally completed in 5–10 mins. Fish were reweighed weekly and feeding rate was adjusted accordingly with the use of 200g weighing scale (Scout Pro SPU202 Model). Water temperature, pH and dissolved oxygen concentrations in water were monitored twice a week, while ammonia and nitrate were measured week in each of the treatment tanks. Temperature was measured using a mercury in-glass thermometer. pH and dissolved oxygen were measured with a pH meter (BICASA model B.E.104), while nitrite and nitrate were determined in the laboratory as described by APHA (1995).

Table 1. Macronutrient composition of three commercial feeds used (Manufacturers label)

	Fish feeds		
Variable	CP	AQ	BC
Feed size (mm)	2.0	2.0	2.0
Crude Protein (%)	42.00	45.00	45.00
Crude Fat (%)	13.00	8.00	8.00 – 12.00
Ash (%)	7.70	8.00	8.00
Moisture (%)	-	8.00	8.00
Fiber (%)	1.70	2.00 – 4.00	2.00 – 4.50
Calcium (%)	1.10	1.50 – 2.00	1.50 – 2.00
Phosphorus (%)	1.07	1.10	1.10
Sodium (%)	0.20	0.30	0.30

Growth and nutrient utilization parameters were assessed in terms of Mean Weight Gain (MWG), Specific Growth Rate (SGR), Food Conversion Ratio (FCR) and Survival Rate (SR) following the formulae used by Akinwole and Faturoti, (2006). The cost-effectiveness of feeds used in the present study was assessed by calculating the cost of feed based on market price. The incidence cost and profit index were estimated following the formular of Faturoti and Lawal (1986). Data from the experiment were subjected to descriptive and one-way analysis of variance and presented as Mean±Standard deviation (S.D). Fisher's LSD was further used to evaluate the mean differences at 0.05 significant level. Statistical analysis was performed using SPSS software statistical program version 20.0 (SPSS Inc., Chicago, IL, United States of America).

RESULTS

The growth performance and nutrient utilization efficiency of *Clarias gariepinus* juveniles fed different commercial feeds are presented in Table 2. Final weight ranged between 912.33±75.59 g and 1119.67±37.29 g in the three commercial feeds and was significantly lower ($p>0.05$) in AQ compared to CP and BC feeds. The final weight gain was significantly varied between the investigated feeds ($p<0.05$) with BC and AQ feeds had the highest (1050.33±39.37 g) and least (912.33±75.59 g) values respectively. The specific growth rate (SGR) varied significantly among the three commercial feeds ($p<0.05$). The BC gave the highest SGR (1.44±0.07 %), while AQ feed had the least (1.29±0.05 %). Similarly, the feed intake was significantly higher in CP (277.48±1.73 g feed/fish) compared to AQ (251.10±2.84 g feed/fish) and BC diets (217.73±4.41 g feed/fish). A considerable variation was also noted in the Feed conversion ratio (FCR), which ranged from 1.21±0.01 – 1.30±0.03 %. The BC feed had the best FCR value of 1.21±0.01%. The survival rate during the experiment was between 94.12% – 100% (Figure 1). The highest survival rate was recorded for fish fed AQ feed followed by CP and BC feeds. However, there was no significant difference in survival rate between the experimental sets ($p>0.05$). Table 3 shows the economics of the three commercial feeds during the feeding experiment. The estimated feed input was significantly highest in experimental group fed CP (0.274±0.00 kg) while the lowest was recorded in fish groups fed with BC feed (0.219±0.00 kg). The CP feed have the highest costs per kilogram (N2000.00), followed by BC (N800.00) while the least was AQ (N650.00). Estimate cost of feeding was markedly highest ($p<0.05$) in fish fed CP (N546.67±11.55) while the least value occurred in fish group fed with AQ (N162.50±0.00). However, there were no significant

Table 2. Mean growth performance and nutrient utilization efficiency of *C. gariepinus* **juveniles fed different commercial feeds**

Variable	Feeds		
	CP	**AQ**	**BC**
Initial Weight (g)	$70.67±3.06_a$	$71.00±1.00_a$	$69.33±8.33_a$
Initial mean Weight (g)	$4.39±0.18_a$	$4.41±0.06_a$	$4.08±0.49_a$
Mean Weight gain (g)	$60.03±2.29_a$	$49.10±4.61_b$	$65.90±2.45_a$
Final weight (g)	$1030.67±38.84_a$	$912.33±75.59_b$	$1119.67±37.29_a$
Final mean weight (g)	$64.42±2.34_a$	$53.51±4.56_b$	$69.98±2.33_a$
Final weight gain (g)	$956.00±36.35_a$	$834.67±78.36_b$	$1050.33±39.37_a$
Specific growth rate (% day^{-1})	$1.36±0.01_{ab}$	$1.29±0.05_b$	$1.44±0.07_a$
Feed intake (g feed/fish)	$277.48±1.73_a$	$251.10±2.84_b$	$217.73±4.41_c$
Feed conversion ratio	$1.29±0.01_a$	$1.30±0.03_a$	$1.21±0.01_b$

Means across the same row differently subscripted differ significantly ($P < 0.05$). Values are means ± SD.

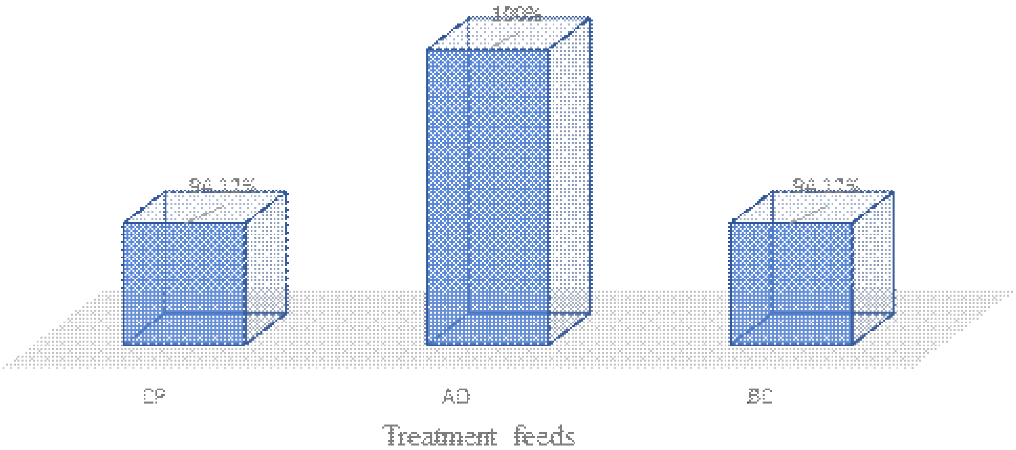


Figure 1. Survival rate of C. *gariepinus* juveniles fed different commercial feeds

(differences (P>0.05) in cost of feeding among fish fed on AQ and BC feeds. The highest Profit Index (6.14±0.34) and least Incidence of cost (2.48±0.13) was recorded in fish fed on Blue Crown feed. The physicochemical water quality parameters of fish culture environment in each treatment aquaria were presented in Table 4. Dissolved oxygen level in treatments CP (5.30±0.42 mg/l) and AQ (5.29±0.39 mg/l) aquaria was significantly higher (p<0.05) while treatment BC (4.91±0.47 mg/l) had the least. The highest pH concentration was found in treatments BC (7.65±0.29) and AQ (7.65±0.23) while treatment CP showed the least (7.53±0.24). However, pH concentration was not significantly different (p>0.05) in all the treatment aquaria. Temperature ranged from 28.17±0.72 oC (CP) to 28.33±0.49 oC (AQ) and varied non-significantly (p>0.05) among the different treatment tanks. Significant higher (p<0.05) concentration of nitrate was detected in treatment BC (12.90±5.12 mg/l) while treatment CP had the least (4.57±1.05 mg/l). The mean nitrite values varied from 0.02±0.01 mg/l to 0.03±0.03 mg/l. There was no significant variation in mean nitrite values among the three treatments (p>0.05).

DISCUSSION

Knowledge of fish growth (i.e., weight gain) is of vital importance for obtaining high yield of fish, which is an indication of better nutrient utilization. In this study, it was observed that the mean weight gain of the fish was significantly highest in BC (65.90±2.45 g) and CP feeds (60.03±2.29 g) as compared to AQ feed (49.10±4.61 g). The high weight gain of catfish fingerlings observed in BC diet could be attributed to its balanced nutritional content and the availability of amino acids responsible for growth. Previous studies have reported high weight gain in

Table 3. Economic performance of the three commercial feeds used in the study

	Treatments		
Parameters	CP	AQ	BC
Feed input (kg)	$0.274{\pm}0.00_a$	$0.251{\pm}0.00_b$	$0.219{\pm}0.00_c$
Cost of feed per kg (₦)	2000.00	650.00	800.00
Cost of feed used (₦)	$546.67{\pm}11.55_a$	$162.50{\pm}0.00_b$	$173.33{\pm}4.62_b$
Incidence cost	$8.49{\pm}0.15_a$	$3.05{\pm}0.25_b$	$2.48{\pm}0.13_c$
Profit index	$1.79{\pm}0.03_c$	$5.32{\pm}0.45_b$	$6.14{\pm}0.34_a$

Means across the same row differently subscripted differ significantly (P < 0.05). Values are means ± SD.

Table 4. Water quality parameters of C. gariepinus juveniles fed different commercial diets

	Treatments		
Water parameters	CP	AQ	BC
Dissolved Oxygen (mg/l)	$5.30 \pm 0.42_a$	$5.29 \pm 0.39_a$	$4.91 \pm 0.47_b$
pH	$7.53 \pm 0.24_a$	$7.65 \pm 0.23_a$	$7.65 \pm 0.29_a$
Temperature (°C)	$28.17 \pm 0.72_a$	$28.33 \pm 0.49_a$	$28.25 \pm 0.45_a$
Nitrate (mg/l)	$4.57 \pm 1.05_c$	$8.45 \pm 0.60_b$	$12.90 \pm 5.12_a$
Nitrite (mg/l)	$0.03 \pm 0.03_a$	$0.03 \pm 0.01_a$	$0.02 \pm 0.01_a$

Means across the same row differently subscripted differ significantly ($P < 0.05$). Values are means ± SD.

Coppens (Agokei *et al.*, 2011) for C*larias gariepinus* juveniles, Vita feeds (Jamabo and Dienye, 2017) for C. *gariepinus* fingerlings and Coppens (Wokeh et al., 2020) for post-fingerlings C. gariepinus. However, there is no documented work on Blue crown which can be used in comparison to the present study. Specific growth rate (SGR) measures growth performance over a long period of time as against the average daily growth which is a daily effect. Therefore, specific growth rate become a better parameter to determine which treatment would be the best for the optimum production of C. gariepinus. According to present study, the specific growth rate varied among the tested diets but was significantly higher in BC feed compared to others. It seems however that there is close homogeneity in the SGR values of fingerlings fed on BC and CP feeds as shown from statistical analysis. Similar higher SGR value were obtained in Coppens feed by Agokei *et al.* (2010) for C. *gariepinus* (3.19±0.00 %) fingerlings as against other commercial feeds compared in their study. In another report, Cheikyula et al. (2020) observed similar SGR value in Oreochromis niloticus fingerlings fed on Blue crown feed (0.323±0.01 %) and Skretting feed (0.323±0.01 %). Jamabo and Dienye (2017) also found significant high SGR value in C*larias gariepinus* fingerlings fed with Coppens as against other commercial feeds used in their study.

In fish culture, Feed Conversion Ratio (FCR) is important because it help the farmer to know how much amount of feed will be required in the growth cycle of fish. Hence, it serves as a powerful tool by letting the farmer know what choices he should make in order to maximize the profitability of his business. However, a low FCR is a good indication of a high-quality feed (Ajani *et al.*, 2015). The FCR observed in this study significantly varied among the experimental diets and was highest in BC feed. In the results of Jamabo and Dienye (2017), significant high growth performance of C*larias gariepinus* fingerlings was found in Vital feed (0.41) as compared to other feeds investigated. Ajiboye *et al.*, (2015) also report the best FCR value (0.09±0.05) in Coppens among other feeds tested in their study. However, Cheikyula et al. (2020) report no significant variation in the FCR obtained in O*reochromis niloticus* fingerlings fed on Blue crown feed (15.42±0.51 %) and Skretting feed (15.18±0.52 %).

The survival rate recorded in this study was generally high in all treatments. Therefore, C. *gariepinus* survival is not likely to be affected by the treatment diets. The high survival rate in this study could be associated to proper nutrients in these feeds, proper handling of fish and possibly tolerable physico-chemical qualities of the culture water (Falaye *et al.*, 2011). Although, the marginal difference in treatments fed on CP and BC feeds could be as a result of fish jumping out of tanks which was observed during experiment. Previous studies have reported high survival rate of 93.33 % in Coppens (Agokei *et al.*, 2010; Jamabo and Dienye, 2017) for C. *gariepinus* fingerlings. The economic performance of the various experimental feed based on profit index and incidence of cost revealed that BC feed is the best. In this study, water quality parameters such as dissolved oxygen, pH, temperature and nitrite were within the optimum range in all the treatment tanks (Omitoyin, 2007). Thus, the tested feeds do not have any adverse effect on the growth of catfish fingerlings. However, the level of nitrate was above the tolerable limit (0.1 – 3 mg/l) for fish culture as recommended by Boyd (1998). This source of nitrate content may be traced to the source of water rather than the treatment diets.

CONCLUSION

The findings from this study shows that weight gain, specific growth rate and feed conversion ratio of *Clarias gariepinus* were best when fed with BC feed. However, C. *gariepinus* fed on BC and CP have similar weight gain but profit index and incidence of cost is significantly better with BC feed. The results of this study also suggest high survival rates in all the treatment feeds, which can be attributed to the quality of the feeds.

REFERENCES

Adewolu, M.A. and Olakunle, A.O. (2009). Growth, feed utilization and haematology of Clarias gariepinus (Burchell, 1822) fingerlings fed diets containing different levels of Vitamin C. American Journal of Applied Sciences, 6(9), 1675-1681. DOI: 10.3844/ajassp.2009.1675.1681

Agokei, E.O., Oparah, C., Aranyo, A. and Apapa, U. (2011). Growth of Clarias gariepinus juveniles fed five commercial feed. Continental Journal of Fisheries and Aquatic Science, 5(3), 1–5.

Ajani, E.K., Orisasona, O. and Jenyo-Oni, A. (2015). Growth and economic performance of Clarias gariepinus fry reared at various stocking densities. J Fisheries Livest Prod., 3(3), 136. doi:10.4172/2332-2608.1000136

Ajiboye, A.O., Ajani, F. and Folarinwa, O.R. (2015). Nutrient utilization and growth of Clarias gariepinus fed four different commercial feeds. International Journal of Fisheries and Aquaculture, 7(7), 107–110. DOI: 10.5897/IJFA15.0486

Akinwole, A.O. and Faturoti, E.O. (2006). Biological performance of African catfish (Clarias gariepinus) culture in recirculating system in Ibadan. Aquacultural Engineering, 36, 18-23. https://doi.org/10.1016/j.aquaeng.2006.05.001

APHA (1995). Standard Methods for the Examination of Water and Wastewater. 19th Edition, American Public Health Association Inc., New York. ISBN: 0-8755-131-8. 541pp.

Boyd, C.E. (1998). Water Quality for Pond Aquaculture. Research and Development Series No. 43. International Center for Aquaculture and Aquatic Environments, Alabama. Agricultural Experiment Station, Auburn University Publisher, Alabama. 183pp.

Cheikyula, J.O., Torsabo, D. and Nwabuike, A.V. (2020). A comparison of the growth of the Nile tilapia (Oreochromis niloticus, Linnaeus, 1758) fingerlings fed blue crown® and Skretting®. International Journal of Fisheries and Aquatic Studies, 8(1), 20–24.

Dwyer, K.S., Brown, J.A., Parrish, C. and Lall, S.P. (2002). Feeding frequency affects food consumption, feeding pattern and growth of juvenile yellowtail flounder (Limanda ferruginea). Aquaculture, 213, 279–292. https://doi.org/10.1016/S0044-8486(02)00224-7

Falaye, A.E., Omoike, A., Ajani, E.K. and Olanrewaju, A.N. (2011). Comparative growth performance and survival of monosex and mixed sex ratio of African catfish (Clarias gariepinus, Burchell 1822) under culture system. Nigerian Journal of Science, 45, 75–81.

Jamabo, N. and Dienye, H. (2017). Growth performance of Clarias gariepinus fed with different commercial feeds. Journal of Natural Sciences Research, 7(6), 125–129.

Olanrewaju, A.N., Kareem, O.K. and Orisasona, O. (2015). Cryopreservation: A Viable Tool for Sustainable Catfish Aquaculture Industry in Nigeria. Journal of Fisheries and Livestock Production, 3(4), 149. https://dx.doi.org/10.4172 /2332-2608.1000149

Olanrewaju, A.N., Agbelege, O.O. and Ahmed, K.S. (2009): Growth and production of Dutch clarias fry/fingerlings in indoor tanks in arid zone. In: O. A. Fagbenro, E.O. Adeparusi, O. T. Adebayo, L. C. Nwanna, A. A. Dada, and M. O. Olufayo (eds.); Sustainable Fish Production and Food Security in a Global Economic Recession. Proceeding of the 24th Annual Conference of the Fisheries Society of Nigeria (FISON) Held at Federal University of Technology Auditorium, Akure, Ondo State, 26th – 28th October 2009. Pp 108 – 110.

Omitoyin, B. O. 2007. Introduction to fish farming in Nigeria. Ibadan University Press, University 0f Ibadan,

Nigeria. 90pp.
Wokeh, O.K., Ngozi, W.G., Ekinadose, O. and Edafe, O. (2020). Comparison of growth performance of African catfish (Clarias gariepinus) fed with different standard feed. Int. J. Fish. Aquat. Stud., 8, 394-397.
Yakubu, A.F., Ajiboye, N.A., Nwogu, E.D.O. and Adam, T.E. (2013). Growth and economic performance of Nile Tilapia (Oreochromis niloticus) fed two feed type at different stocking densities in Semi-flow through culture system. Journal of Fisheries International, 8(2), 25 – 30.
Yakubu, A.F., Nwogu, N.A., Olaji, E.D. and Adams, T.E. (2015). Impact of three different commercial feed on the growth and survival of Clarias gariepinus Burchell, 1822 fry in aquaria glass tank. American Journal of Experimental Agriculture, 9(1), 1–6. DOI: 10.9734/AJEA/2015/16342

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

PHYTOCHEMICAL SCREENING AND PROXIMATE ANALYSIS OF PAWPAW SEED

[1]Abdulsalam, I., [1]A. O. Odedere, [2]A. Hashimu, [2]M. Yusuf Bin, and [3]S.C. Salihu

[1]National Institute for Oceanography and Marine Research (NIOMR), Lagos, Lagos State
[2]National Institute for Freshwater Fisheries Research (NIFFR), New Bussa, Niger State
[3]Federal Polytechnic Kaltungo, Gombe, Gombe State

Corresponding Author:
ibromuda@gmail.com, 2348055745016, 2348129804953

ABSTRACT
Pharmaceutical sciences have in recent years seen an increase in scientific literature due to the renewed interest in food plants with several medicinal uses. The aim of this study is to determine the nutritional value and the phytochemical composition of C. *papaya*. Ten (10) unripe pawpaw fruit was purchase and cut open and the seeds were removed, dried (at room temperature) and ground to powder form in a clean mortar and pestle. The proximate analysis and phytochemical screening were done using standard methods. The result of phytochemical screening showed that phenol, quinone, terpenoid, steroid, and triterpenoid were not present. Tannin, saponin, reducing sugar, and glycoside were moderately present in the pawpaw seeds. Alkaloid and flavonoids were highly present. Proximate analysis showed that it had high crude protein. The moisture content of the pawpaw seed was within the range of 4.738-5.264%, ash content was between 11.048-12.848, and Crude fiber was within the range of 9.406-10.624%. Crude protein was found to be between 26.349-27.536%. Crude fat was between 13.867-14.924% NFE was at the range of 30.426- 30.938. This study shows that Carica papaya seed contains many nutritional and phytochemical active compounds that are essential to fish nutrition and human.

Keywords:
Carica papaya,
phytochemical,
nutritional value

INTRODUCTION

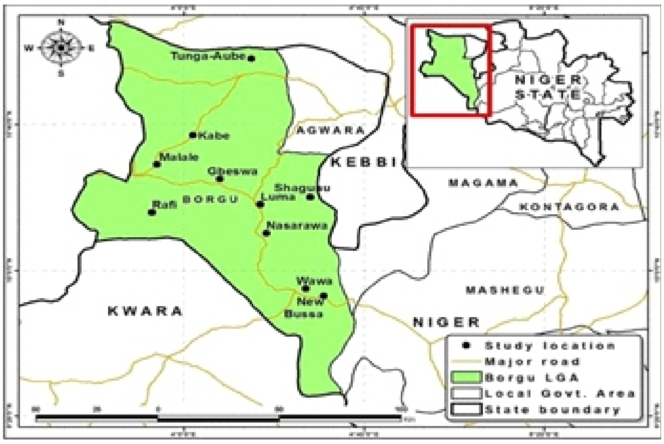
The leaf, seed, stem bark and root are believed possess medical benefits. The seeds are black and enclosed in a transparent aril. The seed is considered as carminative, abortifacient, emmenagogue, counter irritant and vermifuge (Singh and Ali, 2011). The seed of *Carica papaya* has both nutritional and therapeutic benefits (Joachim *et al.*, 2013). The seed is reported to have antibacterial and antifungal properties (Kanadi *et al.*, 2021). Kanadi *et al.* (2019) reported that C. papaya seed possesses preventive measures against potassium bromated induced renal toxicity in rats. It is of great importance to assess the nutritive and medicinal use of this plant for improved usage.

The Food and Agricultural Organization (FAO) of the United Nations has reported that Nigeria is the largest producer of C. *papaya* globally (FAO, 2019). The fruit contains papain, a proteolytic enzyme that is also used in the treatment of trauma, allergies and spot injuries (Parle and Gurditta, 2011). Several vitamins including Vitamin A, Vitamin C and Vitamin E are predominantly found in the fruit. These substances are useful in nutrition and also have documented antioxidant activities (Rajasekhar, 2017). The seeds of C. *papaya* been reported to possess several health benefits including antimicrobial and antifungal activities (Ukaegbu-obi *et al.*, 2018The objective of the present study is to carry out a preliminary investigation on matured C. papaya seed to determine its proximate composition and phytochemical constituents. This is important because awareness on the nutritive value and health benefits of C. papaya seed is of utmost importance in order to enhance its nutritional and medicinal use.

MATERIALS AND METHOD

Study Area

The study was conducted in the Fish Biotechnology Laboratory Department of Aquaculture and Biotechnology of the National Institute for Freshwater Fishery Research, New Bussa, Borgu Local Government, Niger state.



Map of Borgu Local Government Area, New Bussa, Niger State Showing the Study Area Source.
Source: Research gate, 2010

Sample Collection

Ten (10) unripe pawpaw fruit was purchase at Monday market, New Bussa Town, and transported to the laboratory. The fruits were cut open with table knife in the lab and the black seeds where collected by scrubbing the pod and it was poured in a tray to dry at room temperature (25oC), measured using a thermometer. After drying, the seed where grind using mortar and pestle and subjected to extraction using 95% ethanol.

Phytochemical Analysis

To establish the quantity and quality of bioactive constituents inhering in pawpaw seeds were subjected to phytochemical analysis at the NIFFR Central Laboratory by referring standard protocols

Proximate Analysis

The was done to check the proximate composition of pawpaw seeds, such as ash content, crude fiber, crude protein, crude fat, nitrogen free extract, moisture content using method described by Association of Official Analytical Chemist, AOAC (2019).

RESULT AND DISCUSSION

Table 1: Proximate Analysis of *C. papaya*

	Moisture Content (%)	Ash Content (%)	Crude Fibre (%)	Crude Protein (%)	Crude fat (%)	Nfe (%)
Concentration	**4.96±0.27**	**11.96±0.90**	**9.79±0.29**	**27.13±0.67**	**14.25±0.58**	**31.92±2.15**

Table 2: Phytochemical Parameters of Pawpaw Seeds

Phytochemical	Result
Alkaloid	+++
Flavonoid	+++
Tannin	++
Saponin	++
Phenol	–
Quinone	–
Terpenoid	–
Reducing sugar	++
Steroid	–
Triterpenoid	–
Glycoside	++

Keys: + + + = Highly present + + = moderately present + = slightly present - = Absent

The result for proximate analysis for pawpaw seed showed that the pawpaw seeds had high protein content. The moisture content of the pawpaw seed was in moderate range. This finding is in agreement with previous reports (Azevedo *et al.*, 2014; Oche *et al.*, 2017). Dietary fiber is found in the seed and fiber helps in the removal of toxins from the digestive system, help in lowering of cholesterol (Wulansari *et al.*, 2019) and proper functioning of large intestine and protect the gastrointestinal tract from disorders and cancer cells (Otles and Ozgos, 2014).
The results for phytochemical screening showed that phenol, quinone, terpenoid, steroid, and triterpenoid were not present in pawpaw seeds. Tannin, saponin, reducing sugar, and glycoside were moderately present in the pawpaw seeds. While alkaloid and flavonoids were highly present. Carica papaya seed were found to be a rich source of phytochemicals and these phytochemicals are helpful as anti- proliferation of cancer cells, shielding against cellular oxidative injury and help in reducing the risk of non-communicable diseases (Olcum *et al.*, 2020).
Alkaloids are the most important secondary metabolites and have a therapeutic potential of curing diseases (Olanitola *et al.*, 2018). Flavonoids are lipophilic, capable of interrupting cell wall and membrane formation with inhibition of enzymatic activity by formation of complexes with cell wall of the bacteria (Olanitola *et al.*, 2018).

CONCLUSION

This study shows that C*arica papaya* seed was found to be a rich source of phytochemicals and these phytochemicals are helpful as anti- proliferation of cancer cells, shielding against cellular oxidative injury and help in reducing the risk of non-communicable diseases. Its nutritional value was also found contain bioactive compounds that are essential to human health.

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National Institute for Freshwater Fisheries Research (NIFFR) for giving me the right environment and guide throughout this research work.

REFERENCES

AOAC Official (2019). Methods of Analysis of the Association of Official Analytical Chemists: Official Methods of Analysis of AOAC International. 21st Edition, AOAC, Washington DC.

Azevedo, L. and Campagnol, P. (2014). Papaya seed flour (Carica papaya) affects the technological and sensory quality of hamburgers. International Food Research Journal; 21(6): 2141-2145.

FAO (2019). FAOSTAT: Core production data. Food and Agricultural Organization of the United Nations. Available: http://www.fao.org/statistics.

Joachim, M.D., and Siri, A.A. (2021). Nutraceutical value of Carica papaya: A review. Scientific African; 13(1) 0 0 9 3 3, https://doi.org/10.1016/j.sciaf.2021.e00933.

Kanadi, M.A., Alhassan, A.J., Ngwen, A.L., Yaradua, A.I., Nasir, A., and Wudil, A.M. (2019). Dose dependent chemo preventive effect of methanol extract of Carica papaya seed on potassium bromate- induced nephrotoxicity in rats. Asian Journal of Biochemistry, Genetics and Molecular Biology. 2(1):1-12.

Kanadi, M.A., Yila, R., Ibrahim, M.P., Yaradua, A.I., and Nasir, A. (2021) A Proximate Composition and Phytochemical Constituents of Matured Carica papaya Seed Extracts. Asian Journal of Research in Biochmistry; 9: 28 - 33. 10.9734/AJRB/2021/v9i130193.

Oche, O., Rosemary, A., John, O., Chidi, E., Rebecca, S.M. and Vincent, U.A. (2017). Chemical constituents and nutrient composition of Carica papaya and Vernonia amygdalina leaf extracts. Journal of Complementary and Alternative Medical Research: 1–8, doi: 10.9734/JOCAMR/2017/29402.

Olanitola, S., Lawan, F.D. and Muhammad, A. (2018). Antibacterial Activity of Fractionated Extracts of Carica papaya Leaves and Stem Bark against Clinical Isolates of Methicillin Resistant Staphylococcus aureus (MRSA). Modern Applied Pharmacy and Pharmacology; 1(5): MAPP.000525. DOI: 10.31031/MAPP.2018.01.000525.

Olcum, M., Tastan, B. Ercan, Eltutan, I.B., and Genc, S. (2020) Inhibitory effects of phytochemicals on NLRP3 inflamma some activation: a review. Journal of Phytomedicine; 75: 1 5 3 2 3 8, d o i: 1 0. 1 0 1 6 /j. p h yme d. 2020.153238.

Otles, S., and Ozgos, S. (2014). Health effect of dietary fibre. Acta Scientiarum Polonorum Technologia; 13(2):191-202.

Parle, M., and Gurditta, G. (2011). Basketful benefits of Carica papaya. International Research Journal of Pharmacy. 2(7):6-12.

Rajasekhar P. (2017). Nutritional and medicinal value of papaya (Carica papaya). World Journal of Pharmacy.6(8): 2559-78.

Singh, O., and Ali, M. (2011). Phytochemical and antifungal profiles of the seeds of Carica papaya. Indian Journal of Pharmaceutical Science; 73(4): 447-451.

Ukaegbu-Obi, M.K., Anyaegbunam, P.C., and Enya, E. (2018). Antibacterial activity of Carica papaya seeds on some human pathogens. Annals of west university of Timisoara, Ser Biology. 21(1): 11-6.

Wulansari, D.D., Wulandari, D.D., Risthanti, R.R., and Kirtishanti, A. (2019). Ameliorative effect of Carica papaya seed extract on diabetic rat model with muscle atrophy. Media Pharmacy Journal Indonesia; 2 (4): 208- 215. doi: 10.24123/mpi. v2i4.2184.

GROWTH PERFORMANCE AND NUTRIENT UTILISATION OF AFRICAN CATFISH JUVENILES FED VARIEGATED GRASSHOPPER MEAL DIETS AS REPLACEMENT FOR FISHMEAL

[1]Folorunso, T. O., [2]F.O. Akinwumi and [2]A. M. Adewole

[1]Department of Fisheries and Aquaculture, Adekunle Ajasin University, Akungba-Akoko, Nigeria.
[2]Department of Animal and Environmental Biology, Adekunle Ajasin University, Akungba- Akoko, Nigeria.

Corresponding author:
tunmise.folorunso@aaua.edu.ng, +2348135504945

ABSTRACT

This study investigated the substitution of fishmeal with variegated grasshopper meal (VGM) in the diets of African mud catfish (Clarias gariepinus) juveniles. Five diets were formulated using VGM at 0%, 25%, 50%, 75%, 100% and designated diets I, II, III, IV and V, respectively. The juveniles (mean weight 6.92±0.23 g, n=15) were stocked per treatment in triplicates after acclimatization for 2 weeks and fed at 5% body weight for 84 days. The total length and standard length were measured using metre rule and measuring scales. The final mean weight gain (FMWG), specific growth rate (SGR), protein intake (PI) and feed conversion ratio (FCR) were evaluated. FMWG varied significantly, with the highest values (34.26±1.45g) in fish fed diet III and the least (19.28±5.91g) in diet V. Highest SGRs (2.79±0.19%/day) was observed in fish fed diet I and while the least value (1.58±0.57%/day) was observed in fish fed diet V. Highest PI (22.16±2.66) was observed in fish fed diet I and while the least value (13.99±0.75) was observed in fish fed diet V. Highest FCR (1.94±0.62) was observed in fish fed diet V and the least value (1.42±0.15) was observed in fish fed diet IV. The 50% inclusion of grasshopper meal (diet III) significantly enhanced the growth performance of fish. Therefore, VGM could replace fishmeal at 50% level.

Keywords:
Fish nutrition,
biological evaluation,
feed metabolism,
insect meal,
Clarias gariepinus

INTRODUCTION

Aquaculture is a rapidly expanding global food production sector, marked by increasing intensification in nearly every region worldwide (FAO, 2020). This growth has not kept pace with the rising demand for aquatic fish food driven by the continuous increase in the global population. This is partly due to challenges in production management, among other factors (Munguti *et al.*, 2021). African mud catfish *(Clarias gariepinus)* stands out as a significant freshwater species due to its high production levels and strong disease resistance in several countries (Esa *et al.*, 2023). Fish feed accounts for roughly 40-60% of production costs in aquaculture (Fadri *et al.*, 2016). Fishmeal is the primary component in fish feed and it has been the main protein source in fish diets due to its high-quality protein content, essential amino acids, vitamins and minerals (Abdelghani, 2003; Gatlin *et al.*, 2007). High cost of fishmeal in recent time has made it impossible to support the growth of aquaculture (Hardy and Tacon, 2002). Therefore, insect sources are being explored as an alternative to fishmeal in fish diets. Consequently, recent research primarily focused on replacing fish meal with insect meal in fish diet formulations. This study therefore, aimed to evaluate the effect of variegated grasshopper (Zonocerous variegatus) meal on growth performance and nutrient utilization of C*larias gariepinus* juveniles.

MATERIALS AND METHODS

Experimental site

The study was carried out at the Central Laboratory, Department of Fisheries and Aquaculture, Adekunle Ajasin University, Akungba Akoko, Nigeria. The university is located on Latitude 7029' 4.25" N. Altitude, 317 meters above sea level. Longitude 50 45' 14.34" E.

Diet Formulation

The adult variegated grasshoppers were harvested from the wild in Adekunle Ajasin University school farm. Harvested grasshopper (male and female) were placed into a jute bag and then lowered into a pot containing boiled water (95oC) for 7 minutes. After which the grasshoppers were sundried for two weeks and milled using industrial blender (model VTCL 750 watts). The resultant meal was sieved using 1 mm sieve to remove the chaff and to ensure a homogenous size profile (Alegbeleye *et al.* 2012). Other feed ingredients include; maize, soybeans, starch, minerals and vitamin premix were mixed together and pelletized into different diets based on the following proportions 0%, 25%, 50%, 75%, 100% and coded as I, II, III, IV and V, respectively (Table 1). The wet pellets were dried for three days at room temperature, packaged in an air-tight container, and stored in the refrigerator until use as adapted from Folorunso *et al.*, (2024).

Table 1: Gross composition of variegated grasshopper meal-based experimental diets (%)

Ingredients	Diet I	Diet II	Diet III	Diet IV	Diet V
Soybean meal	30.00	30.00	30.00	30.00	30.00
Grasshopper meal	0.00	10.90	21.70	32.60	43.40
Fish meal	40.00	30.00	20.00	10.00	0.00
Maize	12.00	12.00	12.00	12.00	12.00
Di-Calcium Phosphate (DCP)	0.50	0.50	0.50	0.50	0.50
Lysine	0.60	0.60	0.60	0.60	0.60
Methionine	0.40	0.40	0.40	0.40	0.40
Salt	0.10	0.10	0.10	0.10	0.10
Vitamin C	0.50	0.50	0.50	0.50	0.50
Toxin Binder	0.30	0.30	0.30	0.30	0.30
Starch	14.10	13.20	12.40	11.50	10.70
Fish Oil	0.50	0.50	0.50	0.50	0.50
Premix	0.50	0.50	0.50	0.50	0.50
Chromium oxide	0.50	0.50	0.50	0.50	0.50
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Experimental procedure

A total of 350 C. *gariepinus* juveniles, with average weight of 6.92±0.23g, were procured from a reputable Farm in Ondo State and acclimatized for 14 days prior to the commencement of the experiment. The juveniles were assigned to five diets in three replicates in a completely randomized design. Fifteen plastic tanks (50L capacity and dimensions of 65 cm by 40 cm by 30 cm) were stocked with a total of 225 juveniles of C. *gariepinus* at 15 fish per tank. They were fed twice daily at 08:00 and 17:00 hours. The quantity of feed was adjusted based on the new weight attained after two weeks. Changes in the weight and length of the fish were measured using metre rule and weighing scale fortnightly as reported by Folorunso *et al.*, (2024).

Statistical Analysis

All data were subjected to statistical analyses such as arithmetic mean and Analysis of Variance (ANOVA). Duncan multiple range test was used to compare differences among individual treatment means using SPSS statistical software (Version 17.0 for Windows; SPSS Inc., Chicago, USA).

RESULTS

The result showed significant differences among the growth parameters of the fish fed VGM diets. The final weight, final mean weight gain and specific growth had the highest values (454.17±35.88g; 346.54±34.97g; 2.79±0.19) from fish fed Diet III and the lowest values (231.64±56.99g; 123.60±56.52g; 1.58±0.57) from fish fed Diet I. Feed intake, protein intake and protein efficiency ratio had the highest values (55.39±6.66; 22.16±2.66; 0.93±0.12) from fish fed diet I and the lowest values (34.98±1.86; 13.99±0.75; 0.48±0.15) from the fish fed Diet V. the highest survival value (97.78±3.85) was recorded in Diet II and the lowest value (77.78±7.69) in Diet I as shown in Table 2.

Table 2. Growth performance and nutrient utilization of C. *gariepinus* **fed with variegated grasshopper meal diets.**

Parameters	Diet I	Diet II	Diet III	Diet IV	Diet V
Initial weight	105.69 ± 1.41^{a}	107.51 ± 1.11^{a}	107.63 ± 0.91^{a}	108.05 ± 1.26^{a}	108.04 ± 0.47^{a}
Final weight	444.20 ± 41.99^{a}	387.08 ± 72.88^{a}	454.17 ± 35.88^{a}	401.58 ± 22.54^{a}	231.64 ± 56.99^{b}
Weight gain	338.51 ± 40.58^{a}	279.57 ± 71.77^{a}	346.54 ± 34.97^{a}	293.53 ± 21.28^{a}	123.60 ± 56.52^{b}
FMWG	33.27 ± 4.74^{a}	26.46 ± 5.29^{ab}	34.26 ± 1.45^{bc}	29.29 ± 2.59^{b}	19.28 ± 5.91^{c}
SGR	2.79 ± 0.19^{a}	2.15 ± 0.36^{ab}	2.56 ± 0.08^{bc}	2.30 ± 0.16^{bc}	1.58 ± 0.57^{c}
RGR	437.76 ± 62.92^{a}	269.29 ± 74.67^{ab}	363.59 ± 21.55^{bc}	299.38 ± 38.87^{b}	167.60 ± 81.70^{c}
CF	0.82 ± 0.05^{a}	0.76 ± 0.02^{a}	0.71 ± 0.10^{a}	0.87 ± 0.15^{a}	0.70 ± 0.18^{a}
Survival	77.78 ± 7.69^{b}	97.78 ± 3.85^{a}	91.11 ± 7.69^{ab}	93.33 ± 11.55^{ab}	82.22 ± 13.88^{ab}
Feed Intake	55.39 ± 6.66^{a}	47.48 ± 7.30^{ab}	52.52 ± 1.01^{a}	42.91 ± 2.14^{ab}	34.98 ± 1.86^{b}
Protein Intake	22.16 ± 2.66^{c}	18.99 ± 2.92^{bc}	21.01 ± 0.40^{c}	17.16 ± 0.86^{ab}	13.99 ± 0.75^{a}
PER	0.93 ± 0.12^{c}	0.63 ± 0.12^{ab}	0.81 ± 0.05^{bc}	0.72 ± 0.05^{b}	0.48 ± 0.15^{a}
FER	0.69 ± 0.06^{a}	0.55 ± 0.03^{a}	0.63 ± 0.03^{a}	0.68 ± 0.08^{a}	0.55 ± 0.15^{a}
FCR	1.45 ± 0.12^{a}	1.81 ± 0.09^{a}	1.58 ± 0.08^{a}	1.42 ± 0.15^{a}	1.94 ± 0.62^{a}
GEFC	69.24 ± 5.79^{a}	55.43 ± 2.88^{a}	63.35 ± 3.37^{a}	68.48 ± 7.61^{a}	54.70 ± 14.96^{a}
GFCR	69.24 ± 5.79^{a}	55.43 ± 2.89^{a}	63.35 ± 3.37^{a}	68.41 ± 7.61^{a}	54.70 ± 14.96^{a}
NMs	538.77 ± 81.13^{a}	333.61 ± 91.84^{bc}	451.10 ± 25.32^{ab}	379.64 ± 45.97^{b}	208.86 ± 102.04^{c}

Values on the same row with different superscripts are significantly different ($p<0.05$)

FMWG: Final mean weight gain, SGR: Specific growth rate, RGR: Relative growth rate, CF: Condition factor, PER: Protein efficiency ratio, FER: Feed efficiency ratio, FCR: Feed conversion ratio, GEFC: Gross efficiency of feed conversion, GFCR: Gross feed conversion ratio, NM: Nitrogen metabolism

DISCUSSION

The substantial differences in final weight gains between Diet III and the control group Diet I are notable. Diet III resulted in significantly higher weight gain, indicating that this diet may be more effective in promoting growth. This finding is consistent with the observation of Greenway, (2015) and Elisha *et al.* (2017) suggesting that dietary composition can greatly impact the growth of fish. The variations in protein intake, protein efficiency ratio (PER), and feed efficiency ratio (FER) across the treatments highlighted the importance of dietary protein content. The highest protein intake in Diet I which was not significantly different from Diet III suggests that this diet was richer in protein, which could have contributed to improved growth. These results align with the well-established relationship between dietary protein levels and fish growth (Pesta and Samuel, 2014). The significant variation in fish survival among treatments is important for assessing the overall success of the feeding regimes. Diet II resulted in the highest fish survival which is not significantly different from Diet III, suggesting that these diets may be better suited for maintaining fish health and viability. This finding is in line with studies of Fowler et al. (2019) and UI Hassan et al. (2021) emphasizing the importance of diet in fish survival and resistance to stress.

Conclusively, feeding C. *gariepinus* with variegated grasshopper meal showed improve growth performance and effective nutrient utilization with the inclusion at 50% showed the best potential for aquacultural production, therefore recommendation of this dosage to the farmers is highly recommended for sustainable fish production. Further research into haematology, histology and oxidative stress should be carried out in future research to know the effect of prolong intake.

REFERENCES

Abdelghany, A. (2003). Partial and complete replacement of fish meal with gambusia meal in diets for red tilapia Oreochromis niloticus × O. mossambicus. Aquaculture Nutrition, 9,145–154.

Alegbeleye, W. O., Obasa, S. O., Olude, O. O., Otubu, K. and Jimoh, W. (2012). Preliminary evaluation of the nutritive value of the variegated grasshopper (Zonocerus variegatus L.) for African catfish Clarias gariepinus (Burchell. 1822) fingerlings. Aquaculture Research. 43, 412- 420.

Elisha, D. S., Ladu, B. M. B. and Joshua, D. Z. (2017). Effects of Water-Soluble Fractions from Parts of Balanites aegyptiaca (Desert Date) on Growth and Survival of Clarias gariepinus Juveniles in a Static Culture System. International Journal of Research in Agriculture and Forestry, 4,33-37.

Esa, Y. B., Dadile, A. M., Syukri, F., Christianus, A., and Diyaware, M. Y. (2023). Evaluation of fecundity, fertilization, hatching, and gonadosomatic index of exotic Clarias gariepinus (Burchell, 1822) and native Clarias macromystax (Gunther, 1864) under semi-arid conditions of Nigeria. Animals. 13(11), 1723.

Fadri, S., Muchlisin, Z., and Sugito, S. (2016). Growth performance, survival rate, and feed utilization of Nile tilapia, Oreochromis niloticus, fed experimental diet containing jaloh leaves, Salix tetrasperma Roxb, at different levels of EM-4 probiotic. Jurnal Ilmiah Mahasiswa Kelautan dan Perikanan Unsyiah, 1, 210–221.

FAO. (2020). The State of World Fisheries and Aquaculture 2020. In brief. In the state of world fisheries and aquaculture 2020.

Folorunso T.O., Akinwumi F.O. and Adewole A.M. (2024). Assessment of growth performance and blood profile of Clarias gariepinus (Burchell, 1822) fed with maggot meal diets as a replacement for fish meal. Annals of Animal Biological Research, 4(1), 24-35

Fowler, L. A., Williams, M. B., Dennis-Cornelius, L. N., Farmer, S., Barry, R. J., Powell, M. L., and Watts, S. A. (2019). Influence of Commercial and Laboratory Diets on Growth, Body Composition, and Reproduction in the Zebrafish Danio rerio. Zebrafish, 16(6),508–521.

Gatlin, D. M., III, Barrows, F. T., Brown, P., Dabrowski, K., Gaylord, T. G., Hardy, R. W., Herman, E., Hu, G., Krogdahl, A., and Nelson, R. (2007). Expanding the utilization of sustainable plant products in aquafeeds: A review. Aquaculture Research, 38,551–579.

Greenway, F. L. (2015). Physiological adaptations to weight loss and factors favoring weight regain. International Journal of Obesity (2005), 39(8), 1188–1196.

Hardy, R. W., and Tacon, A. G. (2002). Fish meal: Historical uses, production trends and future outlook for sustainable supplies. In Responsible Marine Aquaculture (pp. 311–325).

Munguti, J., Odame, H., Kirim., J.G. and Liti, D. (2021). Fish feeds and feed management practices in the Kenyan aquaculture sector: Challenges and opportunities. Aquatic Ecosystem Health and Management Society. 24(1), 82-89

Pesta, D. H. and Samuel, V. T. (2014). A high-protein diet for reducing body fat: mechanisms and possible caveats. Nutrition and Metabolism, 11(1), 53.

Ul Hassan, H., Mohammad Ali, Q., Ahmad, N., Masood, Z., Yeamin Hossain, M., Gabol, K., Khan, W., Hussain, M., Ali, A., Attaullah, M. and Kamal, M. (2021). Assessment of growth characteristics, the survival rate and body composition of Asian sea bass Lates calcarifer (Bloch, 1790) under different feeding rates in closed aquaculture system. Saudi Journal of Biological Sciences, 28(2), 1324–1330.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

EFFECT OF ROASTED FLAMBOYANT SEED (Delonix regia) ON BLOOD PARAMETERS OF *Clarias gariepinus* FINGERLINGS

N. A. Agbason[1], W. D. Adamu[2], R. M. Tanko[1], C.S. Mwamle[4] S.A. Okunsebor[2], S.U. Ibrahim[3], O. A. Odihi[2], B. R. Salau[1]

[1]Department of Fisheries Technology, College of Agriculture, Science and Technology Lafia, Nasarawa State
[2]Department of Aquaculture and Fisheries Management, Nasarawa State University Keffi
[3]Department of Water Resources, Aquaculture and Fisheries Technology, Federal University of Technology, Minna Niger State
[4]Department of Basic Science, Plateau State College of Agriculture, Garkawa Mikang LGA, Plateau State Nigeria

Email: nelsonagbason2014@gmail.com
Phone: 08058873831

ABSTRACT
The study on effect of roasted flamboyant seed (Delonix regia) on blood parameters of *Clarias gariepinus* fingerlings was conducted at the Teaching and Research Farm of the Faculty of Agriculture Shabu, Lafia Campus, Nasarawa State University Keffi, for twelve (12) weeks. Dried and mature pods of flamboyant (Delonix regia) were harvested in Lafia, Nasarawa State. Seeds were removed from the pods, sorted and roasted for 30mins until the seed coat cracked, cooled at room temperature, and milled into fine particles to formulate 43%CP diets at 0%, 25%, 50% 75% and 100% inclusion levels. Three hundred *Clarias gariepinus* juveniles were weighed and distributed in five treatments T1, T2, T3, T4 and T5 at 20 fish per replicate. Fish were fed experimental diet twice daily at 5% body weight, and feeding was adjusted as the fish advanced in size. Serum biochemistry and haematology were analysed. The results of phytochemical compounds showed low concentration of saponin (1.03mg/100g), tannins (0.98mg/100g), phytate (2.15mg/100g), and oxalate (0.87mg/100g) respectively. The values of haematological and serum biochemical parameters were not significantly different ($P>0.05$) from each other in fish fed experimental diets. Roasted Delonix regia seed meal in diets of *Clarias gariepinus* had no adverse effect and its utilization at 25% inclusion is considered the best.

Keywords:
Flamboyant seed,
Feeds, Serum biochemistry,
Haematology

INTRODUCTION

The African Catfish *Clarias gariepinus* belonging to the family Clariidae is one of the most important aquaculture species in Nigeria because of its fast growth rate, appreciable size, disease resistance, high fecundity, ease of artificial breeding, tolerance of high stocking densities in captivity, tolerance of harsh of environmental conditions, acceptability of farm made feed, good market value, good taste and meat quality (Eyo *et al.*, 2014).

Delonix regia is a leguminous plant which belongs to the family of fabaceae ranked as the second largest family among the dicotyledonous plant (Oluwasina et al., 2020). Delonix Regia is one of the abundantly underutilized materials in Sub-Saharan Africa and even mostly refers to as a waste material (Yuh-Shan and

Malarvizhi, 2009). The proximate composition of (Delonix regia) seeds has shown that the seed contain excellent nutrient, it could promote palatability to foods, reduce emptying time of the stomach, decreases intestinal motility and ensures dietary supply of essential fatty acids and fat soluble vitamins.
The qualitative and quantitative analysis of Delonix regia seeds indicates that Phytate is the major anti-nutrient, therefore, it is advisable to supplement the intake of this seed with other foods which are highly nutritious and proper processing should be ensured before consumption (Abulude *et al.*, 2018). The presence of some of these anti-nutrients could however be reduced by various processing techniques such as drying, cooking, heating and fermentation (Muftau *et al.*, 2019).
Hematological assessment is a rapid approach for the determination of the fish homeostasis, while of the fish while serum biochemical assessment provides information on physio-pathological changes in the organs and or systems of the fish. However, for these tools to be effective there is a need to have a reliable set of reference values (obtained from healthy specimens) upon which results can be compared (Adeyemo and Enefe, 2021). There is high cost of producing animal feeds and this necessitate the need to look for alternative source of protein ingredients with less phytochemical like Delonix regia seeds which are throughly processed.

MATERIALS AND METHODS

Description of Experimental Site

The experiment was conducted at the Teaching and Research Farm of the Faculty of Agriculture, Shabu, Lafia Campus, Nasarawa State University Keffi, Nasarawa for twelve (12) weeks.

Source of Test Ingredient and Preparation

The dried and mature pods of flamboyant (Delonix regia) were harvested from the environment of College of Agriculture Science and Technology Lafia. The collected seeds were washed dried under the sun for three days and were roasted for 30mins until the seed coat cracked. The roasted seeds were milled into fine particles labeled as Delonix regia Meal.

Determination of Anti-nutritional Factors

Anti-nutritional factors such as; saponin, phytates, tannins and oxalates inhibitors were determined according to the method adapted by Kakade et al. (1972).

Experimental Design and Management

The experiment consists of five treatments (T1, T2, T3, T4 and T5) in three replicates and the feeding trial lasted for a period of 12 weeks (90days). Three hundred *Clarias gariepinus* fingerlings were fed at 5% body weight with isonitrogenous formulated diets of 43%CP at 0%, 25%, 50%, 75%, and 100% inclusion of Delonix regia. Growth responses were checked and recorded every two weeks with a sensitive weighing balance (ANTOM electronic compact scale, 600g x 0.01g Digital scale) to the nearest gram.

Haematology Analysis

At the end of the 12 weeks, blood sample was collected from three (3) fish randomly selected from each replicate treatment including the control. The fish were held firmly and blood was collected from the pelvic fin region. The blood was immediately transferred carefully into emptied plastic tube container containing Sodium salt of ethylene diamine tetra acetic acids (Na-EDTA) as anticoagulant for determining haematological parameter as described by Jain (1986).

Serum Biochemical Analysis

Clinical biochemical analysis was performed to obtain serum concentrations of total protein, albumin, urea, uric acid, creatinine obtained from the blood samples using a multichannel automatic chemistry analyzer (Chemwell 4800, Awareness Technology FL. USA) and Dialab clinical chemistry colorimetric diagnostic kits (Dialab Produktion Astria) following the manufacturer's instructions.

Statistical Analysis

All data obtained from the study were subjected to analysis of variance (ANOVA) procedure of STAR 2.0.1 window and significant means separated by Duncan multiple range test at 95% degree of confidence or 0.05 level of significance (Duncan, 1955).

RESULTS AND DISCUSSION

Table 1: Quantitative Phytochemical of Raw and Roasted Delonix regia Seed

S.N	Antinutrients	Raw seed (mg/100g)	Roasted seed (mg/100g)	LOS
1	Saponin	3.47^{a}	1.03^{b}	S
2	Tannins	2.19^{a}	0.98^{b}	S
3	Phytate	4.14^{a}	2.15^{b}	S
4	Oxalate	2.26^{a}	0.87^{b}	S

LOS = Level of Significant., Mg = Milligram., Means with the same superscript across the row are not significantly different (P>0.05).

Table 2: Haematological Parameters of *Clarias gariepinus* Fingerlings Fed Different Inclusion Level of DRM

Parameters	DRM00%	DRM25%	DRM50%	DRM75%	DRM100%	SEM	P-value
PCV (%)	43.43^{a}	38.33^{b}	32.30^{e}	34.57^{d}	36.23^{c}	0.3132	0.0000
Hb (g/dl)	13.63^{a}	11.70^{b}	10.83^{b}	11.33^{b}	11.80^{b}	0.4729	0.0033
RBC ($x10^{12}$ cell/μL)	3.98^{a}	3.85^{a}	3.35^{b}	3.49^{b}	3.47^{b}	0.1546	0.0142
WBC ($x10^{3}$ cell/μL)	116.00^{b}	98.00^{d}	101.00^{d}	150.67^{a}	110.00^{c}	2.28	0.0000
MCV (fl/cell)	106.00^{a}	108.00^{a}	95.00^{c}	93.33^{c}	102.67^{b}	1.41	0.0000
MCH (pg/cell)	34.00^{a}	32.00^{ab}	33.67^{a}	30.00^{b}	31.00^{b}	0.9369	0.0116
MCHC (g/dI)	32.00	33.00	32.00	32.00	32.00	1.45	0.9367
N (%)	5.00^{b}	3.00^{c}	4.00^{c}	9.30^{a}	3.03^{c}	0.1801	0.0000
L (%)	95.00^{b}	94.67^{b}	99.33^{a}	90.67^{c}	97.00^{ab}	1.72	0.0102

Means with the same superscript are not significantly different (P>0.05)

DRM = Delonix regia Meal; PCV = Packed Cell Volume; Hb = Haemoglobin; RBC = Red Blood Cell; WBC = White Blood Cell; MCV = Mean Corpuscular Volume; MCH = Mean Corpuscular Haemoglobin; MCHC = Mean Corpuscular Haemoglobin Concentration; N = Neutrophils; L = Lymphocytes; Fl = fentolitre; pg = picogram; g/d = gram per deciliter.

Table 3: Serum Parameters of *Clarias gariepinus* Fingerlings fed different Inclusion Level of DRM

Parameters	DRM00%	DRM25%	DRM50%	DRM75%	DRM100%	SEM	Pvalue
Creatinine (mmol/l)	42.12^{b}	42.67^{b}	27.31^{c}	49.05^{a}	45.11^{ab}	2.35	0.0001
Total Protein (g/l)	45.11^{c}	54.02^{a}	49.10^{abc}	52.14^{ab}	48.03^{bc}	2.21	0.025
Albumin (g/l)	24.32^{c}	30.21^{b}	28.07^{b}	35.31^{a}	30.11^{b}	1.48	0.001
Globulin (mmol/l)	21.22^{ab}	19.01^{ab}	20.72^{ab}	22.23^{a}	16.67^{b}	1.19	0.0161
Cholesterol (mmol/l)	3.37^{bc}	3.50^{b}	2.90^{c}	4.10^{a}	3.90^{ab}	0.2418	0.008
Urea (mmol/l)	1.10^{c}	1.50^{ab}	1.20^{bc}	1.60^{a}	1.20^{bc}	0.1483	0.0385

Means with the same superscript are not significantly different (P 0.05), g/l = gram per litre mmol/l = millimole per litre

DISCUSSION

Antinutritional Analysis of Raw and Roasted Delonix regia Seeds

Quantitative analysis of the seed showed high concentration of phytate and tannin in the raw state than in the roasted form. After roasted of the seed, the concentration of antinutrient decreased drastically showing less qualitative concentration. This observation showed that roasting of Delonix regia seed could reduce antinutritional content of the seed for utilization in animal's feed. Phytate and tannin that were recorded highest reduced drastically after roasting just like any other processing methods like, drying, blanching and fermenting. Some bioactive substances in plants act as an anti-nutritional factor. Saponins reduce the uptake of certain nutrients including glucose and cholesterol at the gut through intra-lumental physicochemical interaction. Tannins have also been reported to prevent the development of microorganisms by precipitating microbial protein (Ochang *et al.*, 2015). Phytate is capable of suppressing oxidative reactions catalysed by iron in a living system (Ochulor et al., 2018). High content of oxalate in animal's feed depress calcium metabolism (Ochulor *et al.*, 2018). The presence of these anti-nutrients could however be reduced by various processing techniques such as drying, cooking, heating and fermentation (Muftau *et al.*, 2019).

Haematological Parameters of *Clarias gariepinus* Fingerlings in the Study

Haematological analyses of fish are important as these are linked to the health of fish. Hematological parameters were significantly influenced ($P<0.05$) with the inclusion of DRM in the diets, but there was no adverse effect observed in the fish fed varying inclusion of Delonix regia meal diets. The values of blood parameters in the study fell within the normal range established for fish except WBC which showed higher than normal. This could be due to change in water temperature, exposure to air during change of water, and stress-related neuroendocrine elements of immune response. This observation agree with the report of Gayatri and Prafulla (2012), who stated no significant difference ($P>0.05$) in blood parameters of different sexes of walking catfish. Red blood cell (RBC) is responsible in carrying oxygen and carbon dioxide in the body (Isaac *et al.*, 2013). Soetan et al. (2013), reported that a reduction in RBC value implies a reduction in the level of oxygen that would be carried to the tissues as well as the level of carbon (IV) oxide returned in the lungs. The values of Hb, PCV, RBC, MCV, MCH and MCHC could be a clear indication that the animals were well nourished, and possibility that DRM was able to supply all the essential nutrients necessary for the proper functioning of the animal's body. According to Issac *et al.* (2013) pack cell volume (PCV) is involved in the transportation of absorbed nutrients while Hb and MCH are major indices for the diagnosis of anemia. The concentration of PCV in the blood could be due to less toxicity of the seed plant as recorded from the phytochemical analysis.

Serum Parameters of *Clarias gariepinus* Fingerlings in the Study

Serum biochemistry is used as a sensitive tool to assess the aquatic impact in contaminated ecosystems and also would be beneficial in determining the baseline for health and physiological performance of aquatic organisms (Muazzez *et al.*, 2008). This study observed the mean values of total protein between the range of 45.00 and 54g/l. The variation in the values of total protein in the present study was an indication that the fish organism responded positively to the various inclusion of Delonix regia meal in the diet. Jimoh *et al.* (2020) reported high amount serum total proteins indices of liver damage of *Clarias gariepinus* due to high level of inclusion of flamboyant seed meal decimating its deamination capacity by reducing its aminotransferase ability. Urea nitrogen is the product of protein and or amino acids metabolism. The blood urea nitrogen is a critical tool in the clinical assessments of renal function (Jimoh et al., 2020). The urea concentration in the present study were significantly different ($P<0.05$), these concentrations ranged between 1.1mmol/l and 1.6mmol/l which are below the range 1.90 mg/l to 2.30 mg/l values reported by (Adeyemo and Enefe, 2021) for chickens. Values of blood urea nitrogen concentrations in the study disagree with Adeyemo and Enefe (2021) for chicken due to malnutrition even though the case of malnutrition was not recorded throughout the study and thus may be a good indication of health status of fish as suggested by Muazzez *et al.* (2008). The synthetic capacity of the liver may be estimated by the determination of serum albumin concentration (McCue, 2010). The values of creatinine in the study showed that the fish were in good condition as also suggested by Peres *et al.* (2015).

CONCLUSION

The results of phytochemical compounds showed low concentration of saponin (1.03mg/100g), tannins (0.98mg/100g), phytate (2.15mg/100g), and oxalate (0.87mg/100g) respectively. The values of haematological and serum biochemical parameters were not significantly different (P>0.05) from each other in fish fed experimental diets.

RECOMMENDATION

Roasted Delonix regia seed meal in diets of Clarias gariepinus had no adverse effect and its utilization at 25% inclusion is considered the best.

REFERENCES

Abulude, F. O., Olatunde, E. M. and Adejayan, A. W. (2018). Biochemical Profile of flamboyant (Delonix regia) seeds obtained in Akure, Nigeria. Continental Journal of Applied Sciences: 13(2): 29 – 43

Adeyemo, B. and Enefe, N. (2021). Haematological and serum biochemical reference intervals of juvenile African bonytongue fish (Heterotis niloticus. Cuvier, 1829) sampled from the river Benue, Nigeria. Mansoura Veterinary Medical Journal; 22(2) 82-90.

Eyo, V. O., Ekanem, A. P., Jimmy, U. U. (2014). A comparative study of the gonado-somatic index (GSI) and gonad gross morphology of African catfish (Clarias gariepinus) fed Unical aqua feed and Coppens commercial feed. Croatian Journal of Fisheries. 72:63–69.

Gayatri, A. and Prafulla, K. M. (2012). Haematological and Serum Biochemical Parameters in different Sexes of Walking Cat Fish, Clarias batrachus (Linnaeus, 1758). International Journal of Science and Research (IJSR):3.358, pp 2319-7064.

Isaac, L. J., Abah, G., Akpan, B. and Ekaette, I. U. (2013) Haematological Properties of Different Breeds and Sexes of Rabbits. Proceedings of the 18th Annual conference of Animal Association of Nigeria; p. 24-27.

Jain, N. C. (1986). Schalm's veterinay haematology 4th Ed. Lea and Febiger Philadelphia, USA.

Jimoh, W. A., Shittu, M. O., Ayeloja, A. A. and Abdulsalami, S. A. (2020). Histology, serum biochemistry and haematological profiles of Clarias gariepinus fed diets containing Luffa cylindrica seed meal. Agricultural Science and Technology, vol. 12, No 2, pp 130-139.

Kakade, M. L., Simons, N. R., Liener, I. E., and Lambert, J. W. (1972). Biochemical and nutritional assessment of different varieties of soybeans. Journal of Agricultural and Food Chemistry, 20(1), 87-90.

McCue, M. D. (2010). Starvation Physiology; reviewing the different strategies animals use to survive a common challenge. Comparative Biochemistry and Physiology. 156: 1–18.

Muazzez, O., Gülüzar, A. and Mustafa, C. (2008). Changes in serum Biochemical parameters of fresh water fish Oreochromis niloticus following prolonged Metal (Ag Cd Cr Cu Zn) Exposures. Environmental Toxicology and Chemistry. 27(2):360-6.

Muftau, M. A., Malami, B. S., Maigandi, S. A. and Gwandu, H. A. (2019). Evaluation of Proximate, Fibre Fractions, Mineral Compositions and Phytochemical Screening in Camel's Foot (Piliostigma Reticulatum DC) Pods in Kebbi State, Nigeria. World Journal of Innovative Research (WJIR). ISSN: 2454-8236, 7(3): 01-04.

Ochang, S. N., Peter, B. M., Ugbor, O. N. and Egor, A. (2015). Effect of diets with moringa leaf meal on growth, carcass composition and haematology of Clarias gariepinus. International Journal of Fisheries and Aquatic Studies. 3(2):397-401.

Ochulor, O. C., Njoku, O. U., Uroko, R. I. and Egba, S. I. (2018). Nutritional composition of Jatropha tanjorensis leaves and effects of its aqueous extract on carbon tetrachloride induced oxidative

stress in male Wistar albino rats. Journal of Biomedical Research; 29 (19): 3569-3576.
Oluwasina, O., Omoboye, A. J., Bello, L., Oluwasina, O. and Olaoye, O. (2020). Delonix Regia Seeds and Pods: Characterization and Its Potential as a Feedstock for Thermochemical Conversion. IOSR Journal of Applied Chemistry (IOSR-JAC). e-ISSN: 2278-5736. 13(3) 39-49
Peres, H., Costas, B., Perez-Jimenez, A., Guerreiro, I. and Oliva-Tele, A. (2015). Reference values for selected haematological and serum biochemical parameters of Senegalese sole (Solea senegalensis Kaup, 1858) juveniles under intensive aquaculture conditions. Journal of Applied Ichthyology; 31: 65–71.
Yuh-Shan, H. R. and Malarvizhi, S. N. (2009). Equilibrium isotherm studies of methylene blue adsorption onto activated carbon prepared from Delonix regia pods. Journal of Environmental Protection Science. 3:111–116.

CHEMICAL COMPOSITION OF BITTER LEAVE *(Vernonia amygdalina)* FOR FISH FEED UTILIZATION

W. D. Adamu[2], N. A. Agbason[1], B. R. Salau[1], M. T. Rabo[1] S. Y. Olem[4]. O. A. Odihi[2]., C.S. Mwamle[5], S. U. Ibrahim[3]., S. A. Okunsebor[2]

[2]Department of Aquaculture and Fisheries Management, Nasarawa State University Keffi
[1]Department of Fisheries Technology, College of Agriculture, Science and Technology Lafia, Nasarawa State
[3]Department of Water Resources, Aquaculture and Fisheries Technology, Federal University of Technology, Minna Niger State
[4]Department of Zoology, Nasarawa State University Keffi, Nasarawa State
[5]Department of Basic Science, Plateau State College of Agriculture, Garkawa Mikang LGA, Plateau State Nigeria

Email: nelsonagbason2014@gmail.com
Phone number: 07089204556

ABSTRACT
This study on chemical composition of bitter leave (Vernonia amagdalina) for fish feed utilization was conducted to determine the proximate composition, amino acids profile and phytochemical analysis. The bitter leaf was sourced from Panda Development Area of Karu Local Government, Nasarawa State. The leaves were shed dried for seven (7) days and milled into powder form. Thereafter it was transported to the laboratory for chemical analysis according to AOAC method. Bitter leaf meal contain good amount of nutrient such as carbohydrates (46.32%) and crude fibre (37.35%). Amino acid content shows high content of proline (3.74mg/100g) and leucine (7.16mg/100g), phytochemical analysis displayed high content of Tannin (9.62mg/100g) and saponin (5.97mg/100g); and a low content of alkaloid (2.16mg/100g) and oxalate (3.48mg/100g). Also, more research should be conducted on locally feed ingredients in the basis of their usage so as to promote the aquaculture sector.

Keywords:
Bitter leaf,
proximate composition,
amino acids,
phytochemicals

INTRODUCTION

Aquaculture production has quadrupled globally over the past 20 years and is expected to treble over the next 15 years. A necessary and reasonably priced source of high-quality protein and sustenance are fish and fisheries products. At an all-time high of around 17 kg per person, fish provided at least 15% of the average animal protein diet for over 3 billion people (FAO, 2011).

Nutritional study is now focused on finding non-traditional sources that are locally available and have minimal human demand because typical protein ingredients like fish meal, groundnut cake, and soybean are expensive (Owen *et al.*, 2011). Bitter leaf (Vernonia amygdalina) meal is one such non-conventional feed source that could be used to lower the high cost of conventional protein sources in aquaculture diets, with specific reference to fish. A shrub or small tree native to tropical Africa, *Vernonia amygdalina*, often known as bitter leaf, is used as an addition in animal feed. Because of its many bitter components, it is commonly referred to as bitter leaf (Ekpo *et al.*, 2007). The leaves are rich in anti-nutritive elements, such as high concentrations of saponin and tannic acid (FAO, 2011).

Bitter leaf is an edible vegetable leaf that is high in fibre, proteins, carbs, minerals, and vitamins. Moreover, it contains ascorbic acid and betacarotene, a precursor to vitamin A (Aregheore, 2012). The plant contains phytochemicals such as anthraquinones, tannins, flavonoids, alkaloids, saponins, glycosides, and terpenoids. Its antioxidant qualities are attributed to the vitamins A and C as well as the phytochemicals found in bitter leaves (Hamzah *et al.*, 2013). The bitter flavour of *V. amygdalina* is caused by the abundance of saponins that are present (Ijeh and Ejike, 2011). Due to the leaf's high content of lipids, vitamins A and C, and carbohydrates, V. amygdalina can be used as an unconventional feed ingredient in fish feed manufacturing, resulting in a significant price decrease and guaranteed high profit.

MATERIALS AND METHODS

Location of the Study

The experiment was carried out at the fisheries unit of the experimental farm of the Department of Aquaculture and Fisheries Management of the Faculty of Agriculture, Nasarawa State University Keffi, Shabu-Lafia Campus.

Sources and Preparation of Bitter Leaf

Fresh bitter leaf were purchased from Panda Development Area, Karu LGA of Nasarawa State, shed dried and ground into powder form.

Chemical Analysis of Diets and Fish

The bitter leaf meal was analyzed for proximate composition, amino acid profile and phytochemical according to Official Methods of Analysis of Association of official Analytical chemists (AOAC, (1990).

RESULTS

The results of the study are shown in the Tables below;

Table 1: Proximate Composition of Bitter Leaf *(Vernonia amygdalina)*

Parameters	Content (%)
Dry matter	3.25
Crude protein	5.14
Crude fibre	46.32
Moisture	4.74
Ash	1.86
Crude fat	1.34
Carbohydrate	37.35

Table 2: Amino Acid Profile of Bitter Leaf *(Vernonia amygdalina)*

Essential Amino Acids	Content (mg/100g)
Leucine	3.74
Isoleucine	2.91
Lysine	4.19
Arginine	4.39
Tryptophan	4.06
Phenylalanine	3.18
Valine	4.21
Methionine	5.41
Histidine	2.05
Threonine	2.86
Non-Essential Amino Acid	
Glycine	3.42
Alanine	5.12
Serine	3.71
Proline	7.16
Aspartic acid	7.00
Glutamic acid	2.20
Tyrosine	2.56

Table 3: Phytochemical Analysis of Bitter Leaf *(Vernonia amygdalina)*

Parameters	Concentration (mg/100g)
Oxalate	3.48
Phytate	3.95
Tannin	9.62
Saponin	5.97
Flavonoids	4.89
Alkaloids	2.16

DISCUSSION

Proximate composition of bitter leaf

This study shows that Vernonia amygdalina is rich in nutrient composition. Crude protein of 5.14 was recorded in the study though it is lower than 19.23% reported by Biswas et al. (2007) in the leaf of bitter leaf. This vast variation could be attributed to differences in ecological soil in which the plant were grown. The soybean protein content is a quantitative trait mainly controlled by gene additive effects by agronomical traits such as oil content and yield. The genetic variation of accessions in protein suggests their involvement in promoting plant adaptation in natural habitats. Protein content levels represent inherited relationships within a genus species as well as between separate biological systems (Alafari and Abdu-Elgawad, 2021). Moisture content of 4.74% was lower than 7.92% reported by Biswas *et al.* (2007) shows that the leaves can be stored at its dried form for a long period without contamination. Ash content of 1.86% is an indication of good mineral constituent and the value recorded in the study is lower than 7.72% in a study conducted by Chou et al. (2004) for the same plant. Carbohydrate content of 37.35% recorded in the study shows that the leaves are rich in sugar composition and could be used to produce energy when added to fish feed. Dry matter in the study was recorded at 3.25% which is far below the values reported by Hernandez et al. (2007). The content of dry matter in this study disagree with 20.08% reported by Biswas *et al.* (2007) who consider bitter a good source of health maintenance and production. Good amount of fibre was also reported in the study and its addition in fish feed could keep the digestive system healthy. Crude fat recorded in the study is higher than 0.4% reported by Abdel-Tawwab *et al.* (2010) and it is an indication that bitter leaf contains essential fatty acids in commensurable value.

Amino acid profile of bitter leaf (Vernonia amygdalina)

The study recorded eight amino acids (isoleucine, leucine, alanine, phenylalanine, tryrosine, histidine, glutamine and proline). The revealed that bitter leaf is rich in amino acids contents which could be used to build protein in animal body particularly when added to fish diet. Thompson et al. (2010) reported that bitter leaf contain bioactive elements including amino acids that are of benefit to fish. Amino acids recorded in the study were similar to those reported by Venou *et al.* (2006) to play physiological functions such as growth, immunity, protein metabolism, fatty acids metabolism and glucose transportation. Their deficiency in animal's body results to physiological conditions such as depressed immune system, weight loss, and muscles weakening (Lim *et al.*, 2008).

Phytochemical analysis of bitter leaf (Vernonia amygdalina)

Six of phytochemicals component (oxalate, phytate, tannin, saponin, flavonoids and alkaloids) were recorded in the study. Similar phytochemical components were reported by Biswas *et al.* (2007) for *Vernonia amygdalina* leaf, roots and stem. Hernandez *et al.* (2007) suggested that the present of these compounds in animal (fish) feed could regulate blood sugar and protect the body against foreign bodies. The study revealed that *Vernonia amygdalina* is rich in phytochemical contents and it is advisable to supplement the leaves meal with ingredients rich in nutrient to neutralize the content of phytochemicals to avoid low intake during feeding. According to Biswas *et al.* (2007), bitter leaf contains bioactive components linked to medicinal properties; flavonoids show enzymatic activities, such as nitric oxide synthase activity (Hernandez *et al.*, 2007); saponins lower cholesterol levels by interacting with bile acids, causing an accelerated metabolism of cholesterol in the liver and a subsequent decrease in serum cholesterol levels (Abdel-Tawwab *et al.*, 2010); phytate inhibits the transfer of glucose from the stomach to the small intestine, retarding the passage of glucose through the small intestine (Lim *et al.*, 2008); and tannins and alkaloids have antimicrobial properties (Biswas *et al.*, 2007) against pathogenic bacteria and viruses.

CONCLUSION

Bitter leaf meal contain good amount of nutrient such as carbohydrates and crude fibre. Amino acid content shows high content of proline and leucine, phytochemical analysis displayed low content of alkaloid and oxalate.

Recommendation

Also, more research should be conducted on locally feed ingredients in the basis of their usage so as to promote the aquaculture sector.

REFERENCES

Alafari, H.A. and Abd-Elgawad, M.E. (2021). Heat-Induced Protein and Superoxide dismutase changes in wild Tetraena propinqua ssp. Migahidii seedlings. Pakistan journal of biological sciences 24, 310-318.

A.O.A.C. (1990). Official methods of analysis, 14th edition, Association of Official Analytical Chemists, Washington DC. Aquaculture pp.45-53. In: PA Araoye (ed). Proceedings of the 19th Annual Conference of the Fisheries Society of Nigeria (FISON) ILORIN. 896

Abdel-Tawwab, M., Ahmad, M.H., Khattab, Y.A.E. and Shalaby, A.M.E. (2010). Effect on dietary protein lever, initial body weight, and their interaction on the growth, feed utilization, and physiological alterations of Nile tilapia, Oreochromis niloticus (L.). Aquaculture, 298: 267-274.

Aregheore, E. M. (2012). Nutritive value and inherent anti-nutritive factors in four indigenous edible leafy vegetables in human nutrition in Nigeria: A review. Journal of Food Resource Science, 1, 1–14

Biswas, K.A., Kaku, H., Ji, S.C., Seoka, M. and Takii, K. (2007). Use of soybean meal and phytase for partial replacement of fish meal in the diet of red sea bream, Pagrus major. Aquaculture, 267: 284-291. doi: 10.1016/j.aquaculture.2007.01.014.

Chou, R.L., Her, B.Y., Su, M.S., Hwang, G., Wu, Y.H. and Chen, H.Y. 2004. Substituting fish meal with soybean meal in diets of juvenile cobia Rachycentron canadum. Aquaculture, 229: 325–333.

Ekpo, A., Eseyin, O.A., Ikpeme, A.O. and Edoho, E.J. (2007). Studies on some biochemical effects of Vernonia amygdalina in rats. Asian Journal Biochemistry 2: 193 – 197

FAO (2011). The State of World Fisheries and Aquaculture (2010). Edited by FAO Fisheries and Aquaculture Department. Rome, Italy. 67

Hamzah, R. U., Jigam, A. A., Makun, H. A. and Egwim, E. C. (2013). Antioxidant properties of selected African vegetables, fruits and mushrooms: a review. Mycotoxin and Food Safety in Developing Countries, ed. 43

Hernandez, M.D., Martinez, F.J., Jover, M. and Garcia Garcia, B. (2007). Effects of partial replacement of fish meal by soybean meal in sharpsnout seabream (Diplodus puntazzo) diet. Aquaculture, 263: 159-167. doi: 10.1016/j.aquaculture.2006.07.040

Ijeh, I. I. and Ejike, C. E. C. C. (2011). Current perspectives on the medicinal potentials of Vernonia amygdalina Del. Journal of Medicinal Plants Research, 5, 1051–1061

Lim, S.J. and Lee, K.J. (2008). Supplemental iron and phosphorus increase dietary inclusion of cottonseed and soybean meal in olive flounder (Paralichthys olivaceus). Aquac. Nutr., 14: 423–430.

Owen, O. J. and Amakiri, A.O. (2011). Serological and haematological profile of broiler finishers fed graded levels of bitter leaf (Vernonia amygdalina) meal. Advance Agriculture Biotechnology; 1: 77-81

Thompson, K.R., Metts, L.S., Muzinic, L.A., Dasgupta, S. and Webster, C.D. (2006). Effects of feeding practical diets contain different protein levels, with or without fish meal, on growth, survival, body composition and processing traits of male and female Australian red claw crayfish (Cherax quadricarinatus) grown in pounds. Aquaculture Nutrition, 12: 227-238.

Venou, B, Alexis, M.N., Fountoulaki, E. and Haralabous, J. (2006). Effects of extrusion and inclusion level of soybean meal on diet digestibility, performance and nutrient utilization of gilthead sea bream (Sparus aurata). Aquaculture, 261: 343-356.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

EFFECTS OF SUPPLEMENTING GRADED LEVELS OF COWPEA *(Vigna unguiculata)* SHELL MEAL ON GROWTH FEED UTILIZATION AND COST BENEFIT OF *(Clarias gariepinus Burchell*, 1822) AFRICAN CATFISH.

Dambatta M. A[1], M.S. Panda[1], M.A. Haruna[2] and D.M .Shafa[1]

[1]Department of Fisheries and Aquaculture, Aliko Dangote University of Science and Technology Wudil, Kano State, Nigeria
[2]Department of Fisheries And Aquaculture, Federal University Dutse, Jigawa State, Nigeria

Corresponding author:
mansirfish12@gmail.com

ABSTRACT

The efficacy of Cowpea *(Vigna unguiculata)* shell meal as an ingredient in diet of the African catfish Clarias gariepinus was evaluated for 45 days (6 weeks) growth period, Four experimental diets were formulated at 0% (control), 20%, 40%, and 60% inclusion levels of cowpea shell meal with the control diet containing only maize . All diets were iso-nitrogenous (40% protein). The 45-day feeding experiment was conducted in 8 plastic bowls, each treatment having duplicates, Twenty *Clarias gariepinus* fingerlings with average mean weight of 5.50 g (± 0.70) were stocked at 10 fingerlings per bowl for each treatment. The fish were fed 5% body weight twice per day, monitored for weekly growth and mortality. Data collected were analyzed using One-way ANOVA. Fish fed 20% cowpea shell meal recorded the best growth performance in body weight gain (7.79b), Specific Growth Rate (SGR) (0.517b), and Feed conversion Ratio (FCR (2.58)). The best benefit cost ratio (1.56) were from the 60% CSM diet and the highest Net profit Value (843.2) was from 0% cowpea shell meal diet. This study therefore shows that cowpea shell meal can replace maize up to 60% in the diets of C. gariepinus fingerlings for optimum growth performance and also for economic benefit as shown in then economic analyses. Hence, from the study, it can therefore be recommended to replace maize shell with cowpea in the diet of C. gariepinus.

Keywords:
Vigna unguiculata,
Shell, Feed,
Cost benefit
Clarias gariepinus.

INTRODUCTION

Aquaculture is one of the world's fastest-growing food-producing industries and it helps to preserve wild fisheries while also providing food and nutritional security. The increasing need for fish for human consumption has required a quick expansion of fish farming, which has improved aquaculture feed production significantly. Aquaculture is the quick food production sector in the world, with continuous growth over the previous three decades. Progress and developments in current technology and farming practices in terms of fingerling production, culture systems, culture methods and the manufacturing of high-quality fish feed have all contributed to the growth of the fish business. There Aquaculture has increasingly filled the growing demand for seafood, now producing over half of all fish and seafood for human consumption. Sogbesan ,2014

MATERIALS AND METHODS

The present study aimed to investigate the effects of supplementing graded levels of cowpea shell Meal in the diet of *Clarias gariepinus*, commonly known as African Catfish, on its growth performance, feed utilization, and nutrient digestibility. Cowpea shells are an underutilized by-product of cowpea production, and their incorporation in animal diets has been reported to improve their nutritional value. The study was carried out for a period of 8 weeks, during which the fish were fed with four different diets containing increasing levels of cowpea shells as the main protein sources.

Experimental Site

The experiment was carried out for a period of 60 days at the Aliko Dangote University of Science and Technology Wudil Kano State, Fisheries and Aquaculture Department.

Preparation of Cowpea Shell Meal

Cowpea shells was sourced from the Local Market in Wudil Local Government Area of Kano State to and processed into meal form to make them easier for the fish to consume. The cowpea shells were ground, dried, and sieved to obtain the desired particle size.

Feedstuff Processing

The feedstuff has received appropriate processing and handling techniques to improve their digestibility and eliminate toxic substances and anti-nutritional factors. Feedstuff like maize and soybeans were cleaned and sorted to remove diets, stones and other impurities. The grains undergone sun drying to reduce the moisture content to certain amount and mills using machine, package and stored in appropriate place for use. Algebraic method was adopted to calculate the experimental diet.

Formulation of Experimental Diets

Four different diets were formulated to contain graded levels of cowpea shells (0%, 20%, 40%, and 60%) as a partial replacement for Maize in the basal diet. The ingredients and nutrient composition of the experimental diets are presented in Table 1

Table 1. Ingredients Proportion and Proximate Composition of the Experimental Diets

	Percentage [%]			
INGREDIENTS	**BASAL DIET 0% CSM1**	**20% CSM2**	**40% CSM3**	**60% CSM4**
Maize	24.72	19.06	14.84	9.89
Cowpea Shells Meal	0.0	5.30	10.60	15.90
Soybean meal	23.09	23.09	23.09	23.09
Groundnut cake	23.09	23.09	23.09	23.09
Fish meal	23.09	23.09	23.09	23.09
Vitamin premix	1.0	1.0	1.0	1.0
Mineral premix	1.0	1.0	1.0	1.0
Palm oil	1.0	1.0	1.0	1.0
Salt	1.0	1.0	1.0	1.0
Cassava flour	2.0	2.0	2.0	2.0
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Bone meal	0.5	0.5	0.5	0.5
Total	100	100	100	100
PROXIMATE COMPOSITION	**CONTROL**	**20% CSM2**	**40% CSM3**	**60% CSM4**
Dry matter	**0% CSM1**			
Protein (%)	91.68	91.79	91.62	91.56
Lipid (%)	40.25	40.28	40.14	40.16
Fibre (%)	5.80	5.20	5.40	5.60
Ash (%)	9.0	10.3	11.6	12.9
itrogen Free Extract (%)	14.0	14.2	14.4	14.6
	22.63	21.81	20.08	18.3

Source: Field Experimental diet composition. Keys : 0% CSM1 = Control Diet, 20% CSM2 =20% Treatment, 40% CSM3 = 40% Treatment, 60% CSM4 = 60% Treatment.

Feeding Trial

110 African Catfish fingerlings were obtained from the Mallu Agro Allied Company Ltd Kano Fish Farm, acclimated to the experimental conditions for 48 Hours and size-graded to obtain fish with no significant differences in initial weights between treatments. The fish was fed on a 12-hour light and 12-hour dark cycle, and their feeding was be monitored daily. The experiment ran for 45 days, and the fish was fed two times daily a day between 9 - 10 am, and 4 - 5 pm at a feeding rate of 5% of the live body weight per day with four different diets consisting of 0%, 20%, 40%, and 60% Cowpea shell meal.

Experimental Facilities and design

The design adopted in the study is randomized complete design CRD with 4 treatments and 2 replicates. The experiment was conducted in a pond of plastic bowl with a water surface area of 943cm2 (41cm×23cm). Ten "Bowl" were used because there were 5 treatments (4 test diets and the control) and each treatment was replicated once. Each "Bowl" measured 23cm x 41cm x 23cm (length, width and height) and had a mesh size of 1mm. The "Bowl" row was installed 3m away from each other. A 2 inch net was placed on top of each "Bowl" to prevent birds from preying on the fish. Each "Bowl" was stocked with 25 African Catfish. In order to minimise clogging of the "Bowl" with organic matter, they were cleaned after every three days using a brush. After every three weeks, all the fish in each "Bowl" were removed using a scoop net and their individual weights (g) and total lengths (cm) were measured in order to assess growth performance. A day prior to fish measurement, the fish were starved.

Statistical Analysis

Descriptive statistics which involves the use of means and standard deviation were used to analyze the growth performance of *Clarias gariepinus* fed with graded levels of Cowpea shell meal as a partial replacement of maize. Differences in growth performance and feed utilization efficiency between treatments were determined using SPSS software. One-way analysis of variance was carried out and significant differences were considered at $P<0.05$ using Duncan`s multiple comparison test.

RESULT

Table 2. Proximate composition of feed ingredients used for Formulating the test diets

Ingredients	Dry matter	Crude Protein	Crude Lipid	NFE	Crude Fibre	Ash	Moisture content
Cowpea shells	92.0	10.63	2.6	71.32	1.18	6.27	8.0
Soybean meal	91.0	46.00	17.0	18.69	2.11	7.20	9.0
Fish meal	90.0	70.00	7.0	0.89	4.00	8.11	10.0
Maize meal	91.0	10.0	5.0	63.68	7.20	5.13	9.0

Table 3: Mean Water Quality Parameter of the Experiments Bowls

Parameters	Control (0% CSM) diet	20% CSM diet	40% CSM diet	60% CSM diet
Temperature (oC)	24.30	24.20	23.03	21.61
Dissolved oxygen DO (mg/l)	4.63	5.50	4.90	4.68
pH (g)	6.70	7.20	6.21	7.30
Ammonia NH4 (mg/l)	0.09	0.12	0.23	0.18

Source : Experimental Field Data

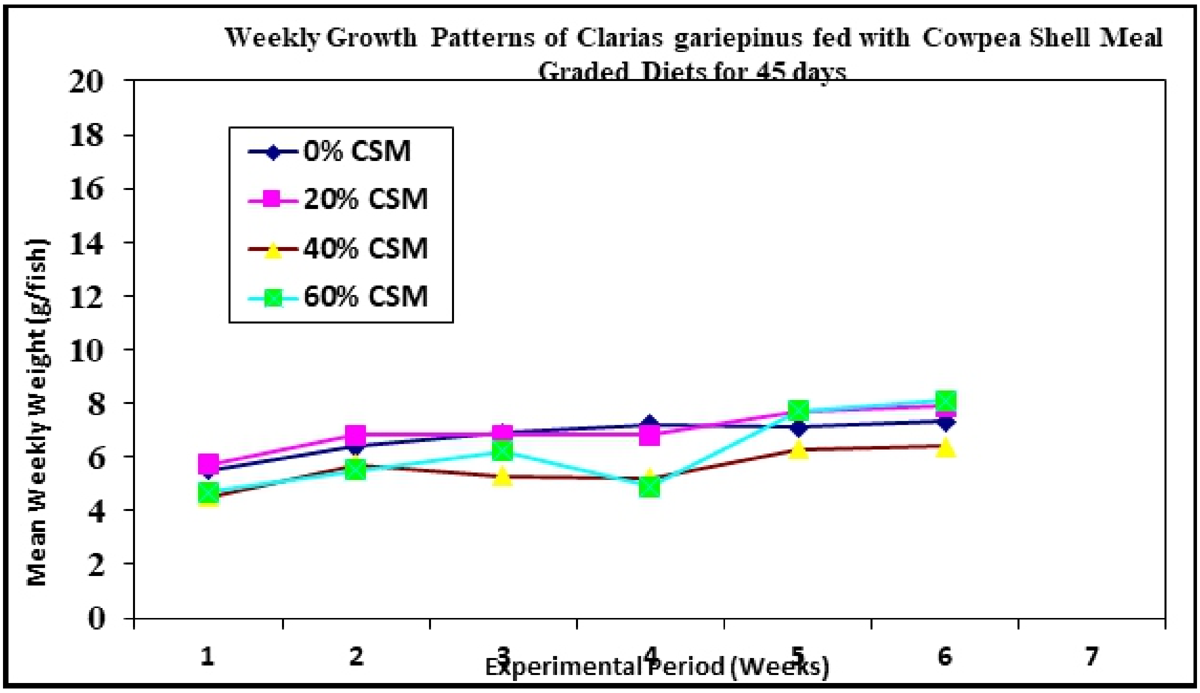

Table 4. Growth and feed Utilization of *Clarias gariepinus* fingerlings fed cowpea shell meal diets

Parameters	**Control (0% CSM) diet**	**20% CSM diet**	**40% CSM diet**	**60% CSM diet**
Total Initial Weight (g)	55.00^{a}	59.50^{a}	52.50^{a}	53.00^{a}
Mean Initial Weight (g)	5.50^{a}	5.95^{a}	5.25^{a}	5.30^{a}
Total Final Weight (g)	92.00^{a}	96.70^{a}	82.00^{b}	72.00^{c}
Mean Final Weight (g)	10.23^{b}	10.17^{b}	9.65^{c}	13.09^{a}
Mean Weight Gain (g)	4.73^{a}	4.22^{a}	4.40^{c}	7.79^{b}
Relative Weight Gain (%/Fish)	86.00^{a}	70.92^{b}	83.81^{c}	146.98^{d}
Specific Growth Rate (%/day)	0.599^{a}	0.517^{b}	0.587^{d}	0.873^{c}
Initial Mean Length (cm/Fish)	7.50^{a}	8.20^{a}	7.70^{a}	7.40^{a}
Final Mean Length (cm/Fish)	11.30^{b}	11.60^{b}	10.10^{c}	10.90^{a}
Protein Intake	19.84^{b}	18.72^{c}	17.20^{d}	11.80^{a}
Mean Protein Intake	1.17^{a}	0.99^{c}	1.01^{b}	1.07^{a}
Protein Efficiency Ratio (PER)	1.86^{b}	1.99^{a}	1.72^{c}	1.61^{d}
Feed Conversion Ratio (FCR)	3.11^{b}	2.58^{d}	2.81^{c}	6.00^{a}
Feed Intake	115^{a}	96^{c}	83^{d}	114^{a}
Mean Feed Intake	10.45^{a}	6.40^{c}	5.53^{d}	8.14^{b}
Initial Condition Factor (K_1)	1.30^{a}	1.08^{b}	1.15^{a}	1.31^{a}
Final Condition Factor (K_2)	0.51^{a}	0.50^{a}	0.64^{b}	0.63^{b}
Stocking Density	10^{a}	10^{a}	10^{a}	10^{a}
Survival Rate (%)	85^{a}	95^{b}	85^{a}	95^{b}

**means of data on the same row with different superscripts are significantly different ($P < 0.05$)
Keys: 0% CSM diet – Control - 0% Cowpea Shell Meal Diet; 20% CSM diet - 20% Cowpea Shell Meal Diet; 40% CSM diet - 40% Cowpea Shell Meal Diet; 60% CSM diet - 60% Cowpea Shell Meal Diet

DISCUSSION

The continuous weekly growth of the experimental fish from all the diets was an indication that the experimental diets contain crude protein value recommended for catfish at fingerling stage and the inclusion of the cowpea shell meal didn't compromise the protein value rather showed an increase as the inclusion of the wheat bran meal increased in the formulated diet. Seria Saldivar (2010) had earlier documented that the extracted wheat bran can he used as food supplement and livestock feed. The highest weight gain in fish fed 60% CSM could have been as result of higher crude protein documented for cowpea shell meal (Table 2). Crude protein has been appraised to the responsible for building up tissues and growth in living organism (AOAC ,2016). The result from this study on economic evaluation which showed that net profit ranged from N809.2/kg of fish to N843.20/kg of fish and these two value were significantly different ($p<0.05$) (Table 4). The highest investment cost analysis of N682.22 was recorded in fish fed the control diet, followed by N636.01 for those fed 20% CSM diet and the lowest for fish fed 60% CSM diet with N527.44. These two extremes were significantly different. The best benefit cost ratio of 1.56 were recorded in catfish fed 60% CSM diet agreed with the work of other scientist Fagbenro *et al.,* (2010) showed the need to use plant meal in combined form to produce the cheapest and required nutrient for fish. Sogbesan *et,.al* (2016) reported that reduction in cost of production of the experimental diets from 426.20 in diet (Control) to N242.20 in fermented experimental diets (2, 3, 4 and 5), is an indication of the cost effectiveness of using groundnut shells as non-conventional feedstuff in fish feed formulation. This is similar to the report that non-conventional feed resources (NCFRs) are very cheap by products or wastes from agriculture, farm-made feeds and processing industries (Sogbesan, 2014). The Mean water quality parameter for each unit (bowl) during the experiment which was measured every week. The temperature ranges from 19.30 – 28.78 oC, dissolved oxygen 3.5mg/l - 6.8mg/l, pH 5.0 – 7.5 and ammonia 0.02mg/l - 0.60mg/l8.

REFERENCES

AOAC., 1990. Official Methods of Analysis. 15th Edn., Association of Official Analytical Chemists, Washington, DC., USA..

Fagbenro, O., A. Oresegun, L. Nwanna, P. Ilona, O. Olurotimi and A. Adebayo, 2017. Performance of diets for Oreochromis niloticus and Tilapia zillii by inclusion of cassava leaf protein concentrate as partial replacement for solvent extracted soybean meal. Appl. Trop. Agric., 22: 16-23.

Sogbesan O.A., Adedeji H.A., Mohammed H., Idowu T.A,, (2016). Growth Performance of Clarias gariepinus (Burchell 1822) Fingerlings Fed Varying Levels of Soaked Plantain Peel Diets International Journal of Scientific Research in Agricultural Sciences, 3(2): 035-038.

Sogbesan OA and Ugwumba A.A.. (2008), Nutritional Values of Some Non-Conventional Animal Protein Feedstuff used as Fishmeal Supplements in Aquaculture Practices in Nigeria, Turkish Journal of Fisheries and Aquatic Sciences: Vol. 8: 159-164.

Serna-Saldivar (2010). Cereal Grains; Properties, Processing and Nutritional Attributes S.RO.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

EFFECT OF PARTIAL REPLACEMENT OF MAIZE WITH CABBAGE IN FISH FEED ON GROWTH PERFORMANCE OF NILE TILAPIA JUVENILES

[1]OGUNMOKUN R.A., [1]J. NDUKWE, [2]J.J. GAUDE, [2]K. EDWARD, [2]Z. FOM

[1]Department of Fisheries Technology, Federal College of Land Resources Technology, Kuru, Jos, Plateau State.
[2]Department of Fisheries Technology, Federal College of Animal Health and Production Technology, Vom, Jos, Plateau State.

Corresponding Author:
ogunmokunrotimi@gmail.com, +2348160911186

ABSTRACT
Four diets were formulated including 0%, 10%, 30%, and 50% of cabbage leaf meal. Fish fed on the diet where 10% of maize was replaced by CLM showed the best body weight and specific growth rate compared with those obtained by fish fed on the diet containing 30% and 50%. No significant differences were found in survival rates, food conversion ratio and protein efficiency ratio. Variable results were noticed in growth rate of fish fed on the various diets. Fish fed on a diet containing 50% CLM had the lowest survival rate. The cost per kg of feed was reduced by increasing cabbage leaf meal in the diets. The best profit index was obtained by fish fed on the diets containing the lowest level of cabbage leaf meal.

Keywords:
Cabbage leaves, tilapia, maize, diet, growth, rate.

INTRODUCTION

The global price of feed ingredients such as fishmeal maize, wheat and soybean meal has greatly increased by 186, 160 118 and 108% respectively in the last decade thereby reducing the profit of fish farmers. Under these conditions, to meet the nutrient requirement of livestock and to sustain their productivity and profitability seem only possible if unconventional, alternative feed sources are explored. Globally, food processing and agro industries have to battle with the problem of by-products generated. The problem is more obvious in developing countries because of underdeveloped processing of such by-products into useful products (Odeyinka *et al.*, 2021). As a result, there are serious environmental pollution and waste potential feed resources. Feed milling has dramatically developed in recent years due to increase in animal productivity. Fish feed production was limited to extensive system, the concept developed was based on helping natural production of food in pond by fertilization and supplying extra food if needed. It is better to formulate a diet that will fulfill all the nutritional requirements of fish. However, when technical or physical quality of fish feed is considered, the processing becomes complicated. Critical considerations have to be made about ingredient availability and price, palatability, pellet handling requirements and storage. Hence, fish diet production is a compromise between the nutritional quality and physical quality of fish feed (Hardy and Barrows, 2022).

Tilapia culture is one of the largest sectors of global aquaculture. Among the different species of tilapia, Nile tilapia *(Oreochromis niloticus)* is perhaps the top cultured species. The production of Nile tilapia has been continually increasing throughout the years resulting in genetic deterioration. Several tilapia strains with better growth performance and adaptive capability to survive in different culture conditions have been developed to alleviate the crisis. Increased demand for Nile tilapia implies higher farming cost. Cabbage is one of the most popular Brassica vegetables in the human diet due to its affordability, availability, and range of health benefits and thus it forms a huge part of worldwide cuisines and diets. (Janko *et al.*, 2020).So it was used in this work to replace Maize partially in order to reduce the cost of producing fish feed.

MATERIALS AND METHODS

Study Area

The experiment was conducted at the Department of Fisheries Technology, Teaching and Research Farm, Chaha Campus, Federal College of Animal Health and Production Technology, Vom, Jos, Plateau State.

Experimental Fish and Set Up

A total of two hundred (200) Juveniles of Nile Tilapia *(Oreochromis niloticus)* were purchased from a reputable farm in Jos-South LGA, Plateau State. The fish were starved for 24hours to empty their guts in order to make them accept the feeding trial. They were later stocked into (40cm diameter x 60cm depth) plastic tanks. Initial total lengths and initial weights of Juveniles in each treatment were recorded for to get the average initial lengths and weights in each tank. (Eyo *et al.*, 2020)

Collection and Processing of Cabbage

The test ingredients Cabbage, Toasted Soybean, Fish meal, Maize, Groundnut cake, Bone meal, Lysine, Methionine, Vitamins/Minerals premix, Vitamin C, Vegetable oil and Salt were bought from a feedmill in Anguldi, Jos-South, Plateau State and was grounded to fine particles in an Hammer mill.

The Cabbage was gotten from K-Vom main market, Jos-South, Plateau State, It was sun-dried for 1 week, grinded into powdery form, stored in sterilized glass container and kept under a room temperature (25°C) until the commencement of experiment. The Cabbage was pounded using pestle and mortar to aid incorporation with other feed ingredients. The pounded cabbage leaf meal was incorporated directly with other finely ground feed stuffs, pelletized, sun-dried and individual feed was packed into separate small plastic containers and then stored in a cool and dry place. (Amisah *et al.*, 2021).

Feed Formulation and Feeding Trial

Four diets having a crude protein of 40% each were formulated. The experimental diets contained varying inclusion levels of Cabbage as replacement for Maize. Diet one (0% Cabbage: Td1), Diet two (10% Cabbage: TD2), Diet three (30% Cabbage: TD3) and Diet four (50% Cabbage: TD4). The feed was pelletized through with 2mm die using a Pelletizer. The pelleted feeds were sun-dried and packaged in clean, dry plastic containers. Daily fish feeding was done based on 5% bodyweight, (2.5%) in the morning and 2.5% in the evening throughout the duration of the experiment with weekly feed adjustment for 8 weeks..Uneaten feed and feaces were siphoned. Topping and changing of water were carried out regularly to maintain the water quality.

Proximate analysis of the cabbage was conducted according to AOAC (1990). This was carried out at the Biochemistry Laboratory of Federal College of Animal Health and Production Technology, Vom, Jos, Plateau State.

Table 1: Quantity of Each Feed Ingredient

Ingredient	TD1 (0%)	TD2(10%)	TD3(30%)	TD4(50%)
Maize	40	36	28	20
Cabbage Meal	--	4	12	20
Fish meal	20	20	20	20
Soya Beans meal	15	15	15	15
Vitamins/Minerals Premix	2	2	2	2
Vegetable oil	2	2	2	2
Methionine	0.5	0.5	0.5	0.5
Lysine	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5
Bone meal	2.5	2.5	2.5	2.5
G N C	17	17	17	17
Total	100	100	100	100

Note: The diets were formulated to contain 40% crude protein.

Measurement of Experimental fish

Data collected were used to calculate the growth parameters. AIBW: Average Initial Body Weight, ATBW: Average Total Body Weight; ATFI:: Average Total Feed Intake, AWG:Average Weight Gain; FCR: Feed Conversion Ratio and SR: Survival Rate

RESULTS AND DISCUSSION

Growth performance and feed utilization parameters of Nile Tilapia *(Oreochromis niloticus)* Juveniles fed with 0% and graded levels of Cabbage Meal for 56 days. The results indicated significant differences in growth performance and feed utilization parameters between the control (Diet 0% Cabbage Meal) and other treatments..There was reduction in fish growth and feed conversion ratio with little difference ($P < 0.05$). With increasing the inclusion levels of Cabbage Meal from 10% to 50 % diet. FWG showed no significant differences ($P < 0.05$) between the control and treatment (T2 10%) inclusion in the feed. However, WG became slightly reduced with increased inclusion levels and increase in FCR from 30% to 50% and FCR from 1.01 to 1.08 respectively.

Diets with 10% inclusion level of dietary cabbage meal recorded better growth than the control deit and the other test diets (30% and 50%) probably due to its ability to meet the essential amino acid requirement of the fish. Nogales-Mérida *et. al.*, (2019) reported that protein requirements of fish are considered to be the sum of the requirements essential for individual amino acids. The decrease in values of live weight gain observed in this study as dietary levels of processed dietary cabbage meal increases could be due to several factors such as the lower feed intake and components which was reported to have the ability to cause marked weight changes (Lilianna *et al.*, 2020). The result showed that Cabbage Meal inclusion at 10% in the diets had significant effect on FCR of Nile Tilapia Juveniles, Although increased quantity of dietary Cabbage Meal to 30%, and 50% slightly reduced the fish growth

and it also reduced the survival rate from 100% to 70%. Thus, growth increased at 10% Cabbage inclusion but further increased inclusion to 30% and 50% slightly reduced the fish growth, this confirms Doan *et. al.*, (2018) who reported an increased growth in Nile tilapia when fed a small level of Xylo-oligosaccharide derived from dietary cabbage Meal. In contrast, Kakwi and Olusegun (2020) observed significantly decreased growth performance in Common Carp (Cyprinus carpio) fed diet containing Mucuna pruriens seed especially as inclusion level increased. The same was observed by Alegbeleye et. al., (2020), who reported inclusion of toasted Lima beans and boiled pigeon pea seed meals at levels of 10-20% and 15-30% respectively without adverse effects or loss in weight in African Catfish (Clarias gariepinus).
The least growth performance was obtained in 50% CLM which contained the lowest proportion of processed maize. Similar results were obtained with higher inclusion level for pigeon pea meal (Kari et al., 2020); Lima bean (Alegbeleye *et al.*, 2020); Pawpaw seed meal in C. *gariepinus* diets. The no significant difference ($P<0.05$) recorded in the growth and nutrient utilization indices of fish fed dietary B. oleracea powder showed that the inclusion level has little effect on the parameters measured. B. oleracea powder increased the growth at 10% inclusion more than the Control dIet (0%). As B. oleracea powder inclusion increased, there was a gradual reduction in weight gain of the Juveniles. This might have resulted because of the anti-nutritional factors in the B. oleracea powder. According to Ogbede *et al.*, (2019), Cabbage powder contained a high level of oxalate. This might be responsible for the reduction in Protein Efficiency Ratio (PER) and Weight Gain (WG).

CONCLUSION
This study established the efficiency of Cabbage (Brassica oleracea) powder at 10% of feed partial maize replacement which favours growth, body composition and survival rate indices. Cabbage is cheaper than Maize. It contains high nutrients and anti-nutrients, it is important to know the method of reducing the ratio of the nutrients to anti-nutrients components to provide beneficial effects to the body without decreasing nutrients bio-availability.

Table. 2. Effect of dietary cabbage meal on growth parameters in Juvenile O. *niloticus* **reared after 56 days in tanks.**
TREATMENTS

WEEKS	TD1(0%)	TD(10%)	TD3(30%)	TD4(50%)	mean± sem
IABW (g)	18.00^{a}	18.00.00^{a}	17.00^{a}	18,00^{a}	17.75± 0.01
FABW (g)	220.00	230.00^{a}	218.00^{b}	216.00 c	221.00± 0.01
ATFI (g)	215	215	215	215	215. 00 ± 0.01
AWG (g)	202.00	212.00a	201.00^{b}	198.00^{a}	203.25± 0,02
FCR	1.06	1.01 ^{a}	1.07^{c}	1.08^{d}	1.05± 0.02
SR (%)	100.00 ^{a}	100.00^{a}	80.00^{a}	70.00^{b}	87.50± 0.02

Note IABW: initial average body weight; FABW: final average body weight; ATFI: average total feed intake AWG: average weight gain; FCR: feed conversion ratio; SR: survival rate. The values represent the mean ± the standard deviation.

REFERENCES

Adekunle, H, L., Orire, A., M. and Sadiku, S. O. E. (2019). Development of Farm-made Floating Feeds for Aquaculture Species. International Journal of Advanced Biological Research, 2(4):579-583.

Ali. A., Al-Asgahn, N. A., Al-Ogaily, M. S. and Ali, S. (2021). Effect of feeding different levels of Alfalfa meal on the growth performance and body composition of Nile Tilapia (Oreochromis niloticus) Fingerlings. Asian Fisheries Science, 16: 59-67

Asimi, O. A. and Sahu, N. P. (2020). Herbs/spices as feed additive in aquaculture. Scientific Journal of Pure and Applied Sciences, 2 (8): 284-292.

Bewick, T. A. (2019). Cabbage: Uses and production. University of Florida: Florida Cooperative Extension Service Fact Sheet HS-712.

Dada A.A., (2017). Use of fluted pumpkin (Telfairia occidentalis) leaf powder as feed additive in African catfish (Clarias gariepinus) fingerlings. Journal of Applied Animal Research 45(1): 566 - 569

Dada A.A. and Abiodun A.D. (2014). Effect of ietary fluted pumpkin (Telfairia occidentalis) extract on growth performance, body composition, and haematological parameters of Nile Tilapia (Oreochromis niloticus Linnaeus). Journal of Fisheries 2(3):203-208.

Hardy and Barrow (2022). Fish Nutrition (Third Edition) Pages 505-600.

Janko, Varga and Glogovac (2020). African Journals of Biotechnology Vol. 10(27), pp.5281-5285.

Odeyinka, Olosunde and Oyedele (2021). Utilization of Soyabean milk residue, cowpea,testa and corn starch residue by weaner rabbits. Livest. Res. Rural Dev.,19:125

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

GAMETE AND PROGENY QUALITY ASSESSMENT OF *Heterobranchus bidorsalis* BROODSTOCK FED VARYING INCLUSION LEVELS OF AQUEOUS *Moringa oleifera* LEAF-EXTRACT

Onuoha S. O., E. K. Ajani and A. Jenyo-Oni

Department of Aquaculture and Fisheries Management, the University of Ibadan, Ibadan, Nigeria

Corresponding Author:
stanobigreat@gmail.com, +2348068535441, 0009-000 4-4722-1211

ABSTRACT
Aquaculture is the panacea to the world's food crisis. Enhancing fish gonadal development and broodstock reproductive performance using natural phytogenic feed additives has increased due to their safety, effectiveness and environmental friendliness. This study investigated the gametes qualities of *Heterobranchus bidorsalis* broodstock fed varying inclusion levels of aqueous *M. oleifera* leaf extract (AMOLE). Four isonitrogenous diets (crude protein=40%) were prepared with AMOLE at concentrations: 0% (control), 1.0%, 2.0% and 3.0% inclusion levels. The Hb (n=108; 800.00+150.00g) were distributed in triplicate to treatment diets in a completely randomized design. The broodstocks were fed at 5% body weight twice daily for 16 weeks. After the feeding trials, the Milt Motility (MM), Milt Volume (MV), Milt Concentration (MC), Gonadosomatic Index (GSI), Egg Diameter (ED), Fecundity and Ovarian Investment (OI) were determined following standard methods. Data were analysed using descriptive statistics and One-way Analysis of Variance at 0.05. with SPSS 20 software. 3.0%-AMOLE diet inclusion gave the best %fertilization (79.48±0.29%), %hatchability (84.98±0.29%), and %survivability (78.07±0.17%) compare to control(0.0%): %fertilization (77.25±0.52), %hatchability (70.69±0.81) and %survivability (68.45±0.66). 3.0% AMOLE diet had the lowest (190.00±0.01 X106/ml) MC while 2.0%-AMOLE diet had highest (223.33±0.04 X106/ml) MC. The highest MM value was in33.33g) and mean total number of eggs (41,889). 3%-AMOLE (85.33±6.06%) and least (81.67±1.7.26%) in 2% AMOLE. 3%-AMOLE diet recorded the highest female weight (1,533.33g) and mean total number of eggs (41,889).
These findings suggest that Aqueous *Moringa oleifera* leaf extracted diet at 3% inclusion induced higher gamete/progeny quality and reproductive performance in H. bidorsalis broodstock.

Keywords:
Feed additives,
Miracle tree, gamete,
African catfish

INTRODUCTION

A gamete's quality is determined by its capacity to fertilize or be fertilized and then grow into a healthy embryo (Bobe & Labbe, 2010). Spermatozoa and seminal plasma, two of the components of sperm, can be used to evaluate their distinct qualities. Parameters like spermatozoa concentration, motility, sperm volume, seminal plasma osmolarity, and pH may be included in a standard analysis. Similarly, ovarian investment, fecundity, gonadosomatic index, egg morphology, and nutrient proximate compositions can all be used to check the quality of eggs (Onuoha, 2024).

H. bidorsalis is one of the most preferred catfish which has received much attention and acceptability among farmers and consumers recently because of its economic importance and desirable attributes such as hardiness, high palatability, fecundity, high disease resistance and fast growth. Hence, it commands high commercial values (Agbebi *et al.*, 2009). However, the high cost of fish seeds, and the high cost of managing fish broodstock demonstrate the urgent need to look into other, less expensive methods of enhancing fish nutrition and reproduction. Phytogenic feed additives (PFAs) have been reported to improve fish gamete quality. Hence, to assess the reproduction potential of *H. bidorsalis* broodstock, it is imperative to ascertain the impact of varying inclusion levels of *Moringa oleifera* on the development of gonads.

M. oleifera commonly known as Miracle tree, has gained tremendous popularity in recent time due to its unlimited pharmacological, nutraceutical and functional properties as well as its rich nutritional benefits for humans and livestock. A wide variety of chemical compounds are found in plants, and many of them have been shown to have beneficial effects on nutrient digestibility, growth, reproduction and immune status of fish broodstock and progeny acting through different mechanisms (Onuoha *et al.*, 2024). Recent studies have shown that fish reproduction can be initiated, moderated, catalyzed, monitored and evaluated using phytogenic feed additives. Yet, the use of natural herbs, medicinal and aromatic plants in fish feeding is still limited both on the experimental and commercial scales (Bello et al., 2014). Therefore, this study was aimed at determining strategies to improve the broodstock nutrition and reproduction performance of *H. bidorsalis* which will assist in enhancing its progenic qualities using Aqueous extract of M. oleifera leaves.

MATERIALS AND METHODS

Experimental Design

08 samples consisting of eight-month-old *H. bidorsalis* weighing 800.00g+150.00g were randomly distributed into 4 treatment groups and replicated thrice in outdoor concrete tanks of size 6m x 4m x1.3m at 0.45m water level and fed at 5% body weight twice daily for 16 weeks. Varying inclusion levels containing 0.0 g/100g (control), 1.0/100g, 2.0/100g, and 3.0/100g of Aqueous extract of Moringa oleifera leaf dietary inclusion were applied during the feeding trial

Male and Female Fish Performance (Milt/Egg quality analysis)

Milt volume: Each testis lobe was incised. The milt was squeezed out into a petri dish and measured with a graduated plastic syringe (Alavi *et al.*, 2008).

Milt motility: In determining milt motiiity, a droplet of (10μl) of milt fluid was collected from the testes of a sacrificed male H. bidorsalis and put on a slide. A drop of distilled water was immediately added (as an activating solution) to the sperm on the slide and covered with a cover slip. The movement of the spermatozoa then was observed under a microscope (400X magnification) (Canyurt *et al.*, 2008).

The Motile Sperm Cells (MC) were calculated thus:

MC = WSC - ISC, %MC = MC x 100/WSC

Where, MC = Motile Sperm Cells, WSC = Whole (total) Sperm Cells, ISC = Immotile Sperm Cells

Percentage of Live/ Dead milt (survivability) (Tijani and Ajani, 2017).

$$\% \text{ of live sperm cells} = \frac{\text{No of live sperm cells}}{\text{Total no of sperm cells}} \times \frac{100}{1}$$

Milt concentration: Haemocytometer counting chamber was used under a light microscope (400X magnification) to calculate the milt concentration (Alavi *et al.*, 2008).

Gonadosomatic index (GSI): The formula used was patterned after the formula expressed and used by Offem et al (2008) for the female gonad, ovary; expressed thus:

$$\% GSI = \frac{\text{Gonad weight(g)}}{\text{Final fish weight (g)}} \times 100 = \frac{\text{Testes weight(g)}}{\text{Final fish weight (g)}} \times 100$$

Oocyte diameter and fecundity estimation: Fecundity Estimation was determined using the formula proposed by Ayinla (1988) thus: Number of eggs stripped (incubated) (AF) = Weight of fish before stripping (g) - Weight of fish after stripping X 66.6

Ovarian Investment: Ovarian Investment (OI) is calculated as OI = F x EV; where, F = fecundity (number of eggs / g of fish) and EV = mean volume of ripe eggs (Opadokun and Ajani, 2015).

PROGENY QUALITY ASSESSMENT

Selection of Brood stock for induced breeding: 24 broodstocks of H. bidorsalis (12 males and 12 females) of average weight, 1300±150g and length, 26.5±1.5cm were used for hormonal treatment (Tijani, 2014).

Hormonal Administration: Induced breeding was carried out using the synthetic hormone, ovaprim at 0.5 ml/kg body weight of the fish (Ajani *et al.*, 2011).

Stripping percentage: This was calculated as described in Brzuska (2003) as follows:

$$\text{Stripping (\%)} = \frac{\text{Weight of stripped eggs}}{\text{Body Weight}} \times \frac{100}{1}$$

Spawning Absolute Fecundity: Total no. of eggs stripped was estimated by counting the egg in 1g sample (Sahoo *et al.*, (2005).

Percentage fertilization: $\% \text{ Fertilization} = \frac{\text{No. of fertilized eggs}}{\text{Total No. of Eggs counted}} \times \frac{100}{1}$

% Hatchability = $\frac{\text{No. of hatchlings}}{\text{Total No. of fertilized eggs}} \times \frac{100}{1}$

Survival rate: This was calculated as described by Ayinla and Akande (1988) as follows:

$$SR = \frac{Ni}{No} \times 100 = \frac{\text{Total No. of fry at the end of the experiment}}{\text{Total No. of fry at the beginning of the experiment.}} \times 100$$

RESULTS AND DISCUSSION

The results of gamete and progeny qualities are found in tables 1.

Table 1: Assessment of the reproductive indices of the ovary and testes of H. bidorsalis fed aqueous extract of Moringa oleifera Leaf extract

	Inclusion Level			
Characteristics	0g/100g	1g/100g	2g/100g	3g/100g
Weight of Fish (kg)	1316.67±44.10	1443.33±52.07	1440.00±66.58	1533.33±44.10
Mean weight of ovary (g)	36.38±10.59	47.73±0.94	59.38±7.97	53.53±8.28
Mean total no of eggs	22580.33±40.98^{b}	28672.67±37.74^{ab}	39531.67±18.24^{a}	41889.00±16.73^{a}
Mean oocyte diameter(mm)	10.57±0.35	10.17±0.30	10.50±1.65	12.37±0.94
Mean length (mm)	113.50±11.55	118.00±3.91	143.83±16.09	148.67±6.87
Absolute fecundity	2791.67±125.22	3798.33±52.59	5533.00±42.46	5394.00±65.50
Relative fecundity	2.16±0.97	2.63±0.34	4.54±0.67	3.85±0.73
Gonadosomatic index	2.80±0.84	3.32±0.10	4.14±0.57	3.51±0.57
Mean volume of ripe eggs (ml)	35.28±10.15	41.65±8.79	57.63±4.05	66.31±5.97
Ovarian investment	123370.35±76.34	161377.28±48.31	322069.15±47.36	350496.48±22.94
	11.35±10	11.80±0.39	14.38±1.61	14.87±0.69
Length of Ovary (cm)	11.35±1.15			
Weight of ovary(g)	36.38±10.59	47.73±0.94	66.04±14.27	51.87±10.08
Diameter of ovary (cm)	5.28±0.18	5.08±0.15	5.25±0.83	6.10±0.43
Volume of egg (ml)	24.48±14.56	41.65±8.79	55.57±4.56	73.90±14.44
No of Eggs $\times 10^5$	0.20±0.05	0.28±0.03	0.50±0.10	0.40±0.06
%Fertilization	77.25±0.52	78.01±0.71	78.35±0.72	79.48±0.29
%Hatchability	75.54±0.79^{c}	80.86±0.40 ^{b}	70.69±0.81^{d}	84.98±0.29^{a}
%Survival rate	72.33±0.55^{b}	75.37±0.61^{ab}	68.45±0.66^{c}	78.07±0.17^{a}
Weight of fish (g)	1250±0.01^{a}	1333±0.12^{b}	1260±0.23^{c}	1377±0.23^{c}
Length of testes (cm)	4.63±0.14	4.53±0.82	5.63±0.67	4.58±0.28
Weight of testes (g)	1.19±0.46	1.81±0.82	3.25±1.50	1.75±0.58
Testes diameter (cm)	2.90±0.35	3.43±0.66	4.23±0.54	3.77±0.37
Milt Volume (ml)	1.42±0.37	1.88±0.68	3.30±0.75	1.60±0.64
Milt Conc ($x10^6$/ml)	211.33±0.02^{a}	208.00±0.01^{a}	223.33±0.04^{b}	190.00±0.01^{c}
Survival rate @ 5mins (%)	75.00±0.01	77.00±0,02	76.02±0.04	79.00±0.02
Milt Motility (%)	85.00±7.51	83.33±6.01	81.67±1.7.26	85.33±6.06
Gonadosamatic Index	0.19±0.01	0.28±0.02	0.40±0.01	0.20±0.01

Mean ± SE in the same row with no superscripts are not significantly different at $p > 0.05$

DISCUSSION

The length of ovary, weight of ovary, diameter of ovary and the volume of the ovary as well as the number of eggs and rate of fertilization of the eggs did not differ significantly ($p > 0.05$) in the fish fed aqueous extract of MOL at the various inclusion levels. The weight of fish, percentage hatchability of the egg and survivability were however significantly influenced ($p < 0.05$) by the dietary aqueous extract of MOL. The weight was significantly higher in the fish fed 3g/100g of MOL diet (1533.33g) compared to the control 0g/100g which had the least weight (1316.66g). The percentage hatchability was significantly highest in fish fed 3g/100g aqueous extracted MOL based-diet (84.98%) while the lowest was recorded in fish fed 2g/100g aqueous extracted MOL based-diet (70.69%). Fish fed 1g/100g aqueous extracted MOL based-diet had a significantly higher ($p < 0.05$) hatchability than the control group (0g/100g).

The survival of hatchling was highest and lowest significantly ($p < 0.05$) in fish fed 3g/100g (78.07%) and 2g/100g (68.45%) respectively (table 1). Of the fertility parameters of the male *H. bidorsalis* fed with AMOLE diet only fish weight and sperm concentration revealed significant differences ($p<0.05$), in values, within treatments compared to control.

The male fish fed A3MOLE diet in values had the lowest sperm concentration (190.00±0.01 X106/ml) while the 2.0g/100g AMOLE recorded the highest sperm concentration (223.33±0.04 X106/ml) while the 1.0g/1oog AMOLE diet had lowest (208.00±0.01 X106/ml SC. Higher significant variations was also observed in weight of male broodstock fed 3.0g/100g inclusion level of AMOLE (1377±0.23g), compare to the control diet 0.0 AMOLE which recorded the lowest weight (1250±0.01g).

The Male fish fed 2.0/100g AMOLE diet, however, produced the highest testicular weight (3.25±1.50g), and sperm volume (3.30±0.75ml) but lowest motility (81.67±1.26 %). However, the lowest testicular weight and sperm volume were recorded in fish treated with the control diet (0/100g), 1.19±0.46g, 1.42±0.37ml respectively. While, the highest motility value (85.33±6.06 %) was recorded in fish fed 3.0/100g AMOLE diet .

In this study, spawners were injected with ovaprim at the rate of 0.5mlkg-1 Live Body Weight (LBW). All treatments had values for number of eggs fertilized (fertilization) being above 20,000, which is comparable to the results from Nwokoye *et. al.* (2007) study. This was also affirmed by Brzuska (2003) submission from a similar study that administration of synthetic ovulation stimulators results in higher quantity of eggs. *H. bidorsalis* broodstock fed with 3.0/100g AMOLE recorded the highest figures for mean total number of eggs (41,889), female weight (1,533.33g), percentage fertilisation (79.48%), percentage hatchability (84.98%) and percentage survivability (78.07%) while the control diet (0/100g) had a lower mean total number of eggs (22,580), female weight (1,316.67g), percentage fertilisation (77.25%), percentage hatchability (75.54%) and percentage survivability (72.33%).

This suggests that Aqueous *Moringa oleifera* leaf extract induces more fecundity than broodstocks fed without its inclusion in the diet. These findings are comparable to those of Nwokoye et al., (2007) studies who reported fertilization rate, hatchability and survivability percentage ranges of 70% - 99.88%.

CONCLUSION:

The import of this result is that the *Heterobranchus bidorsalis* broodstocks fed with Aqueous *Moringa oleifera* Leaf Extracted diet had enhanced gamete and progeny quality with better reproductive performance at 3.0g/100g inclusion level.

REFERENCES

Ajani E.K., Akinwole A.O and Ayodele I.A. (2011). Fundamentals of Fish Farming in Nigeria. Walecrown Publishers Ibadan158p

Agbebi O.T, Ajagbe O, Makinde L. and Afolabi O (2009). Production, growth and effect of varying stocking density of Clariasbranchus fry. Journal of Fisheries International. 4(4):73-78.

Alavi SMH, Cosson J, Karami M, Mojazi AB. and Akhoundzadeh MA (2004). Spermatozoa motility in the persian surgeon, Acipenser persicus. Effects of pH, dillution rate, ions and osmolality. Reproduction 128:819- 828

Ayinla, O.A. and Akande, G.R. 1988. Growth response of Clarias gariepinus (Burchell, 1822) on silage-based diets. Nigerian Institute for Oceanography and Marine Research (NIOMR) Technical Paper (1988). No. 37, 19pp.

Bello O.S., Olaifa F. E. and Emikpe B. O. (2014). Haematological and Blood Biochemical Changes in African Catfish, Clarias gariepinus Fed Walnut (Tetracarpidium conophorum Mull Arg) Leaf and Onion (Allium cepa Linn) Bulb Supplemented Diets. American Journal of Experimental Agriculture 4(12): 1593-1603.

Brzuska, E. (2003). Artificial propagation of African catfish (Clarias gariepinus): Differences between reproduction effects after stimulation of ovulation with carp pituitary homogenate or GnRH-a and dopaminergic inhibitor, Czech J. Anim. Sci, 48(5): 181 – 190.

Canyurt, M.A. and Akhan, S. (2008). Effect of Ascorbic Acid Supplementation on Sperm Quality of Rainbow Trout (Onochorynchus mykiss). Turkish Journal of Fisheries and aquatic Sciences, 8:171-175.

Nwokoye CO, Nwuba LA and Eyo JE (2007). Induced propagation of African clariid catfish, Heterobranchus bidorsalis using synthetic and homoplastic hormones. Afr. J. Biotechnol. 6(23):2687-2693.

Offem.B.O. Ayotunde and G.U. Ikpi, 2008. Dynamics in the reproductive biology of Heterobranchus Longifilis vol,29. (Pisces: 1840) in the Inland Wetlands of Cross river, Nigeria. Res. J. Fish. Hydrobiol., 3: 22-31

Opadokun, I. O., and Ajani, E. K. (2015). Some aspects of the reproductive biology of Gymnarchus niloticus Cuvier, 1829 (Knifefish) in Lekki Lagoon, Nigeria. International Journal of Fisheries and Aquatic Studies, 2(3), 166–170.

Sahoo S. K, Giri S S and Sahu A K (2004). Effect of stocking density on growth and survival of Clarias batrachus (Linn.) larvae and fry during hatchery rearing. Journal of Applied Ichthyology 20: 302-305

Tijani, G. F. and Ajani, E. K (2017). Effects of Fish Oil Replacing and Groundnut Oil on Growth and Digestibility Coefficient of African Catfish, Clarias gariepinus (BURCHELL, 1822), Broodstock. Nigerian Journal of Fisheries and Aquaculture 5(1):22 – 29.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

EFFECTS OF TWO DIFFERENT PROBIOTICS ON GROWTH PERFORMANCE AND SURVIVAL RATE OF *Heterobranchus bidorsalis* (GEOFFROY SAINT-HILAIRE, 1809) FINGERLINGS

Ahmed A. L[1], A. Kotos[1], A. Y, Musa[2], M. U Abubakar[2]. B M Abatcha [3], A Abdullahi [3], A. I Garba[3]

[1],[2]Department of Hydrobiology and Fisheries, Gombe State University. Nigeria
[2,3]Department of Fisheries Technology, Federal College of Freshwater Fisheries Technology, Baga, P.M.B. 1060, Maiduguri, Nigeria

Corresponding Authors:
yakubualimusa@gmail.com, 07065865635.

ABSTRACT
The study was carried out to compare the effect of two different Probiotic as growth promoter and survival rate of H. bidorsalis fingerlings. The feed was formulated using Pearson square method. The results obtained on the study shows that the growth of H. bidorsalis fed orego-stim supplement shows the weight gain was higher in H. bidorsalis fed diet at (15%) inclusion of orego-stim with 247.03±34.42, followed by other groups and also shows the highest at (15%) level of inclusion in superliv with value of 513.67±82.28.The lowest value was obtained in the control group. The result shows that there is significance difference within and between the other groups. The length gain of the H. bidorsalis fed with orego-stim supplemented diet at various level of inclusion the result shows that 15% level of inclusion was recordedthe highest value followed by other groups, and *H. bidorsalis* fed with superliv shows 77.36±11.99 found to be the highest value at 15% level of inclusion and other groups respectively. The control group shows the lowest with 17.8±5.40. The feed conversion ratio (FCR) of fish fed with different level of orego-stim, the 10% group with superliv gives the excellence FCR. This indicates that the fish were able to convert all the feed given to flesh. The value of specific growth rate (205.72±28.65) recorded in the fish fed with 15% of orego-stim inclusion level as the highest value followed by 5% 10% and 0% inclusion level, the results show that there is no significances difference within the treatments. The result of the FCE shows that there is highly significance differences between the treatments which shows the best at group fed with superliv.

Keywords:
Probiotics, Growth Performance, Survival rate and Heterobranchus bidorsalis

INTRODUCTION

Aquaculture has taken an increasingly prominent position globally as a source of protein in a world faced with increasing pressure on capture fisheries resource (Food and Agricultural Organization, FAO, 2018). Nigeria is the largest fish consumer in Africa due to its high population and among the largest fish consumers in the world with over 1.5 million tons of fish consumed annually. Yet, Nigeria imports over 900,000 metric tons of fish while its domestic catch is estimated at 450,000 metric tons/year (Emmanuel *et al.,* 2013). The value of fish cannot be overemphasized. The rate of increase in population, and the demand for fish has necessitated an increase in aquaculture production (Ochokwu *et al.*, 2019). Unlike capture fisheries, aquaculture involves human deliberate activities in the organisms' productivity which results in yields that exceed those from the natural environment alone. According to the Food and Agriculture Organization (FAO, 2010), 28% of the capture fisheries resources are overexploited which result in decrease in fish supplies. With capture fishery production relatively static since the late 1980s, aquaculture has been responsible for the continuing impressive growth in the supply of fish for human consumption. Meanwhile, the demand for fish is increasing with the rising world population (FAO, 2018).

Feed represents around 50 – 80% production cost in aquaculture and proper nutrition is one of the critical factors in aquaculture which depends on a nutritionally balanced diet and low cost of production with the mixture of both organic and inorganic components (Bharathi, *et al.*, 2019). Fish feed enhances optimum growth and resistance to diseases when it contains proper proportion of proteins, carbohydrate, lipids, vitamins and minerals. Nevertheless, nutrients in fish feeds are optimally utilized when the feed stuffs are acceptable and palatable to the fish. Cost of production can be reduced if growth performance and feed efficiency are increased in commercial aquaculture (Dada and Olugbemi, 2013).

Feed additives are substances which are added in trace amounts to a diet or feed ingredient either to preserve its nutritional characteristics prior to feeding, to facilitate ingredient dispersion or feed pelleting, to facilitate growth, facilitate feed ingestion and consumer acceptance of the product, or to supply essential nutrients in purified form (FAO, 2019). Functional feed additives include phytogenic compounds, mycotoxin binders, organic acids, immune – stimulants, yeast products, probiotics, prebiotics, enzymes (Alemayehu *et al.*, 2018). Growth promoters are a kind of feed additives that are principally chemical and/or biological substances added to fish feed with the aim of improving fish growth (Dada, 2012). In intensive and semi-intensive aquaculture systems, growth promoters have become an essential part of fish diet in improving food conversion ratio (FCR), significant reduction in mortality and enhancing digestion of fish. The use of such feed additive has been proven to be successful in aquaculture (Ajiboye *et al.*, 2012). It is necessary for fattening fishes and improving the utilization of food to obtain better production and financial results.

MATERIALS AND METHOD

Study Area

The research was conducted in Disa Fish Farm limited located in T-junction area in Potiskum local government, Yobe state Nigeria on the A3 highway at 11043'N 11004E/11.7170N 11.0670E. The Potiskum lies on 426m above sea level and the average annual temperature of 24.90C and annual precipitation of 713mm. Climate-Data (2012).

Experimental diet collection and preparation

All the feed ingredients used for the experiment were like fishmeal, soybean, wheat offal, groundnut cake, vitamin premix, salt; oil and starch were bought from Potiskum Market except for the probiotics from Animal Care Company in Kano.

Proximate analysis of the experimental diets: Proximate analysis of the experimental feeds was performed based on methods of AOAC (2002), at the Department of Biochemistry Gombe State University Nigeria (Table 2). The moisture content, ash contents, crude protein, crude fiber, crude lipid and carbohydrate was analysed.

Experimental fish

Total number of one hundred and eighty (180) mixed sex with average weight of 2g and length of 4cm fingerlings of African catfish *(Heterobranchus bidorsalis)* fingerlings was purchased from PUTERI fish farm Kano for the experiment. The fish were transported using fifty liters jerry can to Disa Farm where the research was conducted. The fingerlings were then acclimatize for one week before the onset of the experiment and fed with 2mm of vital feed at 5% of their body weight at three times of the day during this period.

Data analysis

The data obtained was subjected to one way analysis of variance (ANOVA) to determine the differences between the mean.

RESULTS

TABLE 4.1 Growth Parameters *H. bidorsalis* feds on Orego-stim growth promoter

Parameters	0 (%)	5 (%)	10 (%)	15 (%)
Initial weight (g)	32.0±4.50[a]	31.15±1.4[a]	34.38±1.30[a]	35.67±1.76[a]
Final weight(g)	170.56±88.39[a]	208.33±4.42[a]	195.83±19.77[a]	282.70±32.66[c]
Initial length (cm)	98.00±4.34[a]	94.83±2.33[a]	102.03±1.22[a]	100.77±1.89[a]
Final length (cm)	113.30±8.50[a]	127.43±7.23[a]	108.27±6.39[a]	153.10±17.67[a]
Weight gain (g)	126.00±6.23[a]	177.03±3.02[a]	161.00±19.55[a]	247.03±34.42[a]
Length gain (cm)	17.8±5.40[a]	32.60±4.95[a]	6.83±5.58[a]	52.36±19.53[a]
SGR	95.00±0.91[a]	147.50±.2.50[a]	134.13±16.27[a]	205.72±28.65[a]
FCR	0.28±0.61[a]	2.70±0.11[a]	1.18±0.14[b]	1.67±0.13[b]
FCE	0.32±0.04[a]	0.43±0.03[a]	0.40±0.05[a]	0.61±0.08[a]
PER	2.65±0.56[a]	3.93±0.06[a]	3.56±0.42[a]	5.48±0.76[a]
Survival rate (%)	93.33±7.43[ab]	62.22±2.22[a]	55.10±5.84[a]	77.33±5.92[a]

Mean ± SE followed by the same superscript letter (a) indicated not significantly different at $P < 0.05$

DISCUSSION

The study on the dietary effects of orego-stim and superliv meal on the growth performance and survival rate of H. bidorsalis fingerlings was conducted. The growth performance in respect of final weight, weight gain, final length, length gain of H. bidorsalis fingerlings was higher in superliv followed by orego-stim and the lower value was obtained in control. This value is similar to higher values of weight gained in C. gariepinus fingerlings fed with ear leaf (Acacia auriculiformis) as feed additive Omosowone (2019). Also Dada, (2015) reported weight gained by C. *gariepinus* fed (Telfairia accidentalis) leaf powder as feed additive which was lower than current study, Aeshad et al. (2021) also reported on the effect of sodium bentonites as a growth promoter tested on Epinephelus fuscoguttatus the result also shows lower values than the current study. Adekunle Ayokanmi Dada, (2012), also reports on Nile tilapia *(O. niloticus)* fed with superliv herbal powder the results was lower than the current study irrespective of the duration. The final mean length recorded in this study was higher than that reported by Anene, (2012) who used Adenosonia digitata seed in the diet of C*larias gariepinus* fingerlings, the higher result may be due to the difference in the dietary composition level of superliv compared to compare to Adenosonia digitata. The higher value obtained in this study may indicate the effectiveness of superliv over oregostim in promoting growth in *H. bidorsali* fingerlings.

TABLE 4.2.1 Growth Parameters of H. bidorsalis feds on Superliv growth promoter

Parameters	0 (%)	5 (%)	10 (%)	15 (%)
Initial weight (g)	32.0±4.50[a]	29.66±1.96[a]	29.66±1.85[a]	35.67±2.84[a]
Final weight(g)	170.56±88.39[b]	250.83±19.47[b]	268.67±14.67[ab]	549.33±84.89[a]
Initial length (cm)	98.00±4.34[a]	98.12±1.58[a]	99.20±2.04[a]	107.47±3.49[a]
Final length (cm)	113.30±8.50[a]	130.33±9.48[b]	135.80±7.85[ab]	184.83±15.43[a]
Weight gain (g)	126.00±6.23[a]	221.00±19.65[b]	239.00±12.85[b]	513.67±82.28[a]
Length gain (cm)	17.8±5.40[a]	31.90±8.89[b]	36.63±7.85[ab]	77.37±11.99[a]
SGR	95.00±0.91[a]	184.15±16.28[b]	198.60±10.77[b]	427.93±68.48[a]
FCR	0.28±0.61[a]	2.29±0.19[a]	2.10±0.11[a]	1.03±0.19[b]
FCE	0.32±0.04[b]	0.54±0.04[b]	0.59±0.03[b]	1.28±0.20[a]
PER	2.65±0.56[a]	4.90±0.43[b]	5.30±0.29[a]	11.41±1.82[a]
Survival rate (%)	93.33±7.43[a]	77.78±5.87[a]	70.89±4.55[a]	77.55±7.93[a]

Mean ± SE followed by the same superscript letter (a) indicated not significantly different at $P < 0.05$

Higher value of feed conversion ratio was found in group fed with superliv followed by orego-stim with 2.70 and 2.20 of *H. bidorsalis* fed A. auriculiformis leaf diet was reported by (Afe *et al.*, 2019). Medicinal herb in diets also promoted growth and feed conversion efficiency in shrimp (Olmedo sanchezet al.2009). Similar results were reported by Turan (2006) who used the medicinal herb red clover Triffolium protense as a growth promoting agents for tilapia O.aureus. Better feed conversion ratio was obtained both in this study which could be as a result of effectiveness and high nutrient composition of the diet supplement. Survival rate was higher in control, this percentage was higher within the group in control than the other groups, this indicates higher than 90% survival of C. *gariepinus* fed commercial herbal feed additive (Aquapro) reported by (Dada and Olubemi, 2013), low survival percentage observed in this work could be attributed to stress and other exogenous substances.

CONCLUSION

This study has shown that incorporating growth promoter supplements in the diet of *H. bidorsalis* can lead to higher growth and better nutrient utilization of feed .Therefore the use of both Superliv and Orego-stim natural herbal as supplement in fish feed can boost feed conversion and also promote growth. Fish farmers should therefore be encouraged to supplement these feed additives in fish diet. Functional feed additives are used for, higher productivity and enhanced resistance to infectious disease, which would ultimately lead to sustainable aquaculture. Therefore based on the results of the present study, I conclude that the effect of the Orego-stim and Superliv as growth promoter on the growth performance of *H. bidorsalis* fingerlings depends on the inclusion level of the growth promoter used for this study.

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REFERENCE

Ajiboye OO, Yakubu A. F, and Adams T.E. (2012).A perspective on the ingestion and nutritional effects of feed additives in farmed fish species.World Journal of Fisheries and Marine Science, 4(1): 87-101.

Anene, D. O. (2012). A perspective on the ingestion and nutritional effects of feed additives in farmed fish species.World Journal of Fisheries and Marine Science, 4(1): 87-101.

Alemayehu TA, Geremew A. and Getahun (2018). The Role of Functional Feed Additives in Tilapia Nutrition, Fisheries and Aquaculture Journal; 9(2).

Bharathi S, Cheryl Antony, Rajago palasamy CBT, Uma A, Ahilan B and Aand S. (2019). Functional feed additives used in fish feeds. International Journal of Fisheries and Aquatic Studies 2019; 7(3): 44-52

Dada A. A. (2015). Use of pumpkin (Talfariaaccidentalis) leaf powder as feed additive in African catfish (Clarias gariepinus) fingerlings. International journal of biological and chemistry science 9:1.

Dada AA. and Olugbemi B. D (2013). Dietary effects of two commercial feed additives on growth performance and body composition of African catfish, Claria gariepinus fingerlings.African Journal of Food Science. 7(9): 325-328.

Dada, A.A (2012). Effects of herbal growth promoter feed additive in fish meal on the performance of Nile Tilapia (Oreochromis niloticus). Egypt Acadamic Biological Science; 4(1):111-117.

Dada, A.A. (2015). Use of fruited pumpkin (Telferia occidentalis) leaf powder as feed additive in African Catfish (Clarias gariepinus) fingerlings. International Journal of Biology and Chemistry Science.9(i): 301- 307.

Diyaware, M. Y., Ahmed, A. B; Akinyemi, A. A. and Suleiman, S. B. (2017).Haemoglobin polymorphism in wild and cultured African catfish (Clarias gariepinus Burchell, 1822).Ife Journal of Science.19(2), 201pp.

Emmanuel, O., Chinenye, C., Gbadebo, F., Richardson, O. and Peter, K.(2013). Development of an automatic fish feeder.African. Journal of Root and Tuber Crop, 10(1): 27-32.

Erondu, E. S., Nwubra, C. and Nwadukwere, F. O., (1993). Haematological studies of four catfish species raised in Freshwater pond in Nigeria. Journal of applied ichthyology. 9:250-156.

FAO. (2010). The state of world fisheries and aquaculture.Food and Agriculture Organization of the United Nations.Review of the state of World Aquaculture. FAO Fisheries Circular Mo. 886, Revised. 1. Rome, Italy..

FAO. (2018). The State of World Fisheries and Aquaculture. Rome: FAO.

FAO.(2019). The State of Food Insecurity in the world. Food and Agriculture Organization of the United Nations, Rome, Italy: 235-240.

Gayatri.A., and Prafulla K. M., (2014). Comparative haematological and serum biochemical analysis of catfishesclaria batrachus (Linnaeus 1758) and Heteropneutes fossilis (Bloch 1794) with respect to sex. Journal of Entomology and Zoology studies.2(6):191-197.

Gayatri.A., and Prafulla K. M., (2014). Comparative haematological and serum biochemical analysis of catfishesclaria batrachus (Linnaeus 1758) and Heteropneutes fossilis (Bloch 1794) with respect to sex. Journal of Entomology and Zoology studies.2(6):191-197.

Ochokwu, I. J., Nwabunike, M. O., and Udeh, G. N. (2019).Evaluation of Milt Quality of Clarias anguillaris (Linnaeus, 1758) Broodstock Fed Varying Inclusion Levels of Wild Hibiscus Azanza garckeana Pulp Meal. Journal of aquatic science. 34(1): 23

Olmedo sanchez, J.A, Curiel Flores, A. and Orozco, J.R. (2009). The effect of a herbal growth promoter feed additive on shrimp performance. Resource Journal of Biological Science. 4: 1022-1024.

Onyia L. U., Diyaware, M. Y., Micheal, K. G. Musa, M. and Ochokwu, I. J. (2015).Comparison of haematological indices, blood group, genbotype of Claria gariepinus (Burchell, 1822) and Claria angullaris (Linneaus, 1758).Journal of fishereies and Aquatric science, 10: 392-399.

Onyia, L. U., Ochokwu, I. J. and Edison, E. S. (2013). Comparison of Haematological Indices, Blood Group and Genotype of Claria gariepinus and Synodontis claria from Goronyo Lake, Journal of Aquatic Science.34 (2).

Onyia, L. U., Ochokwu, I. J. and Edison, E. S. (2019). Comparison of Haematological Indices, Blood Group and Genotype of Chrysicthys Nigrodigtatus and Synodontis Batensoda from Geriyo Lake, Journal of Aquatic Science. 34 (1): 49-56, DOI: 10.4314/jas.v34i1.7

Turan F. (2006). Improvement of growth performance in Tilapia (Oreochromis niloticus Linnaeus) by supplementation of red clover (Trifolium pretense) indiets. Bamidgeh 58: 34-38.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

ASSESSMENT OF NUTRITIONAL AND PHYTOCHEMICAL COMPOSITION OF *Cnidoscolus chayamansa* FOR USE AS ADDITIVES IN AQUACULTURE FEED

Ayo-OlalusI, C. I., I. Megbowon, T. A. Adeleke, B. Y. Adeyemi, B. Edah, H. Jibrin,I. Chidume, N. C. Eze, G. E. Olagunju, O. J. Ayokhai, C. U. Omatah and A. A. Adetoye

Fish Nutrition and Physiology Department of Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos, Nigeria.

Corresponding Author:
ireti.ayoolalusi@yahoo.com, +2348051975562, 0009-0003-8928-6999

ABSTRACT

The nutritional and phytochemical properties of both fresh and dried chaya leaves meal *(Cnidoscolus chayamasa)* for use as additives in aquafeed production was assessed. Fresh leaves of the Chaya plant obtained from chaya plant growing at the residential quarters of Nigerian Institute for Oceanography and Marine Research of Victoria Island Lagos Nigeria, were washed, sun dried and milled into fine powder using a milling machine (Inifitek, Whirlwind mill 370w, 220V). The leaf powder was sieved using a 1.18mm laboratory sieve. The moisture content significantly differed, with its values ranging from 79.00±0.32% in fresh leaves to 9.40±028% in the dried leaves while the protein content of the dried chaya leaves was 28.54± 0. 11% which is significantly higher (P>0.05) than the protein content (5.26±0.23%) of fresh sample. Phytochemical screening of the leaves highlighted the presence of bioactive compounds which included Tannins, Phenols, Oxalate, Antioxidant and Alkaloids. Results of the elemental analysis showed that Chaya leaves contained the minerals, Calcium, Magnesium, Potassium, Sodium, Manganese, Iron, Zinc, Phosphorus and Copper. The results obtained from this study indicated that the leaves of Chaya contain nutrients and mineral elements that may be used as additive in aquafeed production.

Keywords:
Chaya leave, antioxidants, Phytochemical, Minerals, aquafeed

INTRODUCTION

The demand for plant-based protein rich food has increased due to high cost of animal protein. Some plants are reach in plant protein and other nutritional benefits making them an excellent choice for a balanced diet. Chaya, also known as *Cnodosculus chayamasa,* is a green leaf of a shrubs that has many health advantages and consumed in Nigeria (Iwuji *et al.*, 2013). Chaya, a member of the Euphorbiaceous family, is often referred to as "hospital is too far" in Nigeria. It is frequently found in tropical and subtropical regions of the world, such as India, North and South America, Africa, the Sahara, and others (Awoyinka *et al.*, 2007).

Chaya leaves may have antibacterial and anti-diabetic effects in addition to reducing anemia and osmotic fragility brought on by a lack of protein, energy as reported by Oladeinde *et al.,* 2007. Although phytochemicals are regarded to be the main bioactive component promoting the health benefits of most plants, there are also anti nutritional factor that inhibit the absorption of this in animals and human (Alabi and Babalola, 2015). Tannins in plant material have the potential to become anti-nutritional factors at high levels (over 50 g/kg DM), which may impair an animal's intake and digestibility of feed (Jibrin *et al.,* 2018). Juthamas et al., 2021 carried out studies on chaya leaves to determine potential health advantage but complete benefits of the leaves have not been determined due to the presence of toxic and anti- nutritional factors. The complete benefits of this leaf have not yet been discovered due to the presence of naturally occurring toxic components in the plant (Shittu et al., 2014). However, Garcia et al., 2017 reported that chaya leaves are more nutritious than spinach. This study was carried out to assess the nutritional and anti-nutritional properties of chaya leaves for use in aquafeed production.

MATERIALS AND METHODS

Sample Collection

Fresh leaves of the Chaya plant *(C. chayamansa)* were obtained from chaya plant growing at the residential quarters of Nigerian Institute for Oceanography and Marine Research of Victoria Island Lagos Nigeria. The leaves were washed and sun dried. The dried leaves were milled into fine powder using a laboratory milling machine (Inifitek, Whirlwind mill 370w, 220V), sieved using 1.18mm laboratory sieve to remove the residues. The fine particles were used for proximate, mineral and anti-nutrient composition.

Chemical Analysis Chaya Leaves *(C. chayamansa)*.

The sample was analyzed for proximate composition at JAAGEE Nigeria Limited, Ibadan, Oyo State.

Moisture Content: The moisture content was ascertained using the 930.15 method of the Association of Official Analytical Chemists (AOAC). The samples were dried to a consistent weight at 100±5°C in a hot air oven. The moisture content was determined by calculating the difference between the initial and end weights. By burning the material at 550°C, the amount of ash was ascertained (AOAC, 942.05 technique).

Crude Protein: The digestion equipment (Digester, model 2020) processed the sample (2 g) for 45 minutes. After that, the distillation unit (Khjeltdah System, distilling unit, model 1026) was used to distill the digester. Ultimately, crude protein was obtained by multiplying the total nitrogen by a conversion factor of 6.25 after it was titrated with 0.2 N HCL.

Crude Fat and Fiber: The AOAC 920.39 technique was used to analyze crude fat. For crude fibre, two grams were weighed and subjected to a 30-minute digestion process using 0.128 M H2SO4 and a few drops of octanol in a Hot Extractor, Model-1017. The acid was eliminated through filtering and washing with boiling water. After 30 minutes of boiling with 0.223 M KOH, the residue was cleaned using acetone and hot water. The residue was burned for three hours at 500°C in a muffle furnace after being dried for two hours at 130°C in an oven. The weight decrease was indicative of the raw fiber.

Total carbohydrate: The amount of total carbon hydrogen was obtained by deducting the percentages of moisture, fat, protein, and ash from 100%. An examination of mineral content was conducted using the AOAC 968.08 technique. Every measurement was made three times, and the results were given in grams per 100 grams of dry weight samples (g/100gdw).

Mineral Composition of Chaya Leaf

The suggested techniques of the Association of Official Analytical Chemistry (A O A C.968.08) were followed in determining the mineral composition of the leaf.

Determination of Anti-Nutritional Composition of Chaya Leaf

The anti-nutrient composition of fresh and dried Chaya leaf was conducted to identify the presence of Tannins, phenols, oxalate, antioxidant and alkaloids using established techniques (Software, 1982; Trease and Evans, 1993).

Statistical Analysis

Data was analyzed using ANOVA, and the Duncan's Multiple Range Test technique (Steel and Torrie,

1980) was used to separate the treatment means for significant differences. The statistical package for the social sciences, version 20 for Windows (SPSS, 2013), was used for all of the studies.

RESULTS AND DISCUSSION

proximate Composition

The Proximate analysis of fresh and dried leaves was presented in Table 1. Crude protein 5.26±0.23%, ash content 2.49±0.12%, crude fiber content 2.16±0.03% while for the dried leaves crude protein was 28.54± 0. 11%, crude fat 3.01±0.05%, and carbohydrate 42.09±0.46%. The moisture, crude protein, crude fiber and energy content were higher than reported in Cnidoscolus aconitifolius Alemu et al., (2023). However, the author reported ash content to be the same and the carbohydrate lower. The variances in the proximate compositions with the other study could be attributed to environmental factors such as soil types, season, geographical location, provenances, harvesting time and stage of maturity. The protein level of 28.54% obtained in this study indicates its potential as a protein supplement in aquafeed production and may be useful in areas facing a shortage of protein source. The values obtained for energy in this study was higher than obtained in some edible leafy vegetables, Moringa oleifera, Telfairia and Brassica oleracea as reported by Iyaka et al., (2014). The results obtained from this study and early studies indicate that Chaya leaf could be a good source of protein, energy and building block for the body.

Table1. Proximate Composition of Chaya leaf meal.

Parameters	Samples	
	Fresh sample (%)	Dried sample (%)
Moisture	79.00±0.32 ^{a}	9.40±0.28 ^{b}
Crude Protein	5.26±0.23 ^{b}	28.54±0.11^{a}
Crude Fat	0.70±0.02 ^{b}	3.01±0.05 ^{a}
Fiber	2.16±0.03 ^{b}	7.43±0.40 ^{a}
Ash	2.49±0.12 ^{b}	9.53±0.23 ^{a}
Carbohydrate	10.39±0.03 ^{b}	42.09±0.46 ^{a}
Energy (Kcal/kg)	607.25±0.14 ^{b}	2727.90±0.51^{a}

Values with same letters along rows are not significantly ($P<0.05$) different

Mineral Composition

The mineral composition of C*nidoscolus chayamansa* leaves is presented in Table 2. The results showed the presence of calcium, magnesium, potassium, sodium, manganese, iron, copper, zinc and phosphorus in the leaves sample. The value obtained for mineral composition of dried and fresh leaves showed calcium value of 2066.43±23.20 mg/100 g and 514.62±11.61 mg/100 g, the magnesium content 371.67±40.99 mg/100 g and 120.17±1.07 mg/100 g, Potassium content 1270.53±37.52 mg/100 g and 315.37±2.68 mg/100 g, zinc content of 0.72±0.00 mg/100 g and 3.36±0.02 mg/100 g, the iron content 107.76±7.10 mg/100 g and 11.64±0.69 mg/100 g respectively. The report of this study showed that consumption of this vegetable would supply adequate amount of calcium needed by the body as Calcium is an important dietary mineral for strong bones, teeth and absorption of vitamin B12 in the body. The values of Magnesium, Iron, Sodium in this present study is higher than obtained in Cnidoscolus aconitifolius by Iwuji *et al.*, (2013) and Alume *et al.*, (2023). Iron is involved in the formation of hemoglobin, myoglobin, growth, and boost immune system, as cofactor for enzymes. Sodium is required by the body to maintain normal levels of fluid inside the cell and regulates blood pressure. Potassium maintains levels of fluid outside the cell. According to this study, the values of phosphorus and manganese are lower than obtained by Iwuji *et al.*, (2013). Zinc and manganese are dietary trace elements needed for a healthy immune system among other functions.

Table 2. Mineral Composition of Chaya leaf meal; Mean ±SEM

Minerals	Fresh sample (Mg/kg)	Dried sample (Mg/kg)
Calcium	514.62±11.61^{b}	2066.43±23.20^{a}
Magnesium	120.17±1.07^{b}	371.67±40.99^{a}
Potassium	315.37±2.68^{b}	1270.53±37.52^{a}
Sodium	150.07±7.10^{b}	615.37±28.98^{a}
Manganese	1.00±0.11^{b}	3.56±0.28^{a}
Iron	11.64±0.69^{b}	107.76±7.10^{a}
Copper	1.39±0.01^{a}	0.74±0.00^{b}
Zinc	0.72±0.00^{b}	3.36±0.02^{a}
Phosphorus	8.82±0.69^{b}	13.86±0.40^{a}

Anti-Nutritional Composition of Chaya Leaves

The results of anti-nutritional composition as presented in Table 3 revealed the presence of Tannins (12.62±0.04%), Phenols (15.08±0.57%), Oxalate (16.43±0.11%), Antioxidant (37.22±0.23%) and Alkaloids (0.50±0.05%) in fresh leaves. Higher concentration of Tannins (18.25±0.05%), Phenols (22.05±0.28%), Oxalate (110.92±0.72%), Antioxidant (40.98±0.28%) and Alkaloids (1.23±0.02%) were observed in the dried leaves. The phenol content of Chaya leaf in this study is quite higher, although lower than that in Cnidoscolus Aconitifolius by Alemu *et al.*, (2023) and Orji et al., (2016). The presence of phenol is a clear indication that the plant can be exploited in pharmaceuticals for the treatment of many disease conditions. The presence of phenols makes the plant a potential cancer therapy because phenols are well known for the enormous ability to combat cancer Orji *et al.*, (2016).

The value of Oxalate obtained in this study is higher than that reported by Babalola and Alabi (2015). Oxalate is known to interfere with calcium absorption by forming insoluble salt of calcium. This insoluble salt of calcium is capable of passing through the excretory system and interferes with the efficient working of the kidney, otherwise causes a disease called kidney

Table 3. Anti-nutrient composition of Chaya leaf meal; ±SE

Anti-nutrient	Samples	
	Fresh sample (%)	Dried sample (%)
Tannins	12.62±0.04^{b}	18.25±0.05^{a}
Phenols	15.08±0.57^{b}	22.05±0.28^{a}
Oxalate	16.43±0.11^{b}	110.92±0.72^{a}
Antioxidant	37.22±0.23^{b}	40.98±0.28^{a}
Alkaloids	0.50±0.05^{b}	1.23±0.02^{a}

Values with same letters are not significantly ($P<0.05$) different

Tabulated values are expressed as mean ±SD

CONCLUSION AND RECOMMENDATION

The results of this present study showed that Chaya is a rich source of nutrients especially protein and carbohydrate and a good source of energy. However, further studies on the appropriate processing methods and potent means of removing the anti-nutritional factors is highly recommended.

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REFERENCE.

Alemu Gobena D, Girma Shewa A, Abera S, W/Tsadik K, Neme G, and Mahamed W. (2023). Chaya (Cnidoscolus

Aconitifolius) for Enhancing food and Nutrition Security of Arid Lands of Ethiopia. Journal of Nutrition and Food Security (JNFS); 8(3): 4617 -467.

AOAC. 21st. Gaithersburg, Maryland, USA: AOAC International; (2019). Official methods of analysis. [Google Scholar

Awoyinka A.O, Balogun I.O. and Ogunnowo AA. (2007). Phytochemical screening and in vitro bioactivity of Cnidoscolus aconitifolius (Euphorbiaceae). J Med Plant Res; 3: 63- 65.

Babalola, J.O and Alabi, O.O. (2015). Effect of processing methods on nutritional composition, phytochemicals andante-nutrient properties of Chaya leaf (Cnidoscolus aconitifolius). African Journal of Food Science, 9 (12), 560-565.

Garcia A.K, Servin J.L, and Maldonado S.H. (2017) Phenolic profile and antioxidant capacity of Cnidoscolus chayamansa and Cnidoscolus aconitifolius: A review. J Med Plants Res; 11(45):713-727.

Iwuji SC, Nwafor A, Egwurugwu J, Ejeta K, and Akpan U (2013). Comparative Characterization of the Phytomedicinal Constituents of Cnidoscolus aconitifolius Leaf Extracts. American J Pharm Tech; 3(1):779-78.

Iyaka YA, Idris S, Alawode RA and Bagudo BU (2014). Nutrient content of selected edible leafy vegetables. American journal of Applied chemistry. 2 (3): 42 -45.

Jibrin H, Chidume I and Eze N. C. (2018). Proximate and Phyto-Chemical Composition of Cassia tora Leaf Meal. Nigerian Journal of Fisheries.2 (15):1542-1546

Juthamas K, Pornpimol C, Sirirat A, Ubon C and Patimakorn P, (2021). Nutritional and phytochemical properties of Chaya leaves (Cnidoscolus chayamansaMc Vaugh) planted in Northeastern Thailand. Asia -Pacific Journal of Science and Technology. 01 (27): 1-10.

Oladeinde FO, Kinyua AM, and Laditan AA. (2007) Effect of Cnidoscolus aconitifolius leaf extract on blood glucose and insulin levels of inbred type 2 diabetic mice. Cell Mol Biol; 53: 34-41.

Orji O, et al. (2016). Evaluation of the phytochemical and nutritional profiles of Cnidoscolus aconitifolius leaf collected in Abakaliki South East Nigeria. World journal of medical sciences. 13 (3): 213 -217.

Panghal, A., Janghu, S., Virkar, K., Gat, Y., Kumar, V. and Chhikara, N., (2018). Potential non-dairy probiotic products–a healthy approach. Food bioscience, 21, 80-89.

Shittu SA, Olayiwola OA. And Adebayo OR (2014). Nutritional composition and phytochemical constituents of the leaves of Cnidoscolous aconitifolius. Amer. J. Sci. Nutr. Res

EFFECTS OF PROCESSING METHODS ON THE QUALITY OF SOME PLANT BY-PRODUCTS USED AS FEED INGREDIENTS FOR AQUACULTURE FEEDS

[1]Jibrin, H., [2]M. Y. Abubakar, [1]C. I. Ayo-Olalusi, [3]H.F. Maradun., [4]A. A. ADAM and [5]M. Musa

[1]Department of Fish Nutrition and Physiology, Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos
[2]Department of Fisheries and Aquaculture, Usmanu Danfodiyo University Sokoto
[3]Aquaculture and Biotechnology Department, National Institute for Freshwater Fisheries Research. New Bussa, Nigeria
[4]Department of Fisheries Technology, School of Agriculture, Binyaminu Usman Polytechnic Hadeja, Jigawa State
[5]Department of Fish Tech. Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos.

Corresponding author's: haliru475@yahoo.com

ABSTRACT
This research was conducted to assess the effects of processing methods on the quality of some plant by-products use as feed ingredients. The feed ingredients were Guinea corn bran, Millet bran, Maize bran Rice bran and Tofu soybean and the proximate analysis was carried out using AOAC (1990). The results obtained for fermented and sun-dried samples are; crude protein content in the fermented sample ranged from 28.15±0.39 maize bran to 14.37±0.02% rice bran, while the crude protein in the sun-dried sample ranged from 14.44±0.56 rice bran to 3.48±0.24% maize bran. The crude lipid in the fermented sample ranged from 24.15±0.00 millet bran to 4.51±0.01% maize bran, while the crude lipid in the sun-dried sample ranged from 15.21±0.01 Tofu soybean to 5.16±0.01% maize bran. The fiber in the fermented sample ranged from 28.15±0.39 to 0.25±0.10% Guinea corn bran, while the fiber content in the sun-dried sample ranged from 26.65±0.00 rice bran to 3.48±0.24% maize bran. The ash in the fermented sample ranged from 10.53±0.01 soybean bran to 3.75±0.00% guinea corn bran, while the ash content in the sun-dried sample ranged from 15.44±0.01 maize bran to 4.28±0.01% soybean bran. Further studies should be carried to assess the potential of these feed ingredients using cultured fish species.

Keywords:
processing methods,
feed ingredients,
plant by-product,
aquaculture

INTRODUCTION

Wide variations in the quality of diet received by fish exist poor processing methods, poor formulation and processing, lack of knowledge and understanding of dietary requirement or in appropriate storage are factors that could be considered (Southgate, 1993). Fish feed industry has recognized for many years that increased utilization of plant protein in formulated diets is essential, however, there are limits to increasing the use of plant-based ingredients. There is need for these alternative ingredients to be cost effective, support optimal fish performance, have minimal environmental impact, and result in product that is appealing and nutritious (Barros, *et al.,* 2002). The high cost of feed constitutes 40-60% of the re-current cost of most intensive fish farm ventures which negates the economic viability of the farm when cheaper alternatives are not available (Madu *et al.*, 2003). Among the commonly used ingredient, fish meal is considered to be the best ingredient due to it compatibility with protein requirement of the fish (Alam *et al.*, 1996). However, the development of aquaculture systems depends on the use of available local ingredient which will reduce the feeding cost (Allam et al., 2004). The aims of this paper to report the nutritional value and use of some selected nonconventional plant base diet to replace animal protein.

In general, non-conventional feed resources (NCFRS) are feeds that are not usually common in the markets and are not the traditional ingredients used for commercial fish feed production (Devendra, 1988; Madu *et al.*, 2003; Sogbesan and Ugwumba, 20012). Nutrient value estimates from the available non-conventional sources are high and appear to justify continued investigation of their nutritional potentials to enhance profitable fish production (Okoye and Sule, 1999). The major ingredients used for livestock and fish feeds are highly competitive between industries, animals and man, this situation is likely to get worse if non-conventional sources remain unutilized (Sogbesan and Ugwumba, 2008). The nutrient quality of feed ingredients is one of the major prerequisites apart from availability (which some time is a function of cost and season) for production of good quality feeds (Zeiter *et al.*, 1984).

The basic nutrient that cannot be compromised in the choice of ingredient for feed formulation is protein (Zeiter *et al.*, 1984). Hence it became impressive to research into the nutrient composition of some of the easily culturable animal protein sources (Sogbeasan 2014). Research on the nutritive value of some fish feed ingredients of both plant and animals' sources such as plantain (Falaye and Oluruntuyi, 1998), poultry offal (Fasakin, 2008), maggot meal (Faturoti *et al.*, 1995; Faskin *et al.*, 2004), calabash seed (Saidu *et al.*, 2003), calabash seed meal (Mamman *et al.*, 2013), processed pumpkin seed (Jibrin et al., 2018) and water hyacinth (Sotulo, 2008) were reported. There is dearth of information on the nutritional value of some plant by-products and soy bean (Glysine max) subjected to various processing method. The main objective of this research is to evaluate the effects of processing methods on the quality of some by-products as feed ingredients for aquaculture feeds.

MATERIALS AND METHODS

Experimental Location

This research was carried out in Agriculture Chemical laboratory in Usmanu Danfodiyo University, Sokoto. Sokoto has a land mass of 26, 2648, 481km2 and located between longitude 11030" to 13050"E and latitude 4-60. It is bordered to the north by Niger Republic, to the East by Zamfara and Kebbi to the south West (Mamman, 2000). The vegetation, falls within the savanna Zone with semi-arid climate. Open tsetse flies' free grassland suitable for cultivation of grains and animal husbandry. Rainfall starts late May and ends early September with mean annually rainfall from 500-1300mm (Mamman, 2000).

Sample collection

The feed ingredients such as Guinea corn bran, millet bran, maize bran, rice bran and Tofu soybean were purchased from Kasuwar Dankure market, Sokoto State. Proximate composition was carried out using method of AOAC. (1990).

Methods of processing feed ingredients

All the feed ingredients were subjected to sun-dried and fermentation method. 4kg of each ingredient was obtained and processed into two different processing methods. The sample was divided into two different portions. First sample was processed by sun for 3 days which lettered removed grinded, and labeled and lettered subjected to analysis. Second sample was processed by fermenting for 24hrs which lettered removed and dried at room temperature and grinded and labeled lettered subjected to analysis.

Proximate composition

The proximate composition of feed stuffs was done by following the procedures of (AOAC, 1990).

Statistical Analysis

Data obtained were subjected to analysis of variance (ANOVA) and, the treatment means were separated for significant differences following the procedure of Duncan's Multiple Range Test (Steel and Torrie, 1980). All the analyses were carried out using the computer software Statistical Package for the Social Sciences Version 20 for Windows (SPSS, 2013).

RESULTS AND DISCUSSION

Proximate composition of processed feed ingredients

Table 1 shows the proximate composition of processed feed ingredients. The feed ingredients are guinea corn bran, millet bran, maize bran, rice bran and Tofu soybean were subjected to fermentation and sun-drying methods. Ash content of fermented soybean bran recorded the highest value followed by value recorded in millet bran and lower value was recorded in guinea corn bran while ash content of sun dried maize bran recorded the highest value followed by value recorded in Guinea corn bran and the lower value was recorded in Tofu soybean bran, and were significantly different ($p<0.05$) These values were higher than the values obtained by Hassan *et al.* (2007) who reported lower value from unprocessed calabash seeds. Since ash content represents the index of mineral elements present in the sample, this indicates that, the processing has significance effects on the nutritional values of the feed ingredients, this finding is also generally higher than 3.7% reported as the ash content of raw calabash seed (Osagie and Eka, 1998).

The fermented maize bran recorded the highest value of moisture content followed by value recorded in rice bran and lower value was recorded in Guinea corn bran, while sun dried Tofu soybean, recorded the highest moisture content followed by value recorded in rice bran and the lower value was recorded in millet bran, and were significantly different ($p<0.05$). This observation was in line with Boyd (1979) who reported that water hyacinth (Eichornia crassiopes) when dried contain as much as 7% moisture, the author further stated that the plant contains higher moisture and fiber content. The higher moisture contents in all the processed samples, this might be due to processing methods and other environmental factors. The higher value of lipid content for fermented samples was recorded in millet bran followed by value recorded in guinea corn bran and lower value was recorded in maize bran while sun dried Tofu soybean recorded the highest lipid content followed by value recorded in millet bran and the lower value was recorded in maize bran followed by value recorded in rice bran, and were significantly different ($p<0.05$). These variations in lipid content of the processed samples could be attributed to the different processing methods employed. The lipid content for both sun-dried and fermented samples were lower when compared with the value obtained for raw soybean (23.55%) reported by (Paul and Southgate, 1985), except fermented millet bran with higher value of lipid content ($24.15\pm0.00\%$) and also the values of lipid content obtained in this study for both sun-dried and fermented samples were lower than $42.88\pm 0.99\%$ for fermented calabash seed meal reported by Ibeabuchi (2014).

The fermented maize bran recorded the highest value of fiber content followed by values recorded in rice bran and millet bran, and lower value was recorded in guinea corn bran followed by value recorded in soybean bran while sun dried rice bran , recorded the highest value of fiber content followed by value recorded in Tofu soybean and lower value was recorded in maize bran followed by value recorded in guinea corn bran and were significantly different ($p<0.05$) a. Higher fiber was recorded in fermented samples when compared with the values recorded in sun-dried samples, these variations in fiber content of the samples could be attributed to the different processing methods employed. The value recorded in this study was higher than 3.65% as obtained by (Chinyere et al., 2009) who analyzed raw calabash seed, except fermented guinea corn bran with low value of fiber content ($0.25\pm0.10\%$).

Crude protein content for fermented maize bran recorded the highest value followed by value recorded in millet bran and the least value was recorded in rice bran followed by value recorded in guinea corn bran while in sun dried method, the higher value of crude protein content was recorded in rice bran followed by value recorded in soybean bran ad lower value of crude protein content was recorded in maize bran followed by value recorded in guinea corn bran, and were significantly different ($p<0.05$) . Higher crude protein was recorded in fermented samples when compared with the values recorded in sun-dried samples, these variations in crude protein content of the samples could be attributed to the different processing methods employed. The high crude protein values recorded for the fermented samples is in agreement with Idah and Nwankwo, (2013) who stated that crude protein increases with increase in temperature and time. Robinson et al. (2001) reported that feed ingredients with crude protein greater than 20% are considered as protein source.

The higher value of carbohydrate content for fermented samples were recorded in rice bran followed by value recorded in soybean bran and lower of carbohydrate was recorded in maize bran followed by value recorded in millet bran while in sun dried method, the higher value of carbohydrate was recorded in millet bran followed by value recorded in guinea corn bran and lower value was recorded in soybean bran followed by value recorded in rice bran and were significantly different ($p<0.05$) across the treatments. The value of carbohydrate obtained in this study was higher than 13.45± 0.95% for fermented seed as obtained by Ibeabuchi (2014).

Table 1: Proximate composition of processed feed ingredients

Parameters	Fermented Method				
	Guinea corn bran	Millet bran	Maize bran	Rice bran	Tofu Soybean
Ash	3.75 ± 0.00^{e}	10.40 ± 0.005^{ab}	4.72 ± 0.01^{d}	9.92 ± 0.01^{c}	10.53 ± 0.01^{a}
Moisture	3.75 ± 0.00^{e}	10.40 ± 0.01^{c}	24.27 ± 0.02^{a}	17.19 ± 0.00^{b}	7.62 ± 0.01^{d}
Lipid	22.62 ± 0.01^{b}	24.15 ± 0.00^{a}	4.51 ± 0.01^{e}	15.89 ± 0.01^{c}	10.98 ± 0.01^{d}
Fibre	$0..25\pm0.10^{d}$	15.02 ± 0.01^{b}	28.15 ± 0.39^{a}	14.44 ± 0.02^{b}	4.98 ± 0.02^{c}
Crude protein	16.62 ± 0.25^{d}	20.84 ± 0.37^{b}	28.15 ± 0.39^{a}	$14.37\pm0.\ 02^{e}$	18.23 ± 0.38^{c}
Carbohydrate	47.13 ± 0.24^{c}	39.72 ± 0.38^{d}	32.35 ± 0.37^{e}	54.79 ± 0.14^{a}	52.65 ± 0.40^{ab}
		Sun dried method			
Ash	12.65 ± 0.01^{b}	5.34 ± 0.01^{d}	15.44 ± 0.01^{a}	9.67 ± 0.01^{c}	4.28 ± 0.01^{e}
Moisture	12.65 ± 0.01^{c}	3.60 ± 0.01^{e}	11.19 ± 0.01^{d}	14.17 ± 0.00^{b}	19.16 ± 0.01^{a}
Lipid	10.67 ± 0.01^{c}	11.58 ± 0.00^{b}	5.16 ± 0.01^{e}	9.016 ± 0.01^{d}	15.21 ± 0.01^{a}
Fibre	4.22 ± 0.01^{d}	15.35 ± 0.01^{c}	3.48 ± 0.24^{e}	26.65 ± 0.00^{a}	25.42 ± 0.00^{b}
Crude protein	7.87 ± 0.25^{d}	9.69 ± 0.44^{c}	3.48 ± 0.24^{e}	14.44 ± 0.56^{a}	12.97 ± 0.52^{b}
Carbohydrate	58.80 ± 0.25^{b}	69.85 ± 0.50^{a}	52.23 ± 0.24^{c}	50.36 ± 2.04^{d}	48.02 ± 0.88^{e}

Means in rows with the same letters are not significantly different ($p>0.05$).

CONCLUSION

The finding of the present study concluded that fermented maize and millet bran contained higher crude protein and could serve as good source of protein and carbohydrate for aquaculture feeds. Based on the finding processing methods were found to have effect on the chemical composition of the feed ingredients but protein retention was higher in fermented samples.

REFERENCES

Alam, A.K., E. Maugham and Matter, W.J. (1996). Growth response of indigenous and exotic carp species to different protein sources in pelleted feeds. Aqua. Res., 27 (9):673-679.

A.O.A.C. (1990). Official Methods Of Analysis Analysis24TH edition, Association of Official Analytical Chemist.,Washinton D.C.

Barros, M.M., Lime, G.I., & Klesius, P.H. (2002). Effect of soybean replacement by cottonseed meal and iron supplementation on growth, immune response and resistance of Channel cat fish (Iclarurus punctatus) to Edwarsiella ictaluri challenge. Aquaculture, 207: 263- 279.

Boyd, C. E., (1979), Water Quality in Warmwater Fish Ponds, Agriculture Experiment Station, Auburn, Alabama, pp 359.

Chinyere, G.C., Emmanual, I.A., Nwaukwa I. and Ugbogu A.E (2009). Nutritive value of Lagenaria sphaeria Seed (wild Bottle Gourds) from South-Eastern Nigeria. Pakistan Journal of Nutrition, 8 (3)

284–287.Devendra, C. (1988). General approaches to Animal Nutrition Research and their Relevance to Fish production in the Asian Region. In: DeSilver, S.S. (Ed.) Finfish Nutrition Research in Asia. Heinemann Asia Singapore, pp: 724.

Falaye, A.E and Oloruntoyin, O.O. (1998). Nutritive potentials of plantain peel meal and replacement values for maize in diets of African cat fish and (clarias gariepinus) fingerlings. http://www.fao.org accessed 13th Jan. 2006

FAO (2008). The state of Insecurity in the world 2008: High food prices and Food security- Threats and Opportunities. Food and Agricultural Organization of the United Nations Rome, 8p.

Faskin, E.A. (2008). Fish as food yesterday and forever, Inaugural lecture Series, 48, the Federal University of Technology, Akure, 52p

Fturoti, E.O. and Bakare, A.L. (1995). Growth and Nutrient Utilization of Clarias gariepinus fed life maggots in sustainable utilization of aquatic/ wetland resources. 182pp.Hassan, L.G. Sani, N.A. Dangoggo, S.M. and Ladan, M. J. (2007). Nutritional Value of Bottle Gourd (Lagenaria Siceraria) Seeds. Global Journal of Pure and Applied Sciences vol 14, NO. 3:301– 306.

Ibeabuchi, J. C. (2014). Proximate and functional properties of raw and fermented bottle gourd seed (Lagenaria siceraria). International Journal of Biotechnology and Food Science Vol. 2(4), pp. 82-87.

Idah, P.A., and Nwankwo, I. (2013). Effects of smoke-drying temperatures and time on physical and nutritional quality parameters of Tilapia (Oreochromis niloticus). International journal of fisheries and aquaculture, 5(3), pp. 29-34. DOI:10.5897/IJFA12.078.

Jibrin H, Abdul-Aziz I, Edah, B. (2018). Nutritional Evaluation of some Non- Non-conventional oil seeds on different processing Techniques. Discovery, 54(267).

Madu, C.T, Sogbesan, O.A. and Ibiyo, L.M.O. (2003). Some Non-conventional Fish Feed Resources in Nigeria. In: A. A. Eyo (Ed,) Proceeding of the Joint Fisheries Society of Nigeria /National Institute for Freshwater Fisheries Research/FAO-National Special Programme for Food Security, National Workshop in Aquaculture held at the National Institute for Freshwater Fisheries Research,15-19 Sept.2003, New-Bussa: pp. 73-83.

Mamman, A.B (2000). Nigeria: A people United, A Future Assured (Sokoto State). Gabumo publishing Co. Ltd., Lagos Nigeria. 298p.

Mamman, T., Ipinjolu, J.K. and Magawata, I. (2013). Hematological indices of Clarias ghariepinus (Burcheel, 1882) fingerlings fed diet containing graded level of Lagenaria siceraria seeds s (Lagenaria vulgaries) meal. Journal of Biology, Agriculture and Health care, 3(17): 100-104.

Okoye, F.C, and Sule, O.D. (1999). Utilization and composition of conventional and non-conventional fish-feed stuffs in Arid Zone of Nigeria. Journal of Arid Zone Fisheries, 1:23-32.

Osagie, A.U and Eka, O. U. (1998). Nutritional Quality of Plant Foods. Post-Harvest Research Unit, Department of Biochemistry, Univeresity of Benin, Nigeria. pp. 104.

Paul, A.A. and Southgate, D.A.T. (1985). McCance and Widdonson's. The composition of foods. 4th Edn., Her Majesty Stationery office.

Robinson, H.E., Menghe, H.L. and Bruce, B.M. (2001). A practical guide to nutrition feeds and feeding of catfish, MAFES Bulletin 979, Department of Information Services, Division of Agriculture, Forestry and Veterinary Medicine, Mississippi State University; pp 1-9.

Saidu, Y., Bilbis, L.S, Shehu, R.A and D. M. Sahabi. D. M. (2003). Proximate Composition and some Mineral Elements content of Calabash (Lageneria vulgaries) seeds. Nigerian Journal of Biochemistry and Molecular Biology, 18 (2): 87-89.

EFFECTS OF TIGER NUT, DATE PALM AND COCONUT PASTE BASED DIETS ON REPRODUCTIVE PERFORMANCE OF MALE AFRICAN CATFISH *(Clarias gariepinus)* BROODSTOCK

[1]Rabo, M. T., [1] N. A. Agbason, [2] W. D. Adamu, [1] B. R. Salau, [2] S. A. Okunsebor, S. U. Ibrahim[3], O. A. Odihi[2]., S. Y. Olem, and [4] O. B Osuagbalende

[1]Department of Fisheries Technology, College of and Agriculture, Science and Technology Lafia, Nasarawa State
[2]Department of Aquaculture and Fisheries Management, Nasarawa State University Keffi
[3]Department of Water Resources, Aquaculture and Fisheries Technology, Federal University of Technology, Minna Niger State
[4]Department of Zoology, Nasarawa State University Keffi, Nasarawa State

Email: rabomohammedtanko@gmail.com Phone No. 07038965234

ABSTRACT
A study on the effect of Tiger nut, Date palm and Coconut paste based diets on reproductive performance of male African Catfish *(Clarias gariepinus)* broodstock was carried out for eight weeks. The date palm, coconut and tiger nut were purchased from Lafia Modern Market and 1.09±8.23kg each were mixed and blended in four litres of water to form paste stock solution. A 40% experimental diets were formulated using different proportions of stock solution of 0, 400, 800, 1200 and 1600 mls. Twenty (20) male brood stocks of Clarias gariepinus of average weight of 1.09±8.23kg were sourced from Insha'Allah Fish Farm Shabu Lafia. Two of the fish were randomly selected and stocked in five treatments (Control, T1, T2, T3, T4) in two replicates. The fish were fed with the experimental diets for eight weeks at 3% body weight after which they were harvested and taken to the laboratory for analysis for sperms counts, motility and morphology. The fish were evaluated for percentage fertilization, hatchability, and survival rate and charts were used to present results for reproductive indices. The result of the study revealed that Tigernut+Coconut+Date palm paste formulated diets at 1200 mls improved motility, morphology and survival of Clarias gariepinus. Highest percentage of motility was recorded in T5 for sperm activeness (51.33%) while sluggishness in T2 (44.67%) but dead cells were recorded more in T1 (52.33%). Sperm morphology were significantly different (P>0.05) and highest percentage for normal cells were recorded in T5 (86.33%) while abnormal cells were recorded in T1 (42.67%). Fish fed 1600 mls of the paste formulated diets had the highest percentage fertilization (93.76%), hatchability rates (99.16%) while survival rate was highest in T4. Feeding tigernut+coconut+Date palm paste formulated diet to male Clarias gariepinus broodstocks improved reproductive performance. Tigernut+coconut+Date palm paste formulated diets has pro-

Keywords:
Fertilization, hatchability, survival rate, sperm count, sperm morphology

fertility property in the study without any adverse effect. Fish breeders should incorporate tigernut+coconut+Date palm in the diet of Clarias gariepinus broodstock at 1600 mls for high reproductive performance. Further studies on the reproductive capacity of other fish species should be carried out.

INTRODUCTION

Fish with reproductive system impairments, particularly catfish, are typically viewed as sick or as having infertility, a negative concept in most cultures. Some of the etiologies of declining male fertility can be related to falling androgen levels, decreased sexual activity, alterations in sperm quality, especially, motility, morphology, and DNA integrity (Sartorius and Nieschlag, 2010). Study also has shown that sperm motility can be changed in a short period and seems to be closely coupled to diet (Daniel et al., 2019). The benefits of medicinal plants in the treatment of sperm abnormalities have been attributed to their antioxidant, anti-inflammatory, and venotonic activity along with their contents that promote sperm production and increase blood testosterone levels (Tahvilzadeh *et al.*, 2016).

Coconuts have also proven to be strong antioxidant, and source of hydration in the prevention of kidney stones and reduction of blood pressure (Bhagya *et al.*, 2012). It has long been known that using date palm pollen (DPP), the male reproductive dust found in palm blooms, as a dietary supplement can boost libido and enhance fertility in both men and women. It is known to contain a variety of compounds including amino acids, fatty acids, flavonoids, saponins, and sterols (Tahvilzadeh *et al.*, 2016). Tiger nut has a high nutritional mineral content, primarily potassium and phosphorus, as well as a high calorie level (starch, fat, sugar, and protein). The oil of the tuber was found to contain 18% saturated (palmitic acid and stearic acid) and 82% unsaturated (oleic acid and linoleic acid) fatty acids (Adesanya *et al.*, 2007).

The major concern in fish hatchery is the problem of fish inability to supply viable milt, however, little or no mature milt cells could be found which is not enough to complete the process of fertilization. The use of medicinal plants especially like the combination of date palm, coconut and tigernut to ascertain reproductive performance of male Clarias gariepinus could be of help to fish farmers and this will reduce the cost of maintaining brood stocks.

MATERIALS AND METHODS

Description of the Study Area

The research was carried out at the Faculty of Agriculture Shabu, Lafia Campus, Nasarawa State University Keffi, Nasarawa State, Nigeria, for sixty days.

Sample Collection and Preparation of Stock Solution

The date palm, coconut and tigernut were collected from Lafia Modern Market Nasarawa State Nigeria. One kilogramme of coconut, tigernut, and date palm fruits were combined and ground into paste in 4 litres of water using grinding machine before the formulation of the experimental diets.

Collection of Brood stock and Experimental Design

The twenty (20) male brood stocks of Clarias gariepinus male with average weight of 1.09±8.23kg was sourced from a reputable fish farm around College of Agriculture Science and Technology Lafia Community. They were acclimatized for two weeks without feed to burn the fat in their abdominal cavity. Four fish was randomly selected and stocked in five treatments (T1 (Control), T2, T3, T4, T5) in two replicates making a total of twenty fish for the experiment. The fish were fed with the experimental diets (40%CP) containing the stock solution at different proportions. Treatments fish were fed for eight weeks after which they was harvested and taken to the laboratory for analysis.

Table 1: Experimental Diet
TnCnDp = Tigernut+Coconut+Date palm

Ingredients	T1	T2	T3	T4	T5
TnCnDp paste	0mls	400mls	800mls	1200mls	1600mls
Fishmeal (kg)	19	19	19	19	19
GNC(kg)	27	27	27	27	27
SBM(kg)	29	29	29	29	29
Cassava flour(kg)	12	12	12	12	12
Maize Bran(kg)	10	10	10	10	10
Lysine (g)	0.5	0.5	0.5	0.5	0.5
Methionine(g)	0.5	0.5	0.5	0.5	0.5
Bone Meal(g)	0.5	0.5	0.5	0.5	0.5
Vitamin premix(g)	0.25	0.25	0.25	0.25	0.25
Vitamin C (g)	0.5	0.5	0.5	0.5	0.5
Salt(g)	0.5	0.5	0.5	0.5	0.5
Oil (g)	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100

Determination of Sperm Quality

The fish was taken to the laboratory and milt sacs were removed from the abdomen of the fish by sacrificing the fish. Sperm count was done with the aid of hemocytometer according to the method of Eliasson et al. (2003). Motility of spermatozoa was determined according to the methods of Tijee and Oentoeng (2008). Sperm abnormality was determined according to the method adopted by Airaodion et al. (2019) while seminal pH was measured using a pH meter as described by Airaodion et al. (2019).

Fertilization and Hatching Rates

To remove the milt sac, male broodstocks were chosen at random from each treatment and sacrificed. The female broodstock were induced with ovaprim hormone at 0.5ml per 1kg body weight of female broodfish intramuscularly. The female broodstock fish were stripped of their eggs in a clean bowl and then 1g of each egg was measured into fifteen separate bowls. The percentage of egg fertilized as well as the percentage number of egg hatched and percentage survival were computed;

$$\% \text{ Fertilization} = \frac{\text{number of fertilized eggs}}{\text{total number of eggs incubated}} \times 100$$

$$\% \text{ Hatchability} = \frac{\text{number of eggs hatched}}{\text{total number of eggs fertilized}} \times 100$$

$$\% \text{ Survival} = \frac{\text{number of fry}}{\text{total number of hatchlings}} \times 100$$

STATISTICAL ANALYSIS

Charts were used to apply analysis of variance to the data. The results were shown as the mean plus the standard deviation. The means were compared using one-way analysis of variance (ANOVA), which was followed by the Genstat statistical programme version 15. At $p<0.05$, differences in means were deemed significant.

RESULTS

Combined Effect of Tigernut, Coconut and Date Palm on Sperm Motility, morphology and total sperm count of Clarias gariepinus Broodstock

Figure 1, 2, and 3 shows the outcome of the interaction of date palm, coconut, and tigernut on sperm quality. The results indicate that there are substantial differences (P<0.05) in the sperm motility, morphology and total sperm counts.

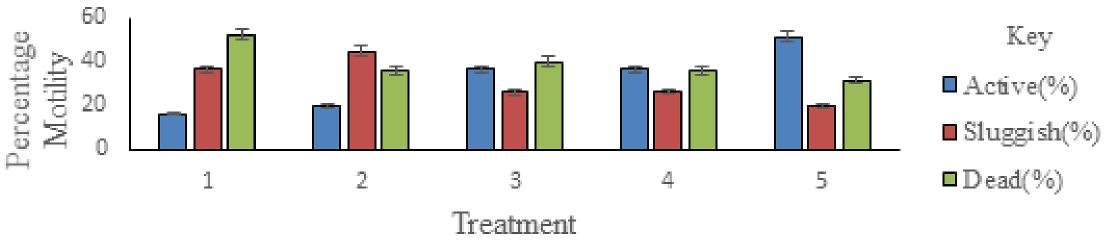

Figure 1: Effect of Tigernut, Coconut and Date Palm paste formulated diet on Sperm Motility of *Clarias gariepinus* Broodstock

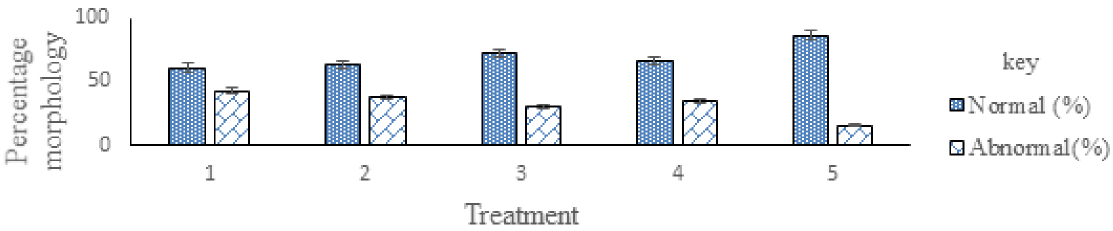

Figure 2: Effect of Tigernut, Coconut and Date Palm paste formulated diets on Sperm Morphology of *Clarias gariepinus* Broodstock

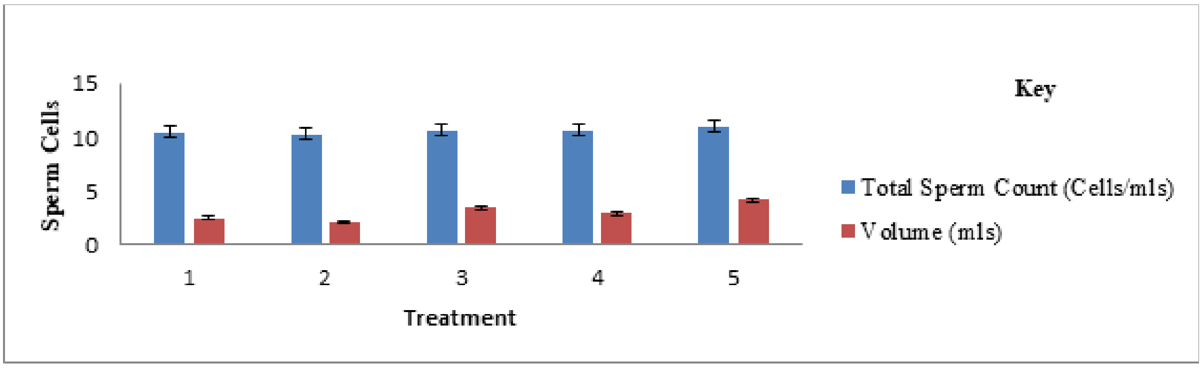

Figure 3: Effect of Tigernut, Coconut and Date Palm paste formulated diets on Total Sperm Count and Sperm Volume of *Clarias gariepinus* Broodstock

Effect of the combination of Tigernut, Date palm and Coconut paste Diet on Reproductive Performance of Male *Clarias gariepinus* Broodstock

The result of reproductive performance of fish fed experimental diets is presented in Table 1. The percentage fertilization varied substantially (P<0.05), with T5 having the highest rate (93.76±1.89) and T4 having the lowest rate (87.03±1.45). Hatchability rates were significantly different (P<0.05) from each other and the highest values was recorded in T5 (99.16±1.11) which was slightly higher than T4 (97.85±2.11) and T2 (97.80±2.12) followed by T3 (96.98±2.31) while T1 (94.34±1.00) was the lowest. The highest survival rate was recorded in T4 (79±0.70), followed by T5 (74±0.66), T3 (72±0.68), T1 (68±0.76) while T1 (65±0.66) was the lowest.

Table 1: Effect of the combination of Tigernut, Date palm and Coconut paste Diet on Reproductive Performance of Male *Clarias gariepinus* Broodstock

Parameter	T1	T2	T3	T4	T5
No. of eggs	20,000	20,000	20,000	20,000	20,000
Hatched eggs	12750±11.12 [d]	14894±11.72 [c]	14786±11.22 [c]	17032±13.21 [b]	18595±13.45 [a]
Dead eggs	6491±4.23 [d]	4770±3.47 [c]	4754±3.1 [c]	2595±2.32 [b]	1248±3.11 [a]
Fert. rate (%)	67.55±1.11 [c]	76.15±1.04 [b]	76.23±1.13 [b]	87.03±1.45 [ab]	93.76±1.89 [a]
Hatch. Rate (%)	94.34±1.00 [c]	97.80±2.12 [ab]	96.98±2.31 [b]	97.85±2.11 [ab]	99.16±1.11 [a]
Surv. Rate (%)	68±0.76 [c]	65±0.66 [d]	72±0.68 [bc]	79±0.70 [a]	74±0.66 [b]

Means with the same superscript are not significantly different (P>0.05) from each other along the row

DISCUSSION

The current study shows that combining tigernut, coconut and date palm had effect on sperm motility. Treatments with inclusion of the combination of tigernut, coconut and date palm shows significant result better than the control which could be attributed to the potency of the active elements contain in the test ingredient. This could be due to presence of a greater concentration of minerals, including copper, potassium, magnesium, manganese, iron, phosphorus and calcium (Baliga et al., 2011) and high concentration of monounsaturated fatty acids, mainly oleic acid (Alharbi et al., 2021). Similar finding was reported by Adeparusi et al. (2010) on male *Clarias gariepinus* broodstock fed diets supplemented with Kigelia African. Adekunle et al. (2019) reported highest milt volume in fish fed highest inclusion of Cyperus esculentus due to presence of anti-oxidants.

Fish fed T5 diets had the highest percentage of normal cell with the lowest percentage of abnormal cells vice versa with the control respectively. These results are in agreement with a study reported by Al-Essawe and Almashhadani (2010), who reported more of normal cells in mice treated with ethanol seed extract of Cyperus esculentus. The results obtained in the study for diets containing test ingredient could be due to the nutritional content possess in the plants materials impacting positive influence on sex hormones (Agbai and Nwanegwo, 2013).

The study's findings demonstrated that the sperm's greater motility percentage was much superior to that of the control diet, with diet T5 having the highest percentages of motility. Fish sperm concentration is an important parameter in hatchery reproduction management and it is highly variable and depends on species, individuals, fish size, and season (Khanam et al., 2008). The findings of this study demonstrated that feeding *Clarias gariepinus* broodstock with diet rich in tigernut, coconut, and date palm paste improves reproductive success. As the amount of test materials is added, the percentage of fertilised eggs, percentage of eggs that hatch, and number of hatched eggs of Clarias gariepinus larvae rise. Highest survival was observed in fish fed 1200mls of the test ingredients. Similar result were obtained by Dada and Ajilore (2009) as they observed high percentage fertilization and hatchability in Clarias gariepimus broodstock using 0.25g of kola seed powder per kg of feed.

CONCLUSION

Combination of tigernut+coconut+Date palm paste at 1600mls in the diet of African catfish (Clarias gariepinus) broodstocks improved survival, motility and morphology of reproductive parameters of *Clarias gariepinus*.

RECOMMENDATIONS

Fish breeders should incorporate tigernut+coconut+Date palm paste in the diet of *Clarias gariepinus* broodstock at 1600ml for high reproductive performance. Further studies on the reproductive capacity of other fish species should be carried out by feeding tigernut+coconut+Date palm paste diet.

REFERENCES

Adekunle, A, D., Gbajuola G. O., Adedapo, A. A. and Oke, I. O. (2019). Dietary Effects of Tiger Nut (Cyperus esculentus) on Egg and Milt Quality of African Catfish (Clarias gariepinus) Broodstocks (Burchell, 1822). Asian Journal of Fisheries and Aquatic Research. 5(1): 1-12.

Adeparusi, E.O., Dada, A.A. and Alale, O.V. (2010). Effect of medicinal plant (Kigelia africana) on sperm quality of African Catfish, Clarias gariepinus (Burchell, 1822) broodstock. Journal of Agricultural Science. 2(1):193–199.

Adesanya, O. A., Oluyemi, K. A., Omotuyi, I.O., Saalu, C. L. and Josiah, S. J. (2007). Erythropoietic and anti-obesity effects of Garcinia cambogia (Bitter Kola) in Wistar rats. Biotechnology and Applied Biochemistry, 46: 69–72.

Agbai, E.O. and Nwanegwo, C.O. (2013). Effect of methanolic extract of Cyperus esculentus L. (tigernut) on luteinizing hormone, follicle stimulating hormone, testosterone, sperm count and motility in male albino Wistar rats. J Med Applied Biosci., 5:52-61.

Airaodion, A. I., Ogbuagu, E. O., Ekenjoku, J. A., Okoroukwu, V. N., Ogbuagu, U. and Airaodion, E. O. (2019). Antifertility effect of ethanolic leaf extract of Carica papaya in male Wistar rats. Merit Research Journal of Medicine and Medical Science;7(10):374-381.

Al Essawe, E.M.A. and Almashhadani, A.A.M. (2010) The effect of Cyperus esculentus on sperm function parameters in prepubertal mice as a model for human. Baghdad Sci J., 7(1):389-393.

Alharbi, K. L., Raman, J. and Shin, H. J. (2021). Date fruit and seed in nutricosmetics Cosmetics, 8 (3), p. 59

Aremu, M. O., Ibrahim, H. and Aremu, S. O. (2016). Lipid composition of black variety of raw and boiled tigernut (Cyperus esculentus L) grown in North-East Nigeria. Pakistan J Nutr 15: 427-438.

Baliga, M.S., Baliga, B.R.V., Kandathil, S.M., Bhat, H.P. and Vayalil, P.K. (2011). A review of the chemistry and pharmacology of the date fruits (Phoenix dactylifera L.). Food Res. Int., 44 (7), pp. 1812-1822

Bhasya, D., Rema, L. and Rajomohan, T. (2012). Therapeutic effects of fender coconut water on oxidative stress in frutise fed insulin resistant hypertensive rats. Asian pac Trop med. 5 (4): 270 –276.

Dada, A. A. and Ajilore, V. O. (2009). Use of ethanol extracts of Garcinia Kola as fertility enhancer in female catfish (Clarias gariepinus) broodstock. International Journal of Fisheries and Aquaculture, 1(1):1-5

Daniel, N., Unn, k., Eduard, C., Elizabeth, N. and Stefan, Z. (2019): Human sperm displays rapid responses to diet.PLOS Biology, 2019; 17(12)

Eliasson, M. T., Bilbis, L.S., Lawal, M. and Akanji, M. A. (2003). Effect of repeated administration of sildenafil citrate on selected enzyme activities of liver and kidney of male albino rats. Nigerian Journal of Pure and Applied Sciences;18:1395-4000.

Sartorius, G. and Nieschlag, E. (2010). Paternal age and reproduction. Hum. Reprod. Update.; 16: 65-79.

Tahvilzadeh, M., Hajimahmoodi, M., Toliyat, T., Karimi, M. and Rahimi, R. (2016). An evidence-based approach to medicinal plants for the treatment of sperm abnormalities in traditional Persian medicine. Andrologia.;48(8):860–79.

Tijee, T.W. and Oentoeng, R.E. (2008). Infertility in Male. pp566

ASSESSMENT OF PROXIMATE COMPOSITION OF HOUSEFLY MAGGOTS (Musca domestica) PRODUCED FROM DIFFERENT SUBSTRATES.

1Abubakar F. B., 2A. Yunusa., 3M. A. Ahmad., 4 E. A. Edward., and 5A. Yusuf.

1Department of Fisheries and Aquaculture, Faculty of Agriculture, Ahmadu Bello University, Zaria, Nigeria
2Prince Abubakar Audu University, (PAAU) Anyigba, Kogi State

Corresponding Author:
fatiimaabubakar@gmail.com Tel: +2348127354882

ABSTRACT

A comparative study analyzed the proximate composition of Musca domestica maggots reared on four substrates: broiler waste, brewers' waste, cow dung, and layers waste. The study aimed to evaluate the potential of maggots as a substitute for fish meal in aquaculture diets, considering the rising cost of fish feed. Each substrate (1 kg dry weight) was prepared in duplicates, with 0.5 kg of blood added as an attractant and water sprinkled to moisten. The setup was maintained under shade at 28–30°C and left open for fly access. Maggots were harvested, washed, dried, and milled into powder for proximate analysis. The results showed that maggots from layer waste had the highest crude protein (40.48%), followed by brewers' waste (40.12%), broiler waste (39.25%), and cow dung (38.36%). Crude fiber (6.30%) and crude lipid (5.28%) were also highest in maggots from layer waste. Ash content was highest in maggots from brewers' waste (7.30%), while those from cow dung had the highest nitrogen-free extract (NFE) at 44.95%. These findings indicated significant differences in the proximate composition of maggots across substrates. All maggot samples contained sufficient crude protein levels, demonstrating their suitability as a potential substitute for fish meal in aquaculture. The study underscores the economic and nutritional benefits of Musca domestica maggots, highlighting their role as a sustainable and cost-effective feed option for the aquaculture industry.

Keywords:
Musca domestica,
Substrates,
Proximate analysis,
Fish meal.

INTRODUCTION

Aquaculture is the world's fastest growing food production sector, contributing significantly to food security and nutrition, poverty reduction, and economic growth, particularly in rural areas (FAO, 2020). Once fish are removed from their natural environment to an artificial one, they must be fed supplementary diet for proper growth and development (Aliu et al., 2016). Fish feed plays a crucial role for fish production in the conventional fish culture system, representing about 60-70% of production costs (FAO, 2020). This can sometimes negate the economic viability of a farm if suitable feed is not used. This problem has become a major source of fear to many prospective fish farmers in Nigeria and an urgent solution must be proffered if fish farming is to be attractive, lucrative and sustainable (Adeoye et al, 2021).

The use of insects as animal feed is increasingly promoted as a replacement for fishmeal, which is the most expensive ingredient in fish feed formulation (Worldbank, 2022). Among insects, fly larvae are particularly promising because they can be produced cheaply and rapidly on organic waste material

(Pastor et al., 2015). The demand for fish feed can be effectively addressed by ensuring the availability of locally produced fish feed. Maggot meal has been identified as a potential alternative to fish meal (FAO, 2020). Culture of maggots is used in converting waste of low economic value, for example animal dung into valuable animal protein (FAO, 2021). They are easy to produce, process and are relatively cheaper than other sources of animal protein (Leyo, et al., 2023). The overall nutrient content (viz: crude protein, lipid and essential amino acid content) of house fly larvae meal may be comparable with fishmeal. Rearing insect could be one way to enhance food and feed security considering that housefly larvae can feed on waste biomass including fruits and vegetable peels, food wastes, sewage, manure and slurry (Adegbeye, et al., 2020), transforming these wastes to high value food and feed resources (Cheng, et al., 2021). This study is aimed to assess proximate composition of maggots produced from different substrates.

MATERIALS AND METHODS

Experimental Design

This study was conducted in NAERLS livestock unit, Ahmadu Bello University, Zaria. The experimental site is located at 11.1512°N latitude and 7.6546°E longitude. The experiment set up was constructed using a 13-liter and 2-liter plastic container with covers. The 6 13-liter containers were perforated at the middle and a hose (12 inches) connected to each 13-liters and 2-liters plastic container which served as a collecting container for the maggot. 1kg (dry weight) of the different substrates (broiler waste, brewery waste, cow dung & layers waste) were weighed and placed in the 13-liter container and replicated 3 times. 0.5kg blood was added as an attractant, water was sprinkled on each unit to moisten the substrate. The set up was kept under a shade and cover was perforated for fly access to the substrates. The temperature was within 28-30 0C. The maggots were harvested, washed, dried and milled into powder.

Proximate Analysis

The proximate composition of the housefly maggots obtained from the different substrates were determined as described by the Association of Official Analytical Collaboration (AOAC, 2010).

Statistical Analysis

The data obtained was subjected to ANOVA using SPSS, Statistical package version 20 for windows software, the means were separated using New Duncan's multiple range test (DMRT). The significance was accepted at $p < 0.05$.

RESULTS AND DISCUSSIONS

The result from the proximate analysis of housefly maggots (Musca domestica) produced from different substrates, as presented in table 1, shows that the maggots produced from the Layer waste has the highest crude protein content at 40.48% while those sourced from Cow dung contain the lowest at 38.36%. These results are comparable to the crude protein content of 47.1% as reported by Aniebo, et al (2008) who produced maggots from the mixture of cattle blood and wheat bran, and also the crude protein content of fish meal (ranging from 31.3%-61.2%) as reported by Emran, et al., (2016). The highest crude fibre content is observed in the maggots produced from Layer waste at 6.30% which is comparable to the crude fibre content at 7.5% as reported by Aniebo, et al (2008). The highest crude lipid content was observed in the maggots produced from layer waste at 5.28% which is significantly lower than the crude lipid content at 25.3% as reported by Aniebo, et al (2008). The highest ash content was observed in the maggots produced from the brewery waste with 7.30% which is comparable to the ash content at 6.25% as reported by Aniebo, et al (2008) but doesn't fall within the range of Ash content of fish meal at 13.3%-36.7% as reported by Emran, et al (2016). The maggots produced from cow dung had the highest NFE with 44.95% which is significantly higher than the range of NFE content in fish meal (0.6%-12.6%) as reported by Emran, et al (2016).

Table 1 Proximate Composition of Housefly Maggot (Musca domestica) using different substrates

	Processing methods			
Constituents	**Broiler waste**	**Brewery waste**	**Cow dung**	**Layer waste**
Crude protein	39.25±0.03[c]	40.12±0.07[b]	38.36±0.07[d]	40.48±0.07[a]
Crude Fibre	5.20±0.02[d]	6.13±0.03[b]	5.65±0.03[c]	6.30±0.03[a]
Crude Lipid	4.92±0.01[c]	5.27±0.03[b]	4.79±0.03[d]	5.28±0.03[a]
Ash	6.12±0.00[d]	7.30±0.00[a]	6.25±0.00[c]	6.44±0.00[b]
NFE	44.51±0.01[b]	41.18±0.00[d]	44.95±0.01[a]	41.51±0.01[c]

Means on the same row with the same superscripts are not significantly different (p<0.0

CONCLUSION

There is significant difference in the proximate composition of the maggots produced from different substrates. The crude protein content of maggots produced from the substrates are all good but the maggots produced from the layer waste has the highest crude protein content which makes it the most suitable substrate for the production of maggots for aquaculture diets.

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REFERENCES

Adegbeye, M. J., Salem, A. Z. M., Reddy, P. R. K., Elghandour, M. M. M., and Oyebamiji, K. J. (2020). Waste recycling for the eco-friendly input use efficiency in agriculture and livestock feeding. Resources use efficiency in agriculture, 1-45.

Adeoye, S.A., Adeogun, A.O., and Oladosu, G.A. (2021). Economic challenges in the Nigerian aquaculture sector: Strategies for improvement. Journal of Aquaculture Research, 14(2), 123-135.

Aliu, B.S., Wunti, D.B., and Babatunde, G.M. (2016). Fish Production in Nigeria: a sustainable approach. International journal of fisheries and aquatic studies, 4(5), 157-162

Aniebo, A. O., Erondu, E. S., and Owen, O. J. (2008). Proximate composition of housefly larvae (Musca domestica) meal generated from mixture of cattle blood and wheat bran. Livestock Research for Rural Development, 20(12), 1-5.

Cheng, Z., Yu, L., Li, H., Xu, X., and Yang, Z. (2021). Use of housefly (Musca domestica L.) larvae to bioconversion food waste for animal nutrition and organic fertilizer. Environmental Science and Pollution Research, 28(35), 48921-48928.

Emran, H., Khodeja, A., and Goutam, B. D., (2016). NUTRITIVE VALUE OF FISH MEAL. Journal of Animal and Feed Research. 6(1): 14-19

Food and Agriculture Organization of the United Nations. (2020). The State of World Fisheries and Aquaculture 2020. FAO.

Food and Agriculture Organization of the United Nations. (2020). National Aquaculture Sector overview: Nigeria. FAO

Food and Agriculture Organization of the United Nations. (2020). The use of insects as animal feed: a sustainable solution for livestock and fish industries. FAO

Food and Agriculture Organization of the United Nations. (2021). Insects as feed: Housefly larvae as a sustainable protein source. FAO,

Leyo, I. H., Ousmane, Z. M., Francis, F., and Megido, R. C. (2023). Optimal substrates for producing housefly larvae with high nutritional composition for sustainable poultry feed in Niger. Journal of Insects as Food and Feed, 9(2), 193-203.

Pastor, B., Velasquez, Y., Gobbi, P., Rojo, S., and Masdeu, M. (2015). Insects as an alternative protein source: production of black soldier fly larvae for human and animal nutrition through waste valorization. Food and Agriculture Organization of the United Nations.

World Bank. (2022). Edible insects as a sustainable alternative for fish feed.

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ASSESSMENT OF AMINO ACID PROFILE OF RAW AND PROCESSED Sesbania sesban SEED AS AN ALTERNATIVE SOURCE OF ESSENTIAL AMINO ACIDS IN Clarias gariepinus DIET

[1]Ahmad, M. A., [1]A. Yunusa, [1]M. Tukur, [2] A. M. Musa, [1]F. B. Abubakar and[1]E. A. Edward

[1]Department of Fisheries and Aquaculture, Faculty of Agriculture, Ahmadu Bello University, Zaria, Kaduna state, Nigeria.
[2]Department of Fisheries and Aquaculture, Faculty of Agriculture, Federal University, Gashua, Yobe state, Nigeria.

Corresponding author:
maimunaamshi246@gmail.com, +2349022141267

ABSTRACT

This study evaluated the amino acid profile of raw and processed Egyptian riverhemp (Sesbania sesban) as an alternative source of protein for Clarias gariepinus diet. Six (6) kg S. sesban seeds were picked and divided equally into 5 portions of 1.2kg each. One portion was kept raw, the second portion was soaked in water, the third portion was boiled at 1000c in water, the fourth portion was fermented, and the fifth portion was roasted. All five portions were milled into powder and subjected to amino acid analysis. The analysis of S. sesban seed meals showed significant differences (P<0.05%) in the amino acid contents of raw and processed meals. Raw S. sesban seed meal showed the highest content of the essential amino acid Phenylalanine (13.87). The fermented S. sesban seed meal showed the highest contents of the EAAs Arginine (9.97), Threonine (8.20), Tyrosine (10.74), Leucine (5.35), and Tryptophan (10.52). Boiled Sesban seed meal treatment reported the highest content of the EAAs Histidine (5.94), Lysine (16.47) and Methionine (12.98). Soaked S. Sesban seed meal treatment reported the highest contents of Valine (12.30) and Isoleucine (13.88). Levels of EAAs observed for raw and processed Sesbania sesban seed meal in this study are sufficient to meet the Amino acid requirement for Clarias gariepinus. Thus, S. sesban seed meal is a good alternative source of EAAs for use in the Clarias gariepinus diet.

Keywords:
Egyptian riverhemp,
Amino acid,
Clarias gariepinus.

INTRODUCTION

Clarias gariepinus is a widely cultivated and consumed fish species in Nigeria, with significant economic and nutritional value. The rising cost of feed ingredients has impacted negatively on the culture of Clarias gariepinus in Nigeria since about 70-80% of the cost of producing fish goes to feeds (Bolorunduro and Adikwu, 2016). With the ever-increasing demand for food nationally, it is expected that the cost of plant-based protein sources will continue to rise. This situation is largely due to the unavailability of inputs, competition between humans, animals, and industries over basic feed ingredients (Dronne, 2018). Fish feed formulation primarily involves the inclusion of proteins and amino acids, lipids, carbohydrates, vitamins, and minerals. Protein is the most critical and expensive component of fish diet and amino acids are the end products of protein digestion which are crucial for growth and development of Clarias gariepinus. Formulating diets based on digestible amino acids allows for the incorporation of alternative protein sources with lower digestibility. This strategy enhances the accuracy of least-cost diets and reduces nitrogen waste from aquaculture operations (Naylor et al., 2021). Despite the recognized benefits of using digestible amino acids, many regions of the world still formulate diets based on total amino acid content (Kim et al., 2020). Nevertheless, the rising cost of traditional protein sources is likely to push the aquaculture industry towards utilizing cheaper, alternative protein supplements such as Sesbania sesban, which have lower digestibility coefficients (Abou-Elezz et al., 2023). Studies have shown that the crude protein content of Sesbania sesban can range from 30-40% depending on the processing methods used (Singh & Srivastava, 2024). This makes it a promising legume for addressing protein deficiencies in fish diet (Chikagwa-Malunga, 2018). However, there is a knowledge gap in understanding the effects of processing methods on the amino acid profile of Sesbania sesban seeds which necessitates this study.

MATERIALS AND METHODS

Collection of Seeds

Sesbania sesban seeds were collected from Amshi, Jakusko Local government area of Yobe State. The area is located at latitude 12.710270 N and longitude 10.875930 E. and processed in the Department of animal science ABU, Zaria. The laboratory analysis was conducted at the Multiuser lab of the department of Chemistry, Faculty of Science, Ahmadu Bello University, Zaria Located at latitude 11°09' 06" N and longitude 7° 38' 55" E.

Experimental Design

Six kilograms (6kg) of Sesbania sesban seeds were thoroughly picked and divided equally into 5 portions.1.2kg of raw Sesbania sesban seeds were milled and labeled as sample A. Another 1.2kg of the seeds were boiled for 1hour 30 minutes at 100oC, the boiled seeds were later sun-dried for 1 day and milled into powder using hammer mill and labeled as sample B. The third 1.2kg of seeds were cleansed, washed, and soaked in water for 24 hours. The soaked seeds were dried for 1 day, milled into powder and labeled as sample C. The fourth 1.2kg seeds were boiled for 1 hour at 100oC and kept in an airtight container to ferment for 72hours. The fermented seeds were washed and sun-dried for 1 day, then milled into powder and labeled as sample D. Lastly, the fifth 1.2kg of the seeds were stir roasted in an open pan for 30minutes. The roasted seeds were set aside for 1 hour then milled into powder and labeled as sample E.

Determination of Amino Acid Profile

The Amino Acid profile in the raw and processed samples of Egyptian riverhemp seeds were determined using the method described by Benitez (1989). The samples were dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator, and loaded into the Technicon Sequential Multi-Sample Amino Acid Analyzer (TSM).

Data analysis

Difference among dietary treatment means were tested by one way Analysis of Variance (ANOVA), and means were compared using Turkey's Multiple Comparison Test (Steele and Torrie, 1960) to test for significance of variation between the means and differences will be considered significant at $p < 0.05$

RESULTS AND DISCUSSION

The amino acid compositions of raw and processed Sesbania sesban seed meals (g/100g) are presented in Table 1. The raw sample of Egyptian riverhemp seed meal was observed to have the highest contents of the amino acids Cystine (11.39) and Phenylalanine (13.87) and the lowest contents of Alanine (7.85), Valine (12.00), Isoleucine (12.31), Methionine (12.68), and Tyrosine (9.37). The boiled Sesban seed meal treatment recorded the highest value of Histidine (5.94), Lysine (16.47), Glycine (7.38), Proline (17.38), Methionine (12.98), and Aspartic acid (1.55) but also the lowest contents of Arginine (8.97), Alanine (7.91), Threonine (7.21), Cysteine (11.32), and Tyrosine (9.43). The soaked Sesban seed meal treatment reported the highest contents of Valine (12.30), Isoleucine (13.88), and

Glutamic acid (1.65) but also the lowest content of Leucine (13.43). The fermented Sesban seed meal showed the highest contents of Arginine (9.97), Alanine (7.99), Threonine (8.20), Tyrosine (10.74), Glutamic acid (1.65), Leucine (5.35), and Tryptophan (10.52) but also the lowest contents of Lysine (16.26) and Glycine (5.78). The roasted Egyptian Sesban seed meal showed the highest content of Proline (17.38). The result of this study showed that processed S. sesban seed meal has significantly higher ($P<0.05$) levels of all essential and non-essential amino acids except Cystine and Phenylalanine. The essential amino acids content of raw and processed Egyptian Sesban reported in this study were significantly higher than the amino acid requirement of Clarias gariepinus as reported by FAO, (2013) (Table 1). In this study, Lysine was observed to be the most concentrated EAA while Proline was the most concentrated amino acid in S. sesban seed meal. This contradicts the findings of Olaofe et al., (1993), Oshodi et al., (1998) and Aremu et al., (2006) all of whom observed that Leucine was the most concentrated EAA while Glutamic acid was the most concentrated amino acid in legumes. The Leucine contents of S. sesban seed meals obtained in this study are significantly higher than the values obtained for some Nigerian legumes; lima bean (7.59 g/100 g protein), pigeon pea (8.40 g/100 g protein) and African yam bean (7.45 g/100 g protein) reported by Oshodi et al. (1998). Transamination and deamination reactions might be responsible for slight changes in the amino acid profiles of raw and processed legumes (Aremu et al., 2009).

Table1. Amino Acid Composition of Raw and Processed Egyptian sesban Meals. (g/100g)

	TREATMENTS					
	A (Raw)	**B (Boiled)**	**C (Soaked)**	**D (FM)**	**E (Roasted)**	*
Arginine	$9.75^{c}\pm0.11$	$8.97^{d}\pm011$	$9.94^{b}\pm0.13$	$9.97^{a}\pm1.10$	$9.94^{b}\pm0.13$	3.52
Histidine	$5.90^{c}\pm0.15$	$5.94^{a}\pm0.29$	$5.92^{b}\pm0.36$	$5.85^{d}\pm0.29$	$5.90^{c}\pm0.36$	1.37
Lysine	$16.39^{b}\pm0.31$	$16.47^{a}\pm0.31$	$16.35^{c}\pm0.39$	$16.26^{e}\pm0.31$	$16.34^{d}\pm0.39$	5.70
Glycine	$7.09^{c}\pm0.10$	$7.38^{a}\pm0.10$	$5.85^{d}\pm0.12$	$5.78^{e}\pm0.10$	$7.29^{b}\pm0.12$	-
Alanine	$7.85^{e}\pm0.16$	$7.91^{d}\pm0.15$	$7.94^{b}\pm0.19$	$7.99^{a}\pm0.16$	$7.93^{c}\pm0.19$	-
Valine	$12.00^{e}\pm0.32$	$12.12^{b}\pm0.32$	$12.30^{a}\pm0.40$	$12.04^{d}\pm0.32$	$12.11^{c}\pm0.40$	2.08
Isoleucine	$12.31^{e}\pm0.40$	$12.97^{b}\pm0.40$	$13.88^{a}\pm0.05$	$12.63^{d}\pm0.40$	$12.88^{c}\pm0.05$	1.56
Proline	$17.35^{c}\pm0.07$	$17.38^{a}\pm0.07$	$17.36^{b}\pm0.08$	$17.25^{d}\pm0.07$	$17.38^{a}\pm0.08$	-
Threonine	$7.78^{c}\pm0.02$	$7.21^{d}\pm0.02$	$8.00^{b}\pm0.02$	$8.20^{a}\pm0.02$	$8.00^{b}\pm0.02$	2.04
Methionine	$12.68^{e}\pm0.18$	$12.98^{a}\pm0.18$	$12.92^{b}\pm0.22$	$12.76^{d}\pm0.22$	$12.91^{c}\pm0.22$	2.50
Cysteine	$11.39^{a}\pm0.10$	$11.32^{d}\pm0.09$	$11.35^{b}\pm0.12$	$11.35^{b}\pm0.09$	$11.34^{c}\pm0.12$	-
Phenylalanine	$13.87^{a}\pm0.23$	$13.51^{c}\pm0.23$	$13.50^{d}\pm0.28$	$13.76^{b}\pm0.23$	$13.50^{d}\pm0.28$	4.56
Tyrosine	$9.37^{e}\pm0.21$	$9.43^{d}\pm0.17$	$10.54^{c}\pm0.21$	$10.74^{a}\pm0.17$	$10.55^{b}\pm0.21$	-
Aspartic acid	$1.50^{b}\pm0.15$	$1.55^{a}\pm0.15$	$1.43^{d}\pm0.19$	$1.49^{c}\pm0.15$	$1.49^{c}\pm0.19$	-
Glutamic Acid	$1.55^{c}\pm0.37$	$1.60^{b}\pm0.37$	$1.65^{a}\pm0.45$	$1.65^{a}\pm0.37$	$1.60^{b}\pm0.45$	-
Leucine	$13.80^{b}\pm0.07$	$13.46^{c}\pm0.07$	$13.43^{e}\pm0.08$	$15.35^{a}\pm0.07$	$13.44^{d}\pm0.08$	4.87
Tryptophan	$10.40^{d}\pm0.04$	$10.47^{c}\pm0.04$	$10.49^{b}\pm0.05$	$10.52^{a}\pm0.04$	$10.40^{d}\pm0.05$	1.10

Means on the same row with the same superscripts are not significantly different ($p<0.05$)
*Amino acid requirement for Clarias gariepinus (FAO, 2013)
FM: Fermented

CONCLUSION

The assessment of the amino acid profile of raw and processed S. sesban seed meal showed significant differences ($P>0.05$) in the EAA contents of all the treatments. Furthermore, all treatments contain significantly high amount of EAAs to meet the dietary requirement of Clarias gariepinus. Thus, S. sesban seed meal is an excellent alternative source of EAAs for Clarias gariepinus diet.

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REFERENCES

Abou-Elezz, F. M., Rahman, M. M., and Ahmed, M. H. (2023). Exploring the potential of Sesbania sesban as a sustainable protein source in fish feed. Aquaculture Reports, 25, 101378.

Aremu, M.O., O. Olaofe and E.T. Akintayo, 2006. Chemical composition and physicochemical characteristic of two varieties of Bambara nut (Vigna subterranean) Flours. Journal of Applied Science, 6: 1900-1903.

Benitez, L. V. (1989). Amino acid and fatty acid profiles in biological samples. In Modern techniques for amino acid and protein analysis (pp. 69–80). CRC Press.

Bolorunduro, P. I., and Adikwu, I. A. (2016). Economic analysis of catfish production in Ibadan, Oyo State, Nigeria. Animal Research International, 13(2), 2225-2232.

Chikagwa-malunga, S.K. (2018). Nutritional evaluation of Sesbania sesban as a protein source in livestock feeds. African journal of Agricultural Research, 13(5),210-217.Dronne, M. (2018). Fish and human health. In Reference Module in Food Science and Biotechnology, Elsevier ,445-452.

FAO, (2013). Amino acid requirements of fish and shrimp (FAO Fisheries and Aquaculture Technical Paper No. 580). Rome: FAO.

Kim, J. D., Yoo, G. Y., and Lee, J. K. (2020). Advances in fish nutrition: Digestible amino acids versus total amino acids in diet formulation. Journal of Aquaculture Nutrition, 28(1), 105-115.

Li, P., Mai, K., & Wu, G. (2023). Advances in amino acid nutrition and metabolism in fish. Annual Review of Animal Biosciences, 11(1), 89-109.

Mohanta, K. N., Subramanian, S., and Kumar, V. (2021). Protein and amino acid requirements of tropical freshwater fish species: A review. Aquaculture Nutrition, 27(2), 301-314.

Naylor, R. L., Hardy, R. W., and Bureau, D. P. (2021). Sustainable fish feeds in aquaculture: Digestibility and environmental impact. Nature Reviews Earth & Environment, 2(4), 210-221.

Olaofe, O., O.Y. Umar and G.O. Adediran, (1993). The effect of nematicides on the nutritive value and functional properties of cowpea seeds. Food Chemistry, 46: 337-342

Oshodi, A.A., K.O. Esuoso and E.T. Akintayo, (1998). Proximate and amino acid composition of some under–utilized legume flour and protein concentrates. La Rivista Italiana Delle Sostanze Grasse, Vol. 75, 409-412.

Singh, S., and Srivastava, M. (2024). Phytochemical investigation and in-vitro antioxidant activity of Sesbania sesban and Sesbania grandiflora seeds. National Academy Science Letters, 47(1), 79-85.

Steele, R.G.D., and Torrie, J.H. (1960). Principals and Procedures of Statistics with Special Reference to the Biological Sciences. McGraw- Hill Book Co., Toronto,Ont. 481 pp.

DIETARY EFFECTS OF *Parquetin anigrescens* LEAF MEAL INCLUSION ON THE GROWTH PERFORMANCE OF AFRICAN CATFISH -*Clarias gariepinus* (BURCHELL 1822)

[1]Olaniyi, C. O., [1]O. O. Fawole, [1]M. O. Awotunde, [1]A. O. Opanike, [1]M.S. Agbaje, and [1]O.M Abiodun-Adeyanju

Department of Fisheries and Aquaculture, Ladoke Akintola University of Technology, 210214, Ogbomoso, Nigeria.

Correspondence Author:
oofawole78@lautech.edu.ng. Phone:+2348035002060

ABSTRACT
The continuous rise in cost of fish feed necessitates the need to look inward for cheaper viable alternative feed ingredients. A nutritional study of African catfish (Clarias gariepinus) fed with Parquetina nigrescens leaf meal diets was undertaken. Seventy (70) juvenile African catfish with an average weight of 237.57g were randomly selected, divided into 5 treatments, and stocked at 7 juveniles per tank (120litres) with two replicates each. Five experimental diets were formulated with 0g (T1), 0.02g (T2), 0.03g (T3), 0.04g (T4) and 0.05g (T5) per 100g of dietary inclusion of P. nigrescens respectively. The fishes were fed on experimental diet to satiation twice daily for 12 weeks. At the end of the feeding trials, data collected on growth performance was subjected to one-way analysis of variance (ANOVA) using completely randomized design (CRD). Results showed significant effect ($p<0.05$) of P. nigrescens in final mean weight, feed conversion ratio and protein efficiency ratio of C. gariepinus in diet T3. Based on these findings, it can be said that the inclusion of P. nigrescens leaf meal at 0.03g is the most suitable for optimum performance of African catfish.

Keywords:
Parquetina nigrescens, inclusion level, growth performance, African catfish

INTRODUCTION

Aquaculture industry is facing challenge of high cost of fish feed, and therefore it is very crucial to explore alternative raw materials for feed formulation at the lowest cost. There is also the need to increase fish production and as such, need for fish farmers to source for feeding that will supply high quality protein to improve the growth of fish (FAO, 2018). Previous studies including that of Ali-Emmanuel et al., (2003) have already evaluated the efficiency of various plant-based ingredients as alternative protein sources in aqua-feed production. Plant sources of feed according to Ayoola and Bamiro (2017) contain appreciable crude protein content for maximum productivity. This had attracted a lot of trial experiments by fish nutritionists around the world on the use of leaf meal as a possible fish meal substitute with the aim of reducing the cost of fish feed (Bairagi et al., 2004). P. nigrescens Popularly called African Parquetina in English, Kwakwani by the Hausas, Mgbidingbe by the Igbos and Ewe Ogbo among the Yorubas is a shrub commonly found growing in equatorial West Africa; not cultivated but as a secondary forest and around villages (Awoniyi et al., 2022; Ayoola et al., 2011; Oluwafemi and Debiri, 2008). Previous phytochemical studies of the plant revealed that the ethanol extract of the leaves, roots, stem bark, and latex contained phytochemical compounds such as phenols, tannins, alkaloids, flavonoids, reducing sugars, phlobatannins, terpenoids, saponins, cardiacgly-cosides, steroids, and coumarin (Airaodion et al., 2019; Ajayi et al., 2021; Ayoola et al., 2011; Sopeyin and Ajayi 2016). There has not been any documented report on the effect of P. nigrescens in fish despite its usage for treating human aliments in Nigeria. This study therefore determined the effects of P. nigrescens on growth performance of African catfish ©. gariepinus).

MATERIALS AND METHODS

Collection and Treatment of Test Ingredients

Fresh leaves of Parquetina nigrenscens samples were obtained within Ladoke Akintola University of Technology, Ogbomoso, Oyo State and Ogbomoso metropolis. Identification and authentication of the leaves were carried out at the Crop Production and Soil Science Department of the University using leaf geometric structure and public plant image database (Zhang et al., 2020). The leaves were washed, air-dried at room temperature for 7days and grounded into fine particles using mortar, pestle and grinding machine then stored in a plastic container to avoid contamination prior to analysis.
Feed ingredients were purchased from a reputable feed mill in Ogbomoso and the ingredients used are maize, wheat offal, ground nut cake, fishmeal, soybean meal, vegetable oil, oyster shell, bone meal, salt, methionine and lysine. Five (35% CP) diets containing varying levels P. nigrescens leaf meal was prepared as shown in Table 1. The control diet (T1) has P. nigrescens leaf meal inclusion of 0g, while diet T2, T3, T4 and T5 were 0.02g, 0.03g, 0.04g and 0.05g inclusion per 100g feed respectively. The feed was pelletized and packaged in polythene bag to avoid contamination wastage and mould invasion.

Table 1: Gross Composition of Experimental Diets

Ingredients	T1 (Control)	T2 (0.02g)	T3 (0.03g)	T4 (0.04g)	T5 (0.05g)
Maize	20.60	20.60	20.60	20.60	20.60
W/offal	10.30	10.30	10.30	10.30	10.30
GNC	22.20	22.20	22.20	22.20	22.20
SBM	33.30	33.30	33.30	33.30	33.30
Fish meal	11.10	11.10	11.10	11.10	11.10
Bone meal	0.50	0.50	0.50	0.50	0.50
Oyster shell	0.50	0.50	0.50	0.50	0.50
V/Premix	0.50	0.50	0.50	0.50	0.50
Lysine	0.50	0.50	0.50	0.50	0.50
Honey	0.25	0.23	0.22	0.21	0.20
Salt	0.25	0.25	0.25	0.25	0.25
PNM	__	0.02	0.03	0.04	0.05
Qty(g)	100	100	100	100	100

GNC=Groundnut cake, SBM=Soya bean meal, V/premix=Vitamin premix, PNM=Parquetina nigrescens meal, Qty= Quantity

Experimental Procedure

Two hundred (200) juveniles African Catfish, (Clarias gariepinus) having an average weight of 237.57g were procured from a reputable farm. The fish were acclimatized for two weeks during which they were fed extruded feed twice daily. The water used was well aerated while waste and faeces in all the tanks were siphoned every day to prevent pollution. After acclimatization period, a total of seventy (70) juveniles were randomly selected and separated into five groups of treatments and then distributed into plastic tanks (120litres) at the rate of 7 catfish per tank having 4 females to 3 males and replicated two times. The fish were fed to satiation twice daily in the morning (8:00am) and evening (4:00pm) while feeding was adjusted every two weeks. The fish were weighed fortnightly for the period of twelve weeks using an electronic digital weighing scale (Camry Model EK5350 of 5kg capacity, manufactured by SENSSUN Weighing) and the record of the feed consumption was also taken.

Data Collection on Growth Performance

Growth nutrients utilization parameters were calculated using the following formulae:

$$WG = FW - IW \text{ ---(I)}$$

Where:

WG = Weight gain(g)
FW = Final weight(g)
IW = Initial weight(g)

$$MWG = WG \div NF \text{ ---(ii)}$$

Where:

MWG = Mean Weight Gain(g)
WG = Weight Gain(g)
NF = Number of Fish

$$SGR = LnW_2 - LnW_1 \div NCD \times 100 \text{ ---------------------------(iii)}$$

Where:

SGR = Specific Growth Rate(%/daay)
W_1 = Initial Weight(g), W_2 = Final weight(g), Ln = Natural Logarithms
NCD = Number of Culture days

$$FCR = DWF \div FWG \text{ ---(iv)}$$

Where:

FCR = Feed Conversion Ratio
DWF = Dry Weight of feed consumed(g)
FWG = Fish Weight Gain(g)

$$PER = WWG \div PI \text{ --(v)}$$

Where:

PER = Protein Efficiency Ratio
WWG = Wet Weight gain(g)
PI = Protein Gain(g)

Proximate Analysis

The proximate composition of the P. nigrescens experimental diet was determined using the method of Association of Analytical Chemistry (AOAC, 2006).

Statistical Analysis

All data collected were subjected to one way analysis of variance (ANOVA) using a completely randomized design (CRD) and means were separated by Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

The proximate composition of P. nigrescens leaf meal is shown in Table 2. The proximate composition of the experimental diet in the study revealed that Crude Protein (23.10%) is slightly higher than the value of 20.6±0.25% and 18.0±0.25% recorded by Adjatin et al., (2013). The protein contents, is however, around the normal reported range of protein level found in green leafy vegetables (20.48 – 41.66%) on dry weight basis as noted by Hussain et al., (2010). Recent research by Abubakar et al., (2015) and Mwangi et al., (2018) also reported as low as 20% crude protein in the diet of African catfish without negative consequence.

Table 2: Proximate Composition of Parquetina nigrescens Leaf Meal

Parameters	Moisture Content	Dry Matter	Ash Content	Crude Fat	Crude Protein	Crude Fibre
%	7.50	92.50	13.50	3.10	23.10	12.20

Growth Performance of African Catfish (Clarias gariepinus) fed with varying inclusion levels of Parquetina nigrescens Leaf Meal.

The growth performance of Clarias gariepinus fed with Parquetina nigrescens at different levels of inclusion as shown in Table 3 recorded highest protein efficiency ratio (PER) in treatment 3 (1.43) which revealed T3 to be the best for C. gariepinus for better feed utilization by converting the feed to flesh. As observed by Davies et al., (2006), protein efficiency ratio, is a measure of how well the protein sources in a diet could provide the essential amino acid requirement of the fish. The best feed conversion ratio (FCR) was also in T3 (1.94). This is in agreement with De Silva (2001), who posited that the best feed conversion ratio is between 1.2–1.95 for fish fed carefully prepared diets, and the result from the present study falls within this range. FCR decreases and PER increases when the quality of protein in the diet improves which indicate increased feed utilization efficiency of fish and reduction of production cost (Zahan et al., 2024). Therefore, this study indicated that treatment 3 shows the best performance in C. gariepinus with regards to FCR, weight gain, and PER. The values of T3 in FMW and MWG were however significantly different ($p<0.05$) across treatments.

Table 3: Growth Performance of the African catfish (Clarias gariepinus) fed with varying inclusion levels of Parquetina nigrescens leaf meal

Growth Parameters	T1 (Control)	T2 (0.02g)	T3 (0.03g)	T4 (0.04g)	T5 (0.05g)	SEM
IMW (g)	237.57	237.57	237.57	237.57	237.57	3.27
FMW(g)	361.92^{b}	347.71^{b}	395.51^{a}	285.43^{c}	322.88^{c}	11.45
MWG (g)	124.35^{ab}	110.14^{b}	157.94^{a}	47.86^{c}	85.31^{bc}	9.42
PMWG (%)	52.34^{a}	46.36^{a}	66.48^{a}	20.15^{b}	35.91^{a}	3.64
SGR (%)	0.22^{a}	0.20^{a}	0.26^{a}	0.09^{b}	0.16^{a}	0.19
FCR	2.67^{b}	2.69^{b}	1.94^{b}	4.67^{a}	3.06^{b}	0.19
PER (%)	1.07^{ab}	1.07^{ab}	1.43^{a}	0.61^{c}	0.93^{bc}	0.07

All the parameters with different superscripts are significantly different ($p<0.05$)
IMW= Initial Mean Weight; FMW= Final Mean Weight; MWG=Mean Weight Gain; PMWG= Percentage Mean Weight Gain; SGR=Specific Growth Rate; FCR=Feed Conversion Ratio; PER=Protein Efficiency Ratio; SEM=Standard Error of Mean.

CONCLUSION

This study established that inclusion of 0.3% Parquetina nigrescens leaf meal as an additive in African catfish (C.gariepinus) feed can be of great benefit to improve their growth rate.

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REFERENCES

Abubakar, N. S., Mohdnasir, N., Lananan, F., Abdul Hamid, S. H., Lam, S. S. and Jusoh, A. (2015). Optimization of C/N ratios for nutrient removal in aquaculture system culturing African catfish, (Clarias gariepinus) utilizing Bioflocs Technology. International Biodeterioration and Biodegradation, 102(2), 100-106. https://doi.org/10.1016/j.ibiod.2015.04.001

Adjatin, A., Dansi, A. and Eze, C. S. (2013). Proximate, Mineral and Vitamin C composition of vegetable Gbolo [Crassocephalum rubens(Juss.exJacq.)S.Moore and C.crepidioides(Benth.) S.Moore] in Benin. International Journal of Biological and Chemical Sciences, 7(1), 319–331. https://doi.org/10.4314/ijbcs.v7i1.27

Airaodion, A. I., Olatoyinbo, P. O. and Ogbuagu. U. (2019). Comparative assessment of phytochemical content and antioxidant potential of Azadirachta indica and Parquetina nigrescens leaves. Asian Plant Research Journal, 2(3), 1–14. https://doi.org/10.9734/aprj/2019/v2i330045

Ajayi, L., Ayeleso, A. Oyedepo, T. and Mukwevho, E. (2021). Ameliorative potential of hydroethanolic leaf extract of Parquetina nigrescenson D-galactose-induced testicular injury. Molecules, 26(11), pp3424. https://doi.org/10.3390/molecules26113424

Ali-Emmanuel, N., Moudachirou, M. and Akakpo, J. A. (2003). Treatment of Bovine dermatophilosis with Sennaalata, Lantana camara and Mitracarpus scaber leaf extracts. Journal of Ethnopharmacology, 86(1), 167–217. https://doi.org/10.1016/s0378-8741(03)00054-0

AOAC (2006). Official Methods of Analysis, AOAC. In: Horwitiz, W. (Ed.). 18th Edition. Association of Official Analytical Chemists, Washington D. C. USA.

Awoniyi, A.O., Abidakun, O. M. and Oladiji, A.T. (2022). P. nigrescens leaf infusion: A food based approach for the management of diet induced iron deficiency in weanling rats. Notulae Scientia Biologicae, 14(3), p.11275. https://doi.org/10.55779/nsb14311275

Ayoola S.O. and A.A. Bamiro. (2017). Genotoxicity, haematological and growth performance of the African catfish Clariasgariepinus fingerlings fed walnut Tetracarpidium conophorum leaves to substitute for rice bran. Journal of Animal Science, 2(2), p 64-76. https://doi.org/10.13170/ajas.2.2.6352

Ayoola, A. O., Akinloye, O., Oguntibeju, O. O., Oke, J. M. and Odetola, A. A. (2011). Antioxidant activities of Parquetina nigrescens. African Journal of Biotechnology, 10(2), 4920–4925. https://doi.org/10.5897/AJB10.1622

Bairagi, A., Sarkar, G. K., Sen, S. K. and Ray A.K. (2004). Evaluation of the nutritive value of Leucaena leucocephala leaf meal, inoculated with fish intestinal bacteria Bacillus subtilis and Bacillus circulans in formulated diets for rohu, Labeo rohita (Hamilton) fingerlings. Aquaculture Research, 35(3),436–446. https://doi.org/10.1111/j.1365-2109.2004.01028.

Davies, O.A., Inko-Tariah M. B. and Amachree. D. (2006). Growth response and survival of Heterobronchus longifilus fingerlings fed at different feeding frequencies. African Journal of Biotechnology 5(9): 788–787.

De Silva, S. S. (2001). Performance of Oreochromis niloticus fry maintained on mixed feeding schedules of different protein levels. Aquaculture and Fisheries, 33(16): 621–633. https://doi.org/10.1111/j.1365-2109.1985.tb00075.x

FAO. (2018). The State of World Fisheries and Aquaculture 2018- Meeting the sustainable development goals. Food and Agriculture Organization of the United Nations.

Hussain, J., Rehman, N. U., Khan, A., Hamayun, M., Hussain, S. M. and Shinwari, Z. K. (2010). Proximate and essential nutrients evaluation of selected vegetables species from Kohat region, Pakistan. Pakistan Journal of Botany, 42(4), 2847– 2855.

Mwangi, J. M., Maina, J. G. and Gachuiri, C. K. (2018). Effects of dietary protein levels on performance of African catfish Clarias gariepinus in fertilized and unfertilized earthen ponds. Livestock Research for Rural Development, 30(3), p48

Oluwafemi, F. and Debiri, F. (2008) Antimicrobial effect of Phyllanthus amarus and Parquetina nigrescens on Salmonella typhi. African Journal of Biomedical Research,11(2),215-219. https://doi.org/10.4314/ajbr.v11i2.50712

Sopeyin, A. O. and Ajayi, G. O. (2016). Pharmacognostic study of Parquetina nigrescens and bullock (Periplocaceae). International Journal of Pharmacognosy and Phytochemical Research, 8(2),321–326. https://doi.org/10.1155/2022/6076707

Zahan, N, Hossain, M.A, Islam, M. R, Saha, J., Akter, T, Fatema, U.K. and Haque, F. (2024). Effects of dietary Spirulina platensis on growth performance, body composition, haematology, immune response, and gut microflora of stinging catfish Heteropneustes fossilis. Aquaculture Reports, 10(35),101-997.. https://doi.org/10.1016/j.aqrep.2024.101997

Zhang, S., Wenzhun H., Yu-an H. and Zhang, C. (2020). Plant species recognition methods using leaf image: Overview. Neuro computing, 408(1), 246-272. https://doi.org/10.1016/j.neucom.2019.09.113

INTESTINAL AND LIVER HISTOPATHOLOGICAL CHARACTERISTICS IN *Clarias gariepinus* FINGERLINGS FED FERMENTED *Prosopis africana* SEED MEAL AS FISH MEAL REPLACEMENT

1Suswam, O., 1S. A. Abdullahi, 2S. J., Oniye, 1A Yusuf, 1M. O. Bello, 1E. O. Ogbe and 1D. G. Wase

1Department of Biology, Ahmabu Bello University Zaria
2National Open University of Nigeria

Corresponding Author:
degengabriel3@gmail.com, +2348060547683

ABSTRACT

Fishmeal scarcity and high cost have led to interest in plant-based protein sources for inclusion in fish diets. In this study, the possibility of substituting fish meal with fermented Prosopis africana seed meal (FPM) in the diet of Clarias gariepinus fingerlings and its resultant effect on the Histopathology of intestine and liver was investigated. In the 84 days feeding trial conducted, diets containing 42% crude protein were formulated using fermented Prosopis africana seed meal to substitute fishmeal at various inclusion levels (FPM0%, FPM10%, FPM20%, FPM30%, FPM40%, FPM50%, and FPM100%). A total of 210 fingerlings of Clarias gariepinus were grouped in seven concrete tanks (2.0 × 2.0 × 1.8 m) in replicates, with each group containing 15 fish. Experimental fish were fed twice daily at 08:00hrs and 17:00hrs. Results obtained revealed villi degeneration in FPM10%, FPM30%, FPM40%, and FPM100%, villi atrophy in FPM20% and FPM50%, and hyperplasia of inflammatory cells in FPM50%, while vascular congestion (FPM20%), sinusoidal congestion (FPM20% and FPM30%), pyknotic nuclei (FPM50%), hyperplasia of inflammatory cells (FPM10% and FPM100%), and vascular congestion in (FPM40%). Villi length and width were inclusion level dependent with FPM10% having the highest among the treatments. It was concluded that fermentation improved the nutrient profile of P. africana seeds; with 10% FPM inclusion recommended for minimal adverse pathological effects in C. gariepinus.

Keywords:
Histopathology,
Clarias gariepinus,
Prosopis Africana, Diet

INTRODUCTION

Recent research has focused on using plant proteins to replace fishmeal in fish feed due to its high cost and limited availability. Studies have examined the suitability of various animal and plant-based ingredients, such as poultry-by-product meal and soybean meal (Goda et al., 2007) and fermented soya pulp (Li et al., 2021) for African catfish diets at different life stages. However, when using plant proteins, caution is needed in their inclusion levels and processing due to limiting factors like high crude fiber and anti-nutritional elements. The main challenge is their potential effects on the liver and intestine, making histological studies crucial for understanding possible pathologies (Hu et al., 2013). The intestine and liver are the most important and vulnerable organs involved in the digestion and absorption of nutrients when feeding fish with plant proteins (Li et al., 2021) thus playing a major role in growth enhancement. Proteins are broken down into amino acids in the gastrointestinal tract, and once these amino acids enter the bloodstream, they are transported to the liver along with other nutrients (Yu and Fukagawa, 2020). Therefore, liver histology is essential for assessing the impact of dietary protein on fish health.

Prosopis africana, a versatile tree from the Fabaceae family, grows naturally in Africa and Asia (Aroyehun et al., 2019). Known as African mesquite or iron tree, it is common in Nigeria's Middle Belt and Northern regions, with various local names. The seed are rich in protein and carbohydrate- which are used in formulation of animal feed and making of local condiments.

African catfish (Clarias gariepinus) is prevalent in Nigerian freshwaters and a key species in aquaculture. It is favored for cultivation in Africa, especially in Nigeria, due to its ease of culture, hardiness, high survival rate, rapid growth, and acceptance of formulated diets (Musa et al., 2021). Recognized for its potential in Nigerian aquaculture, it contributed about 35% of total production in 2003, making aquaculture crucial for reducing overfishing and meeting the growing fish demand (Udo & Umoren, 2011). This study was therefore designed to test the possibility of substituting fish meal with fermented Prosopis africana seed meal (FPM) in the diet of Clarias gariepinus fingerlings and its resultant effect on the Histopathology of intestine and liver.

MATERIALS AND METHODS

Collection and processing of experimental feed ingredients

Dried Prosopis africana seeds were obtained from a local market in Agbo, Vandeikya Local Government Area, Benue state, Nigeria, and fermented according to the method described by Uzodinma et al., (2020). Other feedstuffs such as soybean meal, fish meal, and yellow maize meal, salt, rice bran, palm oil, bone meal, vitamin premix, methionine and lysine were purchased from Sabon Gari market, Zaria, Kaduna State Nigeria. Proximate analysis of fermented Prosopis africana seed meals was carried out according to the method of AOAC (2005). And the result showed crude Protein (29.70%), fibre (5.21%), ash (9.50%), crude lipid (20.40%), carbohydrate (19.14%) and moisture (16.08%)

Experimental diets

All feed ingredients were weighed using a sensitive electronic balance (Sertorius CP8201) and milled into fine particle sizes (0.01mm) and divided for the feeding trial, with one portion used as a control without Prosopis africana seed meal. Seven isonitrogenous and isocaloric diets were formulated with varying levels of fermented Prosopis Meal (FPM) at 0, 70, 140, 210, 280, 330, and 380 g/kg, replacing 0%, 10%, 20%, 30%, 40%, 50%, and 100% of the fishmeal (designated FM0, FPM10, FPM20, FPM30, FPM40, FPM50, and FPM100) according to Acar et al (2018). The feed was then extruded through 2mm dice using a pelletizing machine, dried to constant weight, and stored in plastic bags at room temperature. The diets, containing 42% crude protein, were sampled (20 g each) in two replicates for proximate composition.

Experimental fish and feed administration

A total of 270 fish for the experiment were purchased from Adam's Farms Dede, Abuja, Nigeria, and transported to the Department of Biological Sciences at Ahmadu Bello University, Zaria, Nigeria. The fish were acclimatized for two weeks before the experiment began, during which they were fed a commercial diet twice daily at 8:00 am and 5:00 pm. The feeding trial was conducted within outdoor concrete ponds at Ahmadu Bello University. Fish of uniform sizes were randomly distributed into 14 ponds (2.0 × 2.0 × 1.8 m) with 15 fish per pond, in two replicates. Each diet was randomly assigned to replicate ponds, and fish were weighed at the start. Throughout the 84-day experiment, the fish were fed thrice daily (6:00 am, 12:00 noon, and 6:00 pm) at 5% body weight with diets containing fermented Prosopis africana seed meal. Fish weight was measured every two weeks using a sensitive electronic balance (Sertorius CP8201), and feeding was adjusted according to the new weight. Water exchange at 60% was maintained throughout the trial.

Table 1: Feed Ingredients Composition and Proximate content of the Experimental Diets

Ingredients	FPM0(0g)	FPM10(70g)	FPM20(140g)	FPM30(210g)	FPM40(280g)	FPM50(330g)	FPM100(400g)
P. africana	-	70	140	210	280	330	400
Fishmeal	350	315	280	245	210	175	-
Soya bean	340	350	365	380	400	420	525
Yellow maize	130	110	90	60	30	3	2
Wheat bran	110	85	55	35	10	2	3
Bone meal	10	10	10	10	10	10	10
Vitamin premix	10	10	10	10	10	10	10
Lysine	20	20	20	20	20	20	20
Methionine	20	20	20	20	20	20	20
Sodium chloride	5	5	5	5	5	5	5
Fat	5	5	5	5	5	5	5
Proximate composition (g/kg)							
Crude Protein	41.95	42.16	42.01	42.22	42.04	42.00	42.18
Fat	4.70	5.39	4.80	4.80	4.64	4.48	4.7
Fibre	22.01	15.30	13.75	13.13	12.13	10.62	11.90
Ash	12.22	25.10	27.88	24.73	22.20	19.61	16.12
Moisture	5.26	4.76	5.17	4.48	5.20	4.81	5.42
Nitrogen Free Extracts	14.48	7.77	6.97	8.83	13.84	18.97	19.17

Histological Examination

At the end of the feeding trial, two fish per replicate were sampled then dissected and tissues (intestine and liver) were collected for histological examination. The tissues were fixed, dehydrated, embedded and stained while sections were cut at 5 m thickness at the Department of Anatomy, Ahmadu Bello University, Zaria. Slides were examined under a light microscope and photomicrographs were taken at ×400 using a digital camera (Nikon 9000). Images showing the effects of fermented Prosopis africana seed meal on the intestine and liver wall were captured at × 160 magnifications and ×100 for intestine (Thompson and Hunt, 1966).

Data Analysis

All data collected in this study were subjected to SPSS software (version 23) and analysed using One-way analysis of variance (ANOVA) to test for significant differences ($p < 0.05$) among the diets' treatment groups and control group. Duncan's Multiple Range Test (DMRT) was used to separate significantly different means. Value of $P < 0.05$ was considered significant.

RESULTS AND DISCUSSION

Intestinal Morphometric and histological sections of Clarias gariepinus fed diet with fermented Prosopis africana seed meal

The morphometric and histological sections from the experimental fish, as illustrated in Plate I, highlight several histomorphological changes associated with different levels of FPM substitution. Fish fed with FPM40 and FPM100 exhibited significant villi degeneration. This degeneration is characterized by the loss of cell membrane integrity, suggesting damage likely due to the presence of anti-nutritional factors, such as saponins. Saponins, known for their surface-active properties, can compromise cell membrane integrity and increase mucosal cell permeability, leading to tissue damage. This finding aligns with previous studies by Tusche et al. (2012) in rainbow trout and Wei et al. (2019) in Amur sturgeon, where similar changes were observed due to dietary components like wheat gluten and potato protein concentrate. Additionally, villi atrophy was noted in fish fed with FPM20 and FPM50. This atrophy could indicate a reduction in villi size, potentially due to inadequate nourishment or impaired nutrient circulation. The presence of tannins in plant proteins, which can bind with proteins and amino acids or form indigestible complexes with polyphenols, may further inhibit digestibility or nutrient absorption, contributing to the observed atrophy. Furthermore, the study identified hyperplasia of inflammatory cells in the intestines of fish fed with FPM50. This inflammatory response could be a reaction to the biochemical compounds found in plant proteins, which may induce damage to the intestinal barrier. Similar hyperplastic inflammation has been reported by Kokou et al. (2017) in the intestines of various fish species fed plant-based diets. However, the results in Table 1.0 show a significant decrease ($p < 0.05$) in villi length, ranging from 627.41 cm to 966.07 cm; the highest villi length and width were obtained in FPM10 compared to other treatments except the control. Vill length and width were inclusion level dependent; that is, they decreased with inclusion levels of FPM. It has been reported that plants contain compounds that can negatively affect fish (Kokou et al., 2017). This reduction suggests that FPM negatively impacts intestinal morphology, specifically the villi, which are crucial for nutrient absorption. This finding aligns with Heidarieh et al. (2012), emphasizing the importance of villi dimensions in fish diets. The decrease in villi length may be due to antinutritional compounds like saponins in FPM, which damage cell membranes and increase mucosal cell permeability. Shorter villi reduce the surface area for nutrient absorption, potentially leading to decreased growth, muscle mass, and overall fish health.

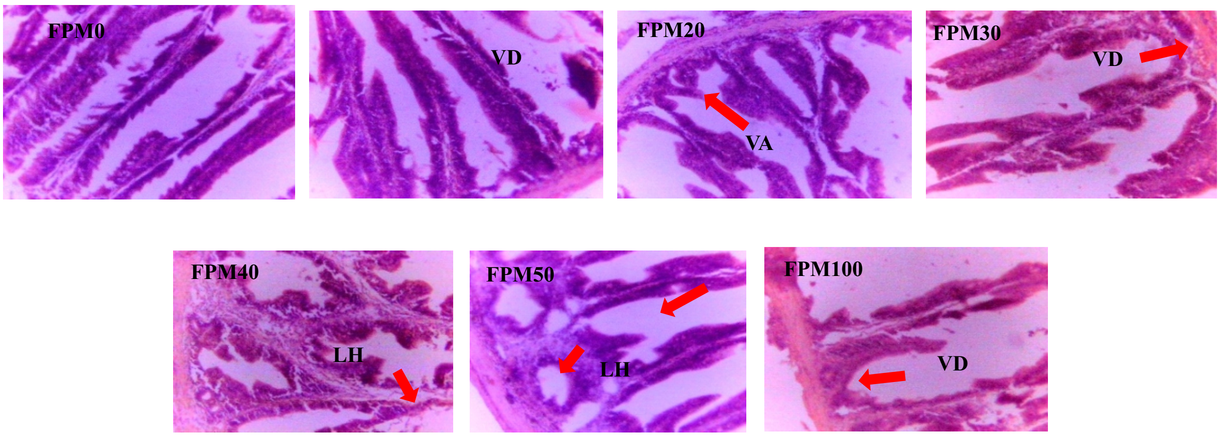

Plate I: Photomicrograph of Heamatoxylin and Eosin Stained Intestinal Histopathological Sections (×100) of Clarias gariepinus Fingerlings Fed Diet with Varying Inclusion Levels of Fermented Prosopis africana Seed Meal Note: FPM = Fermented Prosopis africana Seed Meal, VD= villi necrosis VA= villi atrophy and LH= Hyperplasia of Inflammatory cells.

Table 1.0: Villi Length and Width of Clarias gariepinus Fingerlings Fed Varying Levels of Fermented Prosopis africana Seed Meal

Villi(Px)	FPM0	FPM10	FPM20	FPM30	FPM40	FPM50	FPM100	*p*-value
Length	966.07 ± 0.01^{a}	905.60 ± 0.00^{b}	788.20 ± 0.02^{c}	713.69 ± 0.10^{d}	684.39 ± 0.02^{e}	659.74 ± 0.31^{f}	627.41 ± 0.50^{g}	0.00
Width	224.07 ± 0.01^{a}	220.96 ± 0.01^{b}	198.07 ± 0.01^{c}	194.42 ± 0.02^{d}	170.91 ± 0.10^{e}	161.64 ± 0.00^{f}	136.98 ± 0.02^{g}	0.00

Means with the same superscripts across the rows are not significantly different at $p > 0.05$. Note: FPM = Fermented Prosopis africana Seed Meal.

Histology of Liver of Clarias gariepinus Fed Dietary Fermented Prosopis africana Seed Meal

In this study, the result of histological examination of the liver (Plate II) revealed hepatic cell in FPM10 possibly due to fat accumulation in the liver, as indicated by the high lipid content in the diet and carcass. This aligns with findings by Tusche et al. (2012) in rainbow trout and Wei et al. (2019) in Amur sturgeon Areas of hyperplasia inflammation recorded in FPM100 could be as a result of biochemical compounds in the plant proteins inducing chronic inflammation in liver tissues. Similar findings have been reported by (Wang et al., 2017; Wei et al., 2019) Sinusoidal congestion observed in FPM20 and FPM30 could be attributed to the ingestion of alkaloids as reported by (Yang et al., 2019). Pyknotic nucleus observed in FPM50 may result from oxidative stress, leading to the shrinking of nucleus cells. Similar findings were reported by Wei et al. (2019). Vacuolization, congestion necrosis, and vascular congestion observed in FPM40 could be linked to higher levels of dietary lipids, supported by the elevated lipid content in the carcass and increased blood glucose

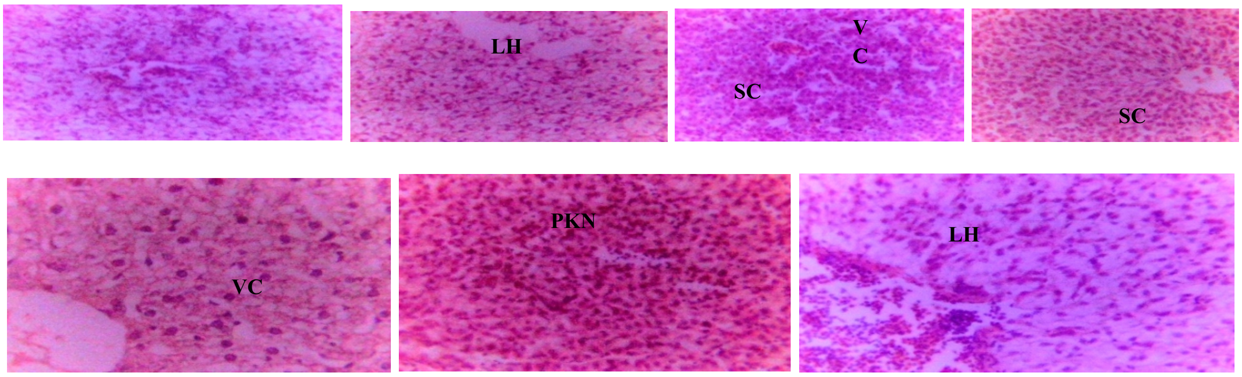

Plate II: Photomicrograph of Liver Histopathological Sections (×400) of Clarias gariepinus Fingerlings Fed Diet with Varying Inclusion Levels of Fermented Prosopis africana Seed Meal.Note: LH= Hyperplasia of inflammatory cells, VC=vascular congestion, SC= Sinusoidal congestion, and PKN= Pyknotic nucleus.

In conclusion, fermented Prosopis africana possesses a higher nutritional value, making it a suitable dietary component for Clarias gariepinus fingerlings. Including fermented Prosopis meal (FPM) at a 10% replacement level for fish meal (FM) in their diet is appropriate and beneficial. However, higher inclusion levels could lead to morphological and physiological abnormalities, which may negatively impact the health of C. gariepinus fingerlings.

REFERENCES

Acar, Ü., Kesbiç, O. S., Yılmaz, S., and Karabayır, A. (2018). Growth performance, haematological and serum biochemical profiles in rainbow trout (Oncorhynchus mykiss) fed diets with varying levels of lupin (Lupinus albus) meal. Aquaculture Research, 49(7), 2579-2586.

Aitken, M. M., Hall, E., Scott, L., Davot, J. L., and Allen, W. M. (2003). Liver‐related biochemical changes in the serum of dogs being treated with phenobarbitone. Veterinary record, 153(1), 13-16.

Ajeniyi, S. A., and Solomon, R. J. (2014). Urea and creatinine of Clarias gariepinus in three different commercial ponds. Natural Science, 12(10), 124-38.

AOAC. (2005). Animal feed. Official methods of analysis, 18th Edition. Association of Official Analytical Chemists, USA. 25–26

Aroyehun, S. A. H., Alegbeleye, W. O., Agbebi, O. T. and Bamgbose, A. M. (2019). Effects of Toasting on Nutritional Value of Mesquite (Prosopis africana) Seeds and Its Utilization by Oreochromis niloticus Fingerlings.

Bello, O. S., Olaifa, F. E., and Emikpe, B. O. (2014). Haematological and blood biochemical changes in African catfish, Clarias gariepinus fed walnut (Tetracarpidium conophorum Mull Arg) leaf and onion (Allium cepa Linn) bulb supplemented diets. American Journal of Experimental Agriculture, 4(12), 1593.

Eyo, A. A. (2001). Fish processing Technology in the Tropics. Published by National Institute for Freshwater Fisheries Research (NIFFR), PMB 6006, and New Bussa, Niger State.

Fawole, F. J., Sahu, N. P., Jain, K. K., Gupta, S., Rajendran, K. V., Shamna, N., and Poojary, N. (2017). Haemato-biochemical, non-specific immunity, antioxidant capacity and histopathological changes in Labeo rohita fingerlings fed rubber protein isolate. Fish physiology and biochemistry, 43(3), 677-690.

Goda, A. M., El-Haroun, E. R., and Kabir Chowdhury, M. A. (2007). Effect of totally or partially replacing fish meal by alternative protein sources on growth of African catfish Clarias gariepinus (Burchell, 1822) reared in concrete tanks. Aquaculture Research, 38(3), 279-287.

Hemre, G. I., Mommsen, T. P., and Krogdahl, Å. (2002). Carbohydrates in fish nutrition: effects on growth, glucose metabolism and hepatic enzymes. Aquaculture nutrition, 8(3), 175-194.

Hu, L., Yun, B., Xue, M., Wang, J., Wu, X., Zheng, Y., and Han, F. (2013). Effects of fish meal quality and fish meal substitution by animal protein blend on growth performance, flesh quality and liver histology of Japanese seabass (Lateolabrax japonicus). Aquaculture, 372: 52–61.

Jacquet, J., Hocevar, J., Lai, S., Majluf, P., Pelletier, N., and Pitcher, T. (2010): Conserving wild fish in a sea of market based efforts. Oryx: The International Journal of Conservation, 44 (1): 45 – 56.

Li, W., Xu, B., Wei, F., Li, S., Wang, S., and Wen, X. (2021). Effects of partial substitution of dietary fishmeal by fermented soybean meal on growth, amino acid and protein metabolism of juvenile Nibea diacanthus. Aquaculture Nutrition, 26(6), 2147-2158.

Musa, B. O., Hernández-Flores, A., Adeogun, O. A., and Oresegun, A. (2021). Determination of a predictive growth model for cultivated African catfish Clarias gariepinus (Burchell, Udo, I. U., and Umoren, U. E. (2011). Nutritional evaluation of some locally available ingredients use for least-cost ration formulation for African catfish (Clarias gariepinus) in Nigeria. Asian Journal of Agricultural Research, 5(3), 164-175.

Oshode, O. A., Bakare, A. A., Adeogun, A. O., Efuntoye, M. O., and Sowunmi, A. A. (2008). Ecotoxicological assessment using Clarias gariepinus and microbial characterization of leachate from municipal solid waste landfill.

Thompson, S. W. (1966). Selected histochemical and histopathological methods. (No Title).

Tusche, K., Arning, S., Wuertz, S., Susenbeth, A., and Schulz, C. (2012). Wheat gluten and potato protein concentrate Promising protein sources for organic farming of rainbow trout (Oncorhynchus mykiss). Aquaculture, 344, 120-125

Udo, I. U., and Umoren, U. E. (2011). Nutritional evaluation of some locally available ingredients use for least-cost ration formulation for African catfish (Clarias gariepinus) in Nigeria. Asian Journal of Agricultural Research, 5(3), 164-175.

Uzodinma, E. O., Mbaeyi-Nwaoha, I. E., and Onwurafor, E. U. (2020). Suitability of bacterial fermentation and foil packaging of condiment from African mesquite (Prosopis africana) seeds for nutritional retention and commercialization. African Journal of Microbiology Research, 14(7), 340-348.

Wang, Y. S., and Shelomi, M. (2017). Review of black soldier fly (Hermetia illucens) as animal feed and human food. Foods, 6(10), 91.

Wei, H.C., Chen, P., Liang, X. F., Yu, H. H., Wu, X. F., Han, J., Luo, L., Gu, X., and Xue, M. (2019). Plant protein diet suppressed immune function by inhibiting spiral valve intestinal mucosal barrier integrity, anti-oxidation, apoptosis, autophagy and proliferation responses in Amur sturgeon (Acipenser schrenckii). Fish Shellfish Immunology. 94, 711–722.

Heidarieh, M., Mirvaghefi, A. R., Akbari, M., Farahmand, H., Sheikhzadeh, N., Shahbazfar, A. A., and Behgar, M. (2012). Effect of dietary Ergosan on growth performance, digestive enzymes, intestinal histology, hematological parameters and body composition of rainbow trout (Oncorhynchus mykiss). Fish Physiology and Biochemistry, 38(4), 1169–1174.

EFFECT OF SUPPLEMENTAL VITAMIN C ON THE GROWTH PERFORMANCE AND BODY COMPOSITION OF *Clarias gariepinus* FED PLANT PROTEIN BASED DIET

Oyedokun J. O.[1], T. O. Folorunso[1], B. D. Okewale[1], O. T. Oyetunji[2], T. V. Akinmoladun[1], A. S. Kolawole[3]

[1]Department of Fisheries and Aquaculture, Adekunle Ajasin University, Akungba-Akoko, Nigeria,
[2]Department of Forestry, Wildlife and Fisheries, Olabisi Onabanjo University, Ago-Iwoye, Nigeria,
[3]Department of Fisheries and Aquatic Resources Management, Osun State University, Ejigbo, Nigeria.

Corresponding author's:
hoyedokun@gmail.com; jacob.oyedokun@aaua.edu.ng.

ABSTRACT

This study was designed to investigating the growth performance and body composition of Clarias gariepinus fed with plant protein-based diet supplemented with varied inclusion of Vitamin C. Two hundred and seventy (n=270) juveniles of Clarias gariepinus, aged eight weeks and weighing 104±2.00grams, were randomly assigned to five different diets with varying inclusion levels of Vitamin C (g/100g). The dietary treatments are as follows; control V_0= 0g/100g vitamin C, V_1 =0.075g/100g vitamin C, V_3 = 0.15g/100g vitamin C, V_3 = 0.225g/100g vitamin C, V_4 = 0.3g/100g vitamin C. For 56 days, the fish were fed until they were completely satisfied. Each treatment was in triplicate. Supplementing dietary Vitamin C in a diet based on plant protein did not significantly (P>0.05) affect the growth parameters. Clarias gariepinus fed diet V3 had the higher survival rate value of 97.78±3.85. No significant differences were observed in the crude protein of the experimental fish and the values of crude protein ranges from 49.36± 0.25 (V2) to 50.67±1.57 (V1). This study showed that supplementation of Vitamin C in plant protein-based diet had on significant influence on the growth performance and synthesis of fish muscles.

Keywords:
Vitamin C,
Clarias gariepinus,
Plant Protein,
Body composition

INTRODUCTION

Aquaculture, as a rapidly growing sector within global food production, plays a crucial role in meeting the increasing demand for protein-rich foods (Hua et al., 2019). Among the various species cultured, Clarias gariepinus stands out due to its high growth rate, adaptability to diverse environmental conditions, and excellent feed conversion efficiency (Ojelade et al., 2022). However, as the cost of conventional fishmeal continues to rise posing a great challenge to the growth of aquaculture in Nigeria, there has been a growing interest in the use of plant-based protein sources as alternatives to sustain catfish production (Begho and Irabor, 2024). While plant proteins are more sustainable and cost-effective, they are often deficient in essential amino acids, vitamins (Vitamin C) and may contain anti-nutritional factors, leading to poor growth and body composition in fish (Oyedokun et al., 2022).

Vitamin C, also known as ascorbic acid, is a vital water-soluble vitamin that serves numerous physiological functions in fish, including collagen synthesis, immune function enhancement, and antioxidant protection (Carr and Maggini, 2017). Unlike most aquatic animals, such as Clarias gariepinus, are unable to synthesize Vitamin C endogenously due to the lack of L-gulonolactone oxidase, the enzyme responsible for its biosynthesis (Zhang et al., 2019). This makes dietary supplementation of Vitamin C essential to support optimum growth, synthesis of muscles in aquaculture systems (Zhang et al., 2019). However, the impact of Vitamin C on Clarias gariepinus when fed plant protein-based diets, which may lack certain nutrients present in fishmeal, remains underexplored. Therefore, this study aims to investigate the effect of supplemental Vitamin C on the growth performance and body composition of Clarias gariepinus fed a plant protein-based diet.

MATERIALS AND METHODS

Experimental Procedure

Two hundred and seventy (n=270) juveniles of Clarias gariepinus were purchased from a reputable commercial farm in Akungba-Akoko, Ondo State, Nigeria. Plant protein diet supplemented with varying inclusion levels of vitamin C was used to formulate five (5) dietary treatments as follows; control V_0= 0g/100g vitamin C, V_1 =0.075g/100g vitamin C, V_3 = 0.15g/100g vitamin C, V_3 = 0.225g/100g vitamin C, V_4 = 0.3g/100g vitamin C. The fish were acclimatized under laboratory condition for two weeks (14 days) during which they were fed with commercial diet and were fed twice daily, morning and evening to satiation. The fish were left for a day (24 hours) unfed before the experiment. The fish were fed to satiation twice daily (8am and 5pm). The weight of the fish was monitored every two weeks. The experiment lasted for 56 days (8 weeks).

The following growth and nutrient utilization parameter were calculated as described by Falayi (2009): Initial weight, Final Weight, Feed Conversion Ratio (FCR), Gross efficiency Feed Conversion (GEFC), Protein Intake (PI), Specific Growth Rate (SGR) Protein Efficiency Ratio (PER), Protein Intake (PI) and survival rate.

Table 1: Composition of Experimental Diets Used for Feeding Trial

INGREDIENTS	V_0	V_1	V_2	V_3	V_4
Soyabean meal	36.14	36.14	36.14	36.14	36.14
Groundnut cake	34.01	34.01	34.01	34.01	34.01
Maize	24.84	24.84	24.84	24.84	24.84
Lysine	0.4	0.4	0.4	0.4	0.4
Methionine	0.6	0.6	0.6	0.6	0.6
Salt	0.2	0.2	0.2	0.2	0.2
D.C.P	0.5	0.5	0.5	0.5	0.5
Vitamin premix	0.5	0.5	0.5	0.5	0.5
Vitamin C	0	0.075	0.15	0.225	0.3
Starch	2.61	2.535	2.46	2.385	2.31
Soya Oil	0.2	0.2	0.2	0.2	0.2
Total	**100**	**100**	**100**	**100**	**100**

V0=0g/100g Vitamin C inclusion; V1= 0.075g/100g Vitamin C inclusion; V2= 0.15g/100g Vitamin C inclusion; V3= 0.225g/100g Vitamin C inclusion; V4= 0.3g/100g Vitamin C inclusion. DCP = Dicarbonate phosphate

Proximate composition

Proximate composition of the diets was determined according to AOAC, 2005.

Statistical Analysis

Data were analyzed using descriptive statistics and analysis of variance (SAS, 2003). Means were separated using Duncan multiple range test option of the same software at a0.05.

RESULTS

Table 2 Growth Performance parameters of Clarias gariepinus Fed Experimental Diets with varied inclusion of Vitamin C

Parameters	V_0	V_1	V_2	V_3	V_4
Initial weight	105.33±3.06	104.67±3.21	102.67±0.58	105.00±3.61	103.00±2.00
Final Weight	248.43±17.53	219.37±30.51	210.90±11.36	215.37±10.15	225.97±30.9
SGR	0.70 ± 0.09^{a}	0.66± 0.03^{ab}	0.59 ± 0.07^{ab}	0.58 ± 0.03^{b}	0.64 ± 0.06^{ab}
FCR	2.83 ± 0.37	2.89 ± 0.28	3.46 ± 0.55	3.22 ± 0.27	2.92 ± 0.39
PER	0.43 ± 0.04^{a}	0.41 ± 0.02^{ab}	0.37 ± 0.03^{b}	0.37 ± 0.00^{b}	0.39 ± 0.04^{ab}
Protein Intake	11.59 ± 0.58^{a}	10.85 ± 0.27^{b}	10.75 ± 0.15^{b}	9.87 ± 0.44^{c}	10.19 ± 0.14^{bc}
GEFC	35.69 ± 4.36	34.81 ± 3.30	29.38 ± 4.53	31.19 ± 2.53	34.72 ± 4.95
Survival Rate%	95.56 ± 7.70	88.89 ± 7.70	95.55 ± 3.85	97.78 ± 3.85	95.55 ± 3.85

The values with different superscripts (a, b, c) within the same rows were significantly different ($P<0.05$). V0=0g/100g Vitamin C inclusion; V1= 0.075g/100g Vitamin C inclusion; V2= 0.15g/100g Vitamin C inclusion; V3= 0.225g/100g Vitamin C inclusion; V4= 0.3g/100g Vitamin C inclusion. FMWG= final mean weight gain, SGR=specific growth rate, FCR= feed conversion ratio, PER=Protein efficiency ratio, IMWG, GEFC, TFC

Growth Performance of Clarias gariepinus fed plant protein-based diet with varied inclusion of Vitamin C as shown in Table 2. The result shows that, supplementation of Vitamin C in a plant protein-based diet had no significant effect on all the growth paraments examined during the experiments except for protein efficiency ratio and protein intake. Protein efficiency ratio and protein intake had a significantly ($P>0.05$) better value of 0.43 ± 0.04 and 11.59 ± 0.58 recorded in the control diet. Clarias gariepinus fed diet V3 had the higher survival rate value of 97.78±3.85.

Table 3: Body Composition of C. gariepinus fed plant protein-based diet supplemented with vitamin C.

Parameters	V^0	V^1	V^2	V^3	V^4
Moisture	70.54± 0.39^{c}	77.49± 1.62^{a}	71.97± 0.48^{bc}	74.68± 0.33^{b}	74.38± 1.64^{b}
Protein	49.56± 0.13	50.67±1.57	49.36± 0.25	50.50± 0.34	50.02± 0.88
Lipid	2.87± 0.21^{b}	5.36± 0.27^{a}	5.50± 0.03^{a}	5.37 ±0.04^{a}	5.80± 0.18^{a}
Ash	0.48± 0.01^{c}	0.62± 0.08^{c}	0.83 ±0.06b	0.91± 0.04^{b}	1.34± 0.06^{a}
Carbohydrate	16.53±0.45^{a}	5.87± 0.24^{d}	12.33± 0.77^{b}	8.53± 0.01^{c}	8.46± 0.52^{c}

a,b,c,d= indicate that mean on the same row but with different superscript are statistically significant ($p<0.05$). The values with different superscripts (a, b, c) within the same rows were significantly different ($P<0.05$). V0=0g/100g Vitamin C inclusion; V1= 0.075g/100g Vitamin C inclusion; V2= 0.15g/100g Vitamin C inclusion; V3= 0.225g/100g Vitamin C inclusion; V4= 0.3g/100g Vitamin C inclusion.

The body composition of the experimental fish shows a significant difference among the treatments except for crude protein as shown on Table 3. The values of crude protein range from 49.36± 0.25 (V2) to 50.67±1.57 (V1). The least moisture content of the experimental was observed in control diet while the fish fed diet V1 had the higher value. Significantly higher crude lipid values were obtained in fish fed supplemental vitamin c while value in control diet had the least value (2.87± 0.21). Significantly higher Ash content was in fish fed diet V4. The carbohydrate value for control diet had a significantly higher of 16.53±0.45 and least value in V1 (5.87± 0.24).

DISCUSSION

This study evaluates the growth performance of juvenile Clarias gariepinus fed plant protein-based diet supplemented with vitamin C. The result revealed the lack of significant effect of Vitamin C on growth parameters, such as weight gain, specific growth rate (SGR), and feed conversion ratio (FCR),

which negates studies on the efficacy of Vitamin C in fish diets (Rathore et al., 2019; Lee et al., 2024). Ai et al., (2006), Shahkar et al., (2015) and Zhang et al. (2019) reported no significant effect of Vitamin C on yellow croaker, brookstock Japanese eel, and juvenile golden pompano, respectively. This might be due to differences in size, developmental stages, cultivation environment and interacting nutrient in the experimental diets (National Research Council, 2011). Also, while Vitamin C is essential for immune function and collagen synthesis in fish, its role in enhancing growth performance may not be as pronounced, especially when the basal diet is nutritionally balanced. This could mean that plant protein-based diet used in the present study may have met the basic nutritional needs of the fish, making additional Vitamin C supplementation less impactful. Furthermore, the significant improvement in protein efficiency ratio (PER) and protein intake observed in the control diet could also proof that the absence of Vitamin C supplementation might have allowed for better protein utilization. Contrary to the above assertion, Clarias gariepinus fed the V3 diet exhibited the highest survival rate (97.78±3.85). This result suggests that while growth parameters were not significantly enhanced, Vitamin C may still play a crucial role in improving fish survival, possibly through its antioxidant properties, which protect against oxidative stress (Mohammad et al., 2020)
The analysis of body composition revealed significant differences among treatments, particularly in crude lipid, ash content, and carbohydrate levels, while crude protein content remained unaffected. The unaffected crude protein in this study could be attributed to the fact that with or without Vitamin C supplementation in plant protein-based diet, synthesis and storage of protein in muscle will still occur (Zhang et al., 2019). The higher crude lipid values in fish fed Vitamin C-supplemented diets suggest an enhanced lipid metabolism or storage, possibly due to Vitamin C's role in lipid oxidation and energy metabolism (Asaikkutti et al., 2016). The significantly higher ash content observed in fish fed the V4 diet might indicate an improved mineral retention or bone mineralization, potentially linked to Vitamin C's role in collagen synthesis and skeletal development (Zhang et al., 2019). Conversely, the control diet had the highest carbohydrate content, which might reflect a different energy utilization pattern in the absence of Vitamin C supplementation.

CONCLUSION

It could be concluded that while Vitamin C supplementation in a plant protein-based diet did not significantly enhance growth performance parameters in Clarias gariepinus, it had a notable effect on protein efficiency ratio, protein intake, survival rate, and certain aspects of body composition. These findings suggest that more research should be conducted beyond growth performance and body composition but on the influence of Vitamin C on other physiological processes that contribute to fish health and its optimum inclusion in plant-based diet.

REFERENCES

Ai, Q. H., Mai, K. S., Tan, B. P., Xu, W., Zhang, W. B., Ma, H. M., and Zhiguo, L. F. (2006). Effects of dietary vitamin C on survival, growth, and immunity of large yellow croaker (Pseudosciaena crocea). Aquaculture, 261, 327- 336.https://doi.org/10.1016/j.aquaculture.2006.07.027.

AOAC. (2005) Official Methods of Analysis of the Association of Analytical Chemists International, 18th ed. Gathersburg, MD U.S.A Official methods, 08.

Asaikkutti, A., Bhavan,P. S., Vimala, K.,Karthik ,M., and Cheruparambath,P. (2016). Effect of different levels dietary vitamin C on growth performance, muscle composition, antioxidant and enzyme activity of freshwater prawn (Macrobrachium malcolmsonii). Aquaculture Reports, 3,229–236.https://doi.org/10.1016/j.aqrep.2016.04.002

Begho Toritseju, and Arnold Ebuka Irabor, (2024). Fish feed formulation: Does Nigerian farmers' risk and time preference play a part in choosing feed protein sources for intensively farmed fish? Aquaculture, 585, 740723, ISSN 0044-8486, https://doi.org/10.1016/j.aquaculture.2024.740723.

Carr A. C., and Maggini S. (2017). Vitamin C and Immune Function. Nutrients. Nov 3;9(11):1211. doi: 10.3390/nu9111211. PMID: 29099763; PMCID: PMC5707683.

Falayi B. A. Feed formulation, manufacture and quality appraisal for fish and livestock. A guide in nutrition technology Book Series 4. First edition 2009, Published by B.A. Falayi, National Institute for Freshwater Fisheries Research (NIFFR), New-Bussa; 2009. ISBN 978-978-48686-9

Katheline Hua, Jennifer M. Cobcroft, Andrew Cole, Kelly Condon, Dean R. Jerry, Arnold Mangott, Christina Praeger, Matthew J. Vucko, Chaoshu Zeng, Kyall Zenger, Jan M. Strugnell, (2019). The Future of Aquatic Protein: Implications for Protein Sources in Aquaculture Diets, One Earth, 1 (3), 316-329, ISSN 2590-3322, https://doi.org/10.1016/j.oneear.2019.10.018.

Lee, K. W., Yoo, H. K., Kim, S. S., Han, G. S., Jung, M. M., Kim, H. S. (2024). Effect of Dietary Vitamin C Supplementation on Growth Performance and Biochemical Parameters in Grower Walleye Pollock, Gadus chalcogrammus. Animals 14, 1026. https://doi.org/10.3390/ani14071026

Mohammad Harsij, Hosna Gholipour Kanani, Hossein Adineh, (2020). Effects of antioxidant supplementation (nano-selenium, vitamin C and E) on growth performance, blood biochemistry, immune status and body composition of rainbow trout (Oncorhynchus mykiss) under sub-lethal ammonia exposure, Aquaculture. 521, 734942, ISSN 0044-8486, https://doi.org/10.1016/j.aquaculture.2020.734942.

Ojelade O. C., Durosaro S. O., Akinde A. O., Abdulraheem I., Oladepo M. B., Sopein C. A., Bhadmus A. S., and Olateju M. (2022). Environmental enrichment improves the growth rate, behavioral and physiological response of juveniles of Clarias gariepinus under laboratory conditions. Front Vet Sci. 12; 9: 980364. doi: 10.3389/fvets.2022.980364. PMID: 36311662; PMCID: PMC9597454.

Oyedokun J. O., O. A. Ogunwole, O. A. Oyelese, I. C. Adene, S. O. Sule, T. Folorunso. (2022): Growth performance and proximate composition of Clarias gariepinus (Burchell, 1822) fed roasted soyabean-based diets with supplemental amino acids. Annal of Animal and Biological Research, 2(1): 76-86.

Rathore S. S., H. S. Murthy, S. Nasren, M. A. A. Mamun and K. Rakesh. (2019) The role of Vitamin C as growth promoter and its effect on intestinal histology in monosex nile tilapia, Oreochromis niloticus. J. Exp. Zool. India, 22 (1), 639-644.

SAS. 2005. Statistical Analysis Software (SAS) systems for Windows, SAS Inc., Cary. NC, USA.

Shahkar,E. , Yun, H., Kim, D. J. , Kim, S. K., Lee, B. I. and Bai, S. (2015).Effects of dietary vitamin C levels on tissue ascorbic acid concentration, hematology, non-specific immune response and gonad histology in broods tock Japanese eel (Anguilla japonica). Aquaculture, 438, 115–121. https ://doi.org/10.1016/j.aquac ulture.2015.01.001

GROWTH PERFORMANCE OF Clarias gariepinus FINGERLINGS FED WITH LEAD TREE LEAVES (Leucaena leucocephala) SUPPLEMENTED DIETS

[1]Onoja,C.R,[1] B. P . Menewa [2] O. A. Akinrotimi, [1] C.F. Ikeogu, [1] P. A Okeke and [3],J.J Okeke

[1]Department of Fisheries and Aquaculture, Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.
[2]African Regional Aquaculture Center of the Nigerian Institute for Marine and Oceanography Research, Aluu, Port Harcourt, Rivers State, Nigeria.
[3]Department of Zoology, Faculty of Biosciences, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.

Corresponding author:
or.clement@unizik.edi.ng, +2347036874269, 0009-0007-7512-5501

ABSTRACT
A feeding trial was conducted to investigate the growth performance of Clarias gariepinus fingerlings fed with Lead tree leaves (Leucaena leucocephala) as a supplementary diet. The study was conducted using 120 fingerlings of Clarias gariepinus, which were equally distributed in twelve (12) experimental tank. 0% (control), 50%, 70%, and 100% had three (3) replicates with 10 fingerlings per tank.The study lasted for 6 weeks.The results of the study showed a significant improvement in the growth parameters of Clarias gariepinus fingerlings fed with Lead tree(leaves) supplemented diets with 50% Lead tree inclusion level having the highest weight gain(6.80g) amongst the treatment diets and 100% lead tree leaves inclusion having the least weight gain (5.27g). Also 50% Lead tree inclusion level having the highest lenght gain(10.01cm) amongst the treatment diets and 100% lead tree leaves inclusion having the least weight gain (8.83cm). The water quality parameters remained within acceptable ranges throughout the feeding trial, indicating no adverse effects on water quality due to the inclusion of Lead tree(leaves) in the diet. In conclusion, this study demonstrated that Lead tree Leucaena leucocephala) shows potential as a supplementary feed for Clarias gariepinus fingerlings. These findings contribute to the development of sustainable and cost-effective feeding strategies in aquaculture and provide valuable insights for future research in the field of fish nutrition.

Keywords:
Treatment,
Clarias gariepinus,
Leucaena leucocephala,
Supplementary diet.

INTRODUCTION

Good nutrition in animal production systems is essential to the economical production of a healthy, high-quality product (Craig et al., 2013). Prepared or artificial feeds can be either complete or supplemental.This project addresses the crucial need to identify and evaluate locally available, plant-based supplements that can enhance the growth performance of Clarias gariepinus fingerlings while maintaining economic viability and sustainability. High feed costs significantly limit the profitability of catfish farming. Locally available, affordable plant-based alternatives like lead tree (Leucaena leucocephala) offer the potential to reduce production costs and improve profit margins for farmers. It is rich in protein, essential amino acids, minerals like calcium, phosphorus, and potassium, and vitamins A, B12, and K (Bairagi et. al., 2004).Replacing expensive fishmeal with locally available, affordable lead tree can significantly reduce production costs, boosting profit margins for farmers and enhancing the economic viability of catfish farming(Okeke et. al.,2016). The aim of the study is to carry out a feeding trial on Clarias gariepinus fingerlings fed with different levels of Lead tree leaves supplemented diets and observing their growth performance.

MATERIALS AND METHODS

Study Area

This study was carried out at the wet laboratory of the Department of Fisheries and Aquaculture, Faculty of Agriculture,Nnamdi Azikiwe University, Awka. The experiment lasted for 56days (8 weeks).

Procurement of Experimental Fish

The experimental fish (Clarias gariepinus fingerlings) was purchased from a commercial farm and transported in a fifty (50) liters well-oxygenated plastic jerrycan water from the farm to the laboratory. On arrival, it was transferred to a large holding tank and allowed to stay in the tank for a period of 7 days to acclimate. During this period of acclimation, the fingerlings were fed 5% of their body weight twice daily.

Collection and Preparation of Lead Tree (Leucaena leucocephala) leaves for Feed Production

The lead tree (Leucaena leucocephala) leaves used for the formulation of feed was obtained from along the Enugu-Onitsha Expressway leading to Nnamdi Azikiwe University Awka. These leaves were plucked in large quantities using bags for easy movement after which thirty (30)kg of lead tree leaves were oven-dried for about 48 hours to reduce moisture content and allow to dry well. After drying it was then grounded into powdered form so that it can be easily used during mixture and pelleting of feed.

Experimental Design

The experiment was made of three treatments and a control. The control that has fish meal as the main protein source, Treatment 1 (T1) which is the 50% lead tree inclusion, Treatment 2 (T2) which is the 70% lead tree inclusion and Treatment 3(T3) is the 100% lead tree inclusion. Each of the Experimental treatments had three replicates designated as R1, R2, and R3 and the replicates contained 10 fish each. The experimental design was, therefore, a Completely Randomized Design (CRD) with three treatments and control.

Feeding

The fish were fed different treatment diets (50%,70%, and 100% inclusion of the Leucaena leucocephala twice daily.The feeding habits of fish were observed and noted. This includes their response to feeding and the quantity of feed they consume.

Feeding of Fish and Sampling for Growth Parameters

The average length and weight measurements of the fish in each experimental tank were taken every week interval using a sensitive weighing scale. The water parameters like water pH, dissolved oxygen, and temperature of the water were checked.The Fish tank were covered with a mesh net which served for protection against predators and to prevent escape of fish from the Fish tank.Sampling collection was done weekly. The fish was observed daily to check for mortality. Dead floating fish were removed and the record taken.The fingerlings were scoped out using hand net. A stand-by plastic bowl with a clean water was used to put the fingerlings after each trial measurement in order to reduce stress.

Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) as described by Akindele (2004). Significant differences in mean for the experiment were evaluated using 5% significance level using the SPSS (Version 23) computer package.

Ingredients/Feed Components	CONTROL	Treatment 1	Treatment 2	Treatment 3
Fish Meal (g)	30	15	9	0
Maize (g)	20	20	20	20
Groundnut Cake (g)	16	16	16	16
Soybean (g)	25	25	25	25
Bone Meal (g)	1.5	1.5	1.5	1.5
Methionine	1.0	1.0	1.0	1.0
Lysine (g)	1.5	1.5	1.5	1.5
Vegetable Oil (g)	3	3	3	3
Vitamin Premix (g)	1.0	1.0	1.0	1.0
Salt (g)	1.0	1.0	1.0	1.0
Leucaena leucocephala (g)	0	15	21	30
TOTAL	**100**	**100**	**100**	**100**

Table 1:Percentage Composition of Experimental Diet for Lead Plant Supplemented Diets

Plate 1: Fresh lead tree leaves (leucaena leucocephala)

Plate 2: Formulated feed lead tree (leucaena leucocephala) of 50%, 70% and 100% Inclusion Level

RESULTS

Water Quality Parameters

The water quality parameters monitored during the study include pH, temperature, and dissolved oxygen and are represented in Table 2. The result in table 1 shows that temperature and pH values are within the acceptable range of fish culture in the tropics as reported by Boyd et al, (2023) but dissolved oxygen is slightly above the range.

	pH (range)	Temperature(ºC)	D O (mg/l)
Control	7.43±0.25	29.20±3.88	2.4±0.03
T1 -50%	6.72±0.28	29.20±5.87	2.5±0.01
T2-70%	7.26±0.24	29.10±3.76	2.10±0.02
T3- 100%	7.34±0.27	29.00±2.54	1.80±0.01

Table 2 : Water Quality Parameter Monitored During the Experiment.

Proximate Analysis of Experimental Feeds

The result of the proximate analysis of the experimental diet which is subjected to one-way analysis of variance (ANOVA) using the statistical package for social science (SPSS) is shown in the table below.

Proximate (%)	Control	Treatment 1	Treatment 2	Treatment 3
Moisture	8.00±0.00	8.30±2.26	8.82±0.03	10.15±0.22
Ash	8.27±0.03	9.11±0.02	9.29±0.01	9.34±0.04
Fat/Oil	6.25±0.01	6.50±0.00	6.77±0.03	8.03±0.04
Crude Fiber	7.94±0.03	9.33±0.01	9.83±0.02	13.86±0.05
Crude Protein	36.43±0.02	36.05±0.05	35.10±0.23	24.86±0.04
Carbohydrate	33.10±0.01	30.70±0.22	30.15±0.26	33.82±0.13

Table 3 : Proximate Analysis of Feed

Growth Performance

Weight gain

The weekly mean weight gain of Clarias gariepinus fingerings fed with control, Treatment 1,Treatment 2 and Treatment 3 feed for six (6) weeks of study are presented in Table 4 which shows that the highest weight gain was recorded by the fish fed with Control feed (7.27g) followed by Treatment 1,50% (6.80g) then Treatment 2, 70%(5.87g) and the least Treatment 3 100% (5.27g).

WEEK	CONTROL(g)	TREATMENT 1(g)	TREATMENT 2(g)	TREATMENT 3(g)
1	4.90±0.20	4.53±1.52	4.37±1.15	4.33±0.58
2	5.67±0.58	5.38±2.51	5.07±3.21	4.39±0.58
3	5.80±0.52	5.57±3.05	5.45±2.00	4.83±0.58
4	6.10±1.00	5.80±2.00	5.67±2.08	4.93±0.58
5	6.63±0.58	6.27±2.08	5.73±0.57	5.10±0.58
6	7.27±0.58	6.80±1.00	5.87±0.57	5.27±0.58

The analysis of variance revealed that there is no significant difference in the specific growth rate of 50%, 70% and 100% inclusion of lead tree(leaves).

Table 4 :Weekly mean weight in g±sd of Clarias gariepinus fingerlings fed with Control, 50%, 70% and 100% Lead tree leaves supplemented diet for six (6) weeks.

Length Gain

The weekly mean lenght gain of Clarias gariepinus fingerings fed with control, Treatment 1,Treatment 2 and Treatment 3 fed for six (6) weeks of study are presented in Table 5 which shows that the highest length gain was recorded by the fish fed with Control feed (10.57cm) followed by Treatment 1, 50% (10.01cm) then then Treatment 2, 70%(9.03cm) and the least Treatment 3, 100% (8.83cm).The analysis of variance result revealed that there was significant difference between the length increase of Clarias gariepinus fingerlings fed with three (3

WEEK	CONTROL (cm)	TREATMENT 1 (cm)	TREATMENT 2 (cm)	TREATMENT 3 (cm)
1	1.66±0.42	1.56±1.75	1.31±1.80	1.90±0.25
2	2.26±0.92	2.06±1.62	1.80±1.86	2.01±0.36
3	3.36±0.81	2.98±1.85	2.26±1.45	2.22±1.13
4	5.10±0.69	4.60±1.12	3.50±0.79	3.20±0.55
5	7.80±0.72	7.20±1.57	6.93±0.89	6.43±0.50
6	10.50±0.72	10.01±0.80	9.03±0.89	8.83±0.72

Table 5: Weekly mean length in cm ±sd of Clarias gariepinus fingerlings fed with Control, 50%, 70% and 100% Lead tree leaves supplemented diet for six (6) weeks.

DISCUSSION

Throughout the world, the efficiency of various alternative protein sources as partial or complete dietary replacements for fish meals has been evaluated in fish diets (Ali et. al., 2003). The use of leaf meals as a possible fish meal substitute to reduce the cost of fish feed is receiving increasing attention from fish nutritionists around the world (Bairagi et. al., 2004). It is, however, important that the selected protein sources do not conflict with human food security interests. The use of Leucaena leucocephala leaves does not conflict with human food security issues and this study has demonstrated that the leaves have the potential to partly replace fish meal and considerably reduce expenditure on fish meal, without compromising the growth performances of the African catfish. No mortalities occurred throughout the period and, therefore, the meal did not have any deleterious effects on the fish.

CONCLUSION AND RECOMMENDATIONS

The findings of this project suggest that feeding Clarias gariepinus fingerlings with lead tree (Leucaena leucocephala) supplementary diets can positively impact their growth performance. The study demonstrated that lead trees contains essential nutrients and bioactive compounds that can support the growth and development of Clarias gariepinus fingerlings. The fish were able to convert the feed they consumed into body weight more effectively, resulting in higher growth rates. The higher survival rate observed in the lead tree-supplemented groups also indicates the positive impact of this feed supplement on the overall health and resilience of the fish. Overall, the results of this project support the potential use of lead tree as a valuable supplementary feed ingredient for Clarias gariepinus fingerlings. Further research could focus on exploring optimal inclusion levels and long-term effects of lead tree supplementation on larger fish.

Further research should be conducted to validate these findings and explore the optimal inclusion levels of lead tree in fish diets. Conduction of economic analysis to determine the cost-effectiveness of using lead tree as a supplemental feed for Clarias gariepinus fingerlings. Collaboration with fish farmers and researchers can greatly benefit the adoption of lead tree as a supplementary fed ingredient. Diversification of feed resources can not only increase growth performance but also enhance the resilience of fish to changing environmental conditions and dependency on specific feed ingredients.

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REFERENCES

Akindele, S. O. (2004). Statistics for Research and Development. Ibadan: Sam Publications.

Ali, A., Al-Asgah, NA., Al-Ogaily, SM. and Ali, S. 2003. Effect of feeding different levels of Alfalfa Meal on the growth performance and body composition of Nile Tilapia (Oreochromis niloticus). Asian Fisheries Science 16, 59-67 Asian Fisheries Society, Manila, Philippines

Bairagi, A., Sarkar Ghosh, KS, and Ray, AK., 2004. Evaluation of the nutritive value of Leucaena leucocephala leaf meal, inoculated with fish intestinal bacteria Bacillus subtilis and Bacillus circulans in formulated diets for rohu, Labeo rohita (Hamilton) fingerlings. Aquaculture Research, 35, 436-446.

Boyd,C.E and SmitH,J.L (2023). "Nutrition and Feeding Management in Catfish Aquaculture", published in the book "Catfish Production and Management" (2023). Pages 56-57 Source: https://doi.org/10.1007/978-3-031-11386-2_5 - accessed 2nd December, 2023).

Craig, S. and Helfrich, L.A. (2013). Understanding fish nutrition, feeds, and feed:A Manual on the Preparation and Presentation of Compound Feeds for Shrimp and Fish in Aquaculture. Rome: Food and Agriculture Organization of the United Nations and United Nations Environment Programme.

Okeke, J.J., Otikpa, C.A., Okeke, P.A. , Ezeonyejiaku, D.C. , Okoye, C.O., Arazu, V.N , Ibemenuga, K.N.and Nwosu, M.C. (2016):A comparative study of the effect of feeding frequency on growth and feed utilization of Clarias Gariepinus fed on the commercial feed – Coppens. Scholarly Journal of Agricultural Science Vol. 6(7), pp. 216-220.

CHEMICAL EVALUATION OF PROTEIN CONCENTRATES PRODUCED FROM CATFISH ROE, HERRINGS ROE, MACKEREL AND AFRICAN LUNGFISH MUSCLES

[1]Mustapha F.A, [2]A.O. Igwegbe, [2] P. Y Idakwo, [2]F. M. Adam, [1]B. GONIRI, and [3]A. Mohammed

[1]National Institute for Freshwater Fisheries Research, Maiduguri Zonal Station, Maiduguri, Borno State.
[2]Department of Food Science and Technology, University of Maiduguri
[3]Department of Veterinary Public Health and Preventive Medicine, University of Maiduguri

Corresponding Author:
fulaimah@gmail.com, +2348034633367 https://orcid.org/0009-0005-9828-3284

ABSTRACT
Four different protein concentrates were produced from four species of fish, namely, African lungfish, Mackerel, Catfish roe and Herrings roe. Samples were processed and subjected to chemical analysis (proximate, mineral and amino acid compositions) using standard methods of analysis. Average proximate composition (%) ranged from 2.03±0.05 to 6.02±0.65 for moisture, 61.71±0.16 to 70.88±0.40 for protein, 2.75±0.37 to 6.89±0.20 for fat, 4.96±0.04 to 8.35±0.61 for ash, 2.87±0.21 to 9.77±0.45 for fiber and 7.45±0.26 to 23.45±0.43 for carbohydrates. The results showed significant variations ($p \geq 0.05$) in the components among species, with the African lungfish concentrate containing higher amount of protein, moisture, and ash. Higher amount of fat was observed in CFR. Mackerel protein concentrate was higher in fat and it was also higher in energy level. The percent mineral composition (mg/g) ranges from 1.50±0.04 to 4.30±0.01 for calcium, 864.51±1.25 to 3663.01±21.92 for sodium, 1.60±0.01 to 2.30±0.01 for phosphorus, 1.30±0.01 to 2.30±0.01 for iron and 13.50±0.35 to 54.00±0.14 for potassium. The results of mineral analysis of the samples indicated significant differences ($P \leq 0.05$) in the mineral composition. Sodium and Potassium were the most abundant minerals and the highest values were observed in African lungfish Protein Concentrate. Herrings roe protein concentrate contained highest amount of calcium and phosphorus, but lower in sodium and potassium. The essential amino acid concentrations (g/100g protein) ranged from 7.70±0.00 to 8.03±0.01, 4.35±0.07 to 6.02±0.02, 3.50±0.00 to 4.54±0.31, 3.76±0.06 to 4.80±0.26, 0.81±0.01 to 1.38±0.23, 3.30±0.00 to 4.00±0.00, 1.30±0.01 to 2.87±0.17, 1.99±0.01 to 2.91±0.05, and 3.52±0.02 to 4.37±0.21, for leucine, lysine, isoleucine, phenylalanine, tryptophan, valine, methionine, histidine and threonine, respectively. Also, amino acid profile indicates leucine and lysine being the most predominant essential amino acids recorded. Fish and/or roe protein concentrates contained high amounts of protein, fat and ash, as well as minerals and amino acid contents.

Keywords:
amino acids,
defatting, eggs

INTRODUCTION

Fish provides a good source of high-quality protein and contains many vitamins and minerals. The importance of better utilization of fish resources has been demonstrated for long time as the world population increases and the wild stocks are fully exploited. However, today most of the fish by-products are used for low price fish feed ingredients such as fish meal and fish oil (Sovik and Rustad, 2005). Only 10% is made into food or other value-added products. However, these 10% accounts for nearly half of the total value of all fish by-products (Li, 2014). Interest in fish consumption increased of late due to the high content of health significant. Fish has been reported to have a good complement of the essential amino acids, particularly lysine which is low in cereals, thus providing a nutritional balance in the overall quality of a mixed diet (FAO, 2005). Fish are important sources of many other nutrients namely vitamins such as Vitamin A, D and E as well as minerals including calcium, iodine, selenium etc. There are abundant evidence indicating the significance of fish in brain development and learning ability in children, protects vision and eye health, and protection from cardiovascular disease and some cancers (Sankar et al., 2013). Roe is the term used to describe fish eggs (oocytes) gathered in skeins (Mahmoud et al., 2008). Roe has a high content of nutritive lipids, particularly phospholipids and long chain unsaturated fatty acids (LCUFAs) (Mahmoud et al., 2008). The major components of fish tissue are water, lipids, protein and micro nutrients. The proximate composition of fish may vary depending on certain factors such as the geographical locale, season of the year, the feed intake, the metabolic efficiency of the fish, the energy expended by the fish, sex, species, age, and size. It can also vary within the individual fish (Andrew, 2001). Studies have shown that fish roes are an excellent source of protein and essential amino acids (Sathivel, 2009). This study was conducted to determine the chemical composition of roe and muscles of four species of fish with a view to creating the evidence for effective and efficient value addition in producing fish products.

MATERIALS AND METHODS

Sample acquisition and preparation:

Fresh fish samples were purchased directly from fish dealers in Maiduguri Monday market, Maiduguri, Borno State. The fish was cleaned, viscera, head and bones were removed to obtain fish muscles from African Lungfish and mackerel. To obtain fish roes, the fish was cleaned and roes were separated from the body. Samples were stored in an ice block containing coolers before further processing. Protein concentrates were processed at the Food Processing Laboratory, Department of Food Science and Technology. Standard methods were used (AOAC, 2006) in all the chemical analysis (Amino Acid, Protein, Fat, Ash, and Moisture); and the analyses were carried out in the National Agency for Food and Drug Administration and Control laboratories (NAFDAC), Maiduguri.

Preparation of Fish Protein Concentrates (FPC) and Roe Protein Concentrates (RPC):

The protein concentrates were prepared according to the method used by Narsing et al., (2012) with minor modifications. Fresh roes of catfish and herrings were separated manually from skins and blood vessels of the fish. The roe was homogenized using a high-speed mixer, and dried at 60°C for about 10 hours in a cabinet tray drier. The dried roes were ground and defatted using isopropanol maintaining a solid to solvent ratio of 1:3 (w/v) with occasional stirring. The solvent was decanted and the extraction was repeated for three times to ensure maximum removal of lipid. The residue was dried in a vacuum drier 50°C for a period of eight hours. The defatted and dried roes were ground to powder using a mixer, and then sieved to obtain roe protein concentrates (RPC). Fish (African lungfish and Mackerel) protein concentrate (FPC) from fish muscles were also prepared using the above technique.

Proximate analysis:

The proximate composition of the concentrates was determined following the guidelines outlined in AOAC (2006).

Mineral:

Mineral content of the concentrates was determined using atomic absorption spectrophotometer. The minerals examined were; Potassium, Iron, Sodium, Calcium, and Phosphorus.

Amino Acid Profile:

The Amino Acid profile in the known sample was determined using methods described by Benitez (1989). The sample was dried to a constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Applied Biosystems PTH Amino Acid Analyzer.

Statistical Analysis:

Data obtained were subjected to analysis of variance (Ihekoronye and Ngoddy, 1985), at 5% levels of significance using the IBM/SPSS version 22 software.

RESULTS AND DISCUSSION

Proximate Composition of the Protein Concentrates:

The proximate composition of the protein concentrates was analyzed and presented in Table 1. The result showed that the most abundant component in the sample was protein, followed by carbohydrate, fat, fiber, and ash was the lowest. There was no significant difference ($p \geq 0.05$) in moisture content of the fish protein concentrates and the roe protein concentrates except in the African lungfish fish protein concentrate which had significantly higher values. The higher moisture content might be due to difference in particle size of the protein concentrates. There was no significant difference in the protein content between AFPC and MFPC which had higher values (64.09 and 70.88%) than the roe protein concentrates (61.71 and 61.93%). The fat content ranged from 2.75-6.89% and the highest was recorded in Mackerel fish protein concentrate. AFPC had the highest amount of moisture (6.02%), protein (70.88%) and ash (8.35%) but lower in carbohydrate (7.45%) and the energy level (338.00%). MFPC contained the highest amount of fat and fiber among the concentrates, this is because mackerel is a fatty fish. There is no significant difference ($p \geq 0.05$) in the ash content of the roe concentrates and were lower compared to the fish concentrates. The fish concentrates also doesn't show any significant difference, only the roe concentrates showed variation. The variation in chemical composition of fish and roes were mainly attributed to biological factors, including species, maturity stages, diet, season, harvest area and processing condition (Mahmoud et al., 2008).

Table 1 Proximate composition of the protein concentrates

CONCENTRATES	MOISTURE (%)	PROTEIN (%)	FAT (%)	ASH (%)	FIBRE (%)	CARBOHYDRATE (%)	ENERGY(KJ/kg)
AFPC	6.02 ± 0.65^d	70.88 ± 0.40^c	2.75 ± 0.37^a	8.35 ± 0.61^c	4.56 ± 0.28^b	7.45 ± 0.26^a	338.00 ± 2.83^a
CRPC	2.03 ± 0.05^a	61.93 ± 0.11^a	6.22 ± 0.84^c	4.96 ± 0.08^a	5.25 ± 0.30^c	19.63 ± 0.68^c	382.18 ± 05.31^b
HRPC	2.90 ± 0.06^c	61.71 ± 0.16^a	4.13 ± 0.09^b	4.96 ± 0.04^a	2.87 ± 0.21^a	23.45 ± 0.43^d	377.75 ± 0.28^b
MFPC	2.06 ± 0.06^b	64.09 ± 0.33^b	6.89 ± 0.20^d	6.73 ± 0.25^b	9.77 ± 0.45^d	10.41 ± 1.19^b	343.47 ± 21.73^a

AFPC-African lungfish fish protein concentrate, CRPC-catfish roe protein concentrate, HRPC-herrings roe protein concentrate,MFPC-mackerel fish protein concentration

Mineral Composition of the Protein Concentrates

Mineral (Ca, Na, P, Fe, and K) composition of the protein concentrates were presented in Table 2. The most abundant mineral in all the samples was Sodium and it was found in excess amount, followed by Potassium and Calcium respectively. Phosphorus and Iron were the minor minerals. For different protein concentrates, varying levels and types of minerals were observed. African lungfish Concentrate had higher Sodium and Phosphorus compared to the other protein concentrates. Higher amount of sodium because they can live out of water for many months in burrows of hardened mud beneath a dried-up stream bed can live out of water for many months in burrows of hardened mud beneath a dried-up stream bed. Catfish Roe Concentrate contained higher amount of Iron than the other three concentrates. The highest Calcium and Phosphorus were observed in Herrings roe Concentrate. Phosphorus have been generally associated with the phospholipid content and the presence of phosphoprotein (Mahmoud et al., 2008). Iron was classified as the essential trace element required for physiological and metabolic process of marine organisms (Thanonkaew et al., 2006). Excess intake of Fe can be detrimental to human health. Metal ions in defatted roes might serve as catalysts for lipid oxidation. Metal ions have been shown to exhibit pro-oxidant activity (Thanonkaew et al., 2006). Different amount and types of elements were suggested to be governed by the maturation stages (Rossawan et al., 2011).

Table 2 Mineral composition of the protein concentrates

CONCENTRATES*	CALCIUM (mg/g)	SODIUM (mg/g)	PHOSPHORUS (mg/g)	IRON (mg/g)	POTASSIUM (mg/g)
AFPC	2.00±0.00^{c}	3663.01±21.92^{d}	1.90±0.01^{b}	1.30±0.01^{a}	54.00±0.14^{d}
CRPC	1.90±0.01^{b}	1011.05±1.27^{b}	1.60±0.01^{a}	2.70±0.01^{d}	49.00±0.28^{c}
HRPC	4.30±0.01^{d}	864.51±1.25^{a}	2.50±0.00^{d}	2.30±0.01^{c}	13.50±0.35^{a}
MFPC	1.50±0.04^{a}	2091.60±1.75^{c}	2.30±0.01^{c}	1.50±0.04^{b}	16.50±0.07^{b}

Essential Amino Acid of the Protein Concentrates

The essential amino acids of the protein concentrates were presented in table 3. The major essential amino acid observed were leucine, lysine, phenylalanine, followed by isoleucine, threonine, valine, and methionine. Tryptophan and histidine were the minor essential amino acids. The roe protein concentrates contained highest amount of leucine (7.80 to 8.03mg/100g) and lysine (5.75 to 6.02mg/100g), but lower phenyl alanine (3.76 to 3.95 mg/100g) than the fish protein concentrates. There was no significant difference in the isoleucine content of the roe concentrates while the fish concentrates differ, and the highest was recorded in African lungfish concentrate (4.54 mg/100g) and the least in mackerel fish concentrate. Significant difference was observed in the threonine content of the protein concentrates and the highest was observed in the African lungfish concentrate and the least in Mackerel concentrate (3.52 mg/100g). Tryptophan was the least essential amino acid observed ranging from 1.38 to 0.81g/100g recorded in AFPC and HRPC. Valine content was higher in CRPC (4.00g/100g) but lower in MFPC (3.30g/100g). African lungfish protein concentrate (AFPC) contained the highest value of the four essential amino acids tryptophan, methionine, histidine and threonine. The lowest value of methionine was observed in HRPC (1.30g/100g), histidine in CRPC (1.99g/100g) and threonine in MFPC (2.99g/100g). The amino acid profile (both essential and non-essential) was favorably comparable with the report of Galla et al., (2012) who reported that fish protein concentrates contain glutamic acid as the major amino acid, followed by aspartic acid. Amino acids namely glutamic acid (12.75g), aspartic acid (8.52), alanine (7.07g), leucine (9.72g), and lysine (8.23g) were reported per 100g roe protein of Alaska Pollock fish (Bechtel et al., 2007).

Table 3 Essential Amino Acids of the Protein Concentrates (g/100g protein

CONCENTRATES*	LEUCINE	LYSINE	ISOLEUCINE	PHENYL	TRYPTOPHAN	VALINE	METHIONINE	HISTIDINE	THREONINE	TEAA
AFPC	7.75±0.10^{c}	4.35±0.07^{a}	4.54±0.31^{d}	4.80±0.26^{d}	1.38±0.23^{d}	3.96±0.06^{c}	2.87±0.17^{d}	2.91±0.05^{d}	4.37±0.21^{d}	36.93
CRPC	8.03±0.01^{d}	5.75±0.27^{c}	4.02±0.00^{c}	3.95±0.07^{b}	1.00±0.01^{c}	4.00±0.00^{d}	2.41±0.08^{c}	1.99±0.01^{a}	4.06±0.08^{c}	35.21
HRPC	7.80±0.29^{b}	6.02±0.02^{d}	3.90±0.14^{b}	3.76±0.06^{a}	0.81±0.01^{a}	3.80±0.00^{b}	1.30±0.01^{a}	2.23±0.00^{c}	3.84±0.01^{b}	33.46
MFPC	7.70±0.00^{a}	5.20±0.01^{b}	3.50±0.00^{a}	4.44±0.01^{c}	0.98±0.01^{c}	3.30±0.00^{a}	2.18±0.02^{b}	2.11±0.01^{b}	3.52±0.02^{a}	32.93
WHO (mg/kg body weight)	39	30	20	25-tyrosine	4	16	10.4	10	15	

Amino Acid Profile (non-Essential) of the protein concentrates

Table 4 presents the amino acid profile (non-essential) of the protein concentrates. The most abundant non-essential amino acids were glutamic acid, aspartic acid and arginine followed by glycine, serine, proline, tyrosine and cystine which was the least. The highest glutamic acid was recorded in AFPC (15.69g/100g) and shows significant variation and the lowest was in mackerel fish protein concentrate. Cystine showed no significant difference, African lungfish Concentrate had higher value while herring roe recorded the lowest. Higher alanine was recorded in catfish roe concentrate and the lowest in African lungfish concentrate. 5.91g/100g of glycine was observed as the highest in catfish roe concentrate and the least in African lungfish concentrate. The African lungfish Concentrate contained higher amounts of Aspartic acid, Proline and Tyrosine, while the Mackerel Concentrate had the least amounts of serine and proline. Catfish roe Concentrate recorded highest amount of serine and arginine, while the herring roe had the lowest amount of Astatine, Arginine and Tyrosine. The difference in amino acid composition of the protein concentrates might be due to the differences in habitat, feeding and season among the fish species as reported by Rossawan et. al., (2011).

Table 4 Amino Acids Profile () of the Protein Concentrates (g/100g protein

CONCENTRATES	CYSTINE	ALANINE	GLUTAMINE	GLYCINE	SERINE	ASPARTINE	PROLINE	ARGININE	TYROSENE	TNEAA
AFPC	1.37±0.23^{d}	3.86±0.11^{a}	15.69±0.13^{d}	4.17±0.08^{a}	3.56±0.30^{c}	9.93±0.07^{d}	3.67±0.30^{d}	6.80±0.12^{c}	3.52±0.11^{c}	52.57
CRPC	1.28±0.08^{c}	4.15±0. 21^{d}	14.18±0.02^{c}	5.91±0.12^{d}	3.89±0.16^{d}	9.58±0.03^{c}	3.02±0.03^{b}	7.17±0.04^{d}	3.28±0.01^{b}	52.46
HRPC	1.08±0.01^{a}	3.92±0.12^{b}	13.46±0.03^{b}	5.41±0.00^{c}	3.48±0.01^{b}	8.92±0.01^{a}	3.38±0.04^{c}	5.69±0.01^{a}	3.09±0.00^{a}	48.43
MFPC	1.22±0.01^{b}	3.97±0.04c	13.05±0.07^{a}	4.92±0.01^{b}	3.13±0.00^{a}	9.00±0.01^{b}	2.80±0.06^{a}	6.04±0.02^{b}	3.08±0.02^{a}	47.21

CONCLUSION

The study concludes that protein concentrates could be prepared from different species of fish and that the protein concentrates are of high nutritional quality. African lungfish protein concentrate contains the highest value of protein, essential amino acids as well as the non-essential amino acids. Fish protein concentrate and roe protein concentrates produced were a rich source of protein, fat and ash. African lungfish protein concentrate (AFPC) contained higher number of non-essential amino acids in higher amount (tryptophan, methionine, histidine, threonine and glycine). In conclusion, protein concentrates made from African lungfish, mackerel, herring roe and catfish roe had higher nutritional value and can be used as ingredients that can be incorporated in different food formulas.

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REFERENCES

Andrew, E. (2001). Fish Processing Technology in the Tropics. published by National Institute for Freshwater Fisheries Research (NIFFR). Pp8.

AOAC (2006). Association of Official Analytical Chemists. Official methods of analysis. 18th Edition, Washington; D. C., AOAC.

Bechtel, P.J., Chantarachoti, J., Oliveura, A.C., and Sathievel, S. (2007). Characterisation of protein fractions from immature Alaska Walleye Pollock roe. Journal of food science, 72. Pp 336-343.

Benitez, L.V. (1989). Amino Acid and fatty acid profiles in aquaculture nutrition studies. Proceedings of the Third Asian Fish Nutrition Network Meeting. Asian fish. Society Special Publication, 4. Pp 166.

FAO (2005) Review of the state of world marine fishery resources. Fisheries technical paper T457, ISBN 92-5-105267-0.

Galla, N.R. (2014). Physico-chemical, Functional, and Antioxidant Properties of Roe Protein Concentrates from Cyprinus carpio and Epinephelus tauvina. Journal of Food and Pharmaceutical Sciences, 2. Pp: 15-22.

Ihekoronye, A. I., and Ngoddy, P. O. (1985). Integrated Food Science and Technology for the Tropics. Macmillan Publishers, London.

Li, G. (2014). Effects of temperature, pH, salt concentration and pre-heating treatment on enzymatic processes in cod and herring roe. Trondheim, 28. Feb 2024. Pp 171–176.

Mahmoud, K. A., Linder, M., Fanni, J., and Parmentier, M. (2008). Characterisation of the lipid fractions obtained by proteolytic and chemical extractions from rainbow trout (Oncorhynchus mykiss) roe. Process Biochemistry, 43(4). Pp 376–383.

Narsing, R.G., Balaswamy, K., Satyanarayana, A., and Prabhakara R. (2012). Physico chemical, amino acid composition, functional & antioxidant properties of roe protein concentrates obtained from Channa striatus and Lates calcarifer. Food Chemistry, 132. Pp 1171–1176.

Rossawan, I., Soottawat, B., and Wonnop V (2011). Chemical compositions of the roe from skipjack, tongol and bonito. Food Chemistry journal. 124 1328–1334.

Sankar, T.V (2013). Anandan, Suseela, Mathew, K. K. Asha, P. T. Lakshman, Jones, Varkey, P. A. Aneesh P and B. P. Mohanty. Chemical composition and nutritional value of Anchovy (stolephorus commersonii) caught from Kerala Coast, India. European Journal of Experimental Biology, 3(1) Pp: 85-89.

Sovik, S.L. and Rustad, T. (2005) Effect of season and fishing ground on the activity of lipases in by products from cod (Gadus morhua). Lwt-Food Science and Technology, 38. Pp :867-876.

Sathivel S., H. Yin, P.J. Bechtel and M.K. Joan, Physical and nutritional properties of catfish roe spray dried protein powder and its application in an emulsion system, Journal of Food Engineering 95 (2009) 76-81.

Thanonkaew, A., Benjakul, S., Visessanguan, W. and Decker, E. A. (2006). The effect of metal ions on lipid oxidation, colour and physicochemical properties of cuttlefish (Sepia pharaonis) subjected to multiple freeze–thaw cycles. Food Chemistry, 95(4), 591–599.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

APPARENT NUTRIENT DIGESTIBILITY OF CLARIAS GARIEPINUS FED DIFFERENTLY PROCESSED Jatropha curcas MEAL

[1]Jimoh, J. O., [2]Omitoyin, B. O., [2]Ajani, E. K., [3]Liew, H. J., [1]Adeyemi, S. O., [1]Fabusoro, A. A. and [1]Kelau, J. S.

[1]Department of Fisheries and Aquaculture, Federal University Oye Ekiti, PMB 373, KM 3, Are/Afao Road, Oye Ekiti, Ekiti State, Nigeria.
[2]Department of Aquaculture and Fisheries Management, Faculty of Renewable Natural Resources, University of Ibadan, Nigeria
[3]Higher Institution Centre of Excellence (HICoE), Institute of Tropical Aquaculture and Fisheries, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia

Corresponding Author:
jeremiah.jimoh@fuoye.edu.ng, +2348161258112, 0001-5633-4411

ABSTRACT
The study investigated the apparent digestibility of processed Jatropha curcas kernel meal by Clarias gariepinus juveniles. Defatted meal of Jatropha curcas was subjected to autoclaving (30 minutes), chemical extraction with methanol (72 hours) or solid-state fermentation with white rot fungi (7 days). 5 isonitrogenous diets were formulated with the processed J. curcas included at 30% inclusion level and chromium oxide as the inert marker. Juveniles of Clarias gariepinus (n = 150) were fed for 21 days with the formulated feed. The collected faeces were analysed for crude protein (CP), lipid and energy digestibility. Data obtained were subjected to ANOVA and mean separated using Duncan Multiple Range Test at 5% level of variation. Results showed no significant differences in all the analysed digestible nutrients ($p \geq 0.05$). This implies that all the processing methods effectively reduced the antinutritional factors in Jatropha curcas.

Keywords:
Physics nut,
digestible nutrients,
African catfish,
crude protein

INTRODUCTION

Clarias gariepinus is a widely used species in aquaculture because of its quick development, excellent feed conversion efficiency, and ability to adapt to a variety of environmental circumstances. Feed materials that are both economical and nutritionally balanced must be used to ensure the best possible growth and health for this species. The use of substitute plant-based protein sources in fish feed has gained popularity recently, especially as a way to lessen dependency on conventional protein sources like fishmeal (Hussain et al., 2024). Jatropha curcas meal, a by-product of extracting oil from Jatropha seeds, is one such substitute.

The non-edible oilseed plant Jatropha curcas is a promising crop for biofuel. Nevertheless, the meal that remains after oil extraction is limited in its direct application in animal feed due to the presence of anti-nutritional factors (ANFs) such phorbol esters. Many processing techniques, like as heat treatment, chemical extraction and fermentation, have been investigated to lessen or eliminate these ANFs in order to make Jatropha curcas meal a viable protein source in aquaculture (Fawole et al., 2018).

In animal nutrition studies, the apparent nutrient digestibility of a feed ingredient is an important index that is used in determining the suitability of such ingredient for inclusion in the animals' diets (Prakash et al., 2023). With it, the extent of nutrients absorption and utilization by the animal is known. This study therefore aimed at evaluating the apparent nutrient digestibility of Clarias gariepinus fed differently processed Jatropha curcas meal.

MATERIALS AND METHODS

Jatropha curcas seed processing

Shelled J. curcas seeds were milled and the oil was extracted using mechanical hydraulic press (Belewu, 2008). Three processing methods were adopted in this study; thermal treatment where moist defatted J. curcas meal was autoclaved at 1210C for 30 minutes (Azzaz et al., 2011), chemical extraction in which the defatted meal was extracted with 80% methanol in a cold maceration set up for 72 hours (Punsuvon and Nokkaew, 2013) and biological treatment where the meal was made to undergo solid state fermentation with white rot fungi, Aspergilus niger for 7 days at 280C (Belewu and Sam, 2010).

Determination of Proximate composition of processed Jatropha curcas seeds

The proximate composition of the processed Jatropha curcas cake meal, experimental diets, and experimental fish before and after the experiment was determined using the methods of the A.O.A.C, (1995).

Digestibility Experiment

A 21-day digestibility experiment was conducted to study the utilization of raw and differently processed Jatropha curcas meal in the diets of Clarias gariepinus. Five experimental diets composed of 70% reference diet and 30% each of test ingredients were produced (Table 1). Each diet was analysed for proximate composition and energy as described by A.O.A.C (2005).

Experimental design and feeding trial

The digestibility experiment was set up in a completely randomized design. The experiment was set up in the hatchery of the Institute of Tropical Aquaculture and Fisheries, Universiti Malaysia Terengganu, Malaysia. A total of 150 Clarias gariepinus seeds used for the digestibility experiment were sourced for from a reputable hatchery within Terengganu, Malaysia. A total of ten juveniles were randomly distributed into plastic tanks in triplicates. Fish were fed 2 times between 8.00 and 8.30 hours and 17.00 and 17.30 hours at 3% body weight for 21 days. Daily feed supplied were recorded. The fish were weighed weekly using a sensitive weighing balance.

Table 1: Percentage Ingredients Composition of the diets for the digestibility experiment.

Ingredients	RFD	RaJKM	MeJKM	FeJKM	AuJKM
Maize meal	23.00	18.00	18.00	18.00	18.00
Soya bean meal	40.00	20.00	20.00	20.00	20.00
Fishmeal	30.00	15.00	15.00	15.00	15.00
Jatropha curcas meal	0.00	40.00	40.00	40.00	40.00
Starch	2.00	2.00	2.00	2.00	2.00
Chromic oxide	1.00	1.00	1.00	1.00	1.00
Fish oil	1.00	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50	0.50
Pre-mix	0.50	0.50	0.50	0.50	0.50
Methionine	1.00	1.00	1.00	1.00	1.00
Lysine	1.00	1.00	1.00	1.00	1.00
TOTAL	100.00	100.00	100.00	100.00	100.00

RFD; Reference diet, RaJKM; Raw Jatropha curcas kernel meal diet, MeJKM; Chemically processed Jatropha curcas kernel meal diet, FeJKM; Fermented Jatropha curcas kernel meal diet, AuJKM; Autoclaved Jatropha curcas kernel meal diet.

Faecal collection and Analytical procedure for determination of digestibility indices

Feeds not consumed after 30 minutes for each feeding, and fecal wastes were siphoned 8 hours after each feeding. The faeces were pooled, dried, and stored for analysis. Chromic oxide levels were determined by digesting organic matter with nitric acid and oxidizing it with perchloric acid (Falaye et al., 2014; Furukawa and Tsukuhara, 1966). Percentage chromic oxide content will be calculated as follows:

Weight of Chromic oxide in sample (X) $$X = \frac{1}{4} \cdot \frac{Y - 0.0032}{0.2089}$$

Where: Y = absorption as read on the spectrophotometer while 0.0032 and 0.2089 are constants.

% Chromic oxide = $$\text{Chromic Oxide}\,\% = 100\frac{X}{A}$$

Where: X = weight of chromic oxide and A = weight of sample.

Calculation of Apparent Digestibility Coefficient

The apparent digestibility coefficients (ADCs) of protein, lipid and energy for the test ingredients were calculated as follows (Cho and Slinger, 1979 cited in Falaye et al., 2014).

$$\text{ADC (Nutrient)} = 100\text{-}100\ \frac{\textit{Chromium in diet(\%)}}{\textit{Chromium in feaces(\%)}}\ X\ \left(\frac{\textit{Nutrient in feaces}}{\textit{Nutrient in diet}}\right)$$

The digestible nutrient (DN) of the test ingredients was calculated according to the following equation (De Silva and Aderson 1995):

$$DN = \frac{\{ADCTD - (Y \times ADCRD)\}}{Z}$$

Where, ADCTD = Apparent digestibility coefficient in test diet, ADCRD = Apparent digestibility coefficient in reference diet, Y = the reference diet proportion; Z = the test diet proportion.

Statistical analysis

Data were subjected to a one-way analysis of variance. Means were separated using Duncan's multiple range test ($p \leq 0.05$)

RESULTS AND DISCUSSION

Table 2: Proximate composition and anti-nutritional factor profile of raw and processed Jatropha curcas cake meal

Parameters	RJCM	MeJKM	AuJKM	FeJKM
MOISTURE (%)	7.79±2.27^{b}	4.8±1.12^{a}	6.2±0.38^{ab}	7.08±0.75^{ab}
CRUDE PROTEIN (%)	32.29±2.44^{b}	51.35±2.60^{a}	40.22±1.71^{b}	46.64±3.28^{a}
LIPID (%)	27.49±1.41^{b}	10.28±2.29^{a}	17.12±1.77^{ab}	13.41±1.28^{a}
CRUDE FIBRE (%)	9.57±0.52^{b}	8.47±0.65^{a}	9±0.65^{ab}	9.51±0.15^{ab}
ASH (%)	8.58±0.73^{a}	8.01±0.15^{a}	8.57±0.14^{a}	8.51±0.24^{a}
ENERGY (J/g)	23333.33±1790.93	21355.67±650.58	21455.33±550.05	22064.33±1148.98
NFE (%)	14.27±4.78^{a}	15.09±1.2^{a}	18.89±0.83^{a}	14.84±2.66^{a}

RJCM; Raw Jatropha curcas kernel meal diet, MeJKM; Chemically processed Jatropha curcas kernel meal diet, FeJKM; Fermented Jatropha curcas kernel meal diet, AuJKM; Autoclaved Jatropha curcas kernel meal diet. Means in the same row with different superscripts differ significantly ($p \leq 0.05$).

Proximate composition of raw and processed Jatropha curcas kernel meal

Table 2 contains the results of the proximate composition of both the raw and differently processed Jatropha curcas kernel meal. The moisture content ranged between 4.8±1.12 and 7.79±2.27. The values are significantly different across the treatment methods. The best crude protein content

(51.35±2.6) and least lipid content (10.28±2.29) was obtained in the methanol-extracted J. curcas meal. This may be related to the inverse kind of relationship between crude protein and lipid content of feed ingredients. The best energy value was obtained in the raw J. curcas meal.

Table 3: The proximate composition of digestibility diets and the Apparent digestibility coefficient of the fed fish

PARAMETERS	RJCM	MeJKM	AuJKM	FeJKM
ADC PROTEIN	92.95±1.81[a]	93.79±1.83[a]	93.81±2.11[a]	93.48±2.14[a]
ADC FAT	87.37±9.28[a]	88.56±8.69[a]	88.85±9.88[a]	87.76±9.11[a]
ADC ENERGY	81.33±5.02[a]	82.21±4.61[a]	82.01±5.04[a]	81.8±4.97[a]

RJCM; Raw Jatropha curcas kernel meal diet, MeJKM; Chemically processed Jatropha curcas kernel meal diet, FeJKM; Fermented Jatropha curcas kernel meal diet, AuJKM; Autoclaved Jatropha curcas kernel meal diet. Means in the same row with different superscripts differ significantly ($p \leq 0.05$).

Apparent digestibility coefficient (ADC) of Clarias gariepinus with Jatropha curcas based diets

Although the diet made with methanol-extracted Jatropha curcas had the highest digestibility of crude protein (93.81±2.11); however, there was no significant difference among the apparent digestibility coefficient of all the other nutrients across the diets prepared (Table 3). This may be indicating the processing methods used in this study reduced the antinutritional factors significantly. Thus, the high protein digestibility that was recorded in this study across the various processing methods could be related to the effectiveness of the methods. Cooking of feedstuffs through autoclaving could aid palatability and digestibility (Sarker, 2023) while biological processes such as fermentation have been reported to have the ability to break down macronutrients, thereby enhancing digestibility (Mirzakhani et al., 2020). This result is similar to what was reported by Fawole et al. (2018) after they had used protein concentrates from Jatropha curcas kernel to make feed for Labeo rohita. The high lipid digestibility recorded in this study might be an indication that Clarias gariepinus digested the diets efficiently. However, Chi et al. (2017) stated that fatty acid chain length, the amount of dietary fat incorporation, as well as various fatty acid ratios and melting points, had an impact on lipid digestibility coefficients as well. This probably could be the reason why Siniperca chuatsi fed fermented soybeans meal-based diet had greater lipid digestibility (Mo et al., 2019) because the diet contained lower lipid contents than the diets in this study. Omnivorous species of fish are known to be distinct in their ability to digest starch from plants (Lemus et al., 2017). This could be the explanation for the fairly high energy digestibility that was recorded in the fed Clarias gariepinus.

REFERENCES

A.O.A.C. (2005). Official methods of analysis of AOAC International, 18th edition. AOAC International, Arlington, VA.

Azzaza N.A.E, El-Nisr N.A, Elsharkawy E.E., and Elmotleb, E.A. (2011). Chemical and Pathological Evaluation of Jatropha curcas Seed Meal Toxicity with or without Heat and Chemical Treatment. Australian Journal of Basic and Applied Science, 5, 49-59.

Belewu, M.A. (2008). Replacement of fungus treated Jatropha curcas kernel meal in the diet of rat. Green farming Journal. 2(3), 154-157

Chi, S.Y., Wang, W.J., Tan, B.P., Dong, X.H., Yang, Q.H., Liu, H.Y. and Zhang, S. (2017). The Apparent Digestibility Coeffcients of 13 Selected Animal Feedstuff for Cobia, Rachycentron canadum. World Aquaculture Society, 48, 280-289

Farukawa, A. and Tsukahara, H. (1966). On the acid digestion method for the determination of chromic oxide as an index substance in the study of digestibility of fish feed. Bulletin Japanese Soceties

Science Fisheries, 32, 502-506.

Falaye, A.E., Omoike, A. and Orisasona, O. (2014). Apparent digestibility coefficient of differently processed lima bean (Phaseolus lunatus L.) for Clarias gariepinus juveniles. Journal of Fisheries and Aquatic Science, 9, 75-84.

Fawole, F.J., Sahu1, N.P., Shamna, N., Phulia, V., Emikpe, B.O., Adeoye, A.A., Aderolu, A.Z. and Popoola, O.M. (2018). Effects of detoxified Jatropha curcas protein isolate on growth performance, nutrient digestibility and physio-metabolic response of Labeo rohita fingerlings. Aquaculture Nutrition, 24, 1223–1233. DOI: 10.1111/anu.12660.

Hussain, S.M., Bano, A.A., Ali, S., Rizwan, M., Adrees, M., Zahoor, A.F., Sarker, P.K., Hussain, M., Arsalan, M.Z. Yong, J.W.H. and Naeem, A. (2024). Substitution of fishmeal: Highlights of potential plant protein sources for aquaculture sustainability, Heliyon, 10(4), e26573, https://doi.org/10.1016/j.heliyon.2024.e26573.

Lemus, I., Maldonado, C., Cuzon, G., Sanchez, A., Gaxiola, G., Alvarez, A. and Guerrero, M. (2017). Invitro and Invivo Feedstuff Digestibility for Snook, Centropomus undecimalis, Juveniles. World Aquaculture. Society. 49, 205-215.

Mo, A.J., Sun, J.X., Wang, Y.H., Yang, K., Yang, H.S. and Yuan, Y.C. (2019). Apparent digestibility of protein, energy and amino acids in nine protein sources at two content levels for mandarin fish, Siniperca chuatsi. Aquaculture, 499, (2019), 42-50, https://doi.org/10.1016/j.aquaculture.2018.09.023.

Prakash, S., Maas, R.M., Fransen, P.M.M., Kokou, F., Schrama, J.W. and Philip, A.J.P. (2023). Effect of feed ingredients on nutrient digestibility, waste production and physical characteristics of rainbow trout (Oncorhynchus mykiss) faeces., Aquaculture, 574(2023), 739621, https://doi.org/10.1016/j.aquaculture.2023.739621.

Sarker, P.K. (2023). Microorganisms in Fish Feeds, Technological Innovations, and Key Strategies for Sustainable Aquaculture. Microorganisms, 11(2), 439. https://doi.org/10.3390/microorganisms11020439

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

GROWTH PERFORMANCE AND COST BENEFITS OF Clarias gariepinus FINGERLINGS FED YEAST TABLETS ADDITIVE DIETS

Sogbesan, O. A.1, 1M.A. Ahmed and 2M.S. Ityumbe

1Department of Fisheries, Modibbo Adama University, Yola
2Department of Fisheries and Aquaculture, Federal University, DutsinMa

Correspondence: sokayfish@mau.edu.ng

ABSTRACT
In an effort to increase growth and improve feed utilization, a 12 week feeding trial was conducted at the wet laboratory of the Department of Fisheries, Modibbo Adama University Yola to determine the effects of different levels of dietary yeast additive on growth and feed utilization in Clarias gariepinus fingerlings (Burchell, 1822). The proximate of the experimental diets were not significantly different and are within the recommended level for Clarias gariepinus culture. Fish of mean weight 1.64g and length of 6.3cm were fed on experimental diets in triplicate groups. There were significant ($p<0.05$) differences in weight gain among the fish fed all the experimental diets. Weight gain of fish fed diet with 0g of yeast additive were significantly ($p<0.05$) lower than those fed on supplemented yeast tablet diets. Fish fed diet with 2.5g of yeast additive per 100g of feed showed a significantly ($p<0.05$) higher weight gain than fish fed on other diets. Generally, fish fed yeast tablets supplemented diets showed better growth rate, feed conversion ratio and protein efficiency compared with the diet without yeast supplementation (control diet). There were significant different in the carcass proximate composition where crude protein was higher in diet 5 and lower in the control diet while crude lipid was higher in diet 6 at yeast additive inclusion level of 2.5g/100g feed and lower in diet 3 at inclusion level of yeast additive of 2.0g/100g feed. The water quality parameters monitored in this study were observed to be within the optimum ranges recommended for Clarias gariepinus culture. The research demonstrates the efficiency of including yeast tablets in the diets of fish with the best benefit cost ratio at 2.5g of yeast/100g feed. Incorporation of yeast additive at 2.5g/100g feed in the diet of Clarias gariepinus is feasible as profit indices were higher at that inclusion level.

Keywords:
Additives, Yeast tablet, Clarias gariepinus, Growth, Cost benefits

INTRODUCTION

Aquaculture is an important food production sector for meeting global food and nutrition security needs to curb the challenges of hunger and malnutrition and its production and contribution globally have continued to increase significantly reaching to 122.6 million tonnes (FAO, 2022). Yeast contains a high amount of enzymes, fatty acids, amino acids, vitamin B and number of unknown growth factors. Yeasts are used in both terrestrial and aquatic animal nutrition and its supplementation has significantly improved feed utilization, aquatic animals' health, physiological status, and productivity (Zaineldin et al., 2021). Clarias gariepinus is one of the major aquaculture species accountings for 75% of the global aquaculture output (Naylor et al., 2021). Fish feed has been a significant concern in Aquaculture development, every farmer expected an increase and better yield, hence poor growth and this retard aquaculture production (Maulu et al., 2021). Most farmers have utilized the pelleted feeds yet the fish growth rates have not significantly improved as anticipated by the farmers, most fishes consume the feed but few converted it for growth. Therefore, there is a need to source for additives to enhance feed utilization by fish for better growth.

MATERIALS AND METHOD

The experiment was carried out at wet laboratory of the Department of Fisheries, Modibbo Adama University Yola and lasted for 12 weeks.

A factorial design arranged in completely randomized design was used for this experiment. There were five treatments and control which was replicated thrice making a total of eighteen experimental units. Eighteen (18) bowls of 40 liters filled with 30 liters of water were used for this study and ten (10) fingerlingsss of Clarias gariepinus of weight 1.65g and length, 6.3 cm were assigned to each bowl

Six experimental diets were formulated and prepared for this experiment. The experimental diets were isonitrogenous at about 42.5% crude protein and formulated using Pearson Square method along with Least Cost Formulae (LCF) (Sogbesan et al., 2007). In the diets, yeast additive was added at various inclusion levels namely 0g (control), 0.5g, 1.0g, 1.5g, 2.0g and 2.5g as shown in table 1.

Temperature was taken daily with thermometer in degree Celsius while ammonia in mg/l, dissolved oxygen in mg/l and pH was measured using pH meter (E251) Boyd, (1990).

The analyses of biochemical components of the experimental diets for crude protein, crude lipid, crude fibre, moisture, ash and Nitrogen - free extract were carried out, also the proximate analysis was carried out at the end of the experiment, fish from each treatment was sacrificed and the carcass subjected to proximate analysis as described by (AOAC, 2020).

Table 1: Ingredient composition (g/100g diet) of experimental diets containing the additives

Ingredients	Diet 1 Control	Diet 2 0.5g YT	Diet 3 1.0YT	Diet 4 1.5YT	Diet 5 2.0YT	Diet 6 2.5YT
Fish meal	30.0	30.0	30.0	30.0	30.0	30.0
Soybean	18.0	18.0	18.0	18.0	18.0	18.0
Groundnut cake	13.0	13.0	13.0	13.0	13.0	13.0
Maize	35.0	34.5	34.0	33.5	33	32.5
Yeast tablet	0.0	0.5	1.0	1.5	2.0	2.5
Starch	1.5	1.5	1.5	1.5	1.5	1.5
Oil	0.5	0.5	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Calcium tablets	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin C	0.5	0.5	0.5	0.5	0.5	0.5
Mineral Premixes	0.5	0.5	0.5	0.5	0.5	0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0

***YT- Yeast tablet/100g**

Weight was measured with digital sensitive weighing balance and length with meter rule. Fish Performance indices such as growth were expressed as total weight gain, mean weekly weight gain, percentage weight gain, relative weight gain, specific growth rate and survival rate (Fasakin et al., 2001). Feed utilization indices was expressed as Feed conversion ratio, Mean weekly feed intake, feed conversion ratio, Protein intake, Net protein utilization and Protein efficiency ratio (Wilson, 1989). Cost benefits in terms of Net profits, Profit Index, incidence of cost, and benefit cost ratio was determined according to Mazid et al. (1997) as modified by Sogbesan et al (2006) based on the current market price of the ingredients used for formulating the diets and fish cultured.

The Data were analyzed statistically using one way analysis of variance at 5% probability and Means was separated using Least Significance Difference (LSD).

RESULTS AND DISCUSSION

Crude protein content of the experimental diets ranges from 43.6% - 44.6% and are similar with the values, 40.0% - 43.0% reported by Hecht (2013). In his study, higher protein levels in the diet led to better growth than lower protein levels. Crude lipid content values, 14.0% - 14.5% are in disagreement with the finding of Ochang et al. (2007) who observed reduced performance of catfish fingerlings fed diets with 14.26% lipid level. The increase of the lipid in the diets may be as a result of polyunsaturated fatty acids of the fish meal used as reported by Geay et al. (2015). Dry matter content of the experimental diets ranges from 96.5% - 97.5% are higher than the values, 91.19% - 94.03% reported by Agbabiaka et al (2016).

Table 2: Proximate Compositions of the Experimental Diets

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
Dry matter	96.5	96.5	97.5	97.0	97.5	97.5
Crude protein	43.6	43.8	44.6	44.6	44.5	44.4
Crude lipid	14.5	14.2	14.0	14.5	14.0	14.1
Ash	11.2	11.4	10.9	11.0	11.1	10.9
Crude Fibre	10.5	10.1	10.3	10.2	10.5	10.0
N F E	16.7	17.0	17.7	16.7	17.4	18.1

Statistically there was significant difference in the weight gain ($p \leq 0.05$), the diet fed with yeast additive revealed a significant increase in weight gain, specific growth rate, mean feed intake, relative growth rate and protein intake than the control diet, this finding was supported by Rad et al. (2012) who reported that the dietary supplementation of yeast has improve the growth performance of O. niloticus fingerlings. The FCR values, 1.33 - 1.86 reported from this study are lower than 2.42 - 2.88 reported by Sajeevan et al. (2009) for Heterobranchus longifilis fingerlings fed baker's yeast (Saccharocymyces cerevisiae) additive diet. The higher FCR for diets 6 indicates better feed utilization by fish fed this diet and is justified by better growth performance exhibited by fish fed such diet. The PER values, 0.58 - 0.82 reported from this study are similar to the report of Ngbede et al (2023) who reported improvement in PER and FCR of C. gariepinus fed diets with local bakery yeast as additives.

Table 3: Growth performance and nutrients utilization of Clarias gariepinus fingerlings fed Yeast additive diets

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
Mean initial weight (g)	1.65±0.1[a]	1.64±0.1 [a]	1.64±0.2 [a]	1.65±0.1 [a]	1.64±0.1 [a]	1.64±0.1 [a]
Mean final weight (g)	9.51±0.7[c]	12.17±0.5[bc]	18.40±0.7 [b]	19.54±1.6 [ab]	21.79±1.5 [a]	27.15±1.8 [a]
Mean weight gained (g)	7.86±0.4 [c]	10.53±0.8[bc]	16.76±0.6 [b]	17.89±0.8 [ab]	20.15±0.6 [a]	25.51±0.8 [a]
Mean initial length (cm)	6.30±0.3 [a]	6.30±0.2[a]	6.40±0.3 [a]	6.20±0.2 [a]	6.30±0.2 [a]	6.20±0.1 [a]
Mean final length (cm)	11.10±0.2 [b]	11.50±0.3[b]	13.40±0.2 [a]	13.60±0.3 [a]	13.80±0.3 [a]	14.20±0.2 [a]
Mean length gain (cm)	4.80±0.1 [b]	5.20±0.2[ab]	7.00±0.1 [a]	7.40±0.2 [a]	7.50±0.2 [a]	8.00±0.4 [a]
Mean weekly weight gain (g)	0.79±0.1 [c]	1.05±0.2[bc]	1.68±0.3 [b]	1.79±0.1 [ab]	2.02±0.4 [a]	2.55±0.3 [a]
Percentage weight gain (%)	476.36 ±23.0 [d]	642.07 ±47.0 [c]	1021.95 ±47.0 [b]	1084.24 ±67.0 [b]	1228.66 ±79.0 [ab]	1555.49 ±89.0 [a]
Specific growth rate (%/day)	1.09±0.3 [c]	1.24±0.1[bc]	1.49±0.2 [b]	1.53±0.1 [ab]	1.60±0.3 [a]	1.74±0.2 [a]
Mean Feed intake (g)	10.46±0.9 [c]	17.88±0.8[bc]	22.68±0.4 [b]	28.67±0.5 [ab]	33.92±1.9 [a]	47.56±1.5 [a]
Feed conversion ratio	1.33±0.1 [c]	1.73±0.2[a]	1.35±0.1 [b]	1.60±0.2 [ab]	1.68±0.1 [ab]	1.86±0.2 [a]
Protein intake	4.56±0.8 [d]	7.83±0.6[cd]	10.11±0.9 [bc]	12.79±0.8 [b]	15.09±0.6 [ab]	20.97±0.9 [a]
Protein efficiency ratio	0.58±0.2 [c]	0.74±0.4[ab]	0.60±0.1 [bc]	0.71±0.3 [ab]	0.75±0.1 [ab]	0.82±0.2 [a]
Survival (%)	65.0±2.5 [c]	65.0±3.0[c]	65.0±2.5 [c]	70.0±2.5 [bc]	75.0±5.0 [ab]	80.0±2.5 [a]
Investment cost (#)	55.83 [d]	64.84 [cd]	71.13[bc]	78.69 [b]	85.43[b]	105.87[a]
Mean final weight gain (g)	9.51 [c]	12.17[bc]	18.40 [b]	19.54[ab]	21.79[a]	27.15[a]
Cost of fish/kg (#)	261.00	331.91	504.89	532.91	597.89	744.97
Mean yield cost (#)	141.03 [d]	180.48 [d]	272.87 [c]	289.78[bc]	323.15[ab]	402.63[a]
Mean net profit (#)	85.20 [d]	115.64 [c]	201.74 [b]	211.09[b]	237.72[b]	301.76[a]
Gross profit (#)	29.37 [c]	50.80 [c]	123.05 [b]	132.40[b]	152.29[ab]	200.89[a]
Profit index(#)	24.09 [a]	16.73[ab]	19.32[b]	15.82[ab]	14.79[c]	13.33[c]
Incidence of cost (#)	1.14 [e]	1.63 [c]	1.42 [d]	1.72[bc]	1.86 [b]	2.06[a]
Benefit cost ratio (#)	4.67 [c]	5.12[bc]	7.09 [a]	6.77[ab]	6.99[ab]	7.04[a]

Data on the same row with different superscripts are significantly different ($p<0.05$)

The highest net profit was recorded from the fish fed diet 6 but diet 3 which was the incorporation of yeast additive at 1.5g/100g feed was therefore the most cost-effective diet. This finding is in consistent with the report of Khatun et al. (2014) which reported that the incorporation of additives into fish diet resulted into highest weight gain and also produced fish with the highest value for Cyprinus carpio fed betaine and β - glucan additives diet. Falaye et al. (2016) reported that when cost benefit ratio is greater than one or equal to one indicates profit, but less than one shows lack of viability or unprofitability of the venture.

CONCLUSION

All the five diets containing yeast additives at different inclusion levels performed better than the control diet, which indicated that any of these additives could be incorporated into the diets of Clarias gariepinus. Yeast additive at 2.0 to 2.5g/100g feed had the highest survival rates and better growth, it is therefore recommended for better growth and high survival rate. Yeast additive at 2.5g/100g feed had the best economic benefits, it is therefore recommended for Clarias gariepinus diet for better economic benefits.

REFERENCES

AOAC (2020). Official Methods of Analysis (18th ed.) Association of Official Analytical Chemists, Arlington, Virginia, p. 542.

Falaye, A. E., Elezuo, K. O., Ajani, E. K. and Omoike, A. (2016). Digestibility and nutrient utilization of differently processed tropical almond (Terminalia catappa) kernel meal and cake based diets by

Clarias gariepinus juveniles. JAGST © Jomo Kenyatta University of Agriculture and Technology, 17(1): 42 - 60.

FAO (2022). The state of World Fisheries and Aquaculture 2022. Towards blue transformation. https://doi.org/10.4060/cc0461en

Geay, F., and Kestemont, P. (2015). Feeding and nutrition of percid fishes during ongrowing stages. In P. Kestemont, K. Dabrowski, and R. C. Summerfelt (Eds.), Biology and culture of percid fishes (pp. 587–622). Springer Netherlands.

Hecht, T. (2013). A review of on-farm feed management practices for North African catfish (Clarias gariepinus) in sub-Saharan Africa. Food and Agriculture Organization Fisheries and Aquaculture Technical Paper, 15–24.

Khatun B, Rahman R. and Rahman M. (2014). Evaluation of yeast Saccharomyces cerevisiae and algae Chlorella vulgaris as diet for rotifer Brachionus calyciflorus. Agriculturists 12:1-9

Ngbede, S.O, Yunusa, A., Ogbaje, C.O., Yusuf, A. and Salifu, S. (2023). Effect of replacement of Fishmeal with local baker's yeast (Sacchromyces cerevisiae) on the growth performance of the African catfish, Clarias gariepinus. Proceeding of the 38th Annual Conference, Fisheries Society of Nigeria, Bayelsa 2023

Sogbesan, O. A. and Ugwumba, A. A. A. (2006). Effects of different dietary replacement of fish meal with earthworm (Hyperrodrilus euryaulos, clausen, 1914: Oligocheata: Eudrilidae) meal in the diet of Heterobranchus longifilis (Teleostei, Clariidae) fingerlings under laboratory conditions. South African Journal of Aquatic Sciences, 3(2): 422 - 426.

Sogbesan O. A., Ugwumba A. A. A., Madu C. T., Eze S. S. and Isa J. (2007) Culture and utilization of earthworm as animal protein supplement in the diet of Heterobranchus longifilis fingerlings. Journal of Fisheries and Aquatic Science 2:375–386

Zaineldin A.I., Hegazi S., Koshio S., Ishikawa M., Dawood M.A., Dossou S., Yukun Z. and Mzengereza K. (2021). Singular effects of Bacillus subtilis C-3102 or Saccharomyces cerevisiae type 1 on the growth, gut morphology, immunity, and stress resistance of red sea bream (Pagrus major). Ann. Anim. Sci., 21: 589–608.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

NUTRITIONAL COMPOSITION OF WATERMELON RIND MEAL FOR FISH FEED PRODUCTION

[1]Salau, B. R., [1]N. A. Agbason, [1]M. T. Rabo, [1]A .M. Addra, [2]W. D. Adamu and [3]S. Y. Olem.

[1]Department of Fisheries Technology College of Agriculture, Science and Technology Lafia
[2]Department of Aquaculture and Fisheries Management, Nasarawa State University Keffi
[3]Department of Zoology, Nasarawa State University Keffi

Corresponding Author:
sirbas22@gmail.com; salaubarnabas@yahoo.com; 07061653390

ABSTRACT

The study investigated the nutritional composition of watermelon (Citrullus lanatus) rind meal. The result of the proximate composition revealed that the rind had crude protein of 10.9%, nitrogen free extract 53.87%, ether extract 11.55%, ash 7.75%, crude fiber 4.56%, and moisture 11.33% respectively. The result of amino acid profile of the rind showed essential amino acid such as arginine 8.43mg/100g, lysine 4.75 mg/100g and leucine 4.61 mg/100g in high concentration, other essential amino acid found in the rind were histidine 1.92 mg/100g, isoleucine 3.14 mg/100g, phenylalanine 1.51 mg/100g, threonine 1.28 mg/100g, valine 3.45 mg/100g, methionine 0.37 mg/100g and tryptophan 0.58 mg/100g respectively. Non-essential amino acid of the rind showed high concentration of glutamic acid 9.39 mg/100g, aspartic acid 6.45 mg/100g and alanine 5.46 mg/100g while glycine 4.84 mg/100g, proline 1.32 mg/100g, serine 2.32 mg/100g, tyrosine 2.92 mg/100g and cysteine 0.42 mg/100g were recorded in low concentration respectively. Anti-nutrients discovered in the rind included phytate 317.11 mg/100g, saponins 3.06 mg/100g, alkaloid 1.26 mg/100g and tannins 1.47 mg/100g respectively. The study agreed with earlier reports that watermelon rind is a good source of feed ingredient which could be used to replace a carbohydrate source of feedstuff for fish and other animals. Also, utilization of watermelon rind will help to minimize cost of producing fish feed.

Keywords:
Essential amino acid,
non-essential amino acid

INTRODUCTION

High cost of fish conventional feedstuff causes low profit, losses and closure of some farms, adversely affecting aquaculture production. Maize which is the major source of energy is used as food by humans, it is in high demand by industries for the production of human, animal and fish feeds and this makes the product and feeds expensive.

The need to reduce the cost of fish feed is imperative in the aquaculture business. An inexpensive source of fish feeds will make fish farming attractive due to its profitability. Research and studies into cheaper alternative energy sources for the development of least cost feeds for a small-enterprise fish farmer is an utmost priority in developing countries.

For Nigeria to be successful in fish production, the quest to make it profitable by using low cost feed with good energy content that can be sourced locally will be of great value and interest to farmers. In addition, Nigeria spent over 150 billion naira on fish importation in 2014 (FAO, 2014). If there are readily available fish feeds, locally produced and of high-quality, many people will be attracted to fish farming, thereby boosting fish production and reducing fish importation. Consequently, the use of watermelon rind as a fish feed ingredient may lead to profitable fish farming via reduction in the cost of feed.

The rind of a watermelon is the tough, outer layer of a watermelon, and is typically green on the outside, before giving way to the red and pink flesh of the fruit, which turns pale white on the inside. Not only do watermelon rinds contain all the nutrients found in the juicy fruit, but they also contain higher concentrations of certain antioxidants, minerals, vitamins and active ingredients.

This hard peel has low-calorie levels, but high amounts of vitamin C, vitamin A, vitamin B6, potassium and zinc. Watermelon rind is also rich in nutrients with chlorophyll, citrulline, lycopene, amino acids and flavonoids and phenolic compounds (Vedantu, 2024)

Watermelon rinds also offer a high dose of L-citruline; an amino acid which helps in dilating blood vessels, improve blood circulation and gives watermelon its antioxidant effects (Braide et al., 2012). It is also known to contain a variety of bioactive compounds like cucurbitacin, triterpenes, sterols and alkaloid (Johnson et al., 2012).

Therefore, this study was aimed at the determination of the nutritional composition of the watermelon rind for possible inclusion in fish feed formulation as an alternative energy source.

MATERIALS AND METHODS

Collection and Processing of the Rind

Watermelon rind were collected from fruits seller within Lafia Metropolis, washed and sliced to smaller pieces and were spread under the sun for 21 days to dry. The dried watermelon rind were milled into fine particles using the hammer mill and sample was taken to the laboratory for proximate composition and amino acid profile

Determination of Proximate composition and Amino Acid Profile of Watermelon Rind

The proximate composition of the watermelon rind meal was determined using standard AOAC methods. (AOAC 1990). The amino acid profile of the watermelon rind meal was determined using methods described by AOAC (2006).

Determination of Anti- Nutritional Factors

The anti-nutritional factor of the watermelon rind meal was determined using methods described by AOAC (2000)

RESULTS AND DISCUSSION

Proximate Analysis of watermelon Rind Meal

The proximate composition of watermelon rind meal revealed excellent amount of nutrients present in the rind. Moisture content 11.33% was higher than the 8.78% reported by Sadiq et al. (2021) but lower compared to the 12.17% reported by Ashoka et al., (2022). Ash 7.75g was higher than the 5.31% reported by Sadiq et al. (2021) but lower than the 11.82% reported by Ashoka et al. (2022). Crude fibre 4.56% was lower than the 10.66% reported by Sadiq et al., (2021) and the 17.44% reported by Ashoka et al., (2022). The rind had crude protein content of 10.94% which was within the range reported by Ashoka et al., (2022) crude protein 10.18% but higher than the 2.88% reported by Sadiq et al.,(2021). The crude protein content for the rind was higher than the crude protein for maize 9.3% – 9.8% reported by National Research Council (NRC 1998). Nitrogen free extract 53.87% were higher than the 46.02% reported by Ashoka et al., (2022) but lower than the 70.04% reported by Sadiq et al.,(2021). The difference in values of some of the parameters might be due to difference in variety of fruit, processing methods and soil in which the plant was grown. The nutritional value of the watermelon rind revealed by the proximate composition agreed with the report of Mohan et al., (2018) that every part of watermelon fruit has nutritional value, including the peel, the seeds and the rind.

Table 1: Proximate Composition of Watermelon Rind Meal

Parameters	Percentage (%)
Moisture	11.33
Ash	7.75
Crude protein	10.94
Ether extract	11.55
Crude fiber	4.56
Nitrogen free extract	53.87

Amino Acid Profile of Watermelon Rind

The amino acid profile of watermelon rind meal revealed the presence of eight (8) essential amino acid in sufficient quantities; which are arginine 8.43 mg/100g, lysine 4.75 mg/100g, leucine 4.61 mg/100g, isoleucine 3.14 mg/100g, valine 3.45 mg/100g, histidine 1.92 mg/100g, phenylalanine 1.51 mg/100g, threonine 1.28 mg/100g while tryptophan 0.58 mg/100g and methionine 0.37 mg/100g were recorded in small quantity. Arginine 8.43 mg/100g, lysine 4.75 mg/100g, isoleucine 3.14 mg/100g, leucine 4.61 mg/100g, phenylalanine 1.51 mg/100g, threonine 1.28 mg/100g, and valine 3.45 mg/100g were within the range reported by Badr et al., (2018) arginine 8.91 mg/100g, lysine 4.97 mg/100g, isoleucine 3.14 mg/100g, leucine 4.71 mg/100g, phenylalanine 1.57 mg/100g, threonine 1.13 mg/100g, and valine 3.75 mg/100g but were lower compared to the report of Ibrahim et al., (2019) arginine 16.0 mg/100g, isoleucine 5.8 mg/100g, leucine, 7.3 mg/100g, phenylalanine 5.4 mg/100g, threonine 3.0 mg/100g and valine 7.3 mg/100g whereas lysine 2.5 mg/100g was lower.

Also seven (7) non-essential amino acid were detected in sufficient quantities; glutamic acid 9.39 mg/100g, aspartic acid 6.45 mg/100g and alanine 5.46 mg/100g, glycine 4.84 mg/100g, tyrosine 2.92 mg/100g, serine 2.32 mg/100g and proline 1.32 mg/100g whereas cysteine 0.42 mg/100g was present in small quantity.

Aspartic acid 6.45 mg/100g, was within the range reported by both Badr et al., (2018) aspartic acid 6.63 mg/100g and Ibrahim et al., (2019) 6.4mg/100g. Glutamic acid 9.39 mg/100g was within the range reported by Badr et al., (2018) glutamic acid 9.94 mg/100g but lower than the 18.7 mg/100g reported by Ibrahim et al., (2019). Alanine 5.46 mg/100g was lower than the 6.11 mg/100g reported by Badr et al., (2018) and the 7.7 mg/100g reported by Ibrahim et al., (2019). Proline 1.32 mg/100g was within the range reported by Badr et al., (2018). Serine 2.32 mg/100g was within the reported range by Badr et al., (2018) serine 2.09 mg/100g and Ibrahim et al., (2019) serine 2.5 mg/100g. Tyrosine 2.92 mg/100g was within the range reported by Badr et al., (2018) tyrosine 2.61 mg/100g but higher than the 1.0 mg/100g reported by Ibrahim et al., (2019). The values of the essential and none-essential amino acids were within the range reported by Anthony (2015) in the research on assessment of some anti-nutritional properties of Watermelon (Citrullus lanatus) rind and seed reported the following essential amino acids and non-essential amino acids present in the rind 100gm protein; lysine 4.97gm, leucine 4.71gm, valine 3.75gm, isoleucine 3.14gm, glutamic 9.94gm, arginine 8.91gm, aspartic 6.63gm, alanine 6.11gm, and Glycine 5.76gm.

Watermelon rind by virtue of the amino acid profile when included in the diet of fish will contribute in providing the needed protein and amino acid for fish based on the protein and amino acid requirement for fish reported by National Research Council (NRC, 1993).

Table 2: Amino Acid Profile of Watermelon Peel Meal compared with Maize

Amino acid	Watermelon rind (g/100g protein)	Maize (g/100g protein) NRC (1998)
Essential		
Arginine	8.43	4.72
Histidine	1.92	3.02
Isoleucine	3.14	3.41
Lysine	4.75	3.02
Leucine	4.61	11.93
Methionine	0.37	2.10
Phenylalanine	1.51	4.85
Threonine	1.28	3.80
Valine	3.45	4.85
Tryptophan	0.58	0.52
Non-Essential		
Aspartic acid	6.45	6.82
Cystine	0.42	2.36
Glycine	4.84	4.06
Glutamic acid	9.39	19.54
Alanine	5.46	7.34
Proline	1.32	8.00
Serine	2.32	4.72
Tyrosine	2.92	3.67
Anti-nutrients		
Alkaloid	1.26	
Saponins	3.06	
Phytate	317.11	
Tannins	1.47	
Cyanide	0.00	

Watermelon peel amino acid from researcher compilation

Anti-Nutrients content of Watermelon Rind Meal

The phytochemical analysis detected the presence of four phytochemical components in the watermelon rind which included saponins, alkaloids, tannins and phytates, known phytochemicals with antioxidant properties. The highest content of all the anti-nutritional factors detected was in phytate 317.11 (mg/100g) followed by saponin 3.06 (mg/100g), and tannin 1.47 (mg/100g) while alkaloid 1.26 (mg/100g) respectively. The alkaloid content from this study was within the range reported by Mohan et al., (2016) alkaloid 0.62 – 1.42 (mg/100g) while saponins and tannins were higher than the range reported by Mohan et al., (2016) saponin 0.34 – 2.03 (mg/100g), tannins 0.12 – 0.43 (mg/100g). Francis et al., (2002) reported saponins levels below 1 g/kg-1 and the value is unlikely to affect growth performance of fish. Marie-Hélène et al. (2017) opined that tannin supplementation above 10 g kg−1 in diets decreased protein digestibility, and above 20 g kg−1 decrease growth performance in European sea bass juveniles while Brett et al., (2006) reported that alkaloid can have a strong anti-nutritional effect on fish at inclusion concentrations greater than 100 mg/kg. The alkaloids and tannins concentration detected in this study are below the concentration levels as reported by previous studies.

Table 3: Protein and Amino acid requirement for some finfishes

	Channel Catfish	Rainbow trout	Pacific salmon	Common carp	Tilapia
Energy Baseb (Kcal DE/Kg diet)	3000	3600	3600	3200	3000
Crude protein (%)	32	38	38	35	32
Amino acids %					
Arginine	1.20	1.5	2.04	1.31	1.18
Histidine	0.42	0.7	0.61	0.64	0.48
Isoleucine	0.73	0.9	0.75	0.76	0.87
Leucine	0.98	1.4	1.33	1.00	0.95
Lysine	1.43	1.8	1.7	1.14	1.43
Metheonine + Cysteine	0.64	1.0	1.36	0.94	0.90
Phenylalanine+ Tyrosine	1.40	1.8	1.73	1.98	1.55
Threonine	0.56	0.8	0.75	1.19	1.05
Tryptophan	0.14	0.2	0.17	0.24	0.28
Valine	0.56	1.2	1.09	1.10	0.78

Source: (NRC, 1993)

CONCLUSION

The composition of dried watermelon rind meal in the study showed that it can be added into fish diet to replace maize without any adverse effect on growth performance. Therefore this research work confirmed earlier reports that watermelon rind is a rich source of nutrients, essential and non-essential amino acid compared favourably with maize, which is one of the major energy sources in fish feed. Inclusion of watermelon rind meal in the diet of fish will contribute in providing the protein and amino acid requirement for fish. Watermelon rind meal could be used to replace a carbohydrate feedstuff for fish particularly maize. The utilization of watermelon rind will help to minimize cost of producing fish feed and environmental pollution.

REFERENCES

Anthony, C. E (2015). Assessment of some Anti-nutrient Properties of the Watermelon (Citrulluslanatus) Rind and Seed. Journal of Environmental Sciences 9 (5): 225-232

AOAC (1990a). Official Methods of Analysis. Vol.1. 14th (Edition) Association of Official Analytical Chemists, Arlington, VA.1102pp.D.C. U.S.A.

AOAC (2000b). Association of Official Analytical Chemists, Official methods of Analysis, 17th edition, 220pp, Washington, D.C., U.S. A.

AOAC (2006c). Official methods of Analysis of the AOAC, W. Horwitz Editor Eighteen, 380pp. Washington D.C., U.S.A

Ashoka, S., Shamshad, B. S. and Vijayalaxmi, K.G. (2022). Physico-chemical properties and Nutritional Composition of Watermelon (Citrullus lanatus) and its Rind Flour. Biological Forum – An International Journal, 14(3): 505-510

Badr, S., El-Waseif, M. and Ghaly, M. (2018). Effect of Addition Watermelon Rind Powder on Quality Criteria and Microbial Aspects of Beef Burger Patties during Frozen Storage Periods. Journal of Food and Dairy Sciences. 9. 177-187. 10.21608/jfds.2018.35852.

Braide, W., Odiong, I. J. and Orarus, S. (2012). Phito- chemical and anti-bacterial properties of the seed of watermelon (Citrillus lanatus). Prime Journal of Microbiology Research. 2(3) pp.99-104.

Brett, G., David, E., Neil, R., Wayne, H., Peter, M., Ken, D., Brian, J., David, H., Lincoln, M., Mark, S. and Sofie, S. (2006). The influence of the dietary inclusion of the alkaloid gramine, on rainbow trout (Oncorhynchus mykiss) growth, feed utilization and gastrointestinal histology, Aquaculture, Volume 253, Issues 1–4, 512-522, ISSN 0044-8486,

FAO (2014).World Review of Fisheries and Aquaculture, 3 Edition, Academic Press, New York, U.S.A. 88-90pp

Francis, G., Kerem, Z., Makkar, H. P. and Becker, K. (2002). The biological action of saponins in animal systems: A review. British Journal of Nutrition, 88(6), 587–605

Ibrahim, S. E., Sulieman, A. M. E., Ali, N. A., Bothaina, H. S. A., Amin, H. B., Abdelmuhsin, A. A. and Veettil, V. N. (2019). Amino acid Profile of the Watermelon, Citrullus vulgaris and Detection of its Antimicrobial Activity. Biosecurity and Biotechnology Resource Community 12(4).

Johnson, J. T. Iwang, E. U., Hemen, J. T., Odey, M. O., Efiong, E. E. and Eteng, O. F. (2012). Evaluation of anti-nutrient contents of water melon (Citrillus lanatus). Department of Chemical Sciences, College of Natural Sciences, University of Mkar, Mkar. Journal of Annual Biological Research, 3(1):5145-5150.

Marie-Hélène, O., Julien, L., Hervé, L., Nicolas, L., Patrick, Q., Jean, H. R. (2017). Effects of dietary tannin on growth, feed utilization and digestibility, and carcass composition in juvenile European sea bass (Dicentrarchus labrax L.), Aquaculture Reports, 6(2), 21-27, ISSN 2352-5134,

Mohan, A, Shanmugam, S, Nithyalakshmi, V. (2016). Comparison of the nutritional, physico-chemical and anti-nutrient properties of freeze and hot air dried watermelon (Citrullus lanatus) rind. Bioscience Biotechnology Resources Asia 13(2): 1113-1119.

National Research Council. (1993). Nutrient requirements of fish and shrimp. National academies press. National Research Council. 1998. Nutrient Requirements of Swine. 10th Rev. Ed. Natl. Acad. Press, Washington, DC. 110–123

Okai, D.B., Boateng, M., Amaoh, K.O. and Johnson, L.D. (2010). Studies on dried water melon rinds on the nutrient composition and effects on growth performance and carcass characteristics of Albino rats. Proceedings of the 30th Ghana Animal Science Association Conference. 98 – 103

Sadiq, I.S., Saminu, M.Y., Zainab, L., Adeleye, A.O., Sanni, L.E. and Dandalma, Z.A. (2021). Proximate Analysis and Phytochemical Screening of Watermelon (Citrullus lanatus) Pulp, Peels and Seeds Dutse Journal of Pure and Applied Sciences (DUJOPAS), 7(4).

Vedantu (2024). Sourced from https://www.vedantu.com/evs/uses-of-watermelon-rind on 25th November 2024.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

BODY COMPOSITION OF AFRICAN CATFISH Clarias gariepinus (BURCHELL, 1882) FED SICKLE POD (Cassia tora) LEAF MEAL AS INCLUSION LEVELS

Jibrin, H., A. Salawu, Y. Na-Allah, L. A. Argungu, H. F. Maradun

Department of Fisheries and Aquaculture, Usmanu Danfodiyo University, Sokoto

Correspondence author:haliru475@yahoo.com

ABSTRACT

Body composition of African catfish Clarias gariepinus (Burchell, 1882) fed sickle pod (Cassia tora) leaf meal as inclusion levels was assessed. Proximate analysis of leaves of Cassia tora L. was conducted at Department of Fisheries and Aquaculture Fish Hatchery, Faculty of Agriculture, Usmanu Danfodiyo University, Sokoto. The leaves were obtained from Rofia town in Niger State. The leaf was plucked from the stem and sun dried for 3 days, ground using pestle and mortar and sieved using 1.18mm laboratory sieve to remove the residues. The fine particles were used to produce pelleted feed. There were five diets formulated, with 45% crude protein. Groundnut cake was replaced with varied amounts of Cassia tora leaf meal in the diets: 0 (control), 3, 6, 9, and 12%. Using a grinding machine, the feed components and the test ingredient (Cassia tora leaf meal) were mixed into a powder. An electric mixer was used to mixed the feed well, and water was added to speed up the palliating and gelatinization processes. Nutrient values of the fish were found to increase from its initial values of protein 17.91%, fat 2.17%, ash content 2.31% to protein 23.84%, fat 1.83%, ash content 1.97% for feed I; to protein 22.98%, fat 2.85%, ash content 3.05% for feed II; to protein 21.38%, fat 2.74%, ash content 2.15% for feed III; to protein 20.45%, fat 2.74%, ash content 3.02% for feed IV; to protein 24.83%, fat 3.03%, ash content 2.99% for feed V; at the end of the study period. All these results indicate that the leaf of Cassia tora L. contain nutrients that may be useful in nutrition. The study concluded that inclusion of Cassia tora leaf meal in the diet of Clarias gariepinus does have effect on nutritional composition (crude protein) of the fish.

Keywords:
proximate,
Clarias gariepinus,
carcass, leaf meal

INTRODUCTION

An essential component of aquaculture is the body composition of African catfish fingerlings (Clarias gariepinus), especially when it comes to feeding tactics that are optimized to promote growth and health. In an effort to enhance the nutritional profiles of these fish's diets, recent research has looked into the addition of alternative feed items, such as Cassia tora leaf meal. Cassia tora leaves contain an appreciable amount of nutrients, the nutritional composition is as following crude protein (C.P) 27.40%, crude lipids (CL) 3.80%, crude fiber (CF) 16.8%, Ash of 15.20%, Nitrogen free extract (NFE) of 36.80% and metabolizable energy (ME) of 2573.80kcal/kg (Ayssiwede et al., 2011). Studies show that the amount of Cassia tora leaf meal included can have a major impact on the body composition and growth performance of C. gariepinus fingerlings (Amisah et al., 2009). Variations in the amount of this leaf meal included, for example, have been found to affect the fish's total nutrient retention, weight gain, and feed conversion ratios (FCR) (Bello et al., 2013). In order to improve aquaculture sustainability, the ideal inclusion level must strike a balance between nutritional value and cost-effectiveness. Furthermore, optimizing fish protein and lipid retention requires a thorough grasp of Cassia tora's effects on body composition. Better growth rates and feed usage efficiency have been linked to higher inclusion levels (Dienye et al., 2011). This is especially important in areas where it is expensive or difficult to find traditional fish feed ingredients, necessitating the search for affordable local substitutes that might promote the growth of aquaculture.

This research is important because it addresses issues related to aquaculture that are more broadly related to economic and ecological concerns than just specific growth measures. Fish producers can minimize production costs and support local agriculture practices by reducing their reliance on imported feeds by using locally available resources like Cassia tora (FAO, 2012). Additionally, by making fish more readily available in nearby markets, these tactics support food security. In summary, examining the body composition of African catfish fingerlings fed with different concentrations of Cassia tora leaf meal aids in the development of sustainable aquaculture operations in addition to offering insights into ideal feeding procedures. For fish farmers in Africa and elsewhere, this study is essential to maintaining economic viability while improving growth performance.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out from September 2022 to November 2023 at the Department of Fisheries and Aquaculture Fish Hatchery, Usmanu Danfodiyo University, Sokoto. The location of the experiment was 275 meters above sea level in Nigeria, at latitude 130 07' 78"N and longitude 05' 12' 25"E. The region has 500–724 mm of annual rainfall, a mean relative humidity of 14.9%, a high temperature of 410C in March, and 40% humidity between March and June (Mamman, 2000). Fifteen (15) 40-liter round-bottom plastic tanks were used as the culture medium for a duration of 63 days. A mosquito net was placed over the tanks to keep fish from jumping, and a level of twenty-five liters was maintained throughout the trial.

Cassia tora leaf Collection

Cassia tora leaf was obtained from Rofia town, Niger State. The leaf was plucked from the stem and sundried for 3 days, ground using pestle and mortar and sieved using 1.18mm laboratory sieve to remove the residues. The fine particles were used to produce pelleted feed.

Diet Formulation

Five diets were formulated, with 45% crude protein. Groundnut cake was replaced with varied amounts of C. tora leaf meal in the diets: 0 (control), 3, 6, 9, and 12%. Grinding of feed ingredients was done using a grinding machine, the other feed ingredients and the C. tora leaf meal were mixed into a powder using electric feed mixer (Kenwood). The feed was well mixed, and water was added to speed up the palliating and gelatinization processes. Before the experiment started, the meals were dried, placed in an air container, and kept.

Table 1: Gross Composition of Experimental Diets

		Experimental	Diets		
Ingredients	I (0%CLM)	II (3% CLM)	III (6% CLM)	IV (9%CLM)	V (12% CLM)
Maize	14.11	12.39	10.66	8.95	7.20
GNC	39.69	39.06	38.42	37.78	37.15
Fish meal	29.77	29.29	28.82	28.33	27.86
CLM	0.00	3.00	6.00	9.00	12.00
Blood meal	9.92	9.76	9.61	9.44	9.29
Bone meal	2.25	2.25	2.25	2.25	2.25
Vitamin premix	1.00	1.00	1.00	1.00	1.00
Palm oil	2.00	2.00	2.00	2.00	2.00
Salt	0.25	0.25	0.25	0.25	0.25
Methionine	0.50	0.50	0.50	0.50	0.50
Lysine	0.50	0.50	0.50	0.50	0.50
TOTAL	100.00	100.00	100.00	100.00	100.00
Calculated ME (Kcal/kg)	3,480.06	3,479.47	3,478.99	3,477.61	3,476.89

"GNC" Groundnut Cake, "ME" Metabolizable energy, "CLM" Cassia tora leaf meal

Management of Experimental fishes

From Barak Fish Farm in Sokoto, 250 fingerlings of Clarias gariepinus were purchased. After two weeks of acclimation, 150 fish were divided at random into fifteen 40-liter circular plastic bowls. Ten fish per bowl. The fish in each plastic bowl, weighing an average of 2.32g at the beginning, were fed the experimental diets for eight (8) weeks at a body weight percentage of 3%. The daily ratio was divided into three portions, which were supplied at 9:00–10:00, 1:00–2:00, and 5:00–6:00, in that order.

Analytical Procedure

Fish samples were crushed for body composition both before and after the trial, coupled with the feed ingredients, in accordance with (AOAC, 2000) protocols. The moisture content was ascertained by drying to constant weight in an oven between 100 and 1050C. After the samples were digested and the amount of nitrogen was measured using a spectrophotometer according to Devani et al. (1989) method, the crude protein content was calculated by multiplying the amount of nitrogen by coefficient 6.25. Total lipids were extracted continuously using hexane as the solvent for eight hours in a Soxhlet apparatus; ash was determined by burning the sample at 5500 C in a furnace; crude fiber was determined by sequentially hot digesting the defatted sample with diluted acid and alkaline; and total carbohydrates were determined by difference, as per (AOAC, 2000).

Statistical Analysis

The collected data were analyzed using ANOVA, and the treatment means were separated for significant ($p<0.05$) differences using the Duncan Multiple Range Test technique, as described by Steel and Torrie in 1980. The statistical software package Statistical Package for the Social Sciences (SPSS) version 9.0 for Windows was used to perform all of the analyses (SPSS, 2007).

RESULTS AND DISCUSSION

Based on its proximate composition which includes moisture content, crude protein, crude fiber, crude fat, total ash, and nitrogen-free extract a feed material like leaf meal for fish diets can be assessed for potential. The current investigation's proximate composition, nutrient values of the fish have been found to increase from its initial values of protein 17.91%, fat 2.17%, ash content 2.31% to protein 23.84%, fat 1.83%, ash content 1.97% for feed I; to protein 22.98%, fat 2.85%, ash content 3.05% for feed II; to protein 21.38%, fat 2.74%, ash content 2.15% for feed III; to protein 20.45%, fat 2.74%, ash content 3.02% for feed IV; to protein 24.83%, fat 3.03%, ash content 2.99% for feed V. These values were found to be similar to Abu and Muhammad (2016) had discovered.

Increased crude protein and moisture were found in the experimental fish's body composition following the experiment. Another reason for this could be the experiment diets' high crude protein content. But in comparison to the starting body composition, it was found that the ash and ether extract content decreased for all dietary regimens. A clear inverse association between body fat and moisture was seen, which was consistent with the results of Jauncy's earlier experiment (1982). When Konyeme et al. (2005) fed water hyacinth to Clarias gariepinus fingerlings in place of a plant protein source, the fish ether extract before the feeding trial and that of the other diets showed a significant difference. However, when Sotolu and Faturoti (2009) gave C. tora leaf meal to C. gariepinus fingerlings as a plant protein supplement, the parameter was lower. Because the oil extraction methods were less efficient, the ether extract rose as the CSM substitution increased. When compared to fish on all other dietary treatments, including the control, the crude protein content of fish fed diet (V), which contained 24.83 (12%) C. tora leaf meal was higher. However, this difference was not statistically significant. When C. gariepinus were fed a diet comprising mucuna beans, the crude protein was almost as reported by Bekibele (2005); however, it was lower than those reported in Sotolu and Faturoti (2009) when C. gariepinus were fed Leucaena leucocephalus seed meal, and this could be due to the feed's quality.

Table 2. Proximate composition of experimental fish fed experimental diets

			Treatments			
Parameters	Initial fish	1(0%)	II (3%)	III (6%)	IV (9%)	V (12%)
Moisture	75.87±0.27[a]	71.03±1.44[bc]	69.72±0.89[c]	72.32±0.47[b]	72.41±0.66[b]	68.09±0.94[d]
Ash	2.31±1.12	1.97±0.03	3.05±0.40	2.15±0.34	3.02±0.59	2.99±0.28
Crude fiber	0.69±0.16[b]	0.75±0.05[ab]	0.79±0.03[ab]	0.68±0.02[b]	0.82±0.02[b]	0.88±0.02[b]
Crude protein	17.91±0.50[d]	23.84±1.95[a]	22.98±0.57[b]	21.38±0.75[bc]	20.45±1.40[c]	24.83±0.47[a]
Lipid	2.17±0.28[c]	1.83±0.17[c]	2.85±0.15[b]	2.74±0.11[b]	2.74±0.37[b]	3.03±0.33[a]
Nitrogen free extract.	1.23±0.53[a]	0.56±0.43[b]	0.60±0.09[b]	0.73±0.19[ab]	0.49±0.34[b]	0.17±0.04[c]

Means in rows having same letters are not significantly different (P >0.05)

CONCLUSION

The study concluded that inclusion of Cassia tora leaf meal as a substitute for groundnut cake in the diet of Clarias gariepinus does have effect on the body composition (crude protein) content of the fish.

REFERENCES

A.O.A.C (2000). Official Methods of Analysis Analysis 24TH edition, Association of Official Analytical Chemist.,Washinton D.C.

Abu, H. and Muhammad, Y. (2016). Effects of Different Feeding Trial in the Proximate Composition of Shoal Fish (Channa striatus) Cultured in Glass Aquaria. Western Sydney University. Available at SSRN: https://ssrn.com/abstract=3474159.

Amisah, S., Oteng, M. A. and Ofori, j. K. (2009). Growth performance of the African catfish, Clarias gariepinus, fed varying inclusion levels of Leucaena leucocephala leaf meal. Journal of Apply Sciences Environmental Management. Vol. 13(1) 21 – 26. JASEM ISSN 1119-8362.Ayssiwede, S.B., J.C. Zanmenou, Y. Issa, M.B. Hane, A. Dieng, C.A.A.M. Chrysostome, M.R. Houinato, J.L. Hornick and A. Missohou, (2011). Nutrient composition of some unconventional and local feed resources available in Senegal and recoverable in indigenous chickens or animal feeding. Pak. J. Nutr., 10: 707-717.

Bekibele, D.O (2005). The effect of partial replacement of soya bean meal with mucuna beans on the growth and performance of Clarias gariepinus. In Ansa, E.A, Anyanwu, P.E, Ayonoadua, B.W, Erondu, E.S and Dekaye, S.A (eds) Fish for Food and income generation in Nigeria. Proceedings of 20th Annual Conference of Fisheries Society of Nigeria (FISON). Porthacort 14-18 Nov. 2005. Rivers State, Nigeria. pp 136-139.

Bello, N. O. and Nzeh, G. C. (2013). Effects of varying levels of Moringa oleifera leaf meal diet on growth performance, hematological indices and biochemical enzymes of African catfish Clarias gariepinus (Burchell 1822). www.elixirpublishers.com (Elixir International Journal) Elixir Aquaculture 57A (2013) 14459-14466.

Devani, M B., Shishoo, G.I, Shah, S.A, Suhagia, B.N. (1989). Microchemical Methods. Spectrophometric Methods for microdetermination of nitrogen in Kjeldahl digest. Journal of Association of Analytical Chemist, 72 (4): 953-956.

FAO, (2010). The State of World Fisheries and Aquaculture. FAO, Fisheries and Aquaculture Department, Rome, Italy.

Konyeme, J.E. Sogbesan, A.O and Ugwumba A.A.A (2005). Growth Response and Cost benefit of Clarias gariepinus fingerlings fed water Hyacinth (Eichhornia crassipes) meal as plant protein supplement. In Ansa, E.A, Anyanwu, P.E, Ayonoadua, B.W, Erondu, E.S and Dekaye, S.A (Eds) Fish for Food and Income Generation in Nigeria. Proceedings of 20th Annual Conference of Fisheries Society of Nigeria (FISON) PorHacort 14-18 Nov. 2005. Rivers State, Nigeria. pp 145- 148.

Mamman, A. B. (2000). Nigeria: A People United, A future Assured (Sokoto State). Gabumo Publishing Company Ltd, Lagos, Nigeria, 2:986p. ISBN: 9780104321 (v. 2).

S.P.S.S 16.0 (2007). Statistical Package for Social Package Sciences http://www.winwrap.com.

Sotolu, A.O and Faturoti, E.O (2009). Growth performance and haematology of Clarias gariepinus (Burchell, 1822) fed varying inclusion of Leucaena leucocephala seed meal based- diets. Revista UDO A gricola 9 (4): 979-985.

Steel, G. D. and Torrie, J. H (1980). Principles and Procedure of Statistics. A Biometrical Approach. Second edition. 633p.

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THE HISTOPATHOLOGY, HAEMATOLOGY AND CARCASS QUALITY OF Clarias gariepinus POST-FINGERLING FED FRESH AND DRIED HOUSEFLY MAGGOT

Ukagwu, J.I1, 2S.O. Ohaturuonye, 3L.E Osuagwu, 2A. Ossai and 2M. Onwuka

1Agricultural Science Department, Alvan Ikoku Federal University of Education, Owerri
2Fisheries and Aquaculture Department, Nnamdi Azikiwe University, Awka
3Department of Fisheries and Marine Technology, Imo State Polytechnic.

Corresponding Author:
ukagwujohn@yahoo.com, +234-803-764-8878, 0009-0002-0145-7849

ABSTRACT
This study evaluates the histopathology, hematology, and carcass quality of Clarias gariepinus post-fingerlings fed fresh and dried housefly maggots, addressing the increasing demand for quality, affordable feed in aquaculture. Conducted at the Fisheries Department, Nnamdi Azikiwe University, Awka, Nigeria, the experiment involved 60 Clarias gariepinus divided into three groups: one fed fresh housefly maggots, another dried maggots, and a control group on commercial feed. Proximate analysis showed that dry maggot meal had 28.80% protein, 17.90% fat, and 23.90% carbohydrates. The control group had the highest total length, weight, liver weight, and fillet weight ($p<0.05$). However, fish on dry maggot feed showed the highest villi width and goblet cell number in the intestine, indicating better nutrient absorption. Haematological parameters, such as hemoglobin, red blood cells, and white blood cells, were highest in fish fed dried maggot meal, suggesting improved health status. Fish fed with maggot meal also showed higher enzyme activities (catalase and glutathione S-transferase), while histopathological examination revealed mild liver vacuolation and congestion in fish fed with fresh maggots. Overall, the study concludes that dried housefly maggot meal is a promising alternative to fishmeal due to its positive effects on growth, haematological indices, and intestinal morphology. The study recommends further investigation into anti-nutritional factors, optimization of feed formulations, scaling up production, and assessing the safety of maggot meal for other species.

Keywords:
Hepatosomatic index, Blood, Carcass quality, Post fingerlings, Catfish, Maggots

INTRODUCTION

The African catfish (Clarias gariepinus) is a popular aquaculture species due to its fast growth, adaptability to different environments, and high market demand (Adejinmi & Ogungbenro, 2023). As aquaculture expands, sustainable feed alternatives are essential to mitigate the rising cost of conventional fish feeds, particularly fishmeal (Ogunji et al., 2022). Insects, specifically housefly maggots (Musca domestica), have gained attention as potential protein sources in fish diets due to their high nutritional profile and cost-effectiveness (Henry et al., 2023).Fresh and dried housefly maggots have been used as supplementary protein sources in various animal feeds, including fish, owing to their richness in essential amino acids, fats, and micronutrients. However, studies on the physiological effects of these alternative feeds on the histopathology, blood parameters, and carcass quality of

Clarias gariepinus post-fingerlings remain limited (Mbiyu et al., 2021). Understanding these effects is crucial for evaluating the safety and efficacy of maggot-based diets in aquaculture. The increasing reliance on fishmeal in aquaculture feed has raised concerns regarding its sustainability and environmental impact, prompting the search for alternative protein sources (Yildirim et al., 2023). While housefly maggots offer a promising solution, there is insufficient research on how fresh and dried maggots affect the health and growth of Clarias gariepinus post-fingerlings, particularly in terms of histopathological changes, blood parameters, and carcass quality (Adebayo & Ajani, 2023). These factors are critical in ensuring the nutritional safety and market value of fish produced using maggot-based diets. Addressing this gap will provide valuable insights into the viability of insect-based feeds in commercial aquaculture. Thus, the present study seeks to evaluate the histopathology, blood and carcass quality of Clarias gariepinus post-fingerlings fed fresh and dried maggots.

MATERIALS AND METHODS

The study was conducted at the Fisheries Department of Nnamdi Azikiwe University, Awka, Nigeria, located in a tropical wet and dry climate. The experiment utilized ninety (90) pieces ofClarias gariepinus fish, divided into three groups with replicates, each fed different diets: fresh housefly maggots, dried maggots, and commercial feed. Standard pond management practices were followed throughout the study. Proximate analyses of the maggot specimen were conducted using AOAC (2010) methods to determine moisture, ash, fiber, protein, fat, and carbohydrate content. Various haematological indices, such as hemoglobin, red and white blood cell counts, and packed cell volume, were measured. Blood samples were collected post-feeding, and histological analyses were performed on the intestines and liver to assess tissue health. Enzyme activity assays were conducted to measure glutathione S-transferase and catalase activity. Additionally, plasma cortisol and whole blood glucose levels were analyzed. Biometric parameters such as total length, weight, liver weight, and fillet weight were recorded, along with the calculation of condition factor, hepatosomatic index, dressing index, and fillet weight percentage. Histopathological analysis involved preserving liver and intestine samples, which were then examined under a microscope to assess liver degradation and intestinal health, using metrics such as villi height, goblet cell count, and hepatocyte degradation. Data collected from the experiment were subjected to analysis of variance (ANOVA) test, Duncan Multiple Range Test (DMRT) was used to compare differences among individual means and the data were analyzed using SPSS version 20. Differences were considered significant at 0.05 level ($P>0.05$).

RESULTS

The feeding trial was carried out to investigate the histopathology, blood and carcass quality of Clarias gariepinus post-fingerling fed fresh and dried housefly maggot meal. Proximate analysis shows dry maggot meal contains Moisture (8.40%), Ash (9.30%), Crude Fat (11.70%), Fat/Oil (17.90%), Crude protein (28.80%) and Carbohydrate (23.90%).

Table 1: Proximate Analysis of Dried Maggot meal

Dried Maggot meal	Proximate Composition (%)
Moisture	8.40±0.77
Ash	9.30±0.73
Crude Fiber	11.70±1.00
Fat/Oil	17.90±1.11
Crude Protein	28.80±0.50
Carbohydrate	23.90±2.00

Values are means ± standard deviation of three (3) replicates

Table 2: Carcass quality of catfish fed maggot meal

Organ Weight	Control Feed	Fresh Feed	Dried Feed
Total length (TL) (cm)	$19.00^{a} \pm 0.00$	$15.90^{c} \pm 0.00$	$16.00^{b} \pm 0.00$
Total weight (TW) (g)	$316.00^{a} \pm 0.00$	$285.80^{c} \pm 0.00$	$300.00^{b} \pm 0.00$
Dressed weight (DW) (g)	$213.73^{a} \pm 0.10$	$204.73^{c} \pm 0.30$	$207.70^{b} \pm 0.05$
Liver weight (LW) (g)	$18.70^{a} \pm 1.00$	$17.00^{c} \pm 0.00$	$17.50^{b} \pm 0.50$
Fillet weight (FW) (g)	$243.00^{a} \pm 2.00$	$215.80^{c} \pm 1.00$	$223.00^{b} \pm 2.00$
Condition factor	$4.67^{c} \pm 1.00$	$5.68^{b} \pm 1.00$	$7.32^{a} \pm 1.20$
Hepatosomatic index	$16.89^{b} \pm 1.10$	$16.81^{c} \pm 2.00$	$17.14^{a} \pm 0.70$
Dressing index	$1.48^{a} \pm 2.00$	$1.39^{c} \pm 1.00$	$1.44^{b} \pm 0.50$
Fillet yield	$1.30^{c} \pm 0.00$	$1.32^{b} \pm 2.00$	$1.34^{a} \pm 1.00$

Values are means ± standard deviation of three (3) replicates.
Data in the same row bearing different superscript differed significantly ($p<0.05$).

The table 2 showed the growth response of fish fed maggot meal. Fish on control feed had the highest yield on Total length, Total weight, Dressed weight, Liver weight and Fillet weight and the result is significantly different from other samples ($p<0.05$). The values for Total length, Total weight, Dressed weight, Liver weight and Fillet weight ranged from 19.00 ± 0.00 to 15.90 ±0.00, 316.00 ± 0.00t o 285.80 ±0.00, 213.73 ±0.10 to 204.73 ±0.30, 18.70 ±1.00 to 17.00 ± 0.00 and 243.00 ±2.00 to 215.80 ±1.00 respectively. Condition factor ranged from 4.67±1.00 to 7.32±1.20, Hepatosomatotic index, 16.81±2.00 to 17.14±0.70, Dressing index, 1.39±1.00 to 1.48±2.00 and fillet yield 1.30±0.00 to 1.34±1.00. The table 3 showed the haematological parameters of fish fed maggot meal. The values for Packed cell volume, Haemoglobin, Red Blood Cell, Liver glycogen and Plasma Glucose ranges from 24.50 ±0.10 to 25.8 ±1.10, 7.80 ±0.10 to 8.83 ±1.00, 2.40 ±2.00 to 2.79 ±1.00, 38.43 ±0.50 to 45.6±1.00 and 76.00 ±2.00 to 89.00 ±1.00 respectively. The values for Catalase and Glutathione S-transferase ranged from 275.93 ±1.00 to 454.02 ±0.50 and 176.33 ±1.00 to 236.88 ±0.50 respectively. The value for White Blood Cell ranged from 16.28 ±0.50 to 18.76 ±2.00.

Table 3: Hematological Parameters of Fish Fed Maggot Meal

Parameters	Control feed	Fresh feed	Dried feed
Packed cell volume (%)	$25.17^{b} \pm 1.00$	$24.50^{b} \pm 0.10$	$25.8^{a} \pm 1.10$
Haemoglobin (g/100ml)	$8.20^{b} \pm 1.00$	$7.80^{c} \pm 0.10$	$8.83^{a} \pm 1.00$
Red Blood Cell(g/100ml)	$2.77^{b} \pm 3.10$	$2.40^{c} \pm 2.00$	$2.79^{a} \pm 1.00$
White Blood Cell (g/100ml)	$16.28^{c} \pm 0.50$	$18.76^{a} \pm 2.00$	$18.70^{b} \pm 1.00$
Liver glycogen (mg/g)	$38.43^{c} \pm 0.50$	$43.55^{b} \pm 2.00$	$45.65^{a} \pm 1.00$
Catalase (µg/g/1min)	$454.02^{a} \pm 0.50$	$310.88^{b} \pm 2.00$	$275.93^{c} \pm 1.00$
Plasma Glucose (mmol/L)	$69.00^{d} \pm 0.50$	$76.00^{c} \pm 2.00$	$89.00^{a} \pm 1.00$
Plasma Cortisol (×10ng/ml)	$6.28^{c} \pm 0.50$	$8.76^{a} \pm 2.00$	$8.70^{b} \pm 1.00$
Glutathione *S*-transferase (µg/g/1 min)	$236.88^{a} \pm 0.50$	$188.00^{a} \pm 2.00$	$176.33^{b} \pm 1.00$

Values are means ± standard deviation of three (3) replicates.
Data in the same row bearing different superscript differed significantly ($p<0.05$).

Table 4: Intestine histology of catfish fed maggot meal

Intestine histology	Control feed	Fresh feed	Dried feed
Villi length (µm)	$614^{a} \pm 0.10$	$602^{c} \pm 1.00$	$611^{b} \pm 3.00$
Villi width (µm)	$83^{b} \pm 3.00$	$82^{c} \pm 2.00$	$84^{a} \pm 3.00$
Goblet cell number	$450^{c} \pm 1\ .10$	$462^{b} \pm 3.10$	$485^{a} \pm 3.10$

Values are means ± standard deviation of three (3) replicates.
Data in the same row bearing different superscript differed significantly ($p<0.05$).

The table 4 shows the intestine histology of fish fed maggot meal. Fish on dry maggot feed meal had the highest yield on Villi width and Goblet cell number and the result is significantly different from other samples ($p<0.05$). The values for Villi width and Goblet cell number ranged from 82 ± 2.00 to 84 ±3.00 and 450 ±1.10 to 485 ±3.10 respectively. Fish on control feed meal had the highest yield on Villi length and the result is significantly different from other samples ($p<0.05$). The value for Villi length ranged from 602 ±1.00 to 614 ±0.10.

Histopathology of Liver

The FIG 1-2 shows the intestine histology of fish fed maggot. Arrows point to hepatocytes (hp), sinusoids (sn), Kupffer cells (kc) and blood vessels (bv). In the present study, histological changes were also observed in the liver of fish fed with dry and fresh maggot. Severe vacuolation of hepatocytes and mild congestion were seen in fish liver fed with fresh diet (Fig. 2). Also unstained portions showing fat vacuoles were observed in hepatocytes of fish fed with dried maggot (Fig. 2). Vacuolation in hepatocytes with pyknotic nuclei were observed in fish fed on fresh maggot (Fig. 3). He fresh maggot feed caused severe cytoplasmic vacuolation (Fig. 2) while dried maggot feed caused hepatocytes degeneration and mild vacuolation (Fig. 2).

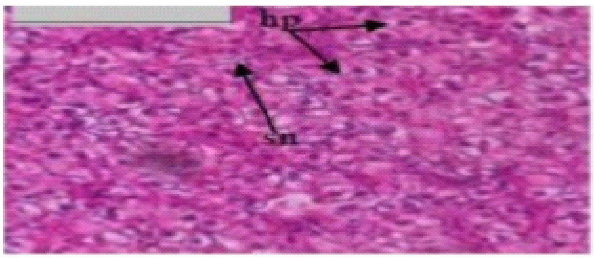


FIG 1. Liver histology in Control feed fish sample. Scale bar = 100 μm. arrows point to hepatocytes (hp), sinusoids (sn), Kupffer cells (kc) and blood vessels (bv).

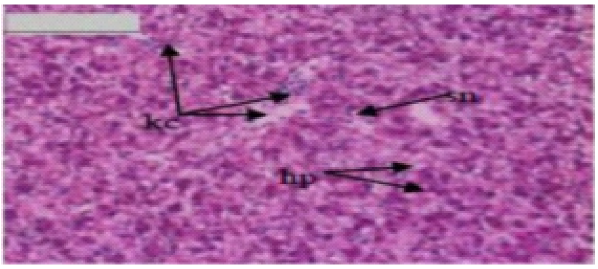


FIG 2. Liver histology in fresh feed fish sample. Scale bar = 100 μm. arrows point to hepatocytes (hp), sinusoids (sn), Kupffer cells (kc) and blood vessels (bv).

DISCUSSION

The proximate composition of dry maggot meal in this study shows Moisture (8.40%), Ash (9.30%), Crude Fat (11.70%), Fat/Oil (17.90%), Crude Protein (28.80%), and Carbohydrate (23.90%). These results align with the findings of Huis (2013), who reported similar proximate values for maggot meals, underscoring the potential of maggot meal as a valuable alternative protein source in fish nutrition. Other studies, such as those by Makkar et al. (2014), also affirm the high protein and lipid content in insect-based feeds, making them comparable to fishmeal. The study's results on carcass quality demonstrate that fish fed on dry maggot meal exhibited the highest yields in Condition Factor, Hepatosomatic Index (HSI), and Fillet Yield, which were significantly different from other treatments ($p<0.05$). Fish on control feed, however, had the highest Dressing Index values. This outcome supports the findings of Stamer et al. (2014), who observed superior growth performance and feed utilization in Clarias gariepinus when maggot meal was incorporated into their diet. Moreover, reduced feed intake and palatability in fish fed with fresh maggot meal may be attributed to anti-nutritional factors (ANFs), as noted by Kroeckel et al. (2012), who observed similar issues when fishmeal was replaced with alternative protein sources. Fish fed with dry maggot meal showed significantly higher values for Packed Cell Volume, Haemoglobin, Red Blood Cell count, Liver Glycogen, and Plasma Glucose ($p<0.05$) compared to other samples, suggesting better physiological health and immune response. The results resonate with the findings of Igoche (2015), who reported enhanced haematological profiles in fish fed maggot-based diets. In contrast, fish on control feed had higher values for Catalase and Glutathione S-transferase, while those on fresh maggot meal showed higher White Blood Cell (WBC) counts, indicating stress or disease response, as pointed out by Peter (2002). These variations in blood parameters suggest that dry maggot meal could serve as a sustainable alternative to conventional fishmeal. Histological examination of the intestine in this study revealed that fish fed dry maggot meal had significantly higher villi width and goblet cell numbers ($p<0.05$), indicating enhanced nutrient absorption and protective mucus secretion. These results are in agreement with Igoche (2015), who reported similar observations in maggot-fed fish, linking increased goblet cell numbers to an immune response against dietary irritants. According to Poleksić et al. (2006), the structural integrity of the intestinal mucosa, submucosa, and muscular layers was maintained, with no observed pathological changes, supporting the idea that maggot meal does not induce adverse intestinal effects.The liver histology showed no significant abnormalities, although fish fed with both dry and fresh maggot meal exhibited slight vacuolization, which could indicate metabolic stress. This is consistent with findings from Parpoura and Alexis (2001), who observed hepatocyte necrosis in fish fed animal protein supplements. Furthermore, Caballero et al. (2004) and Hossain and Jauncey (1989) reported similar liver pathologies when fish were fed suboptimal diets. The present study underscores the liver's role as an indicator of nutritional adequacy, as suggested by Tacon (1992).

CONCLUSION

In summary, the results of this study indicate that dry maggot meal is a promising alternative to fishmeal, with superior effects on fish growth performance, haematological health, and intestinal morphology. The findings align with previous research, such as that of Huis (2013) and Igoche (2015), supporting the potential of maggot meal in aquaculture nutrition. Future studies should focus on optimizing maggot meal inclusion levels to minimize potential anti-nutritional effects and further enhance the performance of fish.

RECOMMENDATIONS

Further Studies on Anti-Nutritional Factors (ANFs): Future research should focus on identifying and quantifying the types and concentrations of ANFs in maggot meals to better understand their impact on feed intake and nutrient absorption.

Optimization of Feed Formulation: To improve the palatability and nutritional balance of maggot-based feeds, blending maggot meal with other ingredients may help mitigate the effects of ANFs and enhance feed intake.

Scaling Up Production: Efforts should be made to scale up the production of dry maggot meal for commercial use in aquaculture, given its proven efficacy as a fishmeal substitute.

Nutritional Safety for Other Species: Additional studies are recommended to assess the nutritional safety and efficacy of maggot meal across a broader range of fish species, particularly in high-value aquaculture sectors.

REFERENCES:

Adejinmi, O., and Ogungbenro, O. (2023). Utilization of insect protein in aquaculture: Prospects and challenges. Aquaculture Research Journal, 56(4), 287-299.

Adebayo, A., and Ajani, E. (2023). Assessment of blood parameters in Clarias gariepinus fed with maggot meal. Journal of Fish Biology, 82(7), 194-202.

Association of Official Analytical Chemists (2010). Official Methods of Analysis. 18th Edition. Association of Official Analytical Chemists, Gaithersburg, MD, USA.

Caballero, M. J., Izquierdo, M. S., Kjørsvik, E., Montero, D., Socorro, J., Fernandez, A. J., and Rosenlund, G. (2004). Morphological aspects of intestinal cells from gilthead sea bream (Sparus aurata) fed diets containing different lipid sources. Aquaculture, 232(1-4), 237-249.

Grisdale-Helland, B., Helland, S. J., Nerland, S., and Hemre, G. I. (2002). A comparison of the effect of dietary lipid level on growth, feed utilization, and nutrient digestibility in juvenile Atlantic halibut (Hippoglossus hippoglossus L.). Aquaculture Nutrition, 8(5), 267-275.

Hossain, M. A., and Jauncey, K. (1989). Nutritional evaluation of some Bangladeshi oilseed meals as partial substitutes for fish meal in the diet of common carp (Cyprinus carpio L.). Aquaculture Research, 20(4), 255-268.

Huis, A. V. (2013). Potential of insects as food and feed in assuring food security. Annual Review of Entomology, 58, 563-583.

Henry, M., Jones, R., Smith, T., and Kumar, A. (2023). Insect meal as an alternative protein source in aquaculture feeds: A review. Aquatic Nutrition Journal, 47(3), 315–328.Igoche, A. (2015). Effects of maggot meal as an alternative protein source in the diet of Clarias gariepinus. Aquaculture Research, 46(7), 1693-1701.

Kroeckel, S., Harjes, A. G., Roth, I., Katz, H., Wuertz, S., Susenbeth, A., and Schulz, C. (2012). When a turbot catches a fly: Evaluation of a partially defatted insect meal in turbot (Psetta maxima L.) nutrition. Aquaculture, 364-365, 345-352.

Makkar, H. P., Tran, G., Heuze, V., and Ankers, P. (2014). State-of-the-art on use of insects as animal feed. Animal Feed Science and Technology, 197, 1-33.

Mbiyu, J., Ochieng, R., Kamau, E., and Otieno, P. (2021). Growth performance of Clarias gariepinus fed on maggot meal: Implications for sustainable aquaculture. African Journal of Fisheries Science, 18(2), 56–67.

Ogunji, J., Okonkwo, C., Eze, S., and Adeola, T. (2022). Sustainable fish feed formulations for African catfish: The role of alternative proteins. International Journal of Fisheries and Aquaculture Science, 44(1), 102–109.

Parpoura, A. C., and Alexis, M. N. (2001). Effect of different dietary oils in sea bass (Dicentrarchus labrax) nutrition. Aquaculture, 2021(3-4), 303-315.

Peter, J. M. (2002). Hematology of fish: Importance in disease diagnosis and health monitoring. Journal of Fish Biology, 60(4), 905-915.

Poleksić, V., Mitrović-Tutundžić, V., & Čupić, Z. (2006). Fish histopathology in ecotoxicology. Fisheries Research, 82(2-3), 174-186.

Yildirim, O., Smith, J., Nguyen, H. T., Garcia, M. P., and Lee, K. W. (2023). Exploring alternatives to fishmeal in aquaculture: A global perspective. Marine Aquaculture Journal, 29(1), 75–85.
Stamer, A., Weth, J., Simon, A., and Roß-Nickoll, M. (2014). Black soldier fly larvae meal as alternative to fishmeal in aquaculture diets. Oecologia Aquatica, 7(1), 41-47.
Tacon, A. G. (1992). Nutritional fish pathology: Morphological signs of nutrient deficiency and toxicity in farmed fish. FAO Fisheries Technical Paper, No. 330.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

EVALUATION OF GROWTH PERFORMANCE AND BODY INDICES OF Oreochromis niloticus FED WITH VARYING INCLUSION LEVELS OF FERMENTED Hyphaene thebaica PULP

Abdulkareem, H.O., A.H Bichi, A.B Dauda and A. Dasuki

Department of Fisheries and Aquaculture, Federal University Dutsin-Ma, PMB 5001, Dutsin-Ma, Katsina State.

Correspondence: habibatabdulkareem27@gmail.com; 08109553365

ABSTRACT

Supply of cheap and quality feed ingredients are major challenge to aquaculture. Therefore, this study assessed growth performance and body indices of Oreochromis niloticus fed with fermented Hyphaene thebaica pulp meal as partial substitute for maize for 12weeks. Five isonitrogenous diets of 35% crude protein were formulated in which yeast fermented doum palm meal (YFDPM) replaced maize at 0%, 25%, 50%, 75% and 100% coded as YFDP0%, YFDP25%, YFDP50%, YFDP75% and YFDP100% respectively. Fifteen plastic containers of 40 litres capacity filled with 30 litres of water each, (5 treatments and 3 replicates), were used for the experiment. The fish were fed at 5% body weight twice daily at 9.00am and 5:00pm. The feeding ration was adjusted every week after weighing. The highest weekly growth was obtained in 50%YFDPM (60.9g) and it differed significantly (P<0.05) from 75% YFDPM (30.5g). The highest hepasomatic index was observed in 75% YFDPM (1.9%) and is significantly different (P<0.05) from 25% YFDPM (1.5%). Highest viserasomatic index was recorded in 50% YFDPM (7.7%) and is differently significant (P<0.05) from 75% YFDPM (6.4%). The best result was produced at the substitution level of 50% inclusion of YFDPM. The inclusion of YFDP meals caused higher VSI in all fish groups except HSI for fish group fed 75% YFDP meal. Therefore, this study showed that YFDPM could be incorporated up to 50% without a negative effect on the growth and health status of the experimental fish. It is recommended that YFDPM be included in the feed of O. niloticus at 50% for optimum growth performance.

Keywords:
Aquaculture, doum pulp meal, growth performance, maize, Oreochromis niloticus

INTRODUCTION

Fish farming is one of the paramount sectors that is being explored and it is viewed as an area with the cheapest source of animal protein for human consumption (Dauda et al., 2017). Fish are considered to be a primary source of animal protein especially in most poor developing countries, thereby creating a huge demand (FAO, 2018). For optimal health, fast growth and sustainable production of farmed fish, a balanced feed with a good physical and chemical characteristic are required (Eze et al., 2018). Every living organism including fish requires food for growth, reproduction and maintenance of tissues. To sustain fish under culture, supplementation diet must be provided to complement natural feeds supply (Karapan et al., 2002).

Oreochromis niloticus is a tropical species native to Africa (Deines et al., 2014) with favourable characteristics, such as tolerance to unfavourable environmental conditions (Edwards, 2015) survival at reduced dissolved oxygen level (Abdel-Tawwab et al., 2014), euryhaline (very tolerant to large change in salinity), high food conversion, fast growth and management condition (Sayed et al., 2015). As a result of these characteristics, O. niloticus is currently one of the preferred fishes for aquaculture (Ferdous et al., 2013).

Feed type and source are some factors that affect growth rate and health status of cultured fish. Despite the high potentials of aquaculture, local fish production has failed to meet the country's domestic demand for aquaculture product due to high cost of production which emanates from high cost of feed ingredients (Umar et al., 2016) and fingerlings for stocking ponds (Etuk et al., 2020). Tilapia is generally accepted cultured fish species, an increase in its production can serve as a bridge to the high demand for animal protein from fish (Wing-keong and Nicholas, 2013). However, the production of tilapia in Nigeria like other tropical and sub-tropical nations is very economical due to the favourable temperature which enhances their growth (Mensah et al., 2013). Other alternative energy-based ingredient especially of plant origins like rice husks, maize cub, cassava peel, and some other agricultural wastes have been sought.

Hyphaene thebaica is commonly referred to as doum, and it is a type of palm tree with edible oval fruit which belongs to the mint family (Arecaceae). Hyphaene thebaica is a good source of essential minerals such as potassium, sodium, calcium, magnesium and phosphorous. Furthermore, doum fruit has shown to provide essential B-complex vitamins, carbohydrate and fibres essential for good nutrition.

The rapid increase in high cost of carbohydrate-based fish feed ingredients in the market is of great concern to fish farmers (Eze and Avwemoya, 2018). However, much attention has been on protein-based ingredients to replace fishmeal, hence, the limited research on the replacement of energy-based ingredients. It may not be out of place to experiment fruits like doum palm that are less demanded by human being, to reduce competition with man. It is an agricultural waste product and can be readily available for aquaculture feed industry as an energy-based ingredient. However, these study attempted to evaluate the potential effect of replacing maize with fermented doum pulp on growth performance and body indices of O. niloticus fingerlings fed at varying inclusion levels.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out at Armana Agro-Allied Entrepreneur Farm opposite Federal University Dutsin-Ma, Dutsin-Ma Local Government Area of Katsina State, Nigeria.

Source and Fermentation of Hyphaene thebaica pulp

The Doum palm pulp (DPP) was gotten from a local market in Dutsin-ma, Katsina State. The doum palm pulp after properly washed, the pulps were sun dried, crushed for further analysis. The doum pulp was fermented artificially following the method described by Yabaya et al., (2009), 2kg Doum palm pulp (DPP) was inculcated with 60.5mg of commercial dry yeast, S. cerevisiae, with a cell density of 3×106 cell g−1 (Fermipan®, GB ingredients, China) and 1.1L of distilled water (50% moisture) and were mixed for 15minutes to homogenize. It was subjected to treatment for 24hrs in an airtight container covered with aluminum foil and incubated at 40°C which is the optimal growth temperature for Sacchromyces cerevisiae. The dried sample was stored in a polyethylene bag for further analysis. The natural fermentation was carried out using the same method as yeast fermented, except that no yeast was added in its process.

Experimental Fish and Design

Two hundred and twenty-five (225) Oreochromis niloticus fingerlings with weight range of 1-3g were obtained from a reputable farm in Nasarawa State. On arrival, the fish was acclimatized for 1 week before the commencement of the experiment. The fish were fed on a commercial pelleted diet for tilapia (2 mm) during acclimation. A completely randomized design (CRD) was used to conduct the experiment with 5 treatments and 3 replicates. After the acclimation, the fish were randomly selected at 15 fish per tank each in triplicates for 25%YFDP 1, 50%YFDP 2, 75%YFDP 3, 100%YFDP 4 (), with 1 control (0% YFDP). Fish were not fed prior to stocking to reduce stress for 24hours. The fish were fed at 5% body weight per day in two equal proportions at 9:00am and 5:00pm for 12weeks. The feed was adjusted weekly based on the weight of the fish. Fish from each tank were weighed weekly using an electronic balance (Shimadzu BL2200H) and the amount feed fed was adjusted accordingly. Mortality was monitored daily and recorded. The weight was monitored weekly and recorded.

Body indices of Cultured Fish

Three fish were selected randomly from each replicate of the treatments making nine fish from each treatment. The fish were dissected, the weights of the whole gut was taken as visceral weight and the liver was weighed and recorded.

The hepatosomatic index (HSI) was calculated as

HIS = [(weight of liver/total fish weight) × 100],

Viscerosomatic index (VSI) was calculated as

VSI = [(weight of viscera/total of fish weight) *100].

Statistical Analysis

Data obtained from the weekly growth performance and body indices were expressed in mean ± error and presented using linear graphs and bar chart respectively. The data were subjected to one way analysis of variance (ANOVA) and where is significant difference at P<0.05, Tukey Honest Significant Difference test was used to compare differences among treatment means. The statistical analyses were carried out with SPSS version 20.0.

RESULTS

The biweekly weight increase of Oreochromis niloticus fed with varying inclusion levels of fermented doum palm pulp is presented in Fig.1. There was a uniform growth pattern of fish fed 0% and 25% YFDP from week 0 to week 7. There is also a partial growth pattern for fish fed 50% and 100% YFDP from the first week up to the end of the feeding trials. Fish fed diet containing 50% YFDP showed a remarkable increase in weight above the other treatments from the first week to the end of the feeding period. This was followed by fish fed diet 100% and 0% while fish fed diet 75% and 25% lagged behind after the third week. Fish fed diet 75% YFDP displayed slowest growth rate from the first week to the end of the feeding trial.

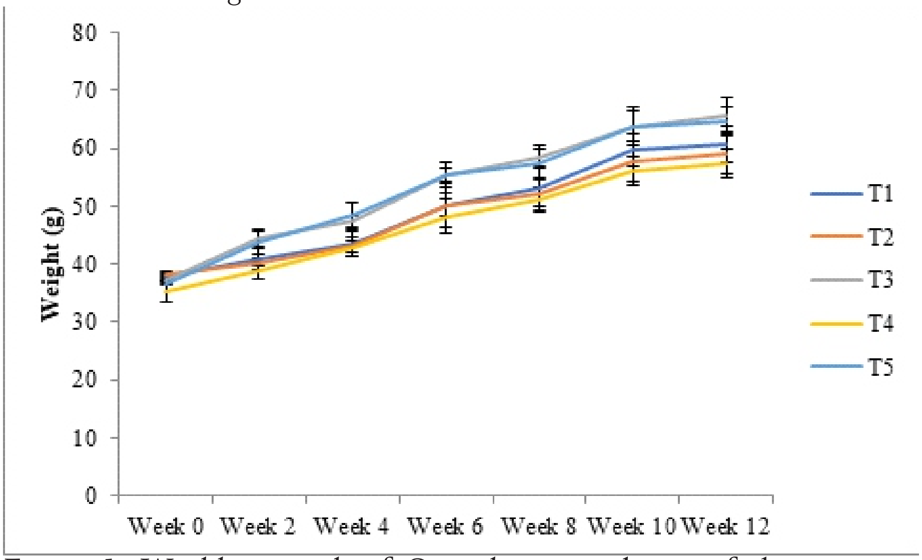


Figure 1: Weekly growth of Oreochromis niloticus fed varying inclusions of fermented Hyphene thebaica as replacement for maize

Body indices of Oreochromis niloticus fed varying inclusion levels of fermented Hyphaene thebaica as replacement for maize

Figure 2 shows the body indices of Oreochromis niloticus fed varying inclusion of fermented Hyphaene thebaica as a replacement for maize. In the hepasomatic index, fish fed 75%YFDP meal was observed to have the highest value of 1.93% followed by fish fed 100%YFDP meal with 1.74% and the least was fish fed 25%YFDP meal with 1.49% values. Among the treatments, fish fed 50%YFDP meal was observed highest with 7.75% values, followed by fish fed 100%YFDP meal with 7.06% and the least was observed in fish fed 75%YFDP meal with 6.36%. The highest HIS was observed in 75% YFDPM (1.9%) and is significantly different (P<0.05) from 25% YFDPM (1.5%). Highest VSI was recorded in 50% YFDPM (7.7%) and is differently significant (P<0.05) from 75% YFDPM (6.4%

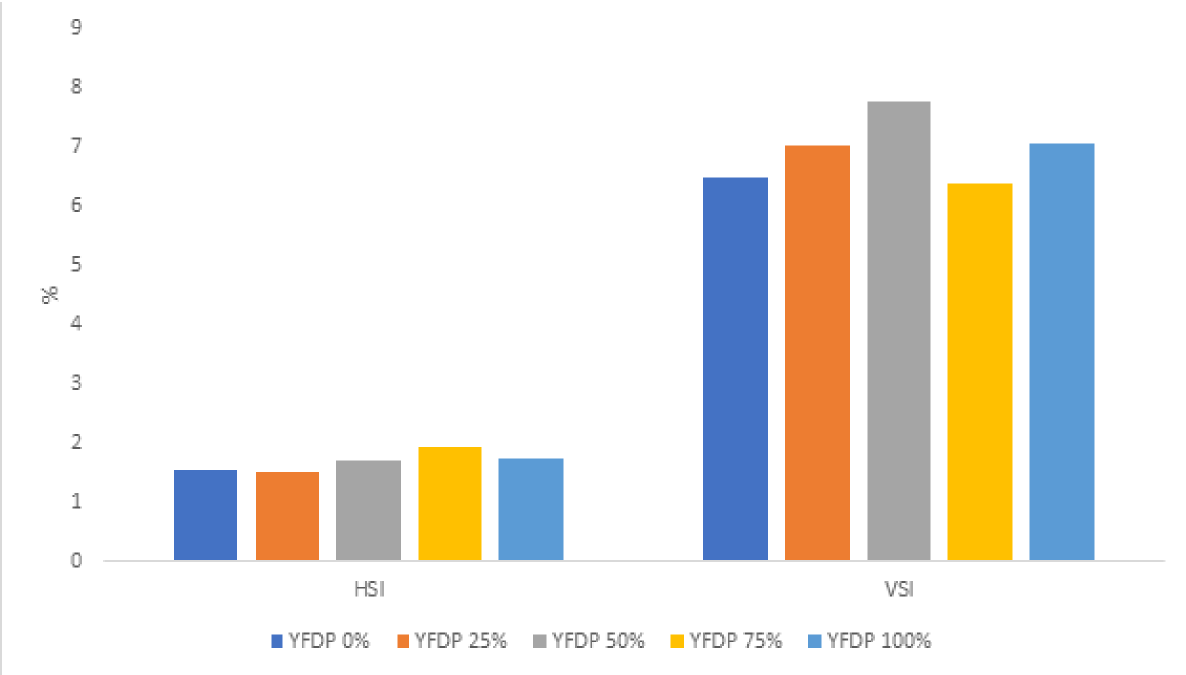


Figure 2: Body indices of Oreochromis niloticus fed fermented Hyphene thebaica meal
*HIS: Hepatosomatic index, *VSI: Viscero0osomatic index, *YFDP: Yeast fermented doum pulp

DISCUSSION

The weekly growth recorded indicated that the fish fed with the experiment diets during the studies responded positively in terms of growth although there were variations where fish in some treatments performed better than other treatments similar to the results obtained by (Bassey et al., 2018). This showed that all the dcccciets were of good quality providing all the nutrients required by fish for good health and optimal growth. Generally, the group fed fermented diet at 50% showed a remarkable increase in weight above the other treatments from the first week to the end of the feeding period.

Murrai et al., (1985) suggested that when excess energy in a diet comes from non-protein sources, it can result in greater deposition of fat in the visceral organs. The HSI values in this study were lower than those reported by Suharmili et al., (2015) and fell below the 8%–9% which is the critical limit suggested by Jobling (1988) beyond which the fish is considered having abnormal liver. The values of HSI and VSI observed in this study were comparable to what was observed by Mohanta et al., (2009) and Mohanta et al., (2007) for silver barb (Puntius gonionotus) fed excess carbohydrate levels, Yengkokpam et al., (2006) for Catla catla fed different sources and levels of gelatinized carbohydrates, and Hemre et al. (1989) for cod (Gadus morhua) fed starch as an energy source. Mohanta et al., (2007) reported that the increase in HSI and VSI are due to excess carbohydrates fed than the required levels by fish which are usually converted into lipid and deposited in the visceral. These findings agreed with the results of Ahmad et al. (2012); Hemre et al., (2002); Krogdahl et al., (2005); Lee et al., (2002) and Nandeesha et al., (2002) that feeding high carbohydrate diets to fish increases their VSI and HSI. Significant increases in HSI have been reported for mrigal and rohu carp fed different inclusion of carbohydrates (Aderolu and Sahu, 2015; Debnath et al., 2007).

CONCLUSION

Observation after 12weeks experimental period showed that the diets containing fermented Hyphaene thebaica is acceptable to O.niloticus as substitution to maize with 50% replacement level produced the best growth performance. Though the doum pulp meal can be included up to 100%, since the fish showed good appetite for all the treatment diets. Inclusion of doum pulp meal in the diet does not have detrimental effect on O. niloticus as revealed by the survival rate and 50% inclusion could be referred as optimum as it led to the best performance.

REFERENCES

Abdel-Tawwab, M., Hagras, A. E., Elbaghdady, H. A. M. and Monier, M. N. (2014). Dissolved oxygen level and stocking density effects on growth, feed utilization, physiology, and innate immunity of Nile tilapia, Oreochromis niloticus. Journal of Applied Aquaculture, 26(4): 340-355.

Aderolu, A. and Sahu, N. (2015). Growth performance, nutrient utilization, metabolic and digestive enzymes studies in mrigal (Cirrhinus mrigala) juveniles fed graded levels of carbohydrate. The Israeli Journal of Aquaculture-Bamidgeh, 67.

Ahmad, M., Qureshi, T. and Singh, A. (2012). Effect of dietary protein, lipid and carbohydrate contents on the viscera composition and organ Indices of Cyprinus carpio communis fingerlings. African Journal of Biotechnology, 11(33), 8361–8366.

Bassey, O.P., Paul, I.A., and Arit, E.T.(2018). The Effect of diet with different inclusion levels of Tigernut (Cyperus esculentus Lativum) on the growth performance of Clarias gariepinus fingerlings. Asian journal of Advances in Agricultural Research 6(1): 1-9.

Dauda A.B, Romano N, Ebrahimi M, Karim M, Ikhsan N, Kamarudin M.S and Ekasari J. (2017). Different carbon sources affects biofloc volume, water quality and the survival and physiology of African catfish Clarias gariepinus fingerlings reared in an intensive biofloc technology system. Fisheries science 83:1037-1048.

Debnath, D., Pal, A., Sahu, N., Yengkokpam, S., Baruah, K., Choudhury, D. and Venkateshwarlu, G. (2007). Digestive enzymes and metabolic pro- file of Labeo rohita fingerlings fed diets with different crude protein levels. Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology, 146(1), 107–114.

Deines, A. M., Bbole, I., Katongo. C., Feder, J. L. and Lodge, D. M. (2014) Hybridization between native oreochromis species and introduced Native tilapia O. niloticus in the Kafue River, Zambia. African Journal of Aquatic Science, 39(1), 23-34.

Eze, F. and Eyo, V. O. (2018) Floating and Stability Effect on Fish Feed Pellets Using Different Concentration of Baobab Leaf Meal (Adansonia digitata) Asian Journal of Fisheries and Aquatic Research 1(4): 1-6.

Edwards, P. (2015). Aquaculture environment interactions: Past, present and likely future trends. Aquaculture, 447:1-128

Etuk, E.A., Ogban, G. O., and Idiong, C.I. (2020). A comparative economicanalysis of aquaculture production system in southern agricultural zone of Cross River State, Nigeria. African journal of Agricultural Research. 17(1): 104-111.

FAO. (2018.) The State of World Fisheries and Aquaculture 2018-Meeting the Sustainable Development Goals; FAO: Rome, Italy,

Fletcher, R. (1997) Listing of useful plants of the world. Australian New Crops.

Hsu, B., Coupar I.Mand Ng K.(2006) Antioxidant activity of hot water extract from the fruit of the Doum palm, Hyphaene thebaica. Food Chemistry.;98:317-328

Hemre, G.-I., Lie, Ø., Lied, E. and Lambertsen, G. (1989). Starch as an energy source in feed for cod (Gadus morhua): Digestibility and retention. Aquaculture, 80(3–4), 261–270.

Karapan, A. (2002) Studies to optimize poly unsaturated fatty acid composition of tilapia for human consumption in S.E. Asia. Aquaculture News.28:6-7.

Krogdahl, Å., Hemre, G. I. andMommsen, T. (2005). Carbohydrates in fish nutrition: Digestion and absorption in post larval stages. Aquaculture Nutrition, 11(2), 103–122.

Lee, S.-M., Jeon, I. G. and Lee, J. Y. (2002). Effects of digestible pro- tein and lipid levels in practical diets on growth, protein uti- lization and body composition of juvenile rockfish (Sebastes schlegeli). Aquaculture, 211(1–4), 227–239.

Mensah, E.T., Attipoe, F.K., and Ashun-Johnson, M. (2013). Effect of different stocking densities on growth performance and profitability of Oreochromis niloticus fry reared in hapa-in-pond system. International journal of fisheries and aquaculture, 5(8) 204-209.

Mohanta, K. N., Mohanty, S. N., Jena, J., Sahu, N. P. and Patro, B. (2009). Carbohydrate level in the diet of silver barb, puntius gonionotus (Bleeker) fingerlings: Effect on growth, nutrient utilization and whole body composition. Aquaculture Research, 40(8), 927–937.

Mohanta, K., Mohanty, S. and Jena, J. (2007). Protein-sparing effect of car- bohydrate in silver barb, Puntius gonionotus fry. Aquaculture Nutrition, 13(4), 311–317.

Murrai, T., Akiyama, T., Takeuchi, T., Watanabe, T. and Nose, T. (1985). Effects of dietary protein and lipid levels on performance and carcass composition of fingerlings carp. Bulletin of the Japanese Society for the Science of Fish, 51(4), 307–316.

Nandeesha, M. C., Gangadhara, B. and Manissery, J. K. (2002). Further studies on the use of mixed feeding schedules with plant and animal-based diets for common carp Cyprinus carpio (Linnaeus). Aquaculture Research, 33, 1157–1162.

Sayed, A. E. D. H., Mahmoud, U. M. and Mekkawy, I. A. (2015). Erythrocyte alterations of monosex tilapia (Oreochromis niloticus, Linnaeus, 1758) produced using methyltestosterone. The Egyptian Journal of Aquatic Research.

Suharmili, R., Kamarudin, M., Saad, C., Ina-Salwany, M., Ramezani-Fard, E., and Mahmud, M. (2015). Effects of varying dietary protein level on the growth, feed efficiency and body composition of lemon fin barb hybrid fingerlings. Iranian Journal of Fisheries Sciences, 14(2), 425–435

Umar, J., Auta, J., Oniye, S. J. and Bolorunduro, P. I. (2016). Growth and Economic Performance of African Catfish, Clarias gariepinus (Burchell. 1822) Juveniles to Imported and Local Feeds in Floating Bamboo Cages. International Journal of Fisheries and Aquatic Studies, 4(2): 221-226.

Waleed, A, Zangh L, Mohammed D, Mohammed, Abubakar M, Elshareif O. and Malik T. (2014) Physiochemical, Nutrition and functional properties of the Epicarp, Flesh and Pited sample of Doum palm fruit (Hyphaene thebaica). Journal of Food and Nutrition Research.;24:180-186.

Wing-Keong, N. and Nicholas R.(2013). A review of the nutrition and feeding management of farmed tilapia throughout the culture cycle. Reviews in Aquaculture, 5: 220-254.

Yengkokpam, S., Sahu, N., Pal, A., Mukherjee, S. and Debnath, D. (2006). Gelatinized carbohydrates in the diet of Catla catla fingerlings: Effect of levels and sources on nutrient utilization, body composition and tissue enzyme activities. Asian-Australasian Journal of Animal Sciences, 20(1), 89–99.

GROWTH PERFORMANCE, FEED UTILIZATION AND COST BENEFIT ANALYSIS OF HYBRID CATFISH AND NILE TILAPIA UNDER SEMI-INTENSIVE POLYCULTURE USING BRAN-BLO

[1]Adams, T. E., [2]*O.A. Akinrotimi, [3]N.K. Owhonda , [4]P.O.Nwosu and [5]F.A. Omodu

[1]Nigerian Institute for Oceanography and Marine Research, Sapele Out Station, Delta State, Nigeria.
[2],3Department of Mariculture, Nigerian Institute for Oceanography and Marine Research, Buguma P.M.B. 5122, Port Harcourt, Rivers State, Nigeria

Corresponding author:
ojoakinrotimi@gmail.com, +2348065770699, 0000-0003-2775-645X

ABSTRACT
The aim of the study is to produce good quality feed using low cost energy source in semi-intensive system to encourage farmers at rural areas to ensure adequate supply of fish feed at affordable price. Four existing earthen ponds of 200m2 were stocked with 1000 post-fingerlings hybrid catfish (Clarias gariepinus female x Heterobranchus Longifilis male) and 500 juvenile Nile tilapia (Oreochromis niloticus) at a rate of 6 fish/m2 and ratio 2:1 (catfish : tilapia). The stocked fish were fed on a mixture of cow blood and wheat bran commonly referred to as bran-blo (Treatment I) for a period of six (6) months with commercial diet coppens (Treatments II) as control. Fish performance by species in term of fish growth, yield and survival were recorded and used to calculate rate of return on investment. The study showed that fish cultured under treatment II exhibited higher growth rates than those in treatment I (Bran Blo). However, in terms of economic profitability, Treatment I in Nile Tilapia and Treatment I in Hybrid catfish showed the highest gross profit of N221,600:00 and N1,474,000:00 respectively, as a result of the low cost of production of Bran-Blo. There were no significant differences (P>0.05) in all water quality parameters except the water transparency where treatment II was more transparent than treatment I. The benefit /cost ratio showed that treatment I in both Nile Tilapia and Hybrid Catfish fed with Bran Blo are viable with values above 1. Based on the results from the present study, it can be concluded that bran blo diet is profitable and can be used efficiently for production of C. gariepinus and O.niloticus in fertilized earthen ponds.

Keywords:
Hybrid (Heteroclarias), Nile Tilapia, Bran-Blo, intensive culture.

INTRODUCTION
Most inputs required for fish production are available in most part of Nigeria, such s; suitable land for construction of earthen ponds, adequate supply of water, hatchery breed fish seed and technical support. One of the inputs that can be considered as a serious knitting factor is good quality fish diet. Dedicated fish feed mill are scarce or unavailable, and the existing ones find it difficult to meet demands of farmers due to competition between man, culture fish and livestock for the available feed stuffs (Benedict *et al.*, 2005). According to Esonu *et al.* (2011) these crippling realities that are characteristics of third world countries has led to the use of locally available and cheap industrial by-

products, novel crop and waste as ingredients.

Wheat bran is a by-product of dry milling of common wheat into flour, it is one of the major agro-industrial by-products used in animal feeding (Boujard *et al.*, 2002). Wheat bran contains many nutritionally valuable components such as dietary fiber and phenolic compound with antioxidative properties (Javed *et al.*, 2011). Aquaculture industry has witnessed the introduction of foreign floating feeds with high cost (Coulibaly *et al.*, 2007). This has made it impossible for many fish farmers to break even at the end of production cycle. Hence the use of non-conventional feed stuff for omnivorous species like catfish is very crucial under the semi-intensive system. The aim of this study is to produce good quality fish feed using low cost energy source in semi intensive system to encourage farmers at the rural level to ensure adequate supply of affordable fish feed for rural farmers.

MATERIAL AND METHODS

The experiment was carried out at the Nigerian Institute for Oceanography and Marine Research, Sapele Out-Station Farm, Sapele, Delta State, Nigeria from February 2023 to August 2023 in earthen ponds culture condition. Wheat bran was purchased from Laterrain Agro Store in Sapele Local Government Area of Delta State Nigeria while fresh cow blood was collected with clean plastic container from Sapele abattoir. The wheat bran was mixed with the cow blood at ratio 2:1 i.e. 50kg of wheat bran to 25kg (20liter) of cow blood respectively and sunned for 5 days. Bran-blo was analyzed to determine its proximate composition (Table 1) according to the methods of AOAC (1990).

Four existing earthen ponds of 200m2 were stocked with 1000 post-fingerlings (mean length 10.32±1.74cm; mean weight 8.10±0.12g) hybrid catfish (*Clarias gariepinus* female x *Heterobranchus Longifilis* male) and juvenile (mean length 7.01±0.55cm; mean weight 5.33±0.44g) Nile tilapia *Oreochromis niloticus* each at a rate of 6 fish/m2 and ratio 2:1 (catfish : tilapia). The stocked fish were fed with a mixture of cow blood and wheat bran commonly referred to as bran-blo for a culture period of six (6) months with a commercial diet, coppens as control. Fish performance by species such as; growth rate, yield and survival were recorded and used to calculate rate of return on investment. The following parameters were determined

$$\text{Bi-weekly mean weight gain (g)} = \frac{\text{Total bi-weekly weight(g)}}{\text{Total No of fish weight (g)}}$$

$$\text{Specific growth rate(SGR\%/day)} = 100X\ \frac{\text{In Final weight-In Initial weight of fish}}{\text{Culture period (days)}}$$

Where;

ln = natural log

$$\text{Final conversion ratio} = \frac{\text{Total weight of feed consumed}}{\text{Total weight of fish produced}}$$

$$\text{Fish survival rate (SR\%0} = \frac{\text{Total fish number harvested}}{\text{Total fish number stocked}} \times 100$$

$$\text{Fish yield} = \frac{\text{Total weight of fish harvested over culture}}{\text{(g/180days/200m2)}} \times 100$$

Data collected was subjected to analysis of variance ANOVA and significantly different means were separated using Duncan's New Multiple Range.

RESULTS

The proximate composition of bran blo and control diet coppens are shown in Table 1. The results indicated that coppens had higher values of crude protein, and fat, than bran blo. Whereas bran blo recorded higher values of crude fiber, moisture, ash fry matter and metabolizable energy. The water quality analysis in the rearing ponds during the trial are presented in Table 2. The results revealed that no significant differences (P>0.05) in all water quality parameters except the water transparency where treatment II was more transparent than treatment I. The growth performance feed utilization and production of Nile tilapia fed with wheat blood (bran blo) and commercial diet (Coppens) are presented in Table 3 the results revealed that final weight gain (g), weight gain (g), no of fish harvested, total weight of fish harvested (kg), specific growth rate and survival rate were significantly ($P<0.05$) higher in fish fed with coppens than those fed with bran blo. However, feed intake and feed efficiency were higher in fish fed bran blo.

Furthermore, The growth performance feed utilization and production of Hybrid Heteroclarias fed with wheat blood (bran blo) and commercial diet (Coppens) are presented in Table 4, the results showed that final weight gain (g), weight gain (g), no of fish harvested, total weight of fish harvested (kg), specific growth rate and survival rate were significantly ($P<0.05$) higher in fish fed with coppens than those fed with bran blo. However, feed intake and feed efficiency were higher in fish fed bran blo. The cost benefit analysis of Nile tilapia and Hybrid Heteroclarias fed with bran blo t1 and commercial feed (coppens) are presented in Table 5 and 6 respectively. The results revealed that Treatment I in Nile Tilapia and Treatment I in Hybrid catfish (fed with Bran Blo) showed the highest gross profit of 221,600 and 1,474,000. The benefit /cost ratio showed that treatment I both in the Nile Tilapia and Hybrid Catfish fed with Bran Blo are viable with values above 1

Table 1: Proximate Composition of Bran Blo and Control Diet Coppens

Nutrients	Bran Blo (TI)	Coppens (TII)
Crude protein	33.48	49
Crude fibre	6.50	0.90
Fat	1.90	13.00
Moisture	12.00	-
Ash	8.50	8.10
Dry matter	88.00	-
M. E. Kcal/Kg	3.085	-

Table 2: Water Quality Analysis in rearing ponds

Parameters	Treatments	
	TI	TII
Temperature (^{0} C)	30.49 ± 3.66^a	30.65 ± 3.04^a
Dissolved Oxygen mg/l	7.78 ± 1.33^a	8.76 ± 2.99^a
pH	6.35 ± 1.09^a	6.60 ± 3.95^a
Transparency (cm)	45.98 ± 4.99^b	26.60 ± 2.90^a

Means within the row with different superscripts are significantly different ($p<0.05$)

Table 3: Growth Performance Feed Utilization and Production of Nile Tilapia Fed with Wheat Blood (Bran Blo) and Commercial Diet (Coppens)

Variables	Wheat Blood (Bran Blo) TI	Commercial Feed (Coppens) TII
Initial weight gain (g)	3.02 ± 0.11^a	3.08 ± 0.12^a
Final weight gain (g)	$280 .02 \pm 0.68^a$	340.88 ± 0.49^b
Weight gain (g)	277.08 ± 0.57^a	337.08 ± 0.37^b
No of fish stocked	500.22 ± 0.00^a	500.00 ± 0.05^a
No of fish harvested	278.65 ± 0.44^a	315.82 ± 0.02^b
Total weight of fish harvested (kg)	88.00 ± 2.00^a	104.66 ± 0.06^b
Specific growth rate	1.58 ± 0.40^a	1.65 ± 0.31^a
Feed intake	1100.00 ± 1.03^b	990.09 ± 0.43^a
Feed efficiency	16.40 ± 1.07^b	11.90 ± 0.99^a
Survival rate %	55.60 ± 0.66^a	63.00 ± 4.66^b

Means within the row with different superscripts are significantly different ($p<0.05$)

Table 4: Growth Performance, Feed Utilization and Production of Hybrid Heteroclarias Fed with Wheat Blood (Bran Blo) and Commercial Feed (Coppens).

Variables	Wheat Blood (Brab Blo) TI	Commercial Feed (Coppens) TII
Initial weight gain (g)	5 .00 ± 0.07 [a]	5.00 ± 0.53 [a]
Final weight gain (g)	500.33 ± 0.68 [a]	750 .00± 9.54 [b]
Weight gain (g)	450.00 ± 3.10 [a]	745.00 ± 9.88 [b]
No of fish stocked	1000.00± 8.00 [a]	1000.00± 8.77 [a]
No of fish harvested	810.00± 7.66 [a]	865.00± 9.02 [a]
Total weight of fish harvested (kg)	450.00± 8.54 [a]	670.00± 8.65 [b]
Specific growth rate	0.01 ± 0.00 [a]	0.01 ± 0.00 [a]
Feed intake	1100.00± 9.13 [b]	990.00± 8.66 [a]
Feed efficiency	2.40± 0.88 [b]	1.40± 0.02 [a]
Survival rate %	81.00± 4.99 [a]	86.12±5.92 [a]

Means within the row with different superscripts are significantly different ($p<0.05$)

Table 5: Cost Benefit Analysis of Nile Tilapia fed with Bran Blo T1 and Commercial feed (Coppens)

S/N	Items	Quantity		Unit Cost		Total Cost		Benefit	
		T1	T2	T1	T2	T1	T2	T1	T2
A	**Fixed Cost**	0	1	25,000	25,000	25,000	25,000		
B	**Variable Cost**								
1	Tilapia Juvenile	500	500	₦20/1	₦20/1	10,000	10,000		
2	Wheat offer	9bags	-	12,000	12,000	108,000	-		
3	Cow blood	9 of 20lit	-	1,500	1,500	108,000	-		
4	Coppens:			-	38,000				
	2mm	-	2bags	-	25,000	-	76,000		
	4mm	-	7bags	-	23,000	-	175,000		
	6mm	-	28bags			-	644,000		
						251,000	930,000		
C	**Revenue**			1700	1700				
1	Tilapia sales	278	315			472,600	535,500		
D	**Profitability**								
1	Gross Profit							221,600	-394,500
2	Profit Index							2.19	0.60
3	Incidence of Cost							2,454.55	8,605.77
E	**Benefit/Cost ratio**							0.88	-0.42

Table 6: Cost Benefit Analysis of Hybrid Catfish fed with Bran Blo T1 and Commercial feed Coppens)

S/N	Item	Quantity		Unit Cost		Total Cost		Benefit	
		T1	T2	T1	T2	T1	T2	T1	T2
A	Fixed Cost	0	1	25,000	25,000	25,000	25,000		
B	Variable Cost								
1	Tilapia Juvenile	1000	1000	₦40	₦40	40,000	40,000		
2	Wheat offer	18bags	-	12,000	-	216,000	-		
3	Cow blood	18 of 20lit	-	1,500	-	27,000	-		
4	Coppens:								
	2mm	-	4bags	-	38,000	-	152,000		
	4mm	-	14bags	-	25,000	-	350,000		
	6mm	-	56bags	-	23,000	-	1,830,000		
						308,000	2,397,000		
C	Revenue								
1	Tilapia sales	810	865	2,200	2,200	1,782,000	1,903,000		
D	Profitability								
1	Gross Profit							1,474,000	-494,000
2	Profit Index							2.30	0.82
3	Incidence of Cost							2,761.36	22,423.08
E	Benefit/Cost ratio							4.79	-0.21

DISCUSSION

In the present study, fish fed on coppens feed exhibited significantly better growth than the other diets. Apart from the nutrient content of the feed, formulation and processing determine bio-availability of nutrients, feed acceptability, palatability and durability which affects growth performance of fish (Afzal *et al.*, 2017). The better performance of Coppens feeds over the un-pelleted bran blo feed could be attributed to the fact that coppens feed may have reduced feed wastage, uniform feed intake and destruction of growth inhibitors (Soltan *et al.*, 2018). It has been noted that fish fed combined type of food especially bran blo are usually the worst performers since such diets are neither complete nor balanced and do not supply all nutrients required by the fish (Yakubu *et al.*, 2014).

The cost benefit analysis in this present study did not take into consideration the cost of both pond construction and water as these were considered a constant. Although there were positive returns for all the diets, Bran blo was the most profitable compared with the other dietary treatments. This observation is in agreement with other authors who indicated that inclusion of wheat bran in fish diets is cost-effective in the production of O. *niloticus* in fertilized ponds (Mugunti *et al.*, 2012). The net economic returns were also higher in the brablo diets. The benefit /cost ratio showed that treatment I both in the Nile Tilapia and Hybrid Catfish fed with Bran Blo are viable with values above 1. Utomakili and Aganmwonyi (1995) stated that benefit/cost ratio that is greater than 1 is viable.

CONCLUSION AND RECOMMENDATIONS

Considering the availability of the used agro-industrial by-products in the country and the results from the present study, it can be concluded that bran blo diet is profitable and can be used efficiently for production of C. gariepinus and O.niloticus in fertilized earthen ponds.

REFERENCES

Afzal, M., Rab, A., Akhtar N, Khan, M.F., Barlas, A., and Qayyum, M. (2017). Performance of Bighead Carp (Aristichthys nobilis) in Polyculture System. International Journal of Agriculture & Biology, 9(6), 931–933.

Benedict, O. O., Gabriel, U. U., and Ezekiel, O. A. (2005). Effect of stocking size of the predatory African Catfish Heterobranchus Longifilis V on the growth performance of Nile Tilapia (Oreochromis niloticus L.) in pond culture. Journal of Fisheries and Aquaculture, 1(3), 35 – 43.

Boujard, T. I., Labbe, L., and Anperin, B. (2002). Feeding behavior, energy expenditure and growth of rainbow in relation to stocking density and Food Accessibility Aquaculture Research, (33), 1233 – 1242.

Coulibaly, A. N., Ouattara, T., Kone, V., Douba, J. N., Snoeks G. B. G., and Kouamelan, E. O. (2007). First results of Floating Cage Culture of the African Catfish Heterobranchus Longifilis Valenciennes 1840. Effect of Stocking Density ion Survival and Growth Rates. Aquaculture, 263, 201 – 207.

Esonu, B. O., Azubuke J. C., Udedibie A. B. J., Emenalon O. O., Iwuji T. C. and Odoneme, A.G. (2011). Evaluation of the Nutritive value of Mixture of fermented Bovine Blood and Rumen Digested for Broiler Finishers. Animal Production, 12,120-127.

Javed, R., Grautan, S. K., Vijh, R. K., and Tantia, M. S. (2011). Si novel PCR-RFLP loci in Milk quality candidate genes in Bubalus bubalis. Scientific Journal, 112, 432-437.

Munguti, J,, Charo-Karisa, H., Opiyo, M.A., Ogello, E., Marijani, E., Nzayisenga, L., and Liti, S. (2012). Nutritive value and availability of commonly utilized feed ingredients for farmed Nile tilapia, Oreochromis niloticus L. and African catfish, Clarias gariepinus, (Burchell) in Kenya, Tanzania and Rwanda. African Journal of Food, Agriculture and Nutrition Development, 12(3), 6135-6155.

Soltan, M.A., Hanafy, M.A., and Wafa, M.K. (2018). An evaluation of fermented silage made from fish by-products as a feed ingredient for African catfish (Clarias gariepinus). Global Veterinaria, 2(2), 80-86.

Utomakili, J. B., and Aganmwonyi, F. E. (1995). Farm management: a basic textbook. 249pp.

Yakubu, A. F., Nwogu, N. A., Olaji E. D., Ajiboye O. O., Apochi J. O., Adams T. E., Obule E. E., and Eke M. A. (2014). Comparative Study on Growth Performance and Survival Rate of Clarias garipinus Burchell 1833 and Heterobranchus longifilis Valencisnne, 1840 under water recirculation system. Agriculture Forestry and Fisheries, 3 (1), 30 – 33.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

PLASMA ENZYME ACTIVITIES OF Clarias gariepinus JUVENILES FED *Pueraria phaseoloides* LEAF MEAL INCLUSION DIETS

[1]Godwin, S. O., [1]E. J. Ansa, [1]J. C. Ike-Onasi, [1]U. B. Eze and [2]M. Anyanwu

[1]African Regional Aquaculture Centre/Nigerian Institute for Oceanography and Marine Research (ARAC/NIOMR), P.M.B. 5122, Port Harcourt, Nigeria.
[2]Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos.

Corresponding Author:
obisimple@gmail.com, +234 806 390 2018

ABSTRACT
A 10-week feeding experiment was conducted to evaluate the plasma enzyme activities of *Clarias gariepinus* juveniles fed diets formulated with varying inclusion levels of Pueraria phaseoloides leaf meal (PLM). Five isonitrogenous diets (D1-D5) were formulated to contain 40% crude protein with inclusion of PLM at 0%, 5%, 10%, 15% and 20% levels, designated as D1 (control), D2, D3, D4, and D5 respectively. One hundred and fifty C. *gariepinus* juveniles of initial mean weight of 79.87 ± 5.85 g were randomly allocated to five dietary groups and three replicates each and fed at 5% of biomass daily. Fifteen concrete tanks of volume 1m3 each were used for the experiment. Each tank was stocked with ten juveniles. All the formulated diets were accepted by the experimental fish. Results showed that inclusion of PLM in the formulated diets up to 20% level did not negatively alter the activities of the plasma enzymes, the bioreaction accelerators. Thus, catalysis of specific biochemical and physiological reactions in the experimental fish were maintained. Hence, PLM can be included in C. *gariepinus* diets up to 20% level for enhanced feed metabolism and maintenance of enzymes activities in African catfish.

Keywords:
Aquaculture, enzymes, feed, fish, plasma.

INTRODUCTION

World demand for food fish is growing owing to population growth, urbanization and income growth. Sadly, increase in yields of the ocean fisheries would result in destruction of the wild fish stocks (Godwin *et al.*, 2021). Aquaculture seems to be one sure alternative means of supplying fish for consumers, to fill the increasing gap between supply and demand for food fish, while maintaining wild fishery harvests at sustainable levels. However, manufactured feed is a key problem of aquaculture as feed gulps at least 60% of the total production costs (Gabriel *et al.*, 2007). Hence, there is pressing need to look for readily available and low-cost plant protein ingredients to partially or completely substitute the costly and scarce conventional protein ingredients in fish feeds for sustainability of the aquaculture industry.

Clarias gariepinus (African mud catfish) is one of the most popular fish for culture in Nigeria (Godwin et al., 2021). Due to the rising demand for catfish in Nigeria in recent years, fish farmers have increased production leading to improved stocking and feeding rates (Akinrotimi *et al.*, 2007). C. *gariepinus* is an omnivorous fish with a preference for a planktonic diet. It exists in the wild, although it is also cultured in ponds, cages, and pens and is of vast commercial significance.

Pueraria phaseoloides is a fast-growing plant species. The leaf is used as forage for animals particularly rabbits in several African counties while the seeds are used as feed for birds in some Asian countries (Ifeanacho *et al.*, 2017). *P. phaseoloides* is a twiner, climbs over other plants, and can become an invasive species due to its fast growth, wide seed distribution, and capacity to fully cover other plants (Godwin *et al.*, 2021). *P. phaseoloides* is readily available all-year-round in the tropics, has no competition for human consumption, and the leaves can easily be prepared as leaf meal.

Enzymes are biomolecules, mainly proteins, that catalyse specific biochemical reactions in living organisms. Enzyme catalysis accelerate the rate of biochemical reactions in the cells of organisms. Almost all metabolic processes in the cells of organisms need enzyme catalysis in order to occur at rates fast enough to sustain life. Metabolic pathways depend upon enzyme activities to catalyse individual steps (Godwin, 2021).

The present study seeks to evaluate the plasma enzyme activities of C. *gariepinus* juveniles fed diets formulated with varying inclusion levels of *P. phaseoloides* leaf meal (PLM).

MATERIALS AND METHODS

Collection and Preparation of P. phaseoloides Leaf Meal

The *P. phaseoloides* leaf sample was sourced and collected from the premises of African Regional Aquaculture Centre (ARAC), Aluu, Rivers State, Nigeria. The leaves were shade-dried at room temperature for three weeks and ground into very fine particles. The ground sample was stored for later usage.

Formulation and Preparation of Experimental Diets

The feed ingredients used in this study include: PLM, wheat bran, soybean meal, fish meal, palm oil, garri (binder), bone meal, iodized salt, fish premix, lysine, methionine, and vitamin C. All the feed ingredients measured out summed up to 100% as shown in Table 1. Five isonitrogenous diets of 40% crude protein were formulated using Pearson Square method. The control diet (Diet 1) contained 0% PLM, Diet 2 contained 5% PLM, Diet 3 contained 10% PLM, Diet 4 contained 15% PLM, and Diet 5 contained 20% PLM. The dough of each practical diet was pelletized separately using Atlas Diesel Engine Pelletizer (R175A, China) through a 4mm die (the appropriate feed size for the juveniles to actively eat) to produce pellets and sun-dried separately for 72 hours and more. The dry pellets were stored in air-tight plastic buckets and labeled accordingly.

Table 1: Percentage Composition of Experimental Diets

Ingredients	Diet 1 (0% PLM)	Diet 2 (5% PLM)	Diet 3 (10% PLM)	Diet 4 (15% PLM)	Diet 5 (20% PLM)
PLM	0.00	5.00	10.00	15.00	20.00
Wheat Bran	19.76	15.02	10.27	5.54	0.79
Soybean Meal	33.80	33.67	33.54	33.41	33.28
Fish Meal	33.80	33.67	33.54	33.41	33.28
Palm Oil	5.00	5.00	5.00	5.00	5.00
Garri (Binder)	5.00	5.00	5.00	5.00	5.00
Bone Meal	1.50	1.50	1.50	1.50	1.50
Salt	0.50	0.50	0.50	0.50	0.50
Premix	0.25	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15	0.15
Methionine	0.15	0.15	0.15	0.15	0.15
Vitamin C	0.10	0.10	0.10	0.10	0.10
Total (%)	100	100	100	100	100

PLM = Pueraria phaseoloides leaf meal

Project Location

The feeding experiment was done at the African Regional Aquaculture Centre (ARAC), a Department of the Nigerian Institute for Oceanography and Marine Research (NIOMR), Aluu, Rivers State, Nigeria.

Proximate Analyses

All proximate analyses were determined on a dry weight basis at the Plant Anatomy and Physiology Research Laboratory, University of Port Harcourt, Rivers State, Nigeria; using the Association of Official Analytical Chemists (AOAC) method (2006). The parameters analyzed were moisture content, ash content, crude protein, crude fat, crude fibre, and total carbohydrates.

Water Quality Analyses

The water quality parameters measured include: temperature, pH, dissolved oxygen, ammonia, nitrite, and total hardness. Temperature was measured with a mercury-in-glass thermometer, while other parameters were determined using LaMotte Fresh Water Aquaculture Test Kit (Code 3633-05, USA).

Source of Experimental Fish/Acclimatization

One hundred and fifty C. *gariepinus* juveniles of the same stock and mean weight 79.87 ± 5.85 g were obtained from ARAC Catfish Hatchery. The fishes were acclimatized for two weeks and fed twice daily with ARAC catfish feed at 5% biomass.

Experimental Design, Rearing Units, and Stocking of Fish

Completely Randomized Design was used, with five treatment levels and three replicates each. A total of 15 concrete tanks of volume 1m3 each were used for the experiment. Each tank was stocked with 10 juveniles. A total of 150 juveniles were stocked.

Feeding of Experimental Fish

The experimental fish were handfed twice daily, morning and evening at 9:00 am and 4:00 pm. The daily ratio of 5% biomass was divided into two, and a half fed to the fish each time. The weight of feed fed was adjusted every two weeks to contain weight gain by fish. The experiment lasted for 10 weeks.

Collection of Blood Samples

Blood samples for biochemical analyses were collected and preserved in sterile ethylenediaminetetraacetic acid (EDTA) bottles, 15 in number, and labeled based on each experimental treatment for easy identification. EDTA salt was used as the anticoagulant because it produces excellent results with preserved blood (Ariweriokuma *et al.*, 2016). The blood sample was drawn from the caudal vein situated near the vertebrae column in the caudal part of the fish (Akinrotimi *et al.*, 2007). A hand net was used to capture individual fish from the experimental tanks and blood samples were collected using 5ml disposable syringes and 21-G hypodermic needles.

During blood collection, the head of each fish was covered with a piece of moist cloth for physical restriction with minimal stress (Nwadukwe and Ayinla, 2004). The needle was inserted perpendicularly on the surface of the fish at a point slightly above the openings of the genital papilla. As the needle pierced the fish vein, blood flowed easily into the syringe and 3ml of blood was collected before the needle was withdrawn. The needle was thereafter detached from the syringe and blood was transferred into EDTA bottles. The blood samples were analyzed for biochemical parameters at the Lively Stones Medical Laboratory, Choba, Port Harcourt, Nigeria.

Data Analysis

Data obtained from the study were subjected to Analysis of Variance (ANOVA) using SPSS (version 21) and comparisons were done at 0.05 significance level. Values were expressed as mean ± standard deviation (mean ± S.D) of triplicate determinations.

RESULTS AND DISCUSSION

Proximate Composition of *P. phaseoloides* Leaf Meal

Table 2 shows the proximate composition of *P. phaseoloides* leaf meal.

Table 2: Proximate Composition of *P. phaseoloides* Leaf Meal

Nutrients	% Composition
Moisture	5.23±0.23
Ash	5.35±0.75
Crude Protein	18.31±2.62
Crude Fat	7.00±0.00
Crude Fibre	20.15±0.57
Carbohydrate	43.96±4.09

Values are mean ± standard deviation of triplicate determinations.

Phytochemicals Screening of *P. phaseoloides* Leaf Sample

Table 3 shows the phytochemical composition of the leaf meal. Phytochemicals are widely known to have protective effects against chemically-induced oxidative damage, by enhancing the antioxidant defence system of animal tissues and blocking oxidative stress (Abarikwu *et al.*, 2018). In the present study, we observed cardiac glycosides, flavonoids, saponins, and quinones as phytochemicals present in the *P. phaseoloides* leaf sample. These phytochemicals improved the quality of the PLM inclusion diets and thus enhanced the survival of the experimental fish.

Table 3: Phytochemicals screening of *P. phaseoloides* leaf sample

S/No.	Phytochemicals	Results
1	Alkaloids	-ve
2	Cardiac glycosides	**+ve**
3	Flavonoids	**+ve**
4	Phenols	-ve
5	Phlobatannins	-ve
6	Saponins	**+ve**
7	Sterols	-ve
8	Tannins	-ve
9	Terpenoids	-ve
10	Quinones	**+ve**
11	Oxalate	-ve
12	Diterpenes	-ve

+ve: Positive
-ve: Negative

Water Quality Parameters

Table 4 shows the water quality parameters of the culture media. Fishes go about their activities inside water and are dependent on water for feeding, respiration, excretion, osmoregulation, growth, and reproduction. Thus, a successful aquaculture business is dependent on the health of the fish and good water quality management. In the present study, the water quality parameters recorded no significant differences ($p>0.05$) in all the experimental tanks and were within acceptable tolerant ranges recommended for freshwater fish culture (Ariweriokuma *et al.*, 2016). Hence, the basic water quality parameters measured did not affect any observed differences in the performance of the experimental fish.

Table 4: Water Quality Parameters

Parameters	Experimental Tanks				
	Tank 1 (control)	Tank 2	Tank 3	Tank 4	Tank 5
pH	6.68±0.02[a]	6.66±0.01[a]	6.61±0.08[a]	6.62±0.03[a]	6.62±0.02[a]
Temperature (°C)	27.27±0.01[b]	27.28±0.01[b]	27.28±0.02[b]	27.29±0.01[b]	27.29±0.01[b]
Dissolved Oxygen (mg/l)	6.62±0.01[c]	6.59±0.02[c]	6.60±0.02[c]	6.59±0.02[c]	6.60±0.02[c]
Ammonia (mg/l)	0.10±0.01[d]	0.11±0.02[d]	0.12±0.02[d]	0.12±0.02[d]	0.12±0.02[d]
Nitrite (mg/l)	0.29±0.01[e]	0.29±0.01[e]	0.29±0.01[e]	0.30±0.02[e]	0.29±0.02[e]
Total Hardness (mg/l)	43.46±0.02[f]	43.48±0.02[f]	43.47±0.02[f]	43.47±0.03[f]	43.45±0.01[f]

Values are mean ± S.D. of triplicate determinations. Values with similar superscript letters along the same row are not significantly different ($p>0.05$) compared to the control (Tank 1).

Plasma Enzyme Activities of the Experimental Fish

Table 5 shows the plasma enzyme activities of the experimental fish at the end of the feeding experiment. The job of enzymes is to catalyze specific biochemical reactions in living organisms. Enzyme activities affect various biochemical and physiological reactions in the fish body (Begum, 2004) and changes in enzyme activities are important stress indicators (Godwin, 2021).

Table 5: Plasma Enzyme Activities of the Experimental Fish

Experimental Groups	AST (u/l)	ALT (u/l)	ALP (u/l)	LDH (u/l)	ACP (u/l)
Group 1 (control)	48.33±1.15[a]	11.67±0.58[a]	22.67±1.15[a]	41.33±12.06[a]	4.93±1.50[a]
Group 2	46.67±1.15[a]	11.33±2.08[a]	21.67±0.58[a]	39.67±0.58[a]	4.73±1.36[a]
Group 3	46.33±1.53[a]	10.33±1.53[a]	18.67±1.15[b]	37.00±5.57[a]	4.43±0.06[a]
Group 4	43.33±0.58[b]	9.00±1.00[b]	18.33±3.51[b]	33.67±3.06[a]	4.00±0.36[a]
Group 5	40.67±1.15[b]	8.33±1.53[b]	16.33±1.53[b]	32.67±3.06[a]	3.83±0.35[a]

Values are mean ± standard deviation ($n=10$). Values with similar superscript letters along the same column are not significantly different ($p>0.05$) compared to the control (Group 1).

AST = Aspartate transaminase; ALT = Alanine transaminase; ALP = Alkaline phosphatase; LDH = Lactate dehydrogenase; ACP = Acid phosphatase.

Gaylord *et al.* (2010) reported decreased enzyme activities of aspartate transaminase (AST), alanine transaminase (ALT), alkaline phosphates (ALP), lactate dehydrogenate (LDH) and acid phosphatase (ACP) in different organs of fish exposed to mercury, which indicated toxic effects in the fish. A significant increase in the activities of AST, ALT, LDH and ALP in the liver of albino rats exposed to monocrotophous, methyl-parathion and dimethoate administered orally for 90 days was reported by Knudsen et al. (2008) and they concluded that such increase indicated cellular toxicity of the various organophosphates. Also, Osuigwe et al. (2005) observed that the inclusion of varying levels of raw and boiled Jack bean seed meal in the diet of hybrid catfish for 56 days caused increased activities of ALT, AST and LDH.

In the present study, enzyme activities in the organs and tissues of the experimental fish were significantly different ($p<0.05$) in some of the treatment groups compared to the control. However, the variations observed in the enzyme activities across different dietary groups did not disrupt normal biochemical and physiological processes in the fish, as growth and survival were enhanced in the culture medium.

According to Godwin et al. (2021), inclusion of PLM in C. gariepinus diets up to 20% level proved to be economically viable, with higher cost/benefit ratio compared to the control values. Hence can help reduce the costs of fish feed for the sustainability of the aquaculture industry.

CONCLUSION

In the present study, all the formulated diets were accepted by the experimental fish, which implied that the levels of inclusion of PLM did not affect the palatability of the diets. Also, inclusion of PLM in the formulated diets up to 20% level did not negatively alter the plasma activities of the enzymes, the biocatalysts. Thus, normal biochemical catalysis and physiological functions in the experimental fish were maintained.

It can then be concluded that PLM can be included in the diets of C. *gariepinus* up to 20% level for enhanced feed metabolism and maintenance of enzyme activities in African catfish.

REFERENCES

Abarikwu, S. O., Godwin, S. O. and Onuoha, S. C. (2018). Morphometric Evaluation of the Seminiferous Tubules and the Antioxidant Protective Effects of Gallic Acid and Quercetin in the Testis and Liver of Butyl Phthalate Treated Rats. Indian Journal of Clinical Biochemistry, 35, 20–31.

Akinrotimi, O. A., Gabriel, U. U., Owhonda, N. K., Onunkwo, D. N., Opara, J. Y. and Cliffe, P. T. (2007). Formulating an environmentally friendly fish feed for sustainable aquaculture development in Nigeria. Agricultural Journal, 2(5), 606-612.

AOAC (2006). Official Methods of Analysis of AOAC. W. Horwitz (ed.) 18th ed. Washington DC, USA.

Ariweriokuma, S. V., Gabriel, U. U., Ansa, E. J. and Akinrotimi, O. A. (2016). Growth response of African catfish (Clarias gariepinus) fed dietary inclusion levels of green leaf (Amaranthus cruentus). International Journal of Innovative Studies in Aquatic Biology and Fisheries (IJISABF), 2(2), 23 – 38.

Begum, G. (2004). Carbofusan insecticide induced Biochemical alterations in liver and muscle tissues of fish, Clarias batrachus (Linn) and recovery response. Aquatic Toxicology, 66 (1), 83 – 92.

Gabriel, U. U., Akinrotimi, O. A., Bekibele, D. O., Onunkwo, D. N. and Anyanwu, P. E. (2007). Locally produced fish feed: potentials for aquaculture development in sub-Saharan Africa. African Journal of Agricultural Research, 2(7), 287-295.

Gaylord, T. G., Barrows, F. T. and Rawles, S. D. (2010). Apparent amino acid availability from feedstuffs in extruded diets for rainbow trout Oncorhynchus mykiss. Aquaculture Nutrition, 16(4), 400-406.

Godwin, S. O. (2021). Nutrient utilization and growth performance of Clarias gariepinus juveniles fed Pueraria phaseoloides leaf meal inclusion diets. PhD Thesis, University of Port Harcourt, Port Harcourt, Nigeria.

Godwin, S. O., Wegwu, M. O. and Ifeanacho, M. O. (2021). Economic viability of Pueraria phaseoloides leaf meal inclusion diets fed to Clarias gariepinus juveniles. Nigerian Journal of Fisheries, 18(1), 2148-2153.

Ifeanacho, M. O., Abbey, B. W. and Ayalogu, E. O. (2017). Variation in Body Weight, Organ Weight and Haematological Parameters of Rats Fed with Diets Based on Treated African kudzu (Pueraria phaseoloides, roxb. Benth) Seeds. Journal of Applied Sciences Environmental Management, 21(6), 1013-1018.

Knudsen, D., Jutfelt, F., Sundh, H., Sundell, K., Koppe, W. and Frokiaer, H. (2008). Dietary soya saponins increase gut permeability and play a key role in the onset of soyabean-induced enteritis in Atlantic salmon (Salmo salar). British Journal of Nutrition, 100(1), 120-129.

Nwadukwe, F. O. and Ayinla, A. O. (2004). The growth and survival of brood catfish fingerlings under three dietary treatments in concrete tanks. African Journal of Applied Zoology and Environment, 3(4), 16-25.

Osuigwe, D. A. L., Obejezie, A. I. and Onwha, G. C. (2005). Some haematological change in hybrid catfish (Heterobranchus longlifilis and Clarias gariepinus) fed different dietary level of raw and boiled jack bean (Canavalia ensiformis) seed meal. Afrcan Journal Biotechnology, 4 (9), 1017-1021.

EVALUATION OF BLACK SOLDIER FLY, Hermetia illucens LARVAE MEAL ON GROWTH PERFORMANCE AND NUTRIENT UTILIZATION OF AFRICAN MUD CATFISH, Clarias gariepinus FINGERLINGS

[1]Alatise, S. P., O. Ogundele, C. O. Jolayemi and M. A. Adedokun

[1]Fisheries Technology Department, Federal College of Freshwater Fisheries Technology, P.M.B. 1500, New Bussa, Niger State, Nigeria
[2]Department of Animal Health and Production Technology (Fisheries Unit) matdokun@gmail.com
The Oke-Ogun Polytechnic, Saki, Oyo State, Nigeria

Corresponding Author's:
segunpeter13@gmail.com, 08057068202

ABSTRACT
A feeding study was conducted to assess the value of black soldier fly, Hermetia illucens larvae meal as dietary protein in the diets of African mud catfish, Clarias gariepinus. Black soldier fly larvae meal were used to replace fish meal at 0%, 25%, 50%, 75% and 100% substitution levels for Treatments 1 to 5. Growth trial was conducted in cylindrical plastic bowls for 42 days. The fishes were fed at 5% body weight twice daily. There were significant difference in the mean weight gain (MWG), specific growth rate (SGR) and food conversion ratio (FCR) and protein efficiency ratio (PER) ($p>0.05$). Mean weight gain (MWG) and food conversion ratio (FCR) were different from 10.03 g and 2.43 respectively fish fed diet 3 (50%BSFLM). Also, protein efficiency ratio (PER) was not different from fish fed diets 1, 0%BSFLM (1.07) and 3, 50%BSFLM (1.02) respectively. It was observed that PER decreased as BSFL increased in the diets. From above results, fish meal could therefore be replaced by black soldier fly larvae meal at 50% level without affecting growth and nutrient utilization in the practical diet of African mud catfish, C. gariepinus fingerlings. Nevertheless, complete replacement of black soldier fly larvae meal decreases growth rate and should not be used for C. gariepinus fingerlings.

Keywords:
Black soldier fly larvae(BSFLM), Fish meal, Nutrient utilization, Clarias gariepinus.

INTRODUCTION

The growing global human population coupled with the rising living standards are factors attributed to the high demand for animal-derived protein sources (Béné et al., 2016). Fish is one of the main sources of quality protein for the human population (Little et al., 2016). However, the aquaculture industry is faced with the challenge of fish feeds, which represents up to 60-70% of operational costs in fish production (Holeh et al., 2020). Fish meal and fish oil have over the years been the main source of protein and essential fats in aquatic feed production (Betancor et al., 2016). This is due to the high nutritional value of fish meal, balanced essential amino acids profile, high essential fatty acids, and phospholipids near to requirement levels of most cultivated aquatic organisms (NRC, 2011; Tacon et al, 2011).

Insects have been a subject of discussion as potential replacements of fish meal in aquaculture because they contain relatively high protein levels with high availabilities (Veldkamp et al., 2012; Van Huis et al., 2013; Bosch et al., 2014). Various species of Coleoptera and Diptera, including BSF (H. illucens) (Newton et al., 2005a), common houseflies (Musa domestica) (Awomyi, 2007) and beetles (Tenebrio molitor) (Li et al.,

2013) that have been reared on low-grade bio-wastes have effectively converted organic wastes into high-quality proteins. The BSF larvae appear to be superior among other insects as a potential source of protein in the fish feed formulations (Muin et al., 2017). This is due to its polyphagous, voracious nature and effectiveness in converting organic waste into high-quality nutrients (Kim et al., 2011; Veldkamp et al., 2012). African mud catfish (Clarias gariepinus) is fish of high economic importance and preferred aquaculture species in Nigeria and is capable of utilizing plant materials in its diets (De Graaf and Janssen 1996, Ali and Jauncey 2005). Therefore, this study was carried out to evaluate black soldier fly larvae (BSFL) meal as a substitute for fish meal in the diets of African mud catfish (Clarias gariepinus) fingerlings.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out at the Feedmill Laboratory of Fisheries Technology Department of the Federal College of Freshwater Fisheries Technology, New Bussa, Niger State, Nigeria.

Experimental Fish

One hundred and fifty (150) fingerlings of African mud catfish (Clarias gariepinus) with average weight of 8.17±0.01 g were obtained from the National Institute for Freshwater Fisheries Research (NIFFR), Hatchery Complex. The fish were acclimatized for three (3) days in the bowls during which they were fed on 40% crude protein feed before the commencement of the experiment.

Production of Black Soldier Fly Larvae meal

The black soldier fly larvae meals were produced using the poultry manure cultured for 30 days at the integrated farm of the FCFFT, New Bussa, Niger State, Nigeria. The black soldier fly larvae meals harvested were thoroughly washed, sun-dried and ground into fine powder using domestic grinding machine and analyzed for proximate composition at Laboratory of JaaGee Nigeria Limited, Ibadan, Oyo State on dry matter basis according to standard method (AOAC, 2016).

Experimental Diet Preparation

The feedstuff, black soldier fly larvae meal (BSFLM) were harvested and processed. The other ingredients which include fish meal, soyabean meal, groundnut cake, yellow maize along with the fixed ingredients such as vitamin premix, vegetable oil, bone meal, methionine, lysine and salt were sourced locally from Jasope feeds depot, Ibadan way, New Bussa, Niger State, Nigeria. Five iso-nitrogenous diets were formulated to provide 40% crude protein. The fish meal was replaced with the black soldier fly larvae meal at 0%, 25%, 50%, 75% and 100% respectively. The various feed ingredients were thoroughly mixed together in a bowl. The resultant mixture was made into a dough and pelleted with Flat-die pelletizer (APF 150 model) of 40-60kg/hr capacity and then sun-dried for 8 hours. The diets were properly packed, labelled accordingly and stored in polyethylene bags at room temperature (37°C). The proximate composition of the black soldier fly larvae meal and the diets (moisture content, crude protein, crude fat, crude fibre and total ash were determined in triplicate samples according to the methods of Association of Official Analytical Chemists (AOAC, 2016).

Experimental Design

Fifteen (15) cylindrical plastic bowls each measuring 25-Litres was used for this study. The Experimental Design consists of five (5) treatments and three replicates in a completely randomized design (CRD). Ten (10) fingerlings of African mud catfish (Clarias gariepinus) with average weight of 8.17±0.01 g were stocked in each bowl. The fish were weighed using an electronic sensitive weighing balance (OHAS 400g model). The plastic bowls were washed, thoroughly rinsed and filled with water 16 cm high. Each of the diets was fed to fishes in triplicate plastic bowls at 5% body weight twice per day between 7 – 8am and 5 – 6 pm for 42 days. Total weight of fishes in each plastic bowl was taken weekly to monitor growth responses and for feed adjustments.

Statistical Analysis

All data obtained from the experiment were analyzed using Statistical Package for Social Science

(SPSS) Version 20.0. One-way Analysis of Variances (ANOVA) and Duncan's multiple range test (Zar, 1984) was used to compare the significant differences between diet treatment means at P<0.05.

RESULTS AND DISCUSSION

The ingredients and percentage composition of black soldier fly larvae meal-based diets are presented in Table 1.

Table 1: Ingredients and percentage composition of black soldier fly larvae meal-based diets (g/100g/DM) fed to Clarias gariepinus fingerlings for 42 days

Ingredients	Diet 1 (0%BSFLM)	Diet 2 (25%BSFLM)	Diet 3 (50%BSFLM)	Diet 4 (75%BSFLM)	Diet 5 (100%BSFLM)
BSFL meal	0.00	7.00	14.00	21.00	28.00
Fish meal	28.00	21.00	14.00	7.00	0.00
Soyabean meal	28.00	28.00	28.00	28.00	28.00
Groundnut cake	28.00	28.00	28.00	28.00	28.00
Yellow maize	8.00	8.00	8.00	8.00	8.00
Vitamin premix	2.00	2.00	2.00	2.00	2.00
Vegetable oil	2.00	2.00	2.00	2.00	2.00
Bone meal	1.50	1.50	1.50	1.50	1.50
Methionine	1.00	1.00	1.00	1.00	1.00
Lysine	1.00	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50	0.50
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Remark: BSFLM = Black Soldier Fly Larvae meal

The proximate composition and energy composition of (% dry matter) of black soldier fly larvae meal and fish meal is presented in Table 2.

Table 2: Proximate and energy composition (% dry matter) of black soldier fly larvae meal and fish meal

Nutrients	Black soldier fly larvae meal	Fish meal
Moisture content (%)	9.07	8.07
Crude protein (%)	42.00	65.75
Crude fat (%)	35.00	16.01
Crude ash (%)	7.30	9.76
Crude fibre (%)	1.05	1.59
NFE (%)	14.65	6.89
GE (Kcal/100g)	628.12	551.03
ME (Kcal/100g)	541.60	434.65

NFE (Nitrogen Free Extract) = 100 – (Crude protein + Crude fat + Crude fibre + Crude ash).
Gross energy = Caloric value of protein 5.65, NFE 4.1 and fat 9.45 kcal/g (NRC, 1993).
Metabolizable energy = Caloric value of protein 4.0, NFE 4.0 and fat 9 kcal/g (Atwater's calculation as described by Foster and Smith (1997).

The percentage composition of black soldier fly larvae meal-based diets is presented in Table 3.

Table 3: Proximate composition of black soldier fly larvae meal-based diets fed to Clarias gariepinus fingerlings for 42 days

Nutrients	Diet 1 (0%BSFLM)	Diet 2 (25%BSFLM)	Diet 3 (50%BSFLM)	Diet 4 (75%BSFLM)	Diet 5 (100%BSFLM)
Moisture content (%)	3.52	4.54	4.56	4.58	4.60
Crude protein (%)	39.12	39.90	40.24	39.97	38.95
Crude fat (%)	9.50	11.24	14.10	17.51	21.22
Crude ash (%)	7.68	8.34	7.56	6.35	5.21
Crude fibre (%)	3.43	5.24	6.23	5.22	4.21
NFE (%)	40.27	35.28	31.87	36.29	30.41
GE (Kcal/100g)	475.92	476.31	491.29	540.09	545.28
ME (Kcal/100g)	403.06	418.72	415.34	474.14	468.42

Values in each row having the same superscripts are not significantly difference (p>0.05)

NFE (Nitrogen Free Extract) = 100 – (Crude protein + Crude fat + Crude fibre + Crude ash).
Gross energy = Caloric value of protein 5.65, NFE 4.1 and fat 9.45 kcal/g (NRC, 1993).
Metabolizable energy = Caloric value of protein 4.0, NFE 4.0 and fat 9 kcal/g (Atwater's calculation as described by Foster and Smith (1997).

The growth performance and nutrient utilization of Clarias gariepinus fingerlings fed black soldier fly larvae meal-based diets is presented in Table 4.

Table 4: Growth and nutrient utilization of Clarias gariepinus fed Black soldier fly larvae meal based diets for 42 days

Parameters	Diet 1 (0%BSFLM)	Diet 2 (25%BSFLM)	Diet 3 (50%BSFLM)	Diet 4 (75%BSFLM)	Diet 5 (100%BSFLM)
Initial mean weight (g)	8.16 ± 0.02^a	8.17 ± 0.01^a	8.17 ± 0.01^a	8.17 ± 0.01^a	8.17 ± 0.01^a
Final mean weight (g)	17.87 ± 0.02^b	16.79 ± 0.10^c	18.20 ± 0.09^a	16.04 ± 0.04^d	16.03 ± 0.06^d
Mean weight gain (g)	9.71 ± 0.13^b	8.62 ± 0.11^c	10.03 ± 0.09^a	7.87 ± 0.05^d	7.86 ± 0.06^d
Specific growth rate (%/day)	1.86 ± 0.02^b	1.72 ± 0.02^c	1.91 ± 0.01^a	1.61 ± 0.01^d	1.61 ± 0.01^d
Feed intake (g)	23.24 ± 0.52^a	23.98 ± 1.92^a	24.39 ± 0.44^a	22.94 ± 0.05^a	22.84 ± 0.05^a
Food conversion ratio (FCR)	2.39 ± 0.08^b	2.79 ± 0.26^a	2.43 ± 0.07^a	2.92 ± 0.02^a	2.91 ± 0.03^a
Protein fed	9.09 ± 0.11^b	9.57 ± 0.78^{ab}	9.81 ± 0.16^a	9.15 ± 0.04^{ab}	8.90 ± 0.02^b
Protein efficiency ratio (PER)	1.07 ± 0.02^a	0.90 ± 0.08^b	1.02 ± 0.02^a	0.86 ± 0.01^b	0.88 ± 0.01^b
Survival rate	95.00 ± 5.00^{ab}	96.67 ± 2.89^{ab}	100.00 ± 0.00^a	91.67 ± 2.89^b	91.67 ± 2.89^b
Total fish production (kg/m^3)	1.70 ± 0.10^b	1.62 ± 0.06^a	1.82 ± 0.01^a	1.44 ± 0.01^c	1.47 ± 0.04^c
Culture period	42	42	42	42	42

Values in each row having the same superscripts are not significantly difference (p>0.05)

The mean weekly weight pattern of Clarias gariepinus fingerlings fed fed black soldier fly larvae meal-based diets is presented in Figure 1.

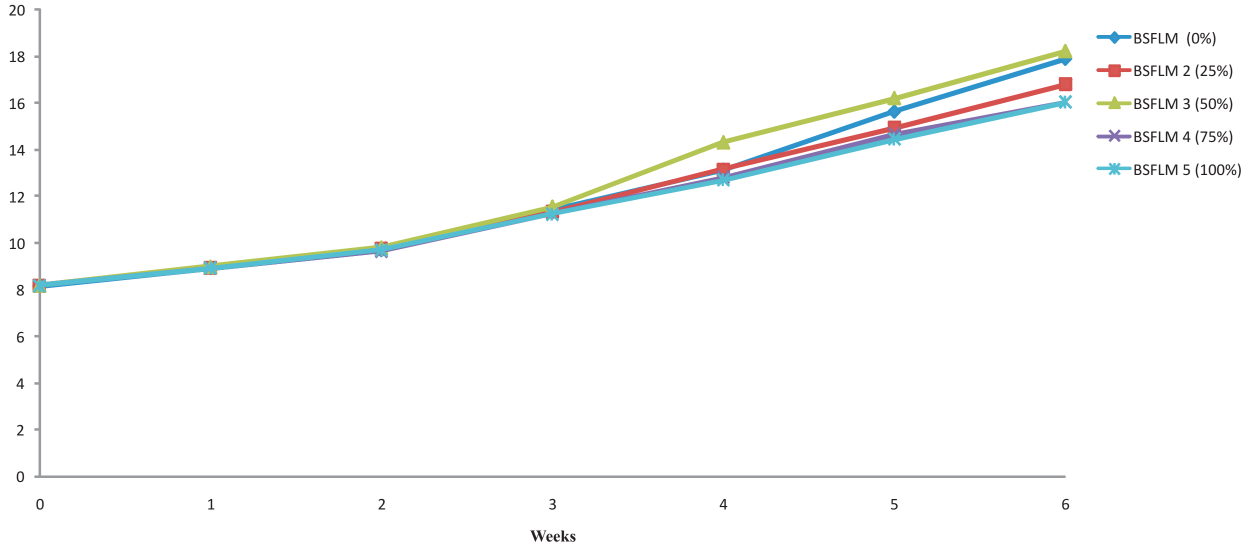


Figure 1: Mean weight (g) of*Clarias gariepinus*fingerlings fed black soldier fly larvae meal based diets

The percentage composition and energy composition of (% dry matter) of black soldier fly larvae meal and fish meal is presented in Table 1. The protein content of black soldier fly larvae meal is high (42.00%) with high fat (35.00%) and low fibre (1.05%) contents. The nitrogen free extract (NFE) is 14.65% and the gross energy is 628.12kcal/100 g. The protein content of black soldier fly larvae meal is closer to that of fish meal (44.00%). The mean value of the dietary fat recorded from this study is within the acceptable range recommended for fish culture (Teshima and Kanazawa, 1986).

Results of the feeding trial (Table 4) showed significant variations in the mean weight gain (MWG), Specific growth rate (SGR), Food conversion ratio (FCR) and Protein efficiency ratio (PER) among the fishes fed diets supplemented with black soldier fly larvae meal at 25%, 50%, 75% and 100% substitution. The mean values of SGR and FCR obtained from this study was close to the mean values of 2.85±0.04%/day and 1.87±0.02 for SGR and FCR reported for Clarias gariepinus fed toasted velvet seed meal based diets (Alatise et al., 2023).

The significant difference ($P<0.05$) in the growth and nutrient utilization indicates that black soldier fly larvae meal increased in the diets of Clarias gariepinus fingerlings, and showed that growth was affected by the inclusion of black soldier fly larvae meal which was used to replace fish meal at different inclusion level. However, the lack of significant difference between the control diet and supplemented diet at 50% showed that fish meal could be supplemented at this level of inclusion in the diets of C. gariepinus without compromising growth performance. This is agreement with similar studies by Obasa et al., 2013 using toasted African breadfruit (Treculia africana) seed meal as protein source in the diets of Clarias gariepinus fingerlings.

The high increase in the growth rate of C. gariepinus in the first two weeks of culture in this work may be due to the initial starvation of the fish which made them more metabolically active. This observation was similar to that of Obasa and Faturoti, (2001) in juvenile Heterotis niloticus, where they recorded an increase in the growth of the fish as they were subjected to delay in feed administration.

CONCLUSION

This growth performance and nutrient utilization can be achieved in intensively cultured Clarias gariepinus fingerlings fed Diet 3, where fish meal has been replaced partially with black soldier fly larvae meal at 50% level of inclusion. The inclusion of this level therefore reduced cost of feed without necessarily compromising the growth of the fish, though black soldier fly larvae meal protein has low nutritional quality than fish meal.

This will in no doubt boost fish production as it leads to decrease in the cost of feeding. Though, black soldier fly larvae meal is not readily available, but its cultivation could be encouraged just as that of house fly larvae meal was done few years back and an easy method of culturing can be invented.
Based on the results of the study, it is therefore recommended that black soldier fly larvae meal of 50% inclusion level along with 50% inclusion level of fish meal under good feed preparation and management can be used in the diet of Clarias gariepinus fingerlings.

REFERENCES

Alatise, S. P., B. D. Ilesanmi and N. O. Abdulwahab (2023). Replacement of Soyabean (Glycine max) meal by Toasted Velvet Beans (Mucuna pruriens) meal in the Diet of Clarias gariepinus Fingerlings. Proceeding of the 36th NAAHHT Annual National Scientific and Technical Conference and Annual General Meeting of the Nigerian Association of Animal Health and Husbandry Technologists held at June 12, Kuto, Abeokuta, Ogun State, Nigeria, Tuesday 21th – Friday, 24th November, 2023, pp. 24-26.

Ali M.Z. and Jauncey K. 2005. Approaches to optimizing dietary protein to energy ratio for African catfish Clarias gariepinus (Burchell, 1822). Aquac. Nutr. 11: 95–101.

Association of Analytical Chemist - AOAC. (2016). Official Methods of Analysis. Association of official Analytical chemists. 14th edition, Washington D.C., USA.

Awomyi, T. (2007). Health, nutritional and consumers' acceptability assurance of maggot meal inclusion in livestock diet: a review. International Journal of Tropical Medicine. 2: 52-56.

Béné, C., Arthur, R., Norbury, H., Allison, E.H., Beveridge, M., Bush, S., Campling, L., Leschen, W., Little, D., Squires, D., Thilsted, S.H., Troell, M., and Williams, M. (2016). Contribution of fisheries and aquaculture to food security and poverty reduction: Assessing the current evidence. World Development. 79: 177-196.

Betancor, M. B., Sprague, M., Montero, D., Usher, S., Sayanova, O., Campbell, P.J., Napier, J.A., Caballero, M.J., Izquierdo, M., and Tocher, D.R. (2016). Replacement of Marine Fish Oil with de novo Omega-3 Oils from Transgenic Camelina sativa in Feeds for Gilthead Sea Bream (Sparus aurata L.). Lipids. 51(10): 1171-1191.

Bosch, G., Zhang, S., Oonincx, D.G.A.B. and Hendriks, W.H. (2014). Protein quality of insects as potential ingredients for dog and cat foods. Journal of Nutritional Science. 3(e29): 1-4.

De Graaf G.J. and Janseen J.A.L. (1996). Artificial reproduction and pond rearing of the African catfish, Clarias gariepinus in sub–Saharan Africa–A handbook. FAO Fisheries Technical paper, Rome Italy, pp. 362.

Duncan, D. B. (1955). Multiple range and multiple F-test. Biometrics, 11:1-42.

Foster, D. N. and Smith E. J. (1997). Determination of true metabolizable energy and Caloric Density of food items. www.drsfostersmith.com/pic/article.cfm

Holeh, G.M., Appanteng, P., Opiyo, M.A., Park, J., and Brown, C.L. (2020). Effects of intermittent feeding regimes on growth performance and economic benefits of Amur catfish (Silurus asotus). Aquatic Research. 3(3): 167-176.

Kim, W., Bae, S., Kim, A., Park, K., Lee, S., Choi, Y., Han, S., Park, Y., and Koh, Y. (2011). Characterization of the molecular features and expression patterns of two serine proteases in Hermetia illucens (Diptera: Stratiomyidae) larvae. BMB Reports. 44: 387.

Li, L., Zhao, Z., and Liu, H. (2013). Feasibility of feeding yellow mealworm (Tenebrio molitor L.) in bioregenerative life support systems as a source of animal protein for humans. Acta Astronautica. 92: 103-109.

Little, D. C., Newton, R. W., and Beveridge, M. C. M. (2016). Aquaculture: a rapidly growing and significant source of sustainable food? Status, transitions and potential. Proceedings of the Nutrition Society. 75(3): 274–286.

Magdi, A. O., (2004). Chemical and nutrient analysis of Baobab (Adansonia digitata) Fruit and Seed protein solubility. Plant. Food. Hum. Nutr., 59: 29-33.

Muin, H., Taufek, N.M., Kamarudin, M.S., and Razak, S.A. (2017). Growth performance, feed utilization and body composition of Nile tilapia, Oreochromis niloticus (Linnaeus, 1758) fed with different levels of black soldier fly, Hermetia illucens (Linnaeus, 1758) maggot meal diet. Iranian Journal of Fisheries Sciences. 16(2): 567 - 577.

National Research Council (NRC). (2011). Nutrient requirements of fish and shrimp. National Academy Press, Washington, DC, USA.

Newton, G.L., Sheppard, D.C., Watson, D.W., Burtle, G.J., Dove, C.R., Tomberlin, J.K., and Thelen, E.E. (2005a). The black soldier fly, Hermetia illucens, as a manure management/resource recovery tool. In: Proceedings of the Symposium State of the Science, Animal Manure and Waste Management, January 5-7 2005, San Antonio, TX, USA.

Newton, L., Sheppard, C., Watson, D.W., and Burtle, G. (2005b). Using the black soldier fly, Hermetia illucens, as a value-added tool for the management of swine manure. Report for Mike Williams, Director of the Animal and Poultry Waste Management Centre, North Carolina State University, Raleigh, NC, USA.

NRC- National Research Council (1993). Nutrient Requirements of fish. National Academy Press, Washington DC, USA. 114.

Obasa, S. O. and Fatoroti E. O. (2001). Growth response and serum component and yield of the African bony tongue (Heterotis niloticus) fed varying Dietary crude protein level Asset series A 2001, 1 (2); 97-104.

Obasa, S. O., W. O. Alegbeleye, A. A. Akinleye, A. A. Idowu, N. A. Bamidele and A. N. Adesanya (2013). Replacement of maize meal by toasted African breadfruit (Treculia africana) seed meal in the diets of Clarias gariepinus (Burchell 1822) fingerlings. Livestock Research for Rural Development 25 (16) 2013. 1-7pp.

Tacon, A. G. J., Hasan, M. R., and Metian, M. (2011). Demand and supply of feed ingredients for farmed fish and crustaceans: trends and prospects. FAO, Fisheries and Aquaculture Technical Paper. No. 564. Rome: FAO.

Teshima, S. and Kanazawa, A. (1986). The growth and nutritive requirements of tilapia. Journal of Aquaculture, Japan, 23: 106-111.

Van Huis, A., Van Itterbeeck, J., Klunder, H., Mertens, E., Halloran, A., Muir, G., and Vantomme, P. (2013). Edible insects: future prospects for food and feed security. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy, FAO Forestry Paper no. 171, 201 pp.

Veldkamp, T., Van Duinkerken, G., Van Huis, A., Lakemond, C.M.M., Ottevanger, E., and Boekel, M.A.J.S. (2012). Insects as a sustainable feed ingredient in pig and poultry diets – a feasibility study. Report 38, Wageningen UR Livestock Production, Wageningen, the Netherlands. pp. 1-48.

Zar, J. H. (1984). Biostatistical analysis. Prentice Hall, Englewood Cliffs, NJ USA, 383pp.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

REPLACEMENT OF SOYABEAN MEAL WITH SUNDRIED CASTOR OIL BEANS (Ricinus communis) LEAF MEAL IN THE DIETS OF NILE TILAPIA (Oreochromis niloticus) FINGERLINGS

1Alatise, S. P., 2G. E. Ajiboye and 1O. F. Ayeni

1Department of Fisheries Technology, Federal College of Freshwater Fisheries Technology, P.M.B 1500, New Bussa, Niger State.
2Department of RUDEG, Agricultural and Rural Management Training Institute, P.M.B 1343, Ilorin, Kwara State. E-mail address: gbegajiboye13@gmail.com/08035871043

Corresponding Author:
segunpeter13@gmail.com, 08057068202

ABSTRACT
A 42-day feeding trial was conducted to evaluate the effects of castor oil beans (Ricinus communis) leaf meal (COBLM) on growth performance and survival of Oreochromis niloticus fingerlings. COBLM was added in the diet by replacing soyabean meal with the sundried castor oil beans leaf meal at the levels of 0%, 25%, 50%, 75% and 100% respectively. Triplicate cylindrical plastic bowls were used for each treatment having 10 fingerlings. These fingerlings fed at the rate of 5% of live wet weight. The highest mean weight gain (11.79%) and lowest FCR (0.99) values were noted at 25% replacing level for above mentioned diet showed that fish was in more healthy condition as compared to control (0% COBLM) and other test diets. Survival rates for COBLM based diet at 25% replacement level of soyabean meal decreased from 96.67%, 93.33% and 90.00% for diets 2, 3, 4 and 5 respectively when compared to control diet. The next higher growth performance and nutrient utilization values were observed at 50% replacement level based diet. It was concluded that the 25% replacement level of soyabean meal with COBLM is optimum for the maximum growth performance of Nile tilapia, Oreochromis niloticus fingerlings.

Keywords:
Conventional ingredient, Plant protein , substitution, Nile tilapia

INTRODUCTION

The ability of tilapia, Oreochromis niloticus (L.) to tolerate environmental stress, reproduce easily, grow at a fast rate coupled with a high market demand for the species has made it an important fish for aquaculture production (El-Sayed, 2006). Tilapias are omnivorous and feed on a variety of foods ranging from zooplankton to fish food (Olaosebikan and Raji, 2004), and means they can use non-conventional plant resources such as castor bean leaf meal when it is supplied in the feed (Alatise and Ajiboye, 2023).

Fish or any animal needs an adequate balanced diet that contains all the required necessary essential nutrients to have optimal growth. These nutrient requirements vary from species to species, sex, age, the environment where it lives, different stages of larval development, and the health status of the species. To have the best optimal growth and reduce pollution in the environment a thorough knowledge of the feeding behaviour and amount of nutrients required by the species is very essential (NRC, 2011).

Castor oil plant (Ricinus communis) belongs to the family of Euphorbiaceae and grows throughout tropical and sub-tropical regions of the world (Ojinnaka et al. 2013; Sousa et al. 2017). Castor bean Leaf Meal (CBLM), proposed as an alternative protein source for fish feed, is rich in protein (31.48%)

of high quality, fat (1.83%), and ash (10.05%). It is also widely distributed since ancient times, and because of the rapidity of its establishment as a native plant. The castor plant is cited in the Bible in the Book of Jonah 4: 6 – 7: "And the LORD God prepared a plant and made it come up over Jonah, that it might be shade for his head to deliver him from his misery. So Jonah was very grateful for the plant. But as morning dawned the downed the next day, God prepared worm, and it so damaged the plant that it withered. Ricinus communis is indigenous to north-eastern tropical Africa, especially in Ethiopian areas below altitude (Modzelevich, 2020)..

The study was designed to assess the optimal replacement levels of soyabean sundried castor oil bean (Ricinus communis) leaf meal in the diets of Nile tilapia (Oreochromis niloticus) fingerlings.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at the Fisheries Technology Department's Fish Mill Unit of the Federal College of Freshwater Fisheries Technology, New Bussa, Niger State, Nigeria.

Experimental Fish

One hundred and fifty (150) fingerlings of Nile tilapia (Oreochromis niloticus) with average weight of 3.29±0.01 g were obtained from the College pond. The fish were acclimatized for three (3) days in the bowls during which they were fed on 35% crude protein feed before the commencement of the experiment.

Experimental Diet Preparation

Castor oil beans (Ricinus communis) leaf (COBL) were harvested from the wild at perennial stream along MAN School, New Bussa, Niger State. Other ingredients includes soyabean meal, fish meal, groundnut cake, yellow maize along with the fixed ingredients such as vitamin premix, vegetable oil, bone meal, methionine, lysine and salt were bought locally from Jasope feeds depot, Ibadan way, New Bussa, Niger State, Nigeria. The castor oil beans leaves were prepared by sun drying under the room temperature at 37°C. Five iso-nitrogenous diets were formulated to provide 30% crude protein. The soyabean meal was replaced with the sundried castor oil beans leaf meal at 0%, 25%, 50%, 75% and 100% respectively. The various feed ingredients were thoroughly mixed together in a bowl. The resultant mixture was made into a dough and pelleted with Flat-die pelletizer (APF 150 model) of 40-60kg/hr capacity and then sun-dried for 8 hours. The diets were properly packed, labelled accordingly and stored in polyethylene bags at room temperature (37°C). The proximate composition of the castor oil bean leaf meal and the diets (moisture content, crude protein (N x 6.25), crude fat, crude fibre and total ash were determined in triplicate samples at Laboratory of JaaGee Nigeria Limited, Ibadan, Oyo State on dry matter basis according to the methods of Association of Official Analytical Chemists (AOAC, 2016).

Experimental Design

Fifteen (15) cylindrical plastic bowls each measuring 25-Litres was used for this study. The Experimental Design consists of five (5) treatments and three replicates in a completely randomized design (CRD). Ten (10) fingerlings of Nile tilapia (Oreochromis niloticus) with average weight of 3.29± 0.01 g were stocked in each bowl. The fish were weighed with an electronic sensitive weighing balance (OHAS 400g model). The plastic bowls were washed, thoroughly rinsed and filled with water 16 cm high. Each of the diets was fed to fishes in triplicate plastic bowls at 5% body weight twice per day between 7 – 8am and 5 – 6 pm for 42 days. Total weight of fishes in each plastic bowl was taken weekly to monitor growth responses and for feed adjustments.

RESULTS AND DISCUSSION

The Results of proximate composition of soyabean meal and Castor oil beans leaf meal (COBLM) are presented in Table 1.

Table 1: Proximate composition of soyabean meal castor oil beans leaf meal

Nutrients	Soyabean meal	Castor oil beans leaf meal
Moisture content (%)	6.00	14.50
Crude protein (%)	48.13	31.48
Crude fat (%)	23.90	1.83
Crude ash (%)	7.90	10.05
Crude fibre (%)	4.11	8.83
NFE (%)	15.96	47.81
GE (Kcal/100g)	563.23	391.17
ME (Kcal/100g)	471.46	333.84

NFE (Nitrogen Free Extract) = 100 – (Moisture content + Crude protein + Crude fat + Crude fibre + Crude ash).

Gross energy = Caloric value of protein 5.65, NFE 4.1 and fat 9.45 kcal/g (NRC, 1993).

Metabolizable energy = Caloric value of protein 4.0, NFE 4.0 and fat 9 kcal/g (Atwater's calculation as described by Foster and Smith (1997).

The percentage composition of sundried castor oil beans leaf meal-based diets is presented on Table 2.

Table 2: Percentage composition of experimental diets (g/100g/DM)

Ingredients	Diet 1 (0%COBLM)	Diet 2 (25%COBLM)	Diet 3 (50%COBLM)	Diet 4 (75%COBLM)	Diet 5 (100%COBLM)
COBLM	0.00	4.50	9.00	13.50	18.00
Soyabean meal	18.00	13.50	9.00	4.50	0.00
Fish meal	18.05	18.05	18.05	18.05	18.05
Groundnut cake	18.05	18.05	18.05	18.05	18.05
Yellow maize	38.00	38.00	38.00	38.00	38.00
Vitamin premix	2.00	2.00	2.00	2.00	2.00
Vegetable oil	2.00	2.00	2.00	2.00	2.00
Bone meal	1.50	1.50	1.50	1.50	1.50
Methionine	1.00	1.00	1.00	1.00	1.00
Lysine	1.00	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50	0.50
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

COBLM: Castor oil beans leaf meal

The proximate composition of sundried castor oil beans leaf meal-based diets is presented on Table 3.

Table 3: Proximate composition of sundried castor oil beans leaf meal-based diets for 42 days

Nutrients	Diet 1 (0%COBLM)	Diet 2 (25%COBLM)	Diet 3 (50%COBLM)	Diet 4 (75%COBLM)	Diet 5 (100%COBLM)
Moisture content (%)	8.43	8.54	8.14	8.50	8.56
Crude protein (%)	32.75	32.29	32.73	31.34	30.89
Crude fat (%)	10.03	12.14	13.44	14.82	15.70
Crude ash (%)	6.64	6.41	6.20	6.08	5.89
Crude fibre (%)	5.42	5.67	5.21	6.65	6.82
NFE (%)	45.16	43.49	42.42	41.11	40.70

Values in each row having the same superscripts are not significantly difference ($p>0.05$)

NFE (Nitrogen Free Extract) = 100 – (Moisture content + Crude protein + Crude fat + Crude fibre + Crude ash).

Table 4: Growth and nutrient utilization of Oreochromis niloticus fed castor oil beans leaf meal-based diets for 42 days

Parameters	Diet 1 (0%COBLM)	Diet 2 (25%COBLM)	Diet 3 (50%COBLM)	Diet 4 (75%COBLM)	Diet 5 (100%COBLM)
Initial mean weight (g)	3.29±0.01^{a}	3.30±0.01^{a}	3.28±0.01^{a}	3.29±0.01a	3.29±0.01^{a}
Final mean weight (g)	14.86±0.34^{a}	15.09±0.12^{a}	12.37±0.18^{b}	9.70±0.04^{c}	7.82±0.28^{d}
Mean weight gain (g)	11.75±0.33^{a}	11.79±0.12^{a}	9.09±0.19^{b}	6.41±0.04^{c}	4.54±0.28^{d}
Daily growth rate (g/day)	0.27±0.01^{a}	0.28±0.00^{a}	0.21±0.01^{b}	0.15±0.00^{c}	0.11±0.01^{d}
Specific growth rate (%/day)	3.59±0.04^{ab}	4.62±1.72^{a}	3.18±0.03^{abc}	2.57±0.01^{bc}	2.06±0.09^{c}
Food conversion ratio (FCR)	1.23±0.03^{c}	0.99±0.01^{d}	1.07±0.02^{d}	1.42±0.01^{b}	1.92±0.10^{a}
Protein efficiency ratio (PER)	2.48±0.05^{c}	3.11±0.02^{a}	2.85±0.05^{b}	2.26±0.05^{d}	1.69±0.11^{e}
Survival rate	93.33±5.77^{a}	96.67±5.77^{a}	93.33±5.77^{a}	90.00±0.00^{a}	90.00±0.00^{a}
Total fish production	1.36±0.04^{a}	1.46±0.09^{a}	1.16±0.09^{b}	0.87±0.01^{c}	0.70±0.03^{d}
Culture period	42	42	42	42	42

Values in each row having the same superscripts are not significantly difference (p>0.05)

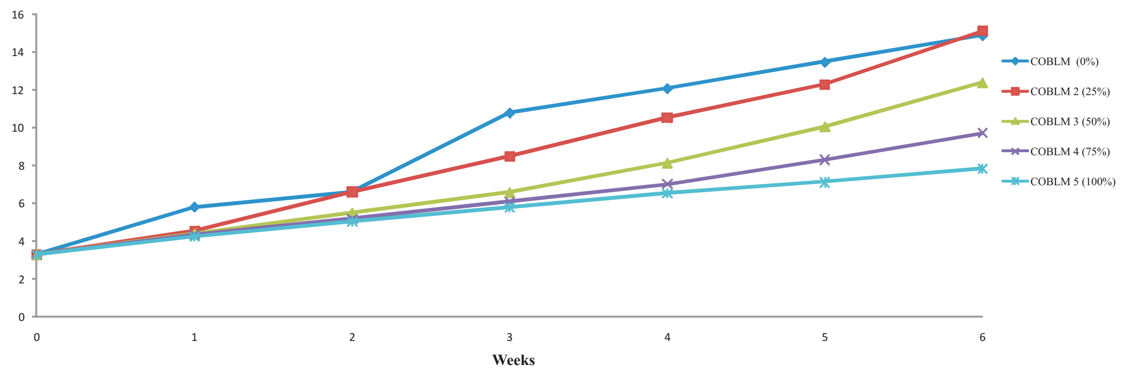


Figure 1: Growth pattern of *Oreochromis niloticus* fingerlings fed castor oil beans leaf meal based diets

Fish fed diets containing 25% castor oil beans leaf meal with 75% soyabean meal were observed to have the best result among the treatments, with final weight gain of 15.09 g, specific growth rate of 4.62 %/day and daily growth rate of 0.28 g/day daily. The survival rate was also 96.67% as in the diet 2. Results of the feeding trial revealed that inclusion of graded levels of sundried castor oil beans leaf meal affected the growth patterns of the experimental fish. There was a trend of differences in growth and nutrient utilization parameters. The 25% COBLM ration gave the best results in terms of growth and survival rates. Diets with high inclusion levels (Diets 3, 4 and 5) resulted in reduced growth of Oreochromis niloticus fingerlings. However, castor oil beans leaf is locally available at a very low cost and its inclusion in animal especially fish feeds will reduce the competition for soyabean by man and animal, a research into effective and efficient usage in fish, livestock and poultry feeds and effective processing methods is recommended. The result is in line with those of other workers e.g. Obasa et al., (2013) and Nawwar et al., (2017).

CONCLUSION

This experiment concludes that soyabean meal could be replaced partially with castor oil beans leaf meal to reduce the cost of feed without affecting the growth rate. This study revealed that 25% castor oil beans leaf meal diet would be optimum for the maximum growth of Nile tilapia, Oreochromis niloticus. Furthermore, plant protein leaf meal based diets are cheaper as compared to the conventional feeds, replacement of plant protein leaves in Nile tilapia, Oreochromis niloticus would also prove economically viable.

REFERENCES

Alatise, S. P. and G. E. Ajiboye (2023). Proximate and Mineral Analysis of Castor oil beans (Ricinus communis) Leaf and Seed Meals. Proceeding of the 38th Annual Conference and General Meeting of the Fisheries Society of Nigeria, (FISON), Bayelsa 2023 at Niger-Delta University Campus, Yenagoa, Bayelsa State, Nigeria. 27th November – 1st December, 2023.

AOAC, (2016). Official methods of analysis, 18th Edn. Association of Official Analytical Chemists, Washington. 2015; 18.

Brett, J. R. and Grove T. D. D. (1979). Physiological energetic. In: Hoar WS, Randall DJ, Brett JR (Eds.), Fish Physiology. Bioenergetics and Growth, Vol. VIII. Academic Press, New York. pp. 279-352.

Duncan, D. B. (1955). Multiple range tests and multiple F – test. Biometrics, 1:1-42.

El-Sayed, A. F. M. (2006). Tilapia culture. CABI publishing, Oxfordshire fatty acid metabolism. Journal of nutrition, 132, 222e230.

Foster, D. N. and Smith E. J. (1997). Determination of true metabolizable energy and Caloric Density of food items. www.drsfostersmith.com/pic/article.cfm

Magdi, A. O., (2004). Chemical and nutrient analysis of Baobab (Adansonia digitata) Fruit and Seed protein solubility. Plant. Food. Hum. Nutr., 59: 29-33.

Modzelevich, (2020). Ricinus communis L., Flowers in Israel website. Herzlyia, Israel.

National Research Council (NRC). (2011). Nutrient requirements of fish and shrimp. National Academy Press, Washington, DC, USA.

Nawwar, Z. M., Izzaah S. M. A. and Seri N. A. N. (2017). Replacement of fish meal by white lead tree meal in the diets for juveniles of Giant River Prawn, Macrobranchium rosenbergii (De Man, 1879). Livestock Research for Rural Development 25 (6) 2013.

NRC- National Research Council (1993). Nutrient Requirements of fish. National Academy Press, Washington DC, USA. 114.

Obasa, S. O., W. O. Alegbeleye, A. A. Akinleye, A. A. Idowu, N. A. Bamidele and A. N. Adesanya (2013). Replacement of maize meal by toasted African breadfruit (Treculia africana) seed meal in the diets of Clarias gariepinus (Burchell 1822) fingerlings. Livestock Research for Rural Development 25 (16) 2013. 1-7pp.

Ojinnaka, M. C., Ojimelukwe, P. C., Ezeama, C. F. (2013). Changes in Enzyme Activities during the Fermentation of Castor Oil Bean Seeds using B. subtilis as Monoculture Starter. Afr J Food Sci Technol 4 (5): 122-128.

Olaosebikan, B. D. and Raji, A Dr. (2004). Field Guide to Nigeria freshwater Fishes. Second edition. Unilorin press, 52p.

Sousa, N. L., Cabral, G. B., Vieira, P. M., Baldoni, A. B. and Aragão, F. J. (2017). Bio-detoxification of ricin in castor bean (Ricinus communis L.) seeds. Sci Rep 7 (1): 15385.

EFFECTS OF DIFFERENT PROCESSING METHODS OF SEED MEAL OF *Cassia tora* ON NUTRITIONAL COMPOSIION, PHYTOCHEMICALS, MINERAL COMPOSITION AND AMINO ACID ASSAY IN NORTH WEST NIGERIA

Adoke[1], I. Y., S. A. Okunsebor[2], and S. U. Ibrahim[3]

[1]Federal University Dutse, Jigawa State.
[2]Nasarawa State University Keffi, Nasarawa State
[3]Federal University of Technology Minna, Niger State

Correspondence Author:
yunusaadoke@gmail.com

ABSTRACT
The effects of different processing methods of seed meal of Cassia tora on nutritional and chemical composition of Cassia tora seed meal were investigated. The pods of the Cassia tora were collected within the premises of Federal University Dutse, it was then threshed and winnowed to obtain the seeds. The raw samples of the Cassia tora seeds were subjected to different processing methods which include toasting, soaking, autoclaving, boiling, fermenting, boiling + fermenting and soaking + toasting. The raw and processed seeds were then subjected to proximate composition, chemical and amino acid analysis in triplicates.The nutritional composition of the raw and differently processed Cassia tora seed meal revealed that the toasted seed meal had significantly better ($P<0.05$) crude protein (18.90%) and metabolisable energy (3393.76 kcal/kg). Likewise, the mineral composition (Calcium, Copper, Iron, Magnesium, Phosphorus, Potassium, Sodium and Zinc) of the raw and differently processed seed meal indicated that the toasted had significantly ($P<0.05$) higher mineral amongst most of the minerals determined. Furthermore, the phytochemicals analysis showed that the toasted seed meal had significantly ($P<0.05$) depleted concentration. Tannins, Phytate and Alkaloids with concentration of 104.42, 508.00 and 240.60 mg/100g in the raw seed meal were significantly ($P<0.05$) degraded to 78.33, 200.04 and 119.11 mg/100g, respectively in the toasted seed meal of Cassia tora. In conclusion, the nutritional composition of the toasted seed meal of Cassia tora showed great potentials to be used as a fish feed ingredient.

Keywords:
Cassia tora, nutritional composition, minerals, processing methods

INTRODUCTION

Legumes are flowering plants producing seeds in pods that are often cultured for food and feeds. They are the third largest family of flowering plants with more than 19 500 species and over 750 genera (Lewis et al., 2016). The nutritional composition of available legumes indicates that they are rich sources of carbohydrates, protein, fats, minerals, fibre, anti-oxidants and vitamins. They have considerable low fats and free from cholesterol but some are rich in oil such as soya bean (Karmas and Harris, 2012; Hayaret al., 2014a; Hayat et al., 2014b).Cassia tora seed are moderate source of protein with reasonable amino acid composition (Ingweyeet al., 2010; Ayssiwede et al., 2012; Augustine, 2017; Augustine et al., 2018a). However, the presence of phytochemicals limits their efficient utilization as feed ingredients, especially in fish diets (Adebowale et al., 2005). Different processing techniques are required to inactivate or remove phytochemicals, thus enhancing the nutritional quality of legumes. Sometimes, a single processing treatment is not effective against phytochemicals, hence combination of two or more methods are used (Sathe et al., 1984b).This study was carried out to explore the effects of using different processing methods on the nutritional quality, mineral composition and anti-nutritional factors of Cassia tora seed meals.

MATERIALS AND METHODS

Collection and Processing of the Cassia tora Seeds

The samples of Cassia tora pods were collected in the premises of Federal University Dutse, Jigawa state. The pods were removed from its shrubs. The samples were then threshed and winnowed to obtain the seeds.The prepared seeds were then washed with distilled water in order to remove dirt, residual pulp and other debris to reduce the level of contamination.

Processing of the Cassia tora Seeds

The seeds of Cassia tora were subjected to various processing methods described by Hernandez et al., (2010); Doss et al. (2011) and Antye, (2018):

- Raw seeds were milled, stored in an air-tight polytene bag and labeled as raw seed meal (RSM)
- Raw seeds were soaked in water in the ratio of 1:3 for 72 hours, oven dried at 500C to constant weight. The seeds were then milled, labeled and stored in an air-tight polythene bag. It was labelled as soaked seed meal (SSM).
- Raw seeds were boiled for 30 minutes, oven dried at 500C to constant weight, then milled and stored in an air-tight polythene bag. It was labelled as boiled seed meal (BSM).
- Raw seeds were toasted at 700C using electric hot plate until the seeds turn brownish in colour, the seeds were then milled, stored in an air-tight polythene bag and labelled as toasted seed meal (TSM).
- Raw seeds were autoclaved at 1200C for 15 minutes, oven dried at 500C in an oven, milled, stored in an air-tight polythene bag and labeled as autoclaved seed meal (ASM).
- Raw seeds were moistened with water, kept in a container with a cover to ferment for 7 days under laboratory condition, the fermented seeds were subsequently oven dried at 500C in an oven, milled, stored in an air-tight polythene bag and labeled as fermented seed meal (FSM).
- Raw seeds were boiled for 30 minutes and thereafter, kept in a container with cover to ferment for 7 days under laboratory condition, oven dried at 500C in an oven, milled, stored in an air-tight polythene bag and labeled as boiled fermented (BFSM).

Determination of proximate composition of Cassia tora seed meal

The raw and processed seeds meal of Cassia tora were subjected to nutritional composition, amino acid and chemical analysis using the method described by AOAC (2010).

RESULTS AND DISCUSSION

The nutritional composition of the raw and differently processed Cassia tora seed meal is as shown in Table 1. The crude protein (CP) is significantly higher ($P<0.05$) in the toasted Cassia tora seed meal (CTSM) with 18.90%, followed by the soaked + toasted CTSM with 18.52% CP. The crude fibre (CF) of the raw CTSM was significantly ($P<0.05$) more than that of the differently processed seeds. The high crude fibre level could be attributed to the lack of substance (acid) to breakdown complex structure. This is followed by the soaked seed meal with CF value of 10.64%..The nitrogen free extract (NFE) value of the soaked seed (57.08%) was significantly higher, followed by that of the fermented (56.04%) and then, the raw (55.56%). The least NFE value (39.38%) was recorded in the toasted CTSM.

The toasted seeds of Cassia tora had the significantly higher (3393.77 KCal/kg) metabolizable energy (ME) value, followed by the soaked + toasted with ME value of 3192.53 KCal/kg. The lowest ME value was obtained (2692.26 KCal/kg) in the raw seed.

Table 1: Nutritional composition of raw and differently processed Cassia tora seed meal

Parameters	Raw and Differently Processed Seed Meal of *Cassia tora*								SEM	P-Value
	T1	T2	T3	T4	T5	T6	T7	T8		
CP (%)	12.48^{g}	18.90^{a}	13.51^{f}	14.03^{e}	14.29^{d}	14.03^{e}	16.40^{c}	18.51^{b}	0.46	0.001
EE (%)	3.49^{g}	16.10^{a}	3.42^{g}	7.47^{e}	5.82^{f}	6.82^{e}	7.06^{d}	10.18^{b}	0.79	0.001
Moisture (%)	7.32^{g}	8.07^{d}	9.82^{b}	7.53^{f}	9.89^{a}	8.48^{c}	6.53^{h}	8.02^{e}	0.22	0.001
CF (%)	11.62a	9.70c	10.64b	10.00d	9.55e	8.55f	7.91g	10.21c	0.22	0.001
Ash (%)	9.52a	7.69c	5.52g	5.89f	7.93b	6.06e	7.06d	5.22h	0.28	0.001
NFE (%)	55.55c	39.38g	57.08a	55.67d	52.50e	56.03b	55.03d	47.81f	1.16	0.001
ME(Kcal/kg)	2692.26^{h}	3393.76^{a}	2777.42^{g}	3058.01^{d}	2842.71^{f}	3038.55^{e}	3110.53^{c}	3192.53^{b}	45.26	0.001

The mineral composition of the raw and differently processed seed of Cassia tora is as shown in Table 2. The calcium (Ca) concentration was significantly higher (P<0.05) in the toasted seed of Cassia tora meal with value of 983.42 mg/100g. This is followed by that of the soaked + toasted (980.67 mg/100g). The least Ca concentration (P<0.05) was recorded in the fermented seed. The magnesium concentration was least (P<0.05) in the raw seed, followed by boiled + fermented. Furthermore, the significantly higher concentration (P<0.05) was recorded in the toasted seed (683.39 mg/100g), and then followed by that of the soaked + toasted (682.87 mg/100g).

The phosphorus concentration of 1650.43 mg/100g recorded in the toasted seed was significantly better (P<0.05) amongst all the processed seeds and the raw seed while the potassium concentration of 961.30 mg/100g found in the soaked + toasted Cassia tora seed was significantly (P<0.05) better. The lowest (P<0.05) of the potassium concentration (924.50 mg/100g) was obtained in the soaked seed. The sodium concentration of 614.71 mg/100g recorded in the toasted seed of Cassia tora was significantly higher (P<0.05) in comparison to the recorded concentration found in the other processed and raw seeds. The autoclaved seed have the significantly higher (P<0.05) concentration (56.19 mg/100g) of zinc.

Table 2: Mineral composition of raw and differently processed Cassia tora seed meal

Parameters	Composition of minerals (mg/100g) of raw and processed *Cassia tora* seed meal								SEM	P-Val
	T1	T2	T3	T4	T5	T6	T7	T8		
Ca	851.10^{e}	983.42^{a}	913.56^{c}	859.76^{d}	823.53^{f}	721.12^{h}	724.80^{g}	980.67^{b}	19.72	0.001
Cu	900.01^{g}	933.42^{a}	904.60^{e}	911.20^{c}	908.57^{d}	902.91^{f}	911.12^{c}	928.43^{b}	2.35	0.001
Fe	215.39^{g}	327.74^{a}	250.55^{c}	234.44^{d}	221.39^{e}	218.32^{f}	215.06^{h}	325.80^{b}	9.44	0.001
Mg	610.70^{h}	683.39^{a}	673.49^{c}	623.29^{f}	657.78^{d}	634.25^{e}	613.22^{g}	682.87^{b}	5.99	0.001
P	1101.25^{g}	1650.43^{a}	1130.68^{e}	1151.33^{d}	1113.69^{f}	1264.59^{c}	1097.72^{h}	1635.88^{h}	46.30	0.001
K	950.8^{1}e	960.57^{b}	924.50^{h}	957.40^{c}	953.53^{d}	929.41^{g}	945.32^{f}	961.30^{a}	2.72	0.001
Na	573.29^{g}	614.71^{a}	581.74^{d}	581.87^{c}	577.75^{f}	579.19^{e}	570.21^{h}	610.34^{b}	3.27	0.001
Zn	51.52^{h}	55.27^{b}	54.50^{d}	56.19^{a}	52.37^{f}	52.97^{e}	52.12^{g}	54.98^{c}	0.33	0.001

Means within the same row with different superscripts differ significantly (P<0.05)

Keys: SEM = Standard error of means, T1 = Raw, T2 = Toasted, T3 = Soaked, T4 = Autoclaved, T5 = Boiled, T6 = Fermented, T7 = Boiled + fermented, T8 = Soaked + Toasted, Ca = Calcium, Cu = Copper, Fe = Iron, Mg = Magnesium, P = Phosphorus, K = Potassium, Na = Sodium, Zn = Zinc

The amino acid composition of the raw seed and processed seeds of Cassia tora is shown in Table 3. The boiled seed had comparably higher (P<0.05) alanine concentration than the raw and the other

differently processed seeds of Cassia tora with value of 4.84 mg/100g. This is followed by the boiled + fermented with value of 4.35 mg/100g. The least value (3.10 mg/100g) of alanine concentration was recorded in the soaked + toasted seed. The boiled and boiled + fermented seed of Cassia tora had significantly higher (P<0.05) level of arginine (6.16 and 6.07 mg/100g, respectively) while the least value of arginine was obtained in the soaked seed. The aspartic acid level was significantly higher (P<0.05) in the toasted seed of Cassia tora, followed by that of the fermented with 10.40 mg/100g while the raw seed of Cassia tora have glutamic acid level (P<0.05) of 13.70. The level of histidine (2.37 mg/100g) was higher significantly (P<0.05) in the boiled + fermented seed meal of Cassia tora. This is followed by that of the fermented (2.27 mg/100g).
The raw, the fermented and the soaked + toasted value of isoleucine did not significantly differs (P>0.05). Likewise, the values were similar (P>0.05) to that of the boiled and fermented. However, the leucine concentration was significantly higher (P<0.05) in boiled and soaked + toasted (7.03 mg/100g) seed meal of Cassia tora. The significantly higher (P<0.05) value of lysine was observed in the toasted (4.94 mg/100g) seed meal while the significantly lower (P<0.05) value (3.56 mg/100g) was recorded in the soaked + toasted. The lysine concentration of the raw and the autoclaved Cassia tora seed meal have no significant difference (P>0.05) with values of 4.79 and 4.75 mg/100g, respectively. Methionine level was higher significantly (P<0.05) in the Cassia tora seed meal processed by boiling (2.13 mg/100g). The boiled seed meal had the highest level (P<0.05) of phenylalanine (4.71 mg/100g), followed by the boiled + fermented with concentration of 4.63 mg/100g. The fermented seed meal of Cassia tora with value of 3.55 mg/100g had significantly (P<0.05) higher level of threonine, while the tryptophan level has no significant difference (P>0.05) in the boiled (3.23 mg/100g) and boiled + fermented (3.18 mg/100g) Cassia tora seed meal. There was no significant difference (P>0.05) in the valine concentration of the raw (4.44 mg/100g) and the soaked (4.42 mg/100g) seed meal. The soaked + toasted Cassia tora seed meal had the least level of valine (3.49 mg/100g).

Table 3: Amino acid assay (mg/100g) of raw and differently processed Cassia tora seed meal

Parameters	Raw and Differently processed seeds of *Cassia tora*								SEM	P-Value
	T1	T2	T3	T4	T5	T6	T7	T8		
Alanine	3.31^{e}	4.01^{c}	3.36^{e}	3.65^{d}	4.84^{a}	3.24^{f}	4.35^{b}	3.10^{g}	0.12	0.001
Arginine	5.51^{b}	5.41^{bc}	5.17^{d}	5.23^{cd}	6.16^{a}	5.40^{bc}	6.07^{a}	5.34^{cd}	0.07	0.001
Aspartic acid	9.55^{d}	10.98^{a}	10.03^{c}	9.30^{e}	8.76^{f}	10.40^{b}	9.07^{e}	8.40^{g}	0.17	0.001
Cystine	1.18^{a}	0.65^{d}	0.93^{b}	0.43^{e}	0.91^{b}	0.90^{b}	0.81^{c}	0.72^{cd}	0.05	0.001
Glutamic acid	13.70^{e}	14.81^{b}	14.10^{d}	15.02^{a}	14.43^{c}	14.51^{c}	15.13^{a}	12.83^{f}	0.15	0.001
Glycine	4.00^{cd}	4.07^{c}	3.81^{e}	3.95^{d}	4.39^{a}	3.93^{d}	4.24^{b}	3.60^{f}	0.05	0.001
Histidine	2.17^{c}	1.94^{e}	1.95^{de}	1.28^{f}	2.13^{c}	2.27^{b}	2.37^{a}	2.01^{d}	0.07	0.001
Isoleucine	3.98^{a}	2.59^{d}	2.87^{bc}	2.70^{d}	2.83^{c}	3.00^{a}	2.99^{ab}	3.07^{a}	0.04	0.001
Leucine	6.17^{d}	6.42^{c}	5.03^{f}	6.03^{e}	7.03^{a}	6.16^{d}	6.91^{b}	4.79^{g}	0.16	0.001
Lysine	4.79^{b}	4.94^{a}	4.46^{c}	4.75^{b}	3.95^{f}	4.27^{e}	4.40^{d}	3.56^{g}	0.09	0.001
Methionine	1.93^{b}	1.49^{e}	1.90^{b}	1.29^{f}	2.13^{a}	1.84^{c}	1.58^{e}	1.72^{d}	0.05	0.001
Phenylalanine	4.47^{c}	3.40^{e}	4.02^{d}	3.17^{g}	4.71^{a}	3.23^{f}	4.63^{b}	4.01^{d}	0.12	0.001
Proline	2.82^{b}	2.04^{e}	3.00^{a}	2.40^{c}	2.05^{e}	3.05^{a}	2.21^{d}	3.01^{a}	0.09	0.001
Serine	3.18^{a}	2.53^{f}	3.00^{bc}	3.02^{e}	2.70^{e}	2.96^{cd}	2.93^{d}	3.04^{b}	0.04	0.001
Threonine	3.15^{d}	3.44^{b}	2.94^{e}	3.02^{e}	3.02^{e}	3.55^{a}	2.96^{e}	3.35^{c}	0.05	0.001
Tryptophan	3.02^{c}	3.07^{bc}	3.01^{c}	3.03^{bc}	3.23^{a}	3.08^{bc}	3.18^{ab}	2.32^{d}	0.06	0.001
Valine	4.44^{c}	4.03^{f}	4.42^{c}	4.18^{e}	4.54^{b}	4.34^{d}	4.83^{a}	3.49^{g}	0.08	0.001

Means within the same row with different superscripts differ significantly (P<0.05)

The phytochemical composition of the raw and differently processed seeds of Cassia tora seed meal is as shown in Table 4. The tannin concentration was higher significantly (P<0.05) in the raw seed (104.42 mg/100g) of the Cassia tora in comparison to concentration of tannin in the differently processed seeds. There was significant difference (P<0.05) in the phytate concentration of the raw and processed seeds of Cassia tora. The raw seed had significantly higher concentration of phytate (808.00 mg/100g), while the least concentration amongst the processed seeds was recorded in the soaked + toasted seeds (194.01 mg/100g). The oxalate concentration was higher (70.05 mg/100g) significantly (P<0.05) in the raw seeds of Cassia tora meal, while the fermented seed had the second highest flavonoid concentration (75.36 mg/100g), which is significantly lower (P<0.05) than the concentration in the raw seed.

Phenolics concentration of the raw Cassia tora seed meal (126.02 mg/100g) was significantly higher (P<0.05) in comparison to those of the differently processed seeds, while the raw seed of Cassia tora had significantly higher (P<0.05) concentration of alkaloids than their processed counterparts. Meanwhile, the least alkaloids was recorded in the soaked + toasted seed (102.29 mg/100g). Saponins level in the raw seed (166.77 mg/100g) was significantly higher (P<0.05) when compared to those of the processed seeds.

Table 4: Phytochemical composition (mg/100g) of raw and differently processed seed meal of Cassia tora

Parameters	Raw and Differently Processed Seed Meal of *Cassia tora*								SEM	P-Value
	T1	T2	T3	T4	T5	T6	T7	T8		
Tannin	104.42^{a}	78.33^{g}	95.47^{c}	83.85^{e}	86.12^{d}	98.28^{b}	79.63^{f}	69.52^{h}	2.27	0.001
Phytate	508.00^{a}	200.04^{g}	435.47^{d}	440.10^{c}	260.80^{f}	462.28^{b}	399.37^{e}	174.01^{h}	25.11	0.001
0xalate	70.05^{a}	17.80^{h}	55.14^{c}	60.11^{b}	36.05^{g}	49.33^{d}	42.93^{e}	38.07^{f}	3.16	0.001
Flavanoid	98.80^{a}	57.29^{e}	60.00^{d}	69.47^{c}	48.67^{f}	75.36^{b}	40.17^{g}	31.70^{h}	4.14	0.001
Alkaloid	240.60^{a}	119.11^{g}	222.39^{b}	150.92^{c}	138.12^{f}	149.37^{d}	140.21^{e}	102.29^{h}	9.45	0.001
Phenolics	126.02^{a}	74.50^{f}	90.09^{d}	93.93^{c}	65.50^{h}	108.76^{b}	78.86^{e}	70.45^{g}	4.03	0.001
Saponin	166.77^{a}	150.38^{b}	121.03^{f}	137.92^{d}	109.32^{g}	141.57^{c}	103.75^{h}	131.03^{e}	4.11	0.001

T1 = Raw, T2 = Toasted, T3= Soaked, T4 = Autoclaved, T5 = Boiled, T6 = Fermented, T7 = Boiled and Fermented and T8 = Soaked and Toasted

DISCUSSION

The recorded crude protein content of the raw Cassia tora seed meal in this study is 12.49%. The findings slightly corresponds with what was obtained by Adamu et al. (2013) who obtained 13.79% crude protein for the raw seed of Cassia tora. Furthermore, Adoke et al. (2018) reported 18.20% crude protein while Augustine et al. (2017) recorded 23.40% crude protein for the raw seed of Cassia tora. In addition, Gohl (1981) reported crude of protein of 18.20% while Augustine et al. (2014) and Augustine et al. (2016) reported crude protein of 21.89 and 19.60%, respectively. Meanwhile, the toasted Cassia tora seed meal recorded significant increase of the crude protein from 12.49% in the raw to 18.90% in the toasted seed. The finding in respect of nutritional composition of this study corroborates the results obtained by Augustine et al. 2016 and Onimisi et al. 2017. They recorded increase in the crude protein of the test ingredients upon subjecting them to different processing methods, which includes toasting. Abbas and Ahmad (2018) supports the assertion that heat treatment improves the nutritional value and quality of legume grains and enhance the protein quality of legume grains by inactivating the anti-nutrients, such as tannins, phytate, phenols to mention but few.

The ether extract of the raw seed of this study (3.50%) is slightly above the value reported by Ingweye et al. (2010) of 2.31% and little below the ether extract value recorded by Gohl (1981) and Augustine et al. (2016) of 4.60% and 4.00%, respectively. However, Adamu et al. (2018) reported much higher ether extract value of 13.79% for the raw seed of Cassia tora. The crude fibre of 11.62% recorded in the raw Cassia tora seed meal of this study was above the acceptable level (=7%) for fish nutrition. However, the processed seed (toasted) had lower crude fibre. The crude fibre findings of this study corroborates the ones reported by Adoke et al. (2018), Augustine et al. (2014), Augustine et al. (2016) and Ingweye et al. (2010) of 13.35, 12.45, 13.80 and 10.18%, respectively. However, much lower crude fibre content was observed by Adamu et al. (2018) and Gohl (1981) of 7.78 and 7.40%, respectively. The difference in some of the proximate composition parameters for the seed of Cassia tora might be attributed to the variation in geographical location of the experimental site.

The amino acid content of the raw Cassia tora seed meal shows slight similarity with the values recorded by Augustine et al. (2017). The methionine and lysine content reported in this study were 1.93 and 4.79 mg/100g as against the 1.30 and 3.90 mg/100g recorded by Augustine et al. (2017). Likewise, Ingweye et al. (2010) who worked on the nutritional evaluation of Cassia tora seed meal from Obanliku reported the lysine and methionine of the seed as 4.02 and 1.02 mg/100g. The values is a little below the recommended range for fish, which is 5.1 and 2.3 mg/100g as reported by FAO (2022). Khattab et al. (2009) reported that different processing treatments such as soaking, toasting, boiling, autoclaving increases the total essential amino acids, which corroborates the findings of this study.

The reported calcium, cupper, iron, magnesium, phosphorus, potassium, sodium and zinc in the raw seed of this study were 851.10, 900.01, 215.39, 610.70, 1101.25, 950.89, 573.29 and 51.52 mg/100g as against the values reported by Augustine et al. (2017) and Ingweye et al. (2010) of 960, 10.48, 234.60, 640, 810, 1200, 600 and 53.12 mg/100g. Some of the minerals such as sodium, magnesium, zinc and copper have similar concentration. Some processing methods reported by El-Adawy (2002) suggests retention of mineral contents in legume seeds as against the report by Lee and Karumanithy (1990) that some processing methods leached down mineral contents in different legumes.

The oxalate concentration revealed in this study for raw, toasted, soaked, autoclaved, boiled, fermented, boiled + fermented and soaked + toasted were 70.05, 17.80, 55.22, 60.06, 36.01, 49.31, 43.00 and 38.10 mg/100g. The percentage reduction in the concentration of oxalate in the processed Cassia tora seed as against the raw seeds were 74.59 and 48.50% for the toasted and autoclaved, respectively. This suggests decrease or degradation of oxalate upon subjecting the seed meal to processing as corroborated by Adoke et al. (2018) who reported oxalate concentration of 1.14, 0.88, 0.65,0.67 and 0.64% for the raw, soaked, boiled, soaked + toasted and toasted seed meal. The percentage decline of oxalate content in differently processed as against the value recorded for the raw seed were 22.81, 42.98, 41.23 and 43.86%, respectively. In addition, this study recorded saponin concentration in the raw seed of 166.90 mg/100g. However, processing through toasting, soaking, autoclaving, boiling, fermenting, boiling + fermenting and soaking + toasting resulted to decrease in the concentration by 9.88, 27.50, 17.35, 34.49, 15.18, 37.77 and 21.51%. Furthermore, Abdullateef et al. (2016) who worked on the growth response and feed utilization of Clarias gariepinus juveniles fed graded levels of boiled Cassia tora seed meal as a replacement for soya bean meal observed significant reduction of the anti-nutritional factor, saponin by 54.17%, which is from 0.96 to 0.44 mg/100g. The reduction in saponin concentration as reported by Augustine (2017) agrees with the findings of this study. Augustine (2017) reported decline in the concentration of saponin from 2.44 to 1.17, 1.18 and 1.31 mg/100g for the seed soaked for 6 hours, 12 hours and 24 hours, respectively.

The content of tannin recorded in this study was 104.43 mg/100g, which reduced by 25.00, 8.46, 19.66, 17.60, 5.87, 23.87 and 33.40% upon subjecting the seeds of Cassia tora seed to different processing method. However, Juji et al. (2023) reported higher tannin concentration (196.56 mg/100g) in the raw seed of Cassia tora seed meal than the value recorded in this study. Thereafter, upon subjecting the seeds to processing via toasting, sprouting, boiling and fermentation, the tannin concentration reduced by 12.90, 43.86, 49.01 and 55.73%.

Irrespective of the processing method adopted, there is an apparent decline in the concentration of anti-nutritional factors, which corroborates the findings of Augustine (2017), Adoke et al. (2018), Adamu et al. (2018) and Juji et al. (2023).

CONCLUSION AND RECOMMENDATIONS

The nutritional composition of the toasted seed meal of Cassia tora showed great potentials as a fish feed ingredient, with crude protein of 18.90%, despite the strong limitations which can be attributed to the presence of anti-nutritional factors that hinders fish ability to absorb and assimilate nutrients from diets administered to them. The concentration of phytochemicals was significantly reduced through the application of different processing methods, but resulted in relatively good amino acid and is rich minerals. Processing of legumes (Cassia tora) should be encouraged to deactivate anti-nutrients and boost the nutritional composition of the seeds in preparation for its usage as a fish feed ingredient.

REFERENCES

Abbas, Y. and Ahmad, A. (2018). Impact of processing on nutritional and antinutritional factors of legumes. A Review. Annals Food Science and Technology. 19(2): 199 215.

Abdullateef, Y., Rilwan, U., David, A.M. and Joseph, O.A. (2016). Growth response and feed utilization of Clarias gariepinus(Burchell, 1822) juveniles fed graded levels of boiled Senna obtusifolia seed meal as a replacement for soybean meal. Journal of Advanced Veterinary and Animal Research, 3(4), 345-352.

Adamu, H.M., Ushie, O.A. and Elisha, B. (2013). Chemical and nutritional analysis of raw and fermented seeds of Cassia tora. Journal of Physical Science and Innovation, 5(1), 125-138.

Adebowale, Y., Adeyemi, A. and Oshodi, A. (2005). Variability in the physicochemical, nutritional and antinutritional attributes of six Mucuna species. Food Chemistry, 89, 37-48.

Adoke, I.Y., Igwebuike, J.U., Diyaware, M.Y., Onimisi, H.U. and Musa, M.I. (2018).Assessment of the nutritional composition of raw and processed Cassia tora seed meal for fish nutrition. Nigerian Journal of Fisheries, 15(2), 1556-1560

AOAC (Association of Official Analytical Chemists, 2010). International Official Methods of Analysis, 17th edition AOAC International Gaithersburg, MD, USA 2000, pp. 25-28.

Augustine, C., Abdulrahman, B.S., Masudi, B. and Ngiki, Y.U. (2014). Comparative evaluation of the proximate composition and anti-nutritive components of tropical sickle pod (Cassia tora) seed meals indigenous to Mubi area of Adamawa State, Nigeria. International Journal of Management and Social Sciences Research, 3(2), 9-12.

Augustine, C., Ismaila, Y.S. and Igwebuike, J.U. (2016). Response of coffee Senna (Sennaoccidentalis) seeds to different fermentation periods. Advanced Biochemistry and Biotechnology Journal, 1: 1-4.

Augustine, C. (2017). Response of tropical sickle pod (Senna obtusifolia) seed meal to varying soaking periods. Researcher, 9(8), 60-68.

Augustine, C., Bashir, F.A., Edward, A., Medugu, C.I., Abdulrahman, B.S. Markus, J. and Mohammed, Y. (2018a). Chemical composition of Sickle pod(Senna obtusifolia) and coffee Senna (Senna occidentalis) leaves indigenous toMubi. New York Science Journal, 11, 86-90.

Ayssiwede, S., Missoko-Mabeki, R., Mankor, A., Dieng, A., Marcel, H., Chrysostome, C., Dahouda, M., Missohou, A. and Hornick, J.L. (2012). Effects of Cassia tora(Linn.) leaves meal inclusion in the diet on growth performances, carcass and organs characteristics and economic margins in growing indigenous Senegal chickens. Revuede Medecine Veterinaire. 163: 375-386.

Doss, A., Pugalenthi, M., Vadivel, V.G., Subhashini, G. and AnithaSubash, R. (2011).Effects of processing technique on the nutritional composition and antinutrients content of underutilized food legume, Canavalia ensiformis LDC. International Food Research Journal, 18(3), 965-970.

El-Adawy, T.A. (2002). Nutritional composition and anti-nutritional factors of chickpeas (Cicer arietinum). undergoing different cooking methods and germination .Plant Foods for Human Nutrition, 57, 83-97.

Gohl, B. (1981). Tropical feeds: Feed Information Summaries and Nutritive Value. FAO. Animal Production Series, FAO, Rome, Italy. 405 p.

Hayat, I., Ahmad, A., Masud, T., Ahmed, A. and Bashir, S. (2014a). Nutritional and health perspectives of

Beans (Phaseolus vulgaris). An Overview. Critical Reviews in Food Science and Nutrition, 54, 580 592.

Hayat, I., Ahmad, A., Ahmed, A., Khalil, S. and Gulfraz, M. (2014b).Exploring the potential of red kidney beans (Phaseolus vulgaris) to develop protein based product for food applications. The Journal of Animal and Plant Sciences. 24(3): 860-868.

Hernandez, A., Borquez, A., Alcaino, L., Morales, J., Dantagnan, P. and Saez, P. (2010). Effects of autoclaving on the apparent digestibility coefficient of dehulled pea seed meal (Pisumsativum L.) in rainbow trout (Oncorhynchus mykiss W.). Ciencia eInvestigacionAgraria, 37(3), 39-46.

Ingweye, J.N., Kalio, G.A., Ubua, J.A. and Umoren, E.P. (2010). Nutritional evaluation of wild sickle pod (Senna obtusifolia) seeds from Obanliku, South-Eastern Nigeria. American Journal of food Technology, 5(1), 1-12.

Juji, C.A., Yusuf, H.B., Gworgwor, Z.A., Yakubu, B., Wafar, R.J. and Abdullahi, A.I. (2023). Effects of raw and processed Senna obtusifolia seed meals on the growth performance, carcass characteristics and blood profile of weaner rabbits. Journal of Agriculture and Veterinary Science, 16(1), 2319-2372.

Karmas, E. and Harris, R.S. (2012). Nutritional evaluation of food processing. Springer Science and Business Media.

Khattab, R., Arntfield, S. and Nyachoti, C. (2009). Nutritional quality of legume seeds as affected by some physical treatments, Part 1: Protein quality evaluation. Food Science and Technology, 42(11), 7-12.

Lee, C.K. and Karumanithy, R. (1990). Effects of germination on the chemical composition of Glycine and Phaseolus beans. Journal of Science and Food, 51(4), 37-45

Lewis, G., Schrire, B., Mackinder, B. and Lock, M. (2016). Legumes of the World Royal Botanic Gardens Google Scholar.

Onimisi, H.U., Oniye, S.J., Balogun, J.K. and Bolorunduro, P.I. (2017). Growth performance of fingerlings of Claria gariepinus fed fermented seed of Senna obtusifolia. Nigerian Journal of Animal Production, 44(2), 271-280.

Sathe, S.K., Salunke, D. and Cheryan, M. (1984). Technology of removal of unwanted components of dry beans. Critical Reviews in Food Science and Nutrition, 21(2), 63-87.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

PHYTOCHEMICAL CONSTITUENTS AND ANTIOXIDANT ACTIVITIES OF SOME FRUIT EXTRACTS AS A POSSIBLE ALTERNATIVE APPROACH TO CHEMOTHERAPEUTICS IN AQUACULTURE

Aderolu[1], A.Z, Lawal[1], M.O; Aluta[1], U.P, Uche[1], S.O and Sanni, R.O

[1]Department of Marine Sciences, University of Lagos, Nigeria.
[2].Adeyemi College of Education Ondo State, Nigeria

Corresponding author: aaderolu@unilag.edu.ng

ABSTRACT

Plants with phytochemical and antioxidant properties are promising and could be important sources of several therapeutics in fish culture. This study therefore examines the antioxidant potential of the extracts derived from the leaves, seeds and peels of two plants; Carica papaya (Pawpaw) and Annona muricata (Soursop) using various solvents. Antioxidant activity at different concentrations (25, 50, 75 and 100μg/ml) from the various plant extracts were estimated using 2,2-Diphenyl-1-picrylhydrazyl (DPPH) assay, Ferric reducing power assay (FRAP), Nitricoxide assay and 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) assay. Totalphenol content (TPC) and total flavonoid content (TFC) were assessed by spectrophotometry while gas chromatographic flame ionization detector was used for the phytochemical screening of plant extracts. In the in-vitro studies, the antioxidant activities of the different plant extracts increased with increase in concentration across graded levels (25, 50, 75 &100μg/ml) significantly (P>0.05) except in few extracts. In the DPPH assay, at a concentration of 100μg/ml. The result revealed that soursop seed hexane extract had a significant (P<0.05) higher scavenging power (88.16 ± 0.07%) than the standard control, ascorbic acid (83.78 ± 0.68%) and other extracts. The ferric reducing power of the brown male pawpaw leaf ethanolic extract, green female pawpaw leaf ethanolic extract and soursop seed hexane extract at 100μg/ml were significantly higher than that of the control (0.48 ± 0.00%) and other extracts investigated. The value of nitric oxide scavenging activity was highest in ascorbic acid (85.81 ± 0.58%) at100μg/ml, while from the plant extracts, the highest nitric inhibition activity was the soursop seed hexane extract (82.72 ± 0.25%) which is significantly higher than the values of other extracts. The ABTS scavenging assay also showed that the ascorbic acid had the highest percentage inhibition (86.69 ± 0.02%) at 100μg/ml while the soursop leaf ethanolic extract had the highest percentage inhibition (78.72 ± 1.88%) amongst the thirteen screened extracts at 100μg/ml. The TPC was highest in aqueous extract of soursop peel ethanolic extract (46.51 ± 0.21%) and lowest in brown male pawpaw leaf ethanolic extract (34.32 ± 0.34%). Highest TFC value

Keywords:
Pawpaw, Soursop, Solvent type, Antioxidant, Phytochemical constituents

was found in unripe pawpaw seed ethanolic extract (45.64 ± 0.07%) and the least in aqueous extract of ripe pawpaw peel aqueous extract (18.79 ± 0.29%). From the investigative studies carried out on the plant extracts, it can be suggested that the antioxidant properties and phytochemical constituents of the plant extracts make them sources of natural antioxidant favoring their possible use in fish feed as nutraceutical.

INTRODUCTION

Animal health is always threatened with infectious disease and other ailments, which are associated with human interventions such as transfer of organisms, environmental degradation, agricultural practices, or technology (Jones *et al.,* 2008; Pilkkinenet *et al.,* 2010). Antibiotics and other chemo-theraputants are especially in intensive cultures, but the use of antibiotics has led to widespread appearance of resistant strains of microbes, bioaccumulation of the drug residues in the fishes which in turn affects man and kills aquatic organisms.

However, several alternative methods are considered to improve the quality and sustainability of aquaculture production and to reduce the use of antibiotics. Of these methods, the use of medicinal plants with antioxidant activities is the main aim of this research work, with specific interest is the inedible parts of some fruits consumed by man. This will save the stress of waste accumulation after harvesting the fruits or herbs and reduce the risk of pollution while the use of excessive antibiotics is also solved.

Carica papaya is a powerhouse of nutrients and is available throughout the year. All the nutrients of papaya improve cardiovascular system, protect against heart diseases, heart attacks, strokes and prevent colon cancer. On the other hand, Soursop is widely used as a traditional medicine for skin disease, respiratory disease, fever, bacterial infections, diabetes, hypertension, and cancer (Moghadamtousi *et al.,* 2015).

This study aims at:

- Extracting bio-active compounds from the leaves, peels and seeds of the Papaya and Soursop fruit using distilled water, ethanol, and hexane as solvents.
- Determining the phytochemical constituents of the extracts from the leaves, seeds and peels of two different plants Carica papaya (Pawpaw) and Annona muricata (Soursop)
- Determining the total phenolic and flavonoid contents of fruit extracts by carrying out a phytochemical screening on the plant extracts.
- Investigating the in-vitro antioxidant activities of the plant extracts using DPPH assay (2,2-diphenylpicrylhydrazyl), ABTS assay (2,2-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)), FRAP assay (ferric reducing antioxidant power), Nitric oxide scavenging activity assay.

MATERIALS AND METHODS

Samples collection and identification

The Carica papaya and Anonna muricata were collected from various sites at the University of Lagos, Akoka, Lagos state, Nigeria, identified at the herbarium of the Department of Plant Biology of the University of Lagos. The leaves, seeds and peels of these fruits were later air dried under shade, latter pulverized and were packed and labelled in airtight containers and stored in a cool place until use.

Solvent extraction

20g of air-dried samples of each plant parts were placed in 250ml conical flask with 200ml of each solvents (Ifesan *et al.,* 2009). For the hexane extraction, the finely ground sample was placed in thimble chamber of the Soxhlet apparatus (AOAC, 2015).

Qualitative and Quantitative Phytochemistry

The extract obtained from the various fruit waste were analysed for the absence or presence of alkaloids, tannins, phlobatannins, saponins, phenols, glycosides, flavonoids, steroids and terpenoids using standard procedures (Harborne, 1998).

IN-VITRO ANTIOXIDANT ACTIVITIES

In vitro antioxidative potential of the various fruit waste was initially evaluated using three in vitro methods as earlier described by Thaipong et al., (2006). These includes 2,2- diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay, 2,2-azinobis-(3-ethylbenzothiazoline-6-sulfonate) (ABTS) radical cation decolourization assay and Ferric reducing antioxidant power (FRAP) assay. Experiments were in triplicate.

Statistical analysis

The data obtained were recorded in excel sheet and subjected to one-way analysis of variance (ANOVA) using IBM statistical package (SPSS version 22) to determine differences among the treatments and control in all parameters. Individual means were separated using Duncan multiple range test. All data were presented as means ± SD and were reported as significant at $P<0.05$.

RESULTS

Total flavonoid contents of the plant extracts

Total flavonoid contents were expressed as milligrams of Rutin equivalents. The flavonoid contents from the different plant materials using hexane, water or ethanol as solvent are shown in Table 1 below.

Table 1: Total flavonoid contents (mg Rutin/g DW) of the plant extracts

Plant Extracts	Hexane	Water	Ethanol
Unripe pawpaw peel	33.41 ± 0.60^{a}	33.54 ± 0.73^{a}	42.56 ± 0.18^{b}
Ripe Pawpaw peel	33.23 ± 0.01^{b}	18.79 ± 0.29^{a}	40.09 ± 0.06^{c}
Ripe pawpaw seed	30.00 ± 0.02^{b}	27.56 ± 0.12^{a}	34.78 ± 0.41^{c}
Unripe pawpaw seed	41.71 ± 0.91^{b}	31.74 ± 0.76^{a}	45.64 ± 0.07^{c}
Green male pawpaw leaf	38.05 ± 1.22^{c}	27.27 ± 0.84^{a}	34.66 ± 0.36^{b}
Wilty male pawpaw leaf	29.47 ± 0.59^{a}	34.69 ± 0.15^{b}	42.77 ± 0.02^{c}
Green female pawpaw leaf	34.37 ± 0.70^{ab}	33.04 ± 0.34^{a}	35.59 ± 1.75^{c}
Wilty female pawpaw leaf	24.26 ± 0.12^{a}	$35.52 \pm. 0.55^{b}$	40.43 ± 0.01^{c}
Soursop seed	45.24 ± 0.69^{c}	38.32 ± 0.03^{a}	41.27 ± 0.91^{b}
Soursop leaf	40.51 ± 0.05^{b}	33.48 ± 0.12^{a}	43.08 ± 0.46^{c}
Soursop peel	33.89 ± 0.86^{a}	38.19 ± 0.28^{b}	40.01 ± 0.10^{c}

Mean values ± SD values in the same column with different superscript differ significantly ($P<0.05$). DW: dry weight; mg GAE/g DW: milligram gallic acid equivalent per gram dry weight; mg Rutin/g DW: milligram Rutin equivalent per gram dry weight.

Table 2: Total phenolic contents (mg GAE/100g DW) of the plant extracts

Material	Hexane	Water	Ethanol
Pawpaw Extracts			
Unripe pawpaw peel	25.28 ± 0.02^{a}	40.87 ± 0.38^{c}	35.88 ± 0.39^{b}
Ripe Pawpaw peel	42.14 ± 0.47^{b}	38.04 ± 0.07^{a}	43.97 ± 0.19^{c}
Ripe pawpaw seed	45.89 ± 0.54^{c}	40.18 ± 0.02^{a}	42.38 ± 0.12^{b}
Unripe pawpaw seed	38.41 ± 0.12^{b}	33.98 ± 0.22^{a}	38.76 ± 0.27^{b}
Green male pawpaw leaf	45.45 ± 0.69^{b}	41.64 ± 1.32^{a}	44.08 ± 0.55^{b}
Brown male pawpaw leaf	34.32 ± 0.34^{a}	44.22 ± 0.01^{b}	45.46 ± 0.26^{c}
Green female pawpaw leaf	45.13 ± 0.55^{c}	35.14 ± 0.27^{a}	42.71 ± 0.31^{b}
Brown female pawpaw leaf	30.96 ± 0.27^{a}	34.52 ± 0.01^{b}	42.20 ± 0.12^{c}
Soursop Extracts			
Soursop seed	38.61 ± 0.16^{a}	44.30 ± 0.03^{c}	40.07 ± 0.08^{b}
Soursop leaf	44.83 ± 0.05^{c}	38.45 ± 0.11^{a}	40.44 ± 0.10^{b}
Soursop peel	40.45 ± 0.19^{a}	42.90 ± 0.57^{b}	46.51 ±0.21^{c}

Mean values ± SD values in the same column with different superscript differ significantly ($P<0.05$). DW: dry weight; mg GAE/g DW: milligram gallic acid equivalent per gram dry weight; mg Rutin/g DW: milligram Rutin equivalent per gram dry weight.

Phytochemical screening; After the total phenolic and flavonoid content of the fruit extracts were ascertained, thirteen of the extracts which had the highest phenolic and flavonoid content in them were selected and then further tested for their qualitative phytochemical properties.

Table 3: Qualitative phytochemical screening of the plant extracts

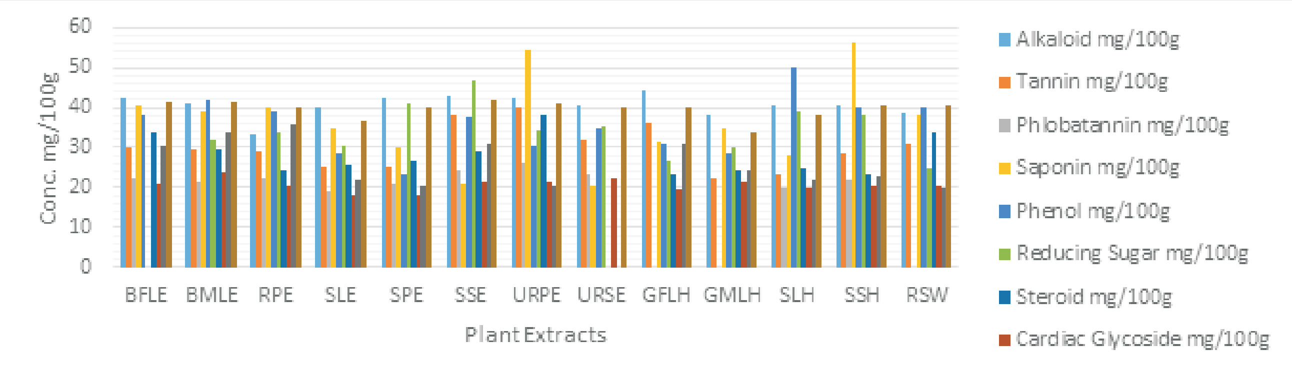
Parameter	Solvents	Alkaloid	Tannin	Phlobatannin	Saponin	Phenol	Reducing Sugar	Steroid	Cardiac Glycoside	Terpenoid	Flavonoid
BFLE	ETH	++	+	+	++	+	-	+	+	+	+
BMLE	ETH	++	+	+	++	++	+	++	+	+	+
RPE	ETH	+	+	+	+	+	++	+	+	+	+
URPE	ETH	+	+	+	+	+	+	-	+	-	+
URSE	ETH	++	+	+	++	++	+	+	+	+	+
GFLH	HEX	++	+	-	+	+	++	+	+	+	+
RSW	AQ	+	+	-	+	+	+	+	+	+	+
GMLH	HEX	++	+	-	+	+	+	+	+	+	+
SLE	ETH	+	+	+	+	+	++	++	++	+	+
SPE	ETH	+	+	+	+	++	++	+	++	+	+
SSE	ETH	++	++	+	+	++	++	++	+	+	+
SLH	HEX	+	+	+	+	++	+	+	+	+	+
SSH	HEX	+	+	+	+	+	+	++	+	+	+

Code: + =Present ++ = Much Present - = Absent

BFLE: Ethanol extracted female pawpaw leaf; BMLE: Ethanol extracted brown male pawpaw leaf; RPE: Ethanol extracted ripe pawpaw peel; URPE: Ethanol extracted unripe pawpaw peel; URSE:

Ethanol extracted unripe pawpaw seed; GFLH: Hexane extracted green female leaf; RSW: Aqueous extracted ripe pawpaw seed; GMLH: Hexane extracted green male leaf; SLE: Ethanol extracted soursop leaf; SPE: Ethanol extracted soursop peel; SSE: Ethanol extracted Soursop seed; SLH: Hexane extracted soursop leaf; SSH: Hexane extracted soursop seed.

Quantitative phytochemical screening of the plant extracts (mg/100g)



The free radical scavenging activities of thirteen selected extracts at 25µg/ml, 50µg/ml, 75µg/ml and 100µg/ml concentration were analyzed using ascorbic acid as the control or standard. Percentage inhibition, using 2,2-Diphenyl-1-picrylhydrazyl was used to define the ability of each extract to scavenge for free radicals.

Table 5: Free radical scavenging activities of the various selected plant extracts (DPPH Inhibition (%) the same column indicate significant differences ($P < 0.05$) of different plant extracts concentrations. Data expressed as Mean±SD.

Parameter	Key	25µg/ml	50µg/ml	75µg/ml	100µg/ml
BFLE	Brown/wilty male pawpaw leaf-Ethanol	47.04 ± 0.00^{gA}	47.14 ± 0.01^{cB}	72.87 ± 0.00^{dC}	78.91 ± 0.01^{bD}
BMLE	Brown/wilty male pawpaw leaf-Hexane	45.93 ±0.01^{defA}	47.79 ± 0.01^{dB}	72.88 ± 0.01^{dC}	79.16 ± 0.12^{bcD}
GFLH	Green female pawpaw leaf-Hexane	46.60 ± 0.01^{fgA}	46.65±0.01^{abB}	72.83 ± 0.01^{dC}	78.93 ± 0.01^{bD}
GMLH	Green male pawpaw leaf-Hexane	45.30 ± 0.02^{dA}	54.55 ± 0.06^{hB}	74.64 ± 0.33^{fC}	79.98 ± 0.57^{dD}
RPE	Ripe pawpaw peel-Ethanol	40.45 ± 0.56^{bA}	47.16 ± 0.01^{cB}	72.83 ± 0.01^{dC}	78.28 ± 0.58^{aD}
RSW	Ripe pawpaw seed-Water	35.55 ± 1.15^{aA}	46.72 ± 0.02^{bB}	73.93 ± 0.78^{eC}	79.25 ± 0.01^{bcD}
URPE	Unripe pawpaw peel-Ethanol	46.58 ± 0.00^{gA}	54.60 ± 0.56^{hB}	74.38 ± 0.06^{efC}	85.87 ± 0.27^{fD}
URSE	Unripe pawpaw seed - Ethanol	45.93 ± 0.01^{defA}	46.42 ± 0.02^{aB}	71.92 ± 0.07^{cC}	79.36 ± 0.01^{bcD}
SLE	Soursop leaf-Ethanol	42.52 ± 0.60^{cA}	52.62 ± 0.06^{fB}	66.51 ± 0.58^{aB}	79.32 ± 0.01^{bcD}
SLH	Soursop leaf-Hexane	45.78 ±0.13^{deA}	53. 23 ± 0.02^{gB}	70.65 ± 0.01^{bC}	79.32 ±0.01^{bcD}
SSE	Soursop seed-Ethanol	45.57 ± 0.02	50.44 ± 0.01^{eB}	74.12 ± 0.02^{eC}	80.27 ± 0.03^{dD}
SSH	Soursop seed-Hexane	47.08 ± 0.02^{gA}	53.55 ± 0.00^{gB}	74.13 ± 0.29^{eC}	88.16 ± 0.07^{gD}
SPE	Soursop peel-Hexane	47.26 ± 0.01^{gA}	47.30 ± 0.02^{cA}	75.13 ± 0.02^{gB}	79.47 ± 0.11^{cC}
ASCA	Ascorbicacid (standard)	46.13 ± 0.33^{efA}	61.50 ± 0.32^{iB}	75.23 ± 0.86^{gC}	83.78 ± 0.68^{eD}

Ethanol (E); Water (Aqueous) (W); Hexane (H).

Ferric reducing antioxidant activity

Across the graded levels 25μg/ml, 5μg/ml, 75μg/ml, and 100 μg/ml, it was found that the reducing power increased with increase in concentration of each sample.

Table 6: Ferric reducing capacities of the tested plant extracts %Fe3+ reduction (%)

Parameter	Key	25µg/ml	50µg/ml	75µg/ml	100µg/ml
BFLE	Brown female pawpaw leaf-Ethanol	0.07 ± 0.00^{eA}	0.19 ± 0.00^{eB}	0.26 ± 0.00^{aC}	0.42 ± 0.00^{bD}
BMLE	Brown/wiltymale pawpaw leaf -Ethanol	0.09 ± 0.00^{hA}	0.17 ± 0.00^{dB}	0.36 ± 0.00^{dC}	0.53 ± 0.01^{dD}
GFLH	Green female pawpaw leaf-Hexane	0.08 ± 0.00^{fA}	0.19 ± 0.00^{fB}	0.24 ± 0.00^{aC}	0.42 ± 0.00^{bD}
GMLH	Green male pawpaw leaf-Hexane	0.04 ± 0.00^{bA}	0.17 ± 0.00^{dB}	0.35 ± 0.00^{dC}	0.53 ± 0.00^{dD}
RPE	Ripe pawpaw peel-Ethanol	0.09 ± 0.00^{hA}	0.17 ± 0.00^{dB}	0.32 ± 0.00^{bcC}	0.49 ± 0.00^{cD}
RSW	Ripe pawpaw seed-Water	0.08 ± 0.00^{gA}	$0.29 \pm 0.00^{h\square}$	0.26 ± 0.00^{aC}	0.41 ± 0.01^{abD}
URPE	Unripe pawpaw peel-Ethanol	0.04 ± 0.00^{aA}	0.16 ± 0.00^{bcB}	0.25 ± 0.00^{aC}	0.41 ± 0.00^{abD}
URSE	Unripe pawpaw seed-Ethanol	0.06 ± 0.00^{dA}	0.16 ± 0.00^{bcB}	0.24 ± 0.00^{aC}	0.40 ± 0.02^{abD}
SLE	Soursop leaf-Ethanol	0.49 ± 0.00^{cA}	$0.16 \pm 0.00^{\square bB}$	0.24 ± 0.01^{aC}	0.38 ± 0.00^{aD}
SLH	Soursop leaf-Hexane	0.10 ± 0.00^{iA}	0.22 ± 0.00^{gB}	0.33 ± 0.00^{bcdC}	0.48 ± 0.00^{cD}
SSE	Soursop seed-Ethanol	0.04 ± 0.00^{aA}	0.16 ± 0.01^{cB}	0.32 ± 0.06^{bC}	0.49 ± 0.07^{cD}
SSH	Soursop seed-Hexane	0.04 ± 0.00^{aA}	0.16 ± 0.01^{abcB}	0.35 ± 0.01^{cdC}	0.53 ± 0.00^{dD}
SPE	Soursop peel-Ethanol	0.05 ± 0.00^{cA}	0.15 ± 0.00^{aB}	0.25 ± 0.00^{aC}	0.38 ± 0.00^{aD}
ASCA	Ascorbic acid (standard)	0.11 ± 0.00^{jA}	0.22 ± 0.00^{gB}	0.34 ± 0.00^{bcdC}	0.48 ± 0.00^{cD}

- j: Different letters across the same row indicate significant differences ($P < 0.05$) of plant extracts.

A-D: Different letters within the same column indicate significant differences ($P < 0.05$) of different plant extracts concentrations. Data expressed as Mean±SD. Ethanol (E); Water (Aqueous) (W); Hexane (H).

- Nitric oxide inhibitory activity

In Table 6, the ability of the extracts to inhibit NO production was higher as the concentration of the extracts increased. There was no significant difference ($P>0.05$) between the percentage inhibition of NO of the various extracts across graded levels; 25μg/ml (72.74 ± 7.73%), 50μg/ml (72.74 ± 7.73%), 75μg/ml (72.74 ± 7.73%) and 100μg/ml (72.74 ± 7.73%). In descending order, the best inhibitory activity on NO synthesis was demonstrated by the control (Ascorbic acid) at 100μg/ml (85.81 ± 0.58%).

content. As the concentration of sample increase the TPC value increase too (Nguyen et al.,2020)

From the TPC and TFC investigation, most of the extracts that had high phenolic and flavonoid content was extracted using ethanol as solvent followed by the hexane extracts and then the aqueous extracts which had the lowest values from the result. The good TPC and TFC values in all fruit extracts tested indicate their potentials as natural antioxidant ingredients that can contribute to quality and nutritional value and also provide health beneficial effects.

Phytochemical screening

The soursop peels and seeds also showed presence of phytochemicals (alkaloids, flavanoids, cardiac glycosides, phlobatanin, saponins, steroids, tannin, terpenoids and phenols) in correlation with the studies carried out by Coria-Téllez et al., (2018) and Lenny *et al.,* (2019). Soursop extracts exhibited varying antioxidant activities at different concentrations as well as phytochemical properties, with ability to neutralize free radicals responsible for inducing oxidative stress and causing tissue damage (Meza-Gutiérrez *et al.,* 2022).

The results indicated alkaloids, phenols, glycoside, quinones, saponins, flavonoids, tannins, and steroids in pawpaw seeds and leaves extracts, as supported by (Ogundele *et al.,* 2017).This is an indication that the seeds and peels of the pawpaw contains secondary metabolites (Hayatie et al., 2015).

In-vitro antioxdant activities

In this study, DPPH, FRAP, NITRIC OXIDE and ABTS scavenging assays were conducted to compare and evaluate the antioxidant properties of different parts of the pawpaw and soursop fruit. The reducing capacities of each of the extracts, measured by the various methods, differed significantly and increased across graded levels from 25-100μg/ml. The activity trends measured by the three scavenging assays were nearly identical, indicating that phenols and flavonoids made a significant contribution to the antioxidant capacity of the studied plant extracts (Niu *et al.,* 2020). Antioxidant activity should not be concluded based on a single antioxidant test model (Badarinath et al., (2010).

Generally, in-vitro antioxidant tests using free radical traps are relatively straightforward to perform. Among free radical scavenging methods, DPPH method is furthermore rapid, simple (i.e., not involved with many steps and reagents) and inexpensive in comparison to other test models. On the other hand, ABTS decolorization assay is applicable for both hydrophilic and lipophilic antioxidants (Alam et al., 2013). The DPPH assay is the most used antioxidant assay for plant extracts because this method is accurate, easy to perform, and economical, providing a screening of the general activity of the antioxidants and is based in a stable and synthetic radical, DPPH (Gonçalves *et al.,* 2018).

Results from various antioxidants analyses, like DPPH, FRAP and ABTS were found to give comparative results for antioxidant activity, in this study and this is in line with the findings of Awika *et al* (2003) and Thoipong *et al* (2006), when they analysed various extracts from guava fruits

CONCLUSION

Conclusively, the use of waste plants parts may be cheaper and more eco-friendly because of presence of phytochemicals and antioxidant activities which compared relatively well with standard ascorbic acid. Interestingly, the broad spectrum of phytochemicals and antioxidants presents in the plant extracts can be regarded as the reservoir of naturally occurring diverse bioactive molecules and therefore could be suggested as a possible alternative to the use of more expensive antioxidant source in aquaculture.

REFERENCES

Alam, M. N., Bristi, N. J. and Rafiquzzaman, M. (2013). Review on in-vivo and in-vitro methods evaluation of antioxidant activity. Saudi pharmaceutical journal. 21(2): 143-152.

Ang Y. K., Sia W. C. M., Khoo H. E., Yim H. S. (2012). Antioxidant potential of Carica papaya peel and seed. Focusing on Modern Food Industry. 1(1):11–16.

AOAC. (2015). Official Methods of Analysis, Association of Official Analytical Chemists, Washington, DC, USA, 14th edition.

Table 7: Nitric oxide inhibitory activities of the tested plant extracts

Parameter	Key	25µg/ml	50µg/ml	75µg/ml	100µg/ml
BFLE	Brownfemale pawpaw leaf-Ethanol	38.12 ± 5.70^{bA}	56.96 ± 7.97^{abB}	66.84 ± 3.56^{abcC}	75.78 ± 4.99^{abcC}
BMLE	Brown/wiltymale pawpaw leaf -Ethanol	34.11 ± 0.58^{abA}	$55.98 \pm 3.10^{\square B}$	71.74 ± 6.05^{abcC}	77.68 ± 4.13^{abcC}
GFLH	Green female pawpaw leaf-Hexane	43.89 ± 0.25^{cA}	65.01 ± 1.20^{cdB}	73.35 ± 3.51^{abcC}	82.14 ± 0.48^{bcD}
GMLH	Green male pawpaw leaf-Hexane	46.89 ± 0.36^{cA}	58.58 ± 10.31^{abcB}	64.30 ± 15.26^{aC}	69.19 ± 19.50^{aA}
RPE	Ripe pawpaw peel-Ethanol	34.39 ± 0.34^{abA}	52.95 ± 0.48^{aB}	68.30 ± 5.87^{abcC}	75.64 ± 3.77^{abcD}
RSW	Ripe pawpaw seed-Water	46.60 ± 0.21^{cA}	$67.49 \pm 0.50^{\square}$	75.35 ± 0.23^{bcC}	81.66 ± 0.84^{bcD}
URPE	Unripe pawpaw peel-Ethanol	32.23 ± 0.20^{aA}	50.59 ± 0.23^{aB}	66.32 ± 0.26^{abC}	76.55 ± 0.37^{abcD}
URSE	Unripe pawpaw seed-Ethanol	46.25 ± 1.31^{cA}	65.16 ± 1.16^{cdB}	74.95 ± 3.21^{abcC}	81.11 ± 1.15^{abcD}
SLE	Soursop leaf-Ethanol	37.01 ± 0.34^{abA}	52.94 ± 0.33^{aB}	66.60 ± 0.28^{abcC}	78.52 ± 0.27^{abcD}
SLH	Soursop leaf-Hexane	32.85 ± 0.35^{aA}	54.54 ± 0.42^{aB}	65.43 ± 0.36^{abC}	77.34 ± 0.34^{abcD}
SSE	Soursop seed-Ethanol	$46.30 \pm 0.67_{cA}$	$66.82 \pm 0.93_{dB}$	$75.20 \pm 0.35_{bcC}$	81.84 ± 0.28^{bcD}
SSH	Soursop seed-Hexane	44.21 ± 0.26^{cA}	64.61 ± 0.53^{bcdB}	77.45 ± 0.25^{cC}	82.72 ± 0.25^{bcD}
SPE	Soursop peel-Ethanol	72.74 ± 7.73^{dA}	72.74 ± 7.73^{dA}	72.74 ± 7.73^{abcB}	72.74 ± 7.73^{abA}
ASCA	Ascorbic acid (standard)	45.08 ± 0.36^{cA}	57.07 ± 0.27^{abB}	75.73 ± 0.25^{bcC}	85.81 ± 0.58^{cD}

c a-d: Different letters across the same row indicate significant differences ($P < 0.05$) of plant extracts. A-D: Different letters within the same column indicate significant differences ($P < 0.05$) of different plant extracts concentrations. Data expressed as Mean±SD. Ethanol (E); Water (Aqueous) (W); Hexane (H).

DISCUSSION AND CONCLUSION

Phytochemicals have been reported to promote various activities, including antistress, growth promotion, appetite stimulation, tonic and immunostimulation, and antimicrobial properties in fish culture (Citarasu 2010).

The phytochemical screening of plants extracts in this study was conducted to compare the total phenolic content and total flavonoid content from the different parts of the pawpaw and soursop plant including their ripe and unripe peels, seeds, and the leaves.

Solvents have different extracting capacity for phytochemicals (Manimekalai *et al.*, 2016), these extracts were selected based on their antioxidant capacities when compared with the control (Ascorbic acid) used for the test. The trend of inhibition of DPPH radical, ferric reducing power, inhibition of nitric oxide radical and inhibition of ABTS radical by extracts was concentration dependent, and the highest values from each assay was derived by increasing the concentration of the extract being tested.

Total phenolic and flavonoid contents

There is an increasing pattern that can be seen between the concentration of sample and level of total phenolic

AwikaJ.M;Rooney L W, Wu X, Prior RL, Cisnero-Zevallos L(2000). Screening methods to measure antioxidant activity of Sorghum and Sorghum products. Journal of Agric Food Chem, Vol 51 No.23:6657-6662

Badarinath, A. V., Rao, K. M., Chetty, C. M. S., Ramkanth, S. T. V. S. R., Rajan, T. V. S and Gnanaprakash, K. (2010). A review on in-vitro antioxidant methods: comparisions, correlations and considerations. International Journal of PharmTech Research. 2(2): 1276-1285.

Citarasu, T. (2010). Herbal biomedicines: a new opportunity for aquaculture industry. Aquaculture International. 18(3): 03-414.

Coria-Téllez, A. V., Montalvo-Gónzalez, E., Yahia, E. M. and Obledo-Vázquez, E. N. (2018). Annona muricata: A comprehensive review on its traditional medicinal uses, phytochemicals, pharmacological activities, mechanisms of action and toxicity. Arabian Journal of chemistry. 11(5): 662-691.

Gonçalves, A. C., Bento, C., Jesus, F., Alves, G. and Silva, L. R. (2018). Sweet cherry phenolic compounds: Identification, characterization, and health benefits. Studies in natural products chemistry. 59: 31-78.

Harborne J.B. Phytochemical Methods—A Guide to Modern Techniques of Plant Analysis. 3rd ed. Chapman and Hall; London, UK: 1998. [Google Scholar]

Hayatie, L., Biworo, A. and Suhartono, E. (2015). Aqueous Extracts of Seed and Peel of Carica papaya against Aedes aegypti. Journal of Medical and Bioengineering Vol. 4(5).

Ifesan, B.O.T., Hamtasin, C., Mahabusarakam, W., Voravuthikunchai, S.P. (2009). Inhibitory effect of Eleutherine americana Merr. Extract on Staphylococcus aureus isolated from food. J. Food Sci. 74: 352-357.

Jones, K.E; Patel,P.G;Levy,M.A; Storeygard A;Balk D;Gittleman J.L & Daszak P (2008).Global Trends in Emerging Infectious Diseases Nature 451(7181):990-3 DOI: 10.1038/nature06536

Lenny M C., Suliman E. (2019). Preliminary Screening of Nutraceutical Potential of Fruit Pulp, Peel and Seeds from Annona Squamosa (L.) and Annona muricata (L.). Growing in Coast Region of Kenya. American Journal of BioScience. 7(3): 58-70

Manimekalai, I., Sivakumari, K., Ashok, K. and Rajesh, S. (2016). Antioxidant and anticancer potential of mangosteen fruit, Garcinia mangostana against hepatocellular carcinoma (HePG-2) cell line. World J Pharm Pharm Sci. 5(2): 253-93.

Meza-Gutiérrez, N. N., Magallón-Servín, P., Balois-Morales, R., Pérez-Ramírez, I. F., López-Guzmán, G. G., Berumen-Varela, G., and Bautista-Rosales, P. U. (2022). Growth promoting activity of Annona muricata L. Leaf extracts on Lactobacillus casei. Plants. 11(5): 581.

Moghadamtousi, S. Z., Rouhollahi, E., Hajrezaie, M., Karimian, H., Abdulla, M. A. and Kadir, H. A. (2015). Annona muricata leaves accelerate wound healing in rats via involvement of Hsp70 and antioxidant defence. International Journal of Surgery. 18: 110-117.

Nguyen, M. T., Nguyen, V. T., Minh, L. V., Trieu, L. H., Cang, M. H., Bui, L. B., Le, X. T. and Danh, V. T. (2020). Determination of the phytochemical screening, total polyphenols, flavonoids content, and antioxidant activity of soursop leaves (Annona muricata Linn.). IOP Conference Series: Materials Science and Engineering. 736(62011) doi:10.1088/1757-899X/736/6/062011

Niu, G. G., Qin, M., You, G., Zhang, Z. R., Guo, D. J. and Qin, M. M. (2020). Analysis of the correlation between the content of active components and antioxidant activity in longan/litchi tissues. Food Ind. 41(2): 344-348.

Ogundele, A. V., K. O. Otun, A. Ajiboye and B. Eunice. (2017). Antidiabetic efficacy and phytochemical screening of methanolic leaf extract of Pawpaw (Carica papaya) grown in North Central Nigeria. Journal of the Turkish Chemical Society4(1): 99-114.

Pokhrel, S. and Karki, P. (2021). Phytochemical Screening, Antioxidant and Antidiabetic Activities of Extracts of Leaves and Seeds of Carica papaya. Nepal Journal of Science and Technology. 20(1): 126–135.

Pulkkinen, K., Suomalainen, L. R., Read, A. F., Ebert, D., Rintamäki, P. and Valtonen, E. T. (2010). Intensive fish farming and the evolution of pathogen virulence: the case of columnaris disease in Finland. Proceedings of the Royal Society B: Biological Sciences. 277(1681): 593-600.

Thaipong K;Boonprokob, U; Crosby, K;Cisneros-zevallas, L and Byrne , D.H (2006). Comparison of ABTS, DPPH,FRAP and ORAC assays for estimating antioxidant activity from guava fruit extracts. Journal of food composition and analysis Vol 19 6-7 pages 669-675.

THE EFFECTS OF HONEY ON SOME REPRODUCTIVE INDICES OF *Oreochromis niloticus* (LINNAEUS, 1758)

[1]Maina, S.M., *[2]H.O. Sadiq, [1]M. Aliyu, [1]U.B. Wakili, and [1]M.Y. Diyaware

[1]Department of Fisheries, Faculty of Agriculture, University of Maiduguri, P.M.B 1069, Maiduguri, Nigeria
[2]Department of Fisheries, Aquaculture and Wildlife, Faculty of Agriculture, University of Abuja, P.M.B. 117, Abuja, Nigeria

Corresponding Author:
hauwa.sadiq@uniabuja.edu.ng, +2348034866267, 0009-0002-6095-6795

ABSTRACT
The reproductive performance of tilapia has been the subject of various tests to improve it. Despite their high prolificacy, there is currently no known supplement or ingredient to enhance reproduction in tilapia. However, honey has the potential to improve reproduction in animals, particularly the size of the offspring, which could be beneficial in aquaculture. This study investigated the effects of honey on certain reproductive indicators of *Oreochromis niloticus* broodstock. A total of 120 *Oreochromis niloticus* broodstock were placed in four 1.2 x 1.2 x 1.2 m deep enclosures stocked at ten fish per enclosure and installed in a 7 x 5 x 1.5 m deep polyethylene-lined fish pond. Different concentrations of honey were included in the enclosure at 0 (control), 1, 2, and 3 ml per 250 ml of water were added to a 30% crude protein powdered diet and pelletized. The various honey-based diets were given to the broodstock in the enclosures. The broodstock were fed with a honey-based diet for 30 days at 3% of their body weight twice daily. The results indicated a significant increase in the gonadosomatic index, fecundity rate, egg size, and testicular weight in the *Oreochromis niloticus* fed the 2ml honey inclusion level. This suggests that honey has the potential to improve reproduction in *Oreochromis niloticus*, thereby increasing Tilapia seed production without any adverse effects.

Keywords:
Nile tilapia, Broodstock, Honey, Improvement, Reproduction,

INTRODUCTION

Nile tilapia *(Oreochromis niloticus)* is among the most important aquaculture species, particularly in tropical and subtropical regions FAO (2020). The species' adaptability to different environmental conditions, such as low oxygen levels, resistance against harsh conditions, and easy production of fingerlings under captivity Gomez-Marquez *et al.* (2003) have contributed to its global aquaculture success. Nile tilapia are prolific breeders. They reach sexual maturity at about 5–6 months of age and reproduce multiple times a year under optimal conditions. Reproduction in Nile tilapia is largely driven by temperature, with breeding activities occurring in temperatures between 22°C and 30°C. Males construct nests for females to lay eggs, and the female incubates the fertilized eggs in her mouth (mouthbrooding) for protection. Studies show that environmental factors such as water quality, diet, and hormonal manipulation can affect reproductive performance. Each female tilapia can produce between 100 to 1,500 eggs per spawning, depending on her size.

Tilapia originates from the Nile Basin in Africa; The Nile tilapia is native to larger parts of Africa, except Maghreb and almost all of Southern Africa. It is native to the tropical West, the Lake Chad basin, and much of the Nile system (Tesfaye *et al.*, 2020). In Nigeria, the Nile tilapia is found in almost every water body including brackish waters. Nile tilapia has been introduced to over 100 countries across the globe for aquaculture purposes. It is now found in Asia, the Americas, and parts of Europe.

In Arab countries, honey is considered to increase human male potency. According to Zaid *et al.* (2021), the main role of honey is to enhance fertility and treat infertility problems by acting as an alternative to hormone replacement therapy for protecting the vagina and uterus from atrophy, protecting against the toxic effects of xeno-oestrogenic agents on female reproductive functions. Honey has been reported to increase sperm motility and spermatogenesis in rats and subnormal humans (Abdul-Ghani *et al.*, 2008; Abdelhafiz and Muhamad, 2008). Honey has beneficial effects on female fertility and it helps regulate reproductive hormones and protects reproductive tissues from damage caused by xenoestrogens (Zaid *et al.*, 2021).

The reproductive success of Nile tilapia *(Oreochromis niloticus)* is crucial for its sustainability and productivity in aquaculture systems. However, there is limited data on the reproductive indices, such as the gonadosomatic index (GSI), fecundity, and egg size, especially in environments affected by fluctuating in the environmental as a result of climate which affects the water quality, or the aquaculture practices. Understanding these indices is vital for optimizing tilapia breeding programmes, ensuring stock sustainability, and improving production yields. Honey has been tried to control reproduction. However, the full potential of the honey on the reproductive indices of the fish has not been fully exploited. This study thus investigated the effects of honey on some reproductive indices (gonadosomatic index, egg, size, testicular weight, and the fecundity of the O. *niloticus* under semi-arid conditions.

MATERIALS AND METHODS

Study Area

The study was conducted at the Teaching and Research Fish Farm of the Department of Fisheries, University of Maiduguri, Borno state, Nigeria. It lies between latitude 110511 N and longitude 130051 E. (PTN, 2015).

Preparation of Honey Solution

One liter of honey for this study was obtained from Bayisa Market in Kurmi Local Government Area, Taraba State, Nigeria. The honey was filtered of its comb through a nylon sieve of 0.2mm to obtain comb free solution. The filtered honey was kept in an airtight bottle until required.

Experimental Fish

One hundred and twenty (120) O*reochromis niloticus* broodstocks (145g; 11.5cm) were obtained from the Department of Fisheries, University of Maiduguri and were acclimatized in a net hapa (2 x 1.5 x 1.2m) installed in a polyethylene-lined fish pond (7x 5 x 1.5m) for one week. During the acclimatization period, the brood fish were fed a diet of 30% crude protein twice daily before the commencement of the experiment.

Experimental Diet

Using Pearson's square method, feed ingredients comprising of fishmeal, soybeans, maize, vitamins, cassava flour, and premix (table 1) were procured from a local market in Maiduguri. The soybeans were toasted in a locally fabricated soybean toaster (Odinga, 2012). The toasted soybean and maize were ground into powder separately using a grinding machine and thoroughly mixed to formulate a 30% crude protein diet.

Table 1: Composition of the Experimental Diet

Feed ingredients	Honey inclusion levels (ml)			
	0.0	**1.0**	**2.0**	**3.0**
Fish meal	28.83	28.83	28.83	28.83
Soybean meal	28.83	28.83	28.83	28.83
Maize flour	30.34	30.34	30.34	30.34
Honey	0.0	1.0	2.0	3.0
Methionine	0.5	0.5	0.5	0.5
Lysine	0.5	0.5	0.5	0.5
Sodium chloride	0.5	0.5	0.5	0.5
Ascorbic acid	0.5	0.5	0.5	0.5
Mineral Premix	1.0	1.0	1.0	1.0
Dicalcium	1.0	1.0	1.0	1.0
Cassava Flour	8.0	8.0	8.0	8.0
Proximate Composition (%)				
Crude protein	31.10	32.00	30.91	31.50
Crude fibre	4.77	4.72	4.75	4.76
Ash	12.92	12.95	12.85	12.94
Lipids	10.60	10.63	10.57	10.69
Moisture	5.16	5.60	5.73	5.68
ME	3193.130	3192.780	3192.780	3192.955

Experimental Design

Three honey solutions comprising 0 (control), 1, 2, and 3 ml were dissolved in 250 ml of water for each kilogram of the powdered 30% crude protein diet. The mixtures were thoroughly combined until the dough was formed. Each of the treatments was pelleted through a 2.0mm die using a flat die pelleting machine (Model: TOPS200C, China) separately. The different experimental diets were oven-dried at 70°C, cooled to room temperature, and packaged in zip polyethylene bags until required. Proximate analysis of the pelleted experimental diets was conducted according to AOAC (2000) methods to confirm their nutrient composition. One hundred and twenty Oreochromis niloticus broodstock were stocked into four hapas (1.2m3) installed in a polyethylene-lined fish pond (7 x 5 x 1.5 m deep) at the rate of 10 fish per hapa in a randomized design. The honey-based diet was fed to the fish at 3% of their body weight twice daily for 30 days. At the end of the 30-day rearing period, the following reproductive indices were determined for each treatment:

Gonadosomatic and Hepatosomatic index

Five (5) fish from each treatment were randomly collected to test the gonadosomatic index and hepatosomatic index (HSI) of O. niloticus gonads. The gonads and liver were removed and weighed using a sensitive scale. The gonadosomatic index for both males and females, as well as the hepatosomatic index, were calculated using the following formulas:

$$GSI(\%) = \frac{\text{Weight of gonads}}{\text{Weight of the fish}} \text{ x } 100$$

$$HSI(\%) = \frac{\text{Weight of liver}}{\text{Weight of the fish}} \text{ x } 100$$

Fecundity

Three female fish were collected from each of the treatments, and the egg sacs were removed, weighed, and preserved in 4% formaldehyde. The fecundity was determined following the procedure described by Shoko et al. (2015). The total number of eggs in the gonad from a single fish was calculated by using the following formula (Shoko et al., 2015):

$$F = \frac{Wges}{We}$$

Where E is the total number of eggs in a gonad, Wg is the weight of the gonad, es is the number of eggs in the sample, and we are the weight of eggs in the egg sample.

Egg size, Testicle weight, and Testicle length
The testicle was weighed using a sensitive weighing scale, and its length (left and right) was measured with a meter rule. The egg diameter was measured using a digital Vernier caliper.

Monitoring of Water Quality Parameters
The water quality parameters were monitored and recorded weekly. Temperature was monitored using a mercury-in-glass thermometer, while pH and dissolved oxygen were monitored using the Hach® Surface Water Test Kit.

Statistical Analysis
Data obtained were subjected to One-way Analysis of Variance (ANOVA). Differences between the means were determined using Fisher's Least Significant Difference (LSD) at a 95% confidence level (P=0.05) with the aid of statistics 8.0.

RESULTS

Table 2 presents some reproductive indices of *Oreochromis niloticus* broodstock fed honey-based. The gonadosomatic index was significantly higher (in males 1.24 and 4.51 for females) and 654.0 eggs, respectively, in fish fed 2ml honey, followed by those fed 1ml honey-based diet. Fecundity was higher in fish fed a 2ml honey-based diet, followed by fish treated with 1ml honey-based diet, while the least fecundity was the group fed with 3ml honey-based diet. Significant variations (P<0.05) were observed between the fecundity of O. *niloticus* broodstock fed a 2ml honey-based diet compared to the rest of the treatments.

Table 2: Some Reproductive Indices of *Oreochromis niloticus* Fed Honey-based diet

Parameters	Honey inclusion level ( )				SEM (p=0.05)
	0	1	2	3	
Gonadosomatic index male(g)	0.61^{c}	1.00^{b}	1.23^{a}	0.86^{b}	0.08^{*}
Gonadosomatic index female	2.54^{b}	4.02^{a}	4.51^{a}	3.06^{b}	0.24^{*}
Fecundity	425.33^{c}	516.00^{b}	654.00^{a}	423.67^{c}	38.07^{*}
Egg diameter (mm)	1.20^{b}	1.33^{ab}	1.60^{a}	1.20^{b}	0.15^{*}
Testes weight(g)	0.57^{c}	0.83^{b}	1.10^{a}	0.93^{b}	0.56^{*}
Left Testes Length (cm)	4.23^{c}	5.40^{a}	5.30^{ab}	5.00^{b}	0.17^{*}
Right Testes Length (cm)	4.10^{c}	5.10^{a}	5.07^{a}	4.70^{b}	0.11^{*}
Hepatosomatic index (g)	0.92^{c}	1.32^{a}	1.37^{a}	1.12^{b}	0.03^{*}

Mean in the same rows with different superscripts indicates significant differences (p < 0.05).
SEM = Standard error of means, NS = Not significant (P>0.05), *= significant (P<0.05).

The egg diameter and testes weight were better in brood fish fed a 2ml honey-based diet. There were significant differences (p<0.05) between the diameter compared to the control groups and those fed a 3ml honey-based diet. However, there were no significant variations (P>0.05) were observed between the testis's weight and length in fish fed with a 1ml honey-based diet compared to those fed a 2ml honey-based diet. Significant differences (P<0.05) exist between the hepatosomatic index of fish fed 1ml and 2ml honey-based diet compared to the control groups and those fed 3ml honey/kg of diet.

Water quality parameters
The water quality observed during the experiment was within the required culture range for O. niloticus. Temperature ranges were between 240C and 25.430C, while pH and dissolved oxygen were between 8 and 9.0 and 8 mg/l and 9 mg/l, respectively.

DISCUSSION

In this study, the gonadosomatic index (GSI) for male and female fish ranged from 0.12 to 2.38 and from 0.19 to 2.80, respectively. This is an improvement compared to the GSI of 0.12 to 2.38 for males and 0.19 to 2.80 for females reported by Oso *et al.* (2013) in Tilapia zilli (Coptodon zilli) from the Ero reservoir in South West Nigeria. However, the GSI of the fish falls within the general ranges of 2% to 10% reported by Bwanika et al. (2007) during the spawning season and the range of 1% to 3% suggested by Duponchelle and Panfili (1998) for non-improved O*reochromis niloticus*. Duponchelle and Panfili (1998) also noted that males typically have smaller gonads relative to their body size compared to females, which is consistent with the findings of this study.

The fecundity of O. *niloticus* fed honey-based diets is lower than the 921 eggs found by Urbano *et al.* (2024) eggs per matured O*reochromis mossambicus* collected from Laguna de Los Patos, Cumaná, Venezuela. The egg sizes reported in this study are lower than 1.36 to 2.04 mm and 1.32–2.20 mm observed by Shoko *et al.* (2015) in O. *niloticus* reared under monoculture and polyculture ponds, respectively, 1.00 3.00 mm reported by Gomez-Marquez *et al.* (2003) and 1.80–2.45 mm reported by Siraj *et al.* (1983), de Graaf *et al.* (1999) and Shalloof and Salama (2008). The variation in environmental conditions might have caused the variation. There were marked differences in the testes length of fish that were fed honey-based diets compared to the control in this study. The testes length recorded in this study is higher than the 2.50 reported in adult O. *niloticus* by Mair *et al.* (1991) but lower than the 16.50 and 12.70cm recorded by Muazu *et al.* (2020) in O. niloticus from the wild. These variations can be attributed to the difference in the body weight of fish.

The Hepatosomatic index in this study was significantly different for fish fed diets with honey compared to the control; however, those fed with 1ml and 2ml honey-based diets were not significantly different. These results were similar to those of Rahmi *et al.* (2023), who recorded HSI of 0.55 to 2.12% in Tilapia and concluded that the result indicated a good digestive system in the fish. They further stated that HIS values show the metabolic state of the fish.

CONCLUSION

The current study concludes that including up to 2ml honey in the diets of Oreochromis niloticus improved the reproductive indices and metabolic rates of the fish without any deleterious effects on them.

REFERENCES

Abdelhafiz A.T. and Muhamad J.A. (2008). Mid-cycle Pericoital Intravaginal Bee Honey and Royal Jelly for Male Factor Infertility. Journal of Gynecology and Obstetrics 101: 146- 149.

Abdul-Ghani A. S., Dabdoub N., Muhammad R., Abdul Ghani, R. and Quazzar M. (2008). Effects of Palestinian honey on spermatogenesis in rats. Journal of Medicinal Food, 11(4): 799 - 802.

AOAC, (2000). Official Methods of Analysis, Association of Official Analytical Chemists, Washington, DC, USA, 17th edition.

Babiker, M. M. and Ibrahim, H. (1979) Studies on the biology of reproduction in the cichlid Tilapia nilotica (L.): gonadal maturation and fecundity. J. Fish. Biol. 14:437–448

Bwanika, G.N., Murie, D.J. and Chapman, L.J. (2007). Comparative age and growth of Nile tilapia (Oreochromis niloticus L.) in lakes Nabugabo and Wamala, Uganda. Hydrobiologia 589: 287 – 301.

de Graaf G.J, Galemoni, F, and Huisman E. A. (1999) The reproductive biology of pond-reared Nile tilapia (Oreochromis niloticus L.). Aquacult. Res. 30:25–33

Duponchelle, F., & Panfili, J. (1998). Variations in age and size at maturity of female Nile tilapia, Oreochromis niloticus, populations from man-made lakes of Côte d'Ivoire. Environmental Biology of Fishes, 52(4): 453-465.

FAO (2020). Sustainability In Action World Fisheries and Aquaculture, Sustainability In Action. Food and Agriculture Organization of the United Nations Rome, pp.224.

Gómez-Márquez, J.L., Peña-Mendoza, B., Salgado-Ugarte, I.H. and Guzmán-Arroyo, M. (2003). Reproductive aspects of Oreochromis niloticus (Perciformes: Cichlidae) at Coatetelco Lake, Morelos, Mexico. Revista de Biología Tropical 51: 221 – 228.

Mair G. C., Scott A., Penman D. J., Beardmore J. A. and Skibinski D.O.F., (1991). Sex determination in the genus Oreochromis I: Sex reversal, gynogenesis, and Triploidy in O. niloticus L. Theoretical and Applied Genetics 82: 144 – 152.

Mashaiia, N., Rajabipoura, F. Mohammadia, M., Sarsangia, Bitarafa, A., Hossein-Zadehb, H, and Sharif-Rohanib, M. (2016). Reproduction of Nile tilapia, Oreochromis niloticus in brackish water. Journal of Applied Aquaculture 27(4),1–8 http://dx.doi.org/10.1080/10454438.2015.1104943.

Muazu, T.A., Sulaiman, M.H. and Hambolu, J. (2020). Comparative anatomy of wild adult tilapia (Oreochromis niloticus) testes during rainy and dry periods in Zaria, Nigeria. Sokoto Journal of Veterinary Sciences 18(3): 171 – 174.

Oso, J.A., Ogunleye, O.A. Idowu, E.O. and Majolagbe, F.A. (2013). Gonado-Somatic Index, Sex Ratio and Fecundity of Tilapia zilli in a Tropical Reservoir, South West Nigeria. Journal of Biology, 1(1), 42-45. www.scientific-journals.co.uk.

Rahmi, R., Akmal, A., Nisaa, K., Sudrajat, I., Relatami, A.N.R., Tampangallo, B.R. and Ikbal, M. (2023). Tilapia growth performance and body physical index given synbiotic feed at different salinities. IOP Conf. Series: Earth and Environmental Science 1137 (2023) 012029. doi:10.1088/1755-1315/1137/1/012029

Shalloof, K.A.S. and Salama, H.M.M. (2008). Investigations on Some Aspects of Reproductive Biology in Oreochromis niloticus (Linnaeus, 1757) inhabited Abu-zabal Lake, Egypt. Global Vet. 2(6):351–359

Shoko, A. P., Limbu, S. M., Mrosso, H. D. J. and Mgaya, Y. D. (2015). Reproductive biology of female Nile tilapia Oreochromis niloticus (Linnaeus) reared in monoculture and polyculture with African sharp tooth catfish Clarias gariepinus (Burchell). SpringerPlus, 4:275 Pp9. DOI 10.1186/s40064-015-1027-2.

Siraj, S.S., Smitherman, R.O., Castillo-Galuser, S. and Dunham, R. A. (1983) Reproductive traits for three-year classes of Tilapia nilotica and maternal effects on their progeny. In: Fishelson L, Yaron Z (eds) Proceedings of International Symposium on Aquaculture. Tel Aviv University, Israel, Nazaret, Israel, pp 210–218

Tesfaye, A., Fetahi, T. and Getahun, A. (2020). Food and feeding habits of juvenile and adult Nile tilapia, Oreochromis niloticus (L.)(Pisces: Cichlidae) in Lake Ziway, Ethiopia. Ethiopian Journal of Science 43(2): 88 – 96.

Urbano, T., Velásquezb, P., Lodeirosd, C. and Maeda-Martínez, A. N. (2024). Reproductive parameters of Oreochromis mossambicus in Laguna de Los Patos, Cumaná, Venezuela. Brazilian Journal of Biology 84: e282485 https://doi.org/10.1590/1519-6984.282485

Zaid, S.S.M., Ruslee, S.S. and Mokhtar, M. H. (2021). Protective Roles of Honey in Reproductive Health: A Review. Molecules 2021, 26 (3322). Pp15. https://doi.org/10.3390/ molecules26113322.

EFFECT OF TEMPERATURE AND FEEDING FREQUENCY ON GROWTH PERFORMANCE AND FEED UTILIZATION OF *Clarias gariepinus* FINGERLINGS

[1]Ekundayo, T.M., [2]S.O.E. Sadiku, [2]G.G. Bake, [2]A.M. Orire, [1]N.U. Ubana, [1]U,B. Eneche, and [1]A.U. Ohunene

[1]National Institute for Freshwater Fisheries Research, New Bussa.
[2]Department of Water Resources, Aquaculture and Fisheries Technology, Federal University of Technology, Minna.

*Corresponding author:numar2412@gmail.com, 07064528285, 07030232055.

ABSTRACT
The effects of temperature and feeding frequency on growth performance and feed utilization of *Clarias gariepinus* was evaluated in the study. Fish of mean weight of 10.23±0.60g were used for the experiments for 56 days (8 weeks). A factorial design of complete randomized in triplicate was used with 15 fish per treatment. Temperature (t) and feeding frequency (ff) treatments (T) were designated as T 1 (low temperature (15-17oC)/Once feeding daily, T2 (low temperature/twice feeding daily, T3 (low temperature/thrice feeding daily), T4 (high temperature (25°C-27°C)/thrice feeding daily), T5 high temp/twice feeding daily) and T6 (high temp/once feeding daily The results obtained indicated that temperature and feeding frequency interaction of treatment 4 has the highest growth response (43.22) while treatment 1 has the least growth response (26.02g). Water temperature interaction with feeding frequency (25°C-27°C/ thrice feeding) had positive influence on growth performance of SGR (2.76%/day) but low survival rate (67.00%). The optimum temperature of 25oC – 27oC) and thrice feeding daily is thus recommended to fish farmers

Keywords:
Frequency, temperature, catfish, feed utilization, survival

INTRODUCTION

Clarias gariepinus is nocturnal which feeds on living, as well as dead and animal matter. It is an omnivore but tends towards a more carnivorous diet. Over and underfeeding could be detrimental to the health of the fish and may cause a marked deterioration in water quality; reduced weight; poor feed utilization; and increased susceptibility to infection (Lawan *et al.*, 2017). This may also affect the specific growth rates and the efficiency of feed conversion as these have been observed to be directly related to feed ration and frequency (Dwyer *et al.*, 2002). Therefore, it is important to be able to predict the most favorable feeding frequency relative to the species and size of fish. When fish are fed at an appropriate feeding frequency, growth and survival are expected to improve because this regulates their feed intake in relation to their energy demand (Ajani *et al.*, 2011). Time of feeding and feeding frequency had been reported to affect feed intake and growth performance of fishes (Ali *et al.*, 2005).The temperature in the tropics varies from less than 10oC to over 40oC. Fish are exposed to the danger of hypothermia at lower temperatures and hyperthermia at higher temperatures.

MATERIALS AND METHODS:

The experiment on the effect of temperature and feeding frequency of *Clarias gariepinus* was conducted at the National Institute for Freshwater Fisheries Research (NIFFR) at New Bussa, Niger State. Effect of temperature and feeding frequency on *Clarias gariepinus*, this comprised of 6 Treatments; once, twice, thrice feeding at a conditioned temperature of high (25-27oC) with the aid of micro water heater and low (15-170C) with the aid of ice block respectively. The experiment has 6 treatments and designated as T6, T1 (once feeding in both high and low temperatures of the stocked bowl. T5 and T2 (Twice feeding for both high and low temperatures) and T4 and T3 (thrice feeding for both high and low temperatures) 3 x 2 factorial design completely randomized in triplicate; the numbers of units in this experiment were 18. Periodic cleanings were carried out with physico-chemical parameters were taken bi-weekly in accordance with American Public Health Association (APHA, 2022).

Biological evaluations

Evaluation of growth performance and nutrient utilization of Clarias gariepinus were determined using the following formulae according to Maynard et al. (1979) and Halver (2003).

Mean weight gain (MWG) MWG (g) = Mean Final Weight (MFW) – Mean Initial Weight (MIW)

Specific growth rate (SGR)

SGR (%) = In final weight (g) - In initial weight (g)/feeding period (day) x 100 ((Brown, 1957)

Feed conversion ratio (FCR)

(FCR) = Weight of feed fed (g)/weight gain (g) (Hardy and Barrows, 2003)

Protein efficiency ratio (PER) = Weight gain/protein consumed (Osborne et al., 1919)

Apparent net protein utilization (ANPU) Bender and Miller (1953), Miller and Bender (1955)

ANPU% = Carcass protein gain (g)/protein fed (g) x 100

Survival rate

Survival rate % = final number of fish stock/ Initial number of fish stocked x 100

Data analysis: Data were analyzed for variation using Minitab 19.0 (Stat Soft, Inc., Oklahoma, USA). Differences treatments were compared by Turkey's test multiple ranges. Level of significance at 5%

RESULTS

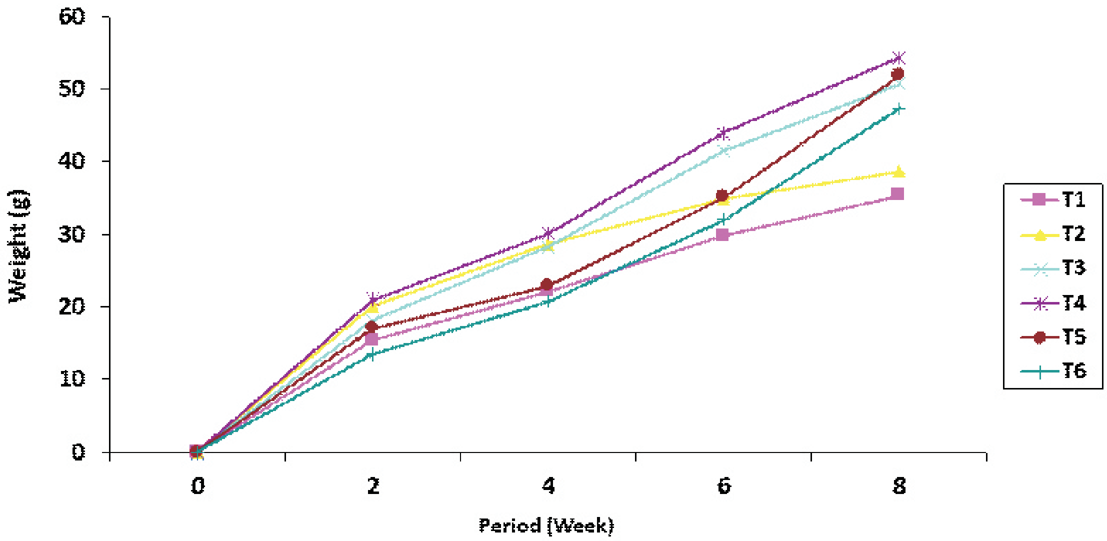
The table below shows the effect of temperature and feeding frequency on growth response and nutrient utilization of Clarias gariepinus fingerlings with significant differences ($p<0.05$) among treatments. The highest mean final weight of 43.22g was recorded for Treatment 4 (43.22g), followed by Treatment 3 (39.20g) while the least of 26.02g was recorded for Treatment 1 (Figure 1). There is a significant difference ($p<0.05$) between the mean weight gain (MWG) of Treatments, there is a difference ($p<0.05$) significant in specific growth rate (SGR), feed conversion ratio (FCR), and protein efficiency ratio (PER), and apparent net protein utilization (ANPU) among all the Treatments. A significant difference ($p<0.05$) in the survival rate of the fish among all Treatments was observed .

Table: Effect of Temperature and Feeding Frequency on Growth and Feed Utilization of *Clarias gariepinus*
Growth Parameters

Treatment	MIW (g)	MFW (g)	MWG (g)	SGR (%/day)	FCR	PER	ANPU (%)	SURVIVAL (%)
1	9.40±0.65	35.33±0.68b	26.02±1.56b	2.23±0.31bc	1.25±0.10ab	1.82±0.06ab	105.0±0.0cd	87.00±0.00a
2	11.78±0.57	36.29±4.11b	26.93±0.59b	2.00±0.24c	1.50±0.04a	1.53±0.24b	94.50±4.95	71.50±12.02ab
3	11.40±0.20	43.72±4,98ab	39.20±5.04a	2.52±0.25abc	1.13±0.02bc	2.22±0.03ab	134.00±2.83bc	66.50±9.19b
4	11.21±0.60	54.36±1.51a	43.22±2.33a	2.76±0.21ab	1.09±0.01bc	2.39±0.19a	137.67±8.02ab	67.00±0.00b
5	9.34±0.40	44.36±3.83ab	34.95±4.36ab	2.93±0.33a	0.87±0.08c	2.47±0.33ab	169.00±12.73a	57.67±4.04b
6	8.28±0.18	47.33±1.41ab	37.38±1.65a	2.98±0.10a	0.92±0.10c	2.51±0.43a	164.5±16.3ab	57.67±4.04b

Data with the same letter are not significantly different ($p>0.05$)

Key: Treatment 1; Low temperature once feeding, T2- Low temperature twice feeding, T3- Low temperature thrice feeding, T4- High Temperature thrice feeding, T5- High temperature twice feeding and T6- High Temperature once feeding.



Growth response for Temperature and Feeding frequency on *Clarias gariepinus* reared for eight weeks.

DISCUSSION

The experiment on effects of temperature and feeding frequency indicated significant differences in MWG, SGR, FCR, PER, ANPU and survival rate. This is in accordance with the report of Tucker et al. (2006) who recorded significant influence of temperature in the growth and survival of snapper. The highest MWG obtained in Treatment 4 (thrice feeding frequency/25°C-27°C) manifested influence of feeding frequency and temperature on weight gain. This showed that good growth performance is obtainable with high temperature, thrice feeding frequency while the highest ANPU value (169.00%) was obtained in Treatment 5 (twice feeding frequency/25°C-27°C) followed by Treatment 6 (Once feeding frequency/25°C-27°C) indicating good nitrogen utilization in the fish (164.50%). The fish performance with respect to ANPU indicates that NPU will be most effective with feeding frequency of once and twice in high temperature, interacting with feeding frequency as in this study.

CONCLUSION

The findings from the research revealed that temperature in the range of 25-27oC and at thrice feeding frequency will give the best result, with high mean weight gain of 43.22 g, SGR (2.76%/day) and survival rate (67.00%) rate of *Clarias gariepinus* fingerlings.

RECOMMENDATION

From the research, it can be recommended that, temperature (25oC – 27oC) at thrice feeding frequency should be practiced

REFERENCE

Ali, M. Z., Hossain, M. A. and Mazid, M. A. (2005). Effect of mixed feeding schedules with varying dietary proteinlevels on the growth of sutchi catfish, Pangasius hypophthalmus (Sauvage) with silver carp, Hypophthalmichthys moIitnx (Valenciennes) in Ponds. Aquaculture research, 36, p.627-634.

American Public Health Association (APHA) (2022). Standard methods for the examination of water and wastewater (24th ed.). American Water Works Association, 6, p.1516. awwa.org/publications.

Association of official Analytical Chemist, AOAC (2010). Official Methods of Analysis Heldrich Association of official Analytical Chemist, Virginia, U.S.A pp.1298.

Asuwaju, F. P., Onyeche , V. O., Ogubuebuna, K. E., Moradun, H. P. and Robert, E. A. (2014). Effect of feeding frequency on growth and survival rate of Clarias gariepinus fingerlings reared in plastic bowls. Journal of Fisheries and Aquatic Science, 9, p.425-429.

Bender, A.E. and Miller, D.S. (1953). A brief method of estimating net protein value. Biochemical Journal, 53(1) p.7.

Brown, M.E. (1957). Experimental Studies on growth. In: Hoar, W.S and D.J Randell (Eds.) Physiology of Fishes. Academic Press New York. pp.361-400.

Bruton, M. N. (1979). The food and feeding behavior of Clarias gariepinus (Pisces: Clariidae) in Lake Sibaya, South Africa, with emphasis on its role as a predator of cichlids." .The transactions of the zoological society of London, 35, p.47-114.

Dwyer, K.S., Brown, J. A., Parrish, C. and Lall, S. P. (2002). Feeding frequency affects food consumption, feeding pattern and growth of juvenile yellowtail flounder (Limanda ferruginea). Aquaculture, 123(1), P.279 - 292.

Halver, J. E. (2003). The vitamins. In Fish nutrition. Academic Press, pp.61-141.

Hardy, R.W., and Barrows, F.T. (2003). Diet formulation and manufacture. In Fish nutrition, Academic Press. pp.505-600.

Lawan I., Hassan, M. and Yusuf A. (2017). Effects of Feeding Frequency on Growth and Feed Efficiency of Rearing African Catfish (Clarias gariepinus, Burchell 1822) Fingerlings. ARC International Journal of Agribusiness Innovations, 4, p.1-8. www.africaresearchcorps.com

Maynard, L.A., Loosli, J.K.., Hintz, H.F. and Warner, R.G. (1979). Animal Nutrition, 7th ED., McGraw-Hill, New York, pp.602.

Miller, D.S. and Bender, A.E. (1955). The determination of the net protein utilization by a shortened method. British Journal of Nutrition, 9(4), p. 382-388.

Ajani, F., Bello, O. and Dawodu, M. (2011). The effects of feeding frequency on growth performance and nutrient utilization of clarias gariepinus fingerlings. African journal of agricultural research. 6(2), p.318-322.

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THE EFFECTS OF COLD-WATER TREATMENT ON THE NUTRITIONAL COMPOSITION OF *Moringa oleifera* LEAVES FOR AQUAFEED PRODUCTION

[1]Orire A. M., [1] S.H. Shafii, [1] U. Isah, and [2] A.O. Ricketts

[1] Department of Water Resources, Aquaculture and Fishery Technology, Federal University of Technology Minna, Niger State, Nigeria.
[2] Department of Fisheries and Aquaculture, Joseph Sarwuan Tarka University Markurdi, Benue State, Nigeria.

Correspondent Author:
abdullahiorire@gmail.com

ABSTRACT
The study examined the effects of cold water soaking on the proximate and antinutritional compositions of Moringa oleifera leaves. Moringa leaves were soaked for 0 (raw), 6, 12, 18, and 24 hours. Significant differences ($p<0.05$) were observed across treatments. Raw moringa leaves had the lowest crude protein (23.07%), while 12 hours of soaking gave the highest value of 42.83%. The anti-nutritional factors of saponin, flavonoid, alkaloid, and phenols were reduced significantly ($p<0.05$). In conclusion, soaking moringa leaves for 12 hours provides optimal nutrient composition for fish feed production.

Keywords:
antinutrients, fishmeal, alternative, fish Feedstuff

INTRODUCTION

Fishmeal is the most utilized animal dietary protein ingredient in aquaculture diets because of its high and balanced nutrients (Hasan, 2023; Pudney *et al.*, 2019). It is also a good source of essential fatty acids, digestible energy, macro and trace minerals, and vitamins, and generally acts as a feed attractant for most finfish species (Serra *et al.*, 2024). However, constantly rising prices of fishmeal, which is a direct result of depleted wild stocks, inconsistent supply and increased demand, have been driving the search for substitutes for decades (Ogunji *et al.*, 2021; Ouko *et al.*, 2022). Plant-based protein sources have been explored for their potential as replacements for fish meal but are limited for their anti-nutritional factors Serra *et al.*, 2024; Kheto *et al.*, 2024). Phytates decrease the availability of minerals and reduce protein digestion by the formation of phytic acid protein complex (Luz et al., 2024). Tannins have been reported to inhibit digestion, induce liver injury and lower growth performance in fish (Qiu et al., 2024; Xie et al., 2022).

Moringa oleifera, commonly referred to as the "Miracle Tree," is renowned for its exceptional nutritional and medicinal properties, particularly its leaves, which are rich in essential nutrients. The leaves of *Moringa* are noted for their high protein content, ranging from 14.80% to 24.50%, making them a viable protein source for animal diets (Barman *et al.*, 2021; Moyo *et al.*, 2011). *Moringa* leaves also contain a substantial amount of carbohydrates (59.19% to 71.46%) and crude fibre (17.81% to 24.72%), along with significant levels of bioactive compounds such as phenols, flavonoids, and carotenoids, known for their antioxidant properties (Ju *et al.*, 2019; Masitlha, 2024). These antioxidants help in combating oxidative stress, contributing to Moringa leaves' potential health benefits, which include anti-inflammatory and anticancer effects (Alasmari *et al.*, 2015; Mansour *et al.*, 2019).

To enhance the utility of Moringa as a feed ingredient, various processing methods have been explored like fermentation, heat, and enzymatic supplementation, which have been reported to reduce the levels of tannins, saponins, and phytic acid (Purkait & Dutta, 2020; Suharman *et al.*, 2022). Puspitasari *et al.* (2024) reported that fermentation using Aspergillus niger significantly decreases crude fibre and neutralises anti-nutritional substances, enhancing fish growth when included in their diets. Therefore, this research evaluated the effect of cold water soaking on the nutrient and anti-nutrient content of the Moringa oleifera leaves for potential use in aqua feed production.

MATERIALS AND METHODS

The materials used included pelleting machine, bowls, tap water, distilled water, sensitive weighing balance, *Moringa* leaves, spatula, test tubes, flasks and pipettes, digestion rack, furnace, burner, Markham's Distillation Apparatus, soxhlet solvent extractor and chemicals.

Experimental Site

This research was carried out at the laboratory of the Department of Water Resources, Aquaculture and Fisheries Technology, School of Agriculture and Agricultural Technology (SAAT), Federal University of Technology Minna, Niger State.

Collecting and Processing of *Moringa oliefera*

Moringa oleifera leaves were collected from Talba Farm in Minna, Niger State. Taxonomic keys were used to identify the plant. The leaves were collected and washed to remove dirt. The leaves were divided into four parts and soaked in cold water (room temperature 20-250C for 6 hours, 12 hours, 18 hours and 24 hours, respectively). The treated leaves were then air-dried. The treated leaves were ground into fine powder and analysed for proximate composition and anti-nutritional factors.

Proximate Composition of feedstuff

The Moisture, crude protein, crude lipid, crude fibre, and ash were analysed according to the official method of analytical chemists (AOAC, 2000).

Anti-Nutritional Factors Analysis

These phytochemical compounds were analysed for saponin, tannin, alkaloid and phenol according to the methods of Kashyap et al., (2022) and Sultana, (2020).

Statistical analysis:

Data collected from the study were subjected to a one-way analysis of variance (ANOVA) using Minitab release version 19. The mean separation was achieved by Tukey's test at 5% significance level.

RESULTS

The result for the proximate composition of raw moringa leaves (RMLM) and cold-water soaking (CWS) for varying durations (6hours-CWSM, 12hrs-CWSM, 18hrs-CWSM, 24hrs-CWSM) is expressed in Table 1. The crude protein content was significantly ($p<0.05$) highest in the 12-hour-soaked leaves (42.83% ± 0.28) and lowest in the raw leaves (23.07% ± 0.04) and the 24-hour-soaked leaves (24.84% ± 0.04). Crude lipid content was highest ($p<0.05$) in the 24-hour-soaked leaves (5.70% ± 0.01) and lowest in the 6-hour-soaked leaves (2.62% ± 0.01). Crude fibre content increased significantly ($p < 0.05$) with longer soaking times, from 2.33% ± 0.15 in raw leaves to 8.67% ± 0.19 in the 24-hour-soaked leaves. Ash content was highest ($p<0.05$) in the raw leaves (9.37% ± 0.04) and lowest in the 18-hour-soaked leaves (4.54% ± 0.04). The moisture content was significantly different ($p<0.05$) across all treatments, with the highest in the 12-hour-soaked leaves (10.10% ± 0.01) and the lowest in the 18-hour-soaked leaves (6.27% ± 0.02).

Table 1: Proximate Composition of *Moringa oleifera* Leaves Soaked in Cold Water at Different Times

Proximate (%)	RMLM	6H- CWSM	12H-CWSM	18H-CWSM	24H-CWSM
Crude protein	23.07±0.04[e]	40.90±0.18[b]	42.83±0.28[a]	36.83±0.08[c]	24.84±0.04[d]
Crude lipid	4.85±0.5[b]	2.62±0.01[e]	4.54±0.63[c]	3.70±0.01[d]	5.70±0.01[a]
Crude fibre	2.33±0.15[e]	3.26±0.20[d]	4.84±0.13[c]	6.31±0.02[b]	8.67±0.19[a]
Ash	9.37±0.04[a]	7.62±0.01[b]	6.09±0.00[c]	4.54±0.04[e]	5.97±0.04[d]
Moisture content	6.74±0.05[d]	9.72±0.02[b]	10.10±0.01[a]	6.27±0.02[e]	8.07±0.04[c]

Mean data with different letters in the same row are significantly different ($p<0.05$).
KEY: RMLM- Raw Moringa leave; 6h- CWSM= 6 Hours Cold Water Soaked Moringa; 12-CWSM= 12 Hours Cold Water Soaked Moringa; 18-CWSM= 18 Hours Cold Water Soaking Moringa; 24-CWSM= 24 Hours Cold Water Soaked Moringa

Table 2 indicates the anti-nutritional compounds found in Moringa oleifera leaf meal soaked at different times in cold water. The saponin content was significantly high ($p<0.05$) in the raw (39.75 %) and low in 24 hours cold water soaking. A similar trend was observed for flavonoids and phenols, respectively. The alkaloid content was significantly low ($p<0.05$) in treatment 4 (20.42 %) and high in treatment 1 (32.63 %), while treatment 1 was significantly high ($p<0.05$) in tannin (26.97 %) and in treatment 4 (14.42 %).

Table 2: Anti-nutrient Composition of *Moringa oleifera* Leaves Soaked in Cold Water at Various Times.

ANCs (%)	RMLM	6H- CWSM	12 H-CWSM	18h-CWSM	24H-CWSM
Saponins	39.75±0.30[a]	35.46±0.42[b]	25.25±0.04[c]	20.31±0.03[e]	23.53±0.55[d]
Tanins	26.97±0.03[a]	24.74±0.25[b]	15.47±0.42[d]	14.42±0.30[e]	16.45±0.14[c]
Flavonoids	35.64±0.44a	33.30±0.04[b]	24.27±0.10[c]	22.70±0.02[d]	21.37±0.45[e]
Alkaloids	32.62±0.51[a]	29.29±0.17[b]	25.87±0.12[c]	20.42±0.02[e]	23.31±0.16[d]
Phenols	38.25±0.31[a]	35.16±0.16[b]	31.61±0.15[c]	30.64±0.02[d]	29.87±0.20[e]

Mean data with different letters in the same row are significantly different ($p<0.05$).
Key:ANCs- Anti-nutritional Compounds; RMLM- Raw Moringa leave; 6h- CWSM= 6 Hours Cold Water Soaked Moringa ; 12-CWSM= 12 Hours Cold Water Soaked Moringa ; 18-CWSM= 18 Hours Cold Water Soaking Moringa ; WSM= 24 Hours Cold Water Soaked Moringa

DISCUSSION

The results of the proximate analysis of *moringa* leaves soaked in cold water for different durations (6, 12, 18, and 24 hours) showed significant variations in their nutrient content, indicating that soaking time influences the nutritional profile of the leaves. This aligns with findings from other studies on *moringa* processing and preparation methods. The increased crude protein content observed in the 12-hour-soaked leaves (42.83% ± 0.28) compared to the raw leaves (23.07% ± 0.04) suggests that soaking for intermediate durations may enhance protein concentration in *moringa* leaves. The higher protein content in the 12-hour-soaked leaves could be due to the partial leaching of non-proteinaceous components, thereby increasing the relative proportion of protein. This result is consistent with the findings of Perveen *et al.,* (2024), who reported higher protein levels in fermented *moringa* leaves. The observed decrease in protein content with longer soaking times (24 hours) could result from extended exposure to water, leading to the loss of soluble proteins and other nutrients. (Bakwo Bassogog *et al.,* 2022). The crude lipid content exhibited an inverse pattern, with the highest levels in the 24-hour-soaked leaves (5.70% ± 0.01) and the lowest in the 6-hour-soaked leaves (2.62% ± 0.01). This could be attributed to the prolonged soaking facilitating the removal of surface-bound lipids or the leaching out of water-soluble lipids. Sultana, (2020) similarly reported variability in fat content based on different drying conditions and ecological zones of *moringa l*eaves.

A significant increase in crude fibre from the raw leaves (2.33% ± 0.15) to the 24-hour-soaked leaves (8.67% ± 0.19) indicates that longer soaking times may help release more bound fibres due to the breakdown of cell wall structures. This trend is comparable to the findings by Perveen *et al.* (2024), who observed an increase in fibre content in *moringa* leaves in lactic acid fermentation. Conversely, the ash content (minerals) was highest in the raw leaves (9.37% ± 0.04) and decreased significantly with soaking time, reaching the lowest in the 18-hour-soaked leaves (4.54% ± 0.04); this could be due to the leaching of water-soluble minerals. This is consistent with Gharsallah *et al.*, (2023), who reported how different processing methods could influence the mineral content in *moringa* seeds and leaves. The highest moisture content in the 12-hour-soaked leaves (10.10% ± 0.01) and the lowest in the 18-hour-soaked leaves (6.27% ± 0.02), an intermediate soaking period could have allowed for maximal water absorption before the leaves started losing moisture or before other metabolic processes such as osmotic dehydration commenced, which could explain the decrease in moisture content at 18 hours. Bhattarai et al., (2024) similarly found variations in moisture content among moringa leaf protein concentrates extracted under different conditions.

The results on anti-nutritional compounds in *Moringa* oleifera leaves soaked in cold water indicated a significant reduction in the concentrations of saponins, tannins, flavonoids, alkaloids, and phenols. This aligned with the study of Perveen *et al.*, (2024), who reported a notable decrease in anti-nutritional compounds of saponins, tannins, alkaloids, and phenolic following lactic acid fermentation of Moringa oleifera leaves. Their results demonstrated that fermentation led to a 20-47% reduction in various anti-nutritional factors, suggesting fermentation's effectiveness; this study shows that soaking in water diminishes these compounds, thus enhancing the nutritional value of moringa leaves. The reduction in anti-nutritional compounds during soaking may be attributed to their solubility in water, which facilitates their leaching out from the leaves over time. Gharsallah *et al.*, (2023) noted that phytochemicals, including saponins, tannins, flavonoids, and phenolic compounds, are present in various parts of *Moringa oleifera*, and different processing methods, such as soaking, drying, or fermentation, can significantly alter their concentrations. High levels of phytochemical compounds can interfere with the absorption of essential nutrients, reduce protein digestibility, and exert toxic effects when consumed in large amounts (Chaudhary *et al.*, 2023). Therefore, soaking in cold water presents a practical, low-cost method to decrease these compounds, making Moringa oleifera leaves safer and more beneficial for dietary use.

Nugraha *et al.*, (2023) reported that nanosuspension extracts reduce anti-nutritional factors, as was observed in this study, that does not compromise the leaves' functional properties. Compared to lactic acid fermentation (Perveen *et al.*, 2024) and nanosuspension formation (Nugraha *et al.*, 2023), soaking in cold water offers a simpler and more accessible approach to reduce anti-nutritional factors. Fermentation can effectively reduce these compounds but requires controlled conditions and specific bacterial strains, making it less feasible for households or small-scale processing. Conversely, cold water soaking can be easily implemented without specialised equipment or expertise, making it a viable alternative for processing *Moringa oleifera* leaves.

CONCLUSION

The study demonstrates that cold water soaking of *Moringa oleifera* leaves improves the proximate composition and reduces anti-nutritional factors of *moringa* leaf meal.

Recommendations: 12-hour soaking period is recommended to achieve a balance between maximising protein content and reducing anti-nutritional factors in *Moringa* oleifera leaves for fish feed production

REFERENCE

Alasmari, A., Albalawi, S. M., Athar, T., Khan, A. Q., Al-Shahrani, H., and Islam, M. M. (2015). Moringa oleifera as an Anti-Cancer Agent Against Breast and Colorectal Cancer Cell Lines. Plos One. https://doi.org/10.1371/journal.pone.0135814

Bakwo Bassogog, C. B., Nyobe, C. E., Ngui, S. P., Minka, S. R., and Mune Mune, M. A. (2022). Effect of heat treatment on the structure, functional properties and composition of Moringa oleifera seed proteins. Food Chemistry, 384, 132546. https://doi.org/https://doi.org/10.1016/j.foodchem.2022.132546

Barman, K., Banik, S., THOMAS, R., Kumar, S., Das, A., Dutta, K. S., and Rajkhowa, S. (2021). Effect of Replacing Groundnut Cake with Dried Moringa oleifera Leaves on Growth and Nutrient Utilization in Crossbred (Hampshire × Ghungroo) Grower Pigs. The Indian Journal of Animal Sciences. https://doi.org/10.56093/ijans.v90i8.109298

Bhattarai, S., Katekhong, W., Klinkesorn, U., and Peanparkdee, M. (2024). Valorization of Bombyx mori pupae and Moringa oleifera leaf as sources of alternative protein: Structural, functional and antioxidant properties. Future Foods, 10, 100408. https://doi.org/https://doi.org/10.1016/j.fufo.2024.100408

Chaudhary, J., Jandu, S., Tailor, G., and Chetna. (2023). Green synthesis and characterization of iron nanoparticles using Moringa oleifera (Leaves) and their phytochemical screening with biological significance. Chemical Data Collections, 47, 101065. https://doi.org/https://doi.org/10.1016/j.cdc.2023.101065

Gharsallah, K., Rezig, L., Rajoka, M. S. R., Mehwish, H. M., Ali, M. A., and Chew, S. C. (2023). Moringa oleifera : Processing, phytochemical composition, and industrial applications. South African Journal of Botany, 160, 180–193. https://doi.org/https://doi.org/10.1016/j.sajb.2023.07.008

Hasan, I. (2023). Chitinase and Insect Meal in Aquaculture Nutrition: A Comprehensive Overview of the Latest Achievements. Fishes. https://doi.org/10.3390/fishes8120607

Hussain, M., Zhong, H., Hussain, K., Manzoor, M. F., Qayum, A., Liu, X., Xu, J., Hussain, A., Ahsan, H. M., and Guan, R. (2024). Emerging high intensity ultrasound for soymilk in boosting bioactivity, amino acids release, reducing anti-nutritional factors and allergenicity. Food Bioscience, 59, 104138. https://doi.org/https://doi.org/10.1016/j.fbio.2024.104138

Ju, A., Baek, S., Kim, S., and Song, K. Bin. (2019). Development of an Antioxidative Packaging Film Based on Khorasan Wheat Starch Containing Moringa Leaf Extract. Food Science and Biotechnology. https://doi.org/10.1007/s10068-018-00546-9

Kashyap, P., Kumar, S., Jindal, N., Guiné, R., Correia, P., Mehra, R., and Kumar, H. (2022). Recent Advances in Drumstick (Moringa oleifera) Leaves Bioactive Compounds: Composition, Health Benefits, Bioaccessibility, and Dietary Applications. Antioxidants. https://doi.org/10.3390/antiox11020402

Kheto, A., Manikpuri, S., Sarkar, A., Das, R., Bebartta, R. P., Kumar, Y., Bist, Y., Vashishth, R., and Sehrawat, R. (2024). How pulse electric field treatment affects anti-nutritional factors and plant protein digestibility: A concise review. Food Bioscience, 61, 104849. https://doi.org/https://doi.org/10.1016/j.fbio.2024.104849

Luz, G. M., Orlando, E. A., Rebellato, A. P., Greiner, R., and Pallone, J. A. L. (2024). Essential minerals and anti-nutritional compounds in plant-based burgers using the infogest in vitro digestion protocol. Journal of Food Composition and Analysis, 135, 106574. https://doi.org/https://doi.org/10.1016/j.jfca.2024.106574

Mansour, M., Mohamed, M. F., Elhalwagi, A., El-Itriby, H. A., Shawki, H. H., and Abdelhamid, I. A. (2019). Moringa Peregrina Leaves Extracts Induce Apoptosis and Cell Cycle Arrest of Hepatocellular Carcinoma. Biomed Research International. https://doi.org/10.1155/2019/2698570

Masitlha, E. P. (2024). Nutritional Composition and Mineral Profile of Leaves of Moringa oleifera Provenances Grown in Gaborone, Botswana. Food Production Processing and Nutrition. https://doi.org/10.1186/s43014-023-00183-8

Moyo, B., Masika, P. J., Hugo, A., and Muchenje, V. (2011). Nutritional Characterization of Moringa (Moringa oleifera Lam.) Leaves. African Journal of Biotechnology. https://doi.org/10.5897/ajb10.1599

Nugraha, A. P., Triwardhani, A., Sitalaksmi, R. M., Ramadhani, N. F., Luthfi, M., Ulfa, N. M., and binti Tengku Ahmad Noor, T. N. E. (2023). Phytochemical, antioxidant, and antibacterial activity of Moringa oleifera nanosuspension against peri-implantitis bacteria: An in vitro study. Journal of Oral Biology and Craniofacial Research, 13(6), 720–726. https://doi.org/https://doi.org/10.1016/j.jobcr.2023.09.004

Ogunji, J. O., Iheanacho, S., Mgbabu, C. C., Amaechi, N., and C. Evulobi, O. O. (2021). Housefly Maggot

Meal as a Potent Bioresource for Fish Feed to Facilitate Early Gonadal Development in Clarias Gariepinus (Burchell,1822). Sustainability. https://doi.org/10.3390/su13020921

Ouko, K. O., Mukhebi, A. W., Obiero, K., Opondo, F. A., Ngo'ng'a, C. A., and Ongor, D. O. (2022). Stakeholders' Perspectives on the Use of Black Soldier Fly Larvae as an Alternative Sustainable Feed Ingredient in Aquaculture, Kenya. African Journal of Agricultural and Resource Economics. https://doi.org/10.53936/afjare.2022.17(1).4

Perveen, S., Akhtar, S., Qamar, M., Saeed, W., Suleman, R., Younis, M., Ismail, T., and Esatbeyoglu, T. (2024). The effect of Lactiplantibacillus plantarum fermentation and blanching on microbial population, nutrients, anti-nutrients and antioxidant properties of fresh and dried mature Moringa oleifera leaves. Journal of Agriculture and Food Research, 18, 101366. https://doi.org/https://doi.org/10.1016/j.jafr.2024.101366

Pudney, A., Gandini, C., Economou, C. K., Smith, R. T., Goddard, P., Napier, J. A., Spicer, A., and Sayanova, O. (2019). Multifunctionalizing the Marine Diatom Phaeodactylum Tricornutum for Sustainable Co-Production of Omega-3 Long Chain Polyunsaturated Fatty Acids and Recombinant Phytase. Scientific Reports. https://doi.org/10.1038/s41598-019-47875-1

Purkait, T., and Dutta, N. (2020). Medicinal Uses and Effect of Different Processing Techniques (Blanching and Drying) of Drumstick Leaves (Moringa oleifera). Ijsr. https://doi.org/10.36106/ijsr/8734508

Puspitasari, C., Pinsirodom, P., and Wattanachaisaereekul, S. (2024). Effect of solid-state fermentation using Aspergillus oryzae and Aspergillus niger on bitter and bioactive compounds of Moringa oleifera seed flour. LWT, 207, 116616. https://doi.org/https://doi.org/10.1016/j.lwt.2024.116616

Qiu, J., Chen, B., Huang, W., Zhao, H., Hu, J., Loh, J.-Y., and Peng, K. (2024). Dietary condensed tannin exhibits stronger growth-inhibiting effect on Chinese sea bass than hydrolysable tannin. Animal Feed Science and Technology, 308, 115880. https://doi.org/https://doi.org/10.1016/j.anifeedsci.2024.115880

Serra, V., Pastorelli, G., Tedesco, D. E. A., Turin, L., and Guerrini, A. (2024). Alternative protein sources in aquafeed: Current scenario and future perspectives. Veterinary and Animal Science, 25, 100381. https://doi.org/https://doi.org/10.1016/j.vas.2024.100381

Suharman, I., Aryani, N., Hasan, B., Adelina, A., Lukistyowati, I., Raysha, L., Karo-Karo, R. M., and A. Caipang, C. M. (2022). Quality Evaluation of Moringa (Moringa oleifera) Leaves Fermented by Various Dosages of Aspergillus Niger as Ingredients for Fish Feeds. Iop Conference Series Earth and Environmental Science. https://doi.org/10.1088/1755-1315/1118/1/012019

Sultana, S. (2020). Nutritional and Functional Properties of Moringa oleifera . Metabolism Open. https://doi.org/10.1016/j.metop.2020.100061

Xie, Z., Wang, M., Deng, Y., Li, J., Li, J., Pang, W., Xie, L., Jiang, D., Huang, Z., He, T., and Yang, G. (2022). Acute toxicity of eucalyptus leachate tannins to zebrafish and the mitigation effect of Fe^{3+} on tannin toxicity. Ecotoxicology and Environmental Safety, 229, 113077. https://doi.org/https://doi.org/10.1016/j.ecoenv.2021.113077

NUTRITIONAL COMPOSITIONS OF RIPE AND UNRIPE WATERMELON RIND AND SEED: IMPLICATIONS FOR AQUACULTURE

Jackson, U. J., S. G. Solomon, and J. S. Jeiyol

Department of Fisheries and Aquaculture, College of Forestry and Fisheries, Joseph Sarwuan Tarka University Makurdi.

Corresponding Author:
ufonimajacks@gmail.com; +2348162232845; 0009-0004-2037-4525

ABSTRACT

This study determined the proximate compositions and amino acid profile of ripe and unripe watermelon rind and seeds. The rind and the seeds from ripe and unripe watermelon fruits (Kaolak variety) were oven dried at 600C to a constant weight and milled separately as T1 (ripe rind), T2 (unripe rind), T3 (ripe seed), T4 (unripe seed). Proximate composition and amino acid profile of the samples were done using standard methods and procedures. The results reveals that all proximate parameters differed significantly (P<0.05) between treatments. Crude protein and Ether were highest in T3 (17.95,15.42) and lowest in T2 (10.21, 4.12), respectively. The results showed that all the essential and non-essential amino acids tested differed significantly (P<0.05) between treatments. T1 recorded the highest levels of arginine, histidine, methionine and valine (11.65, 2.58, 1.57 and 4.36 respectively). T3 recorded the highest levels of leucine, phenylalanine, threonine and tryptophan (6.43, 4.55, 3.98 and 1.17 respectively), while T4 had the least values for histidine, leucine, methionine, phenylalanine, threonine, tyrosine and valine (2.12, 4.60, 1.27, 1.52, 1.12, 0.73 and 3.55 respectively). This study observed that the seed possessed higher crude protein and fat content values (both ripe and unripe) than the rind and that ripe materials (seed and rind) exhibited higher crude protein and fat contents than the unripe ones. The result also revealed that unripe rind had the least crude protein content while the unripe seed had the least score of essential amino acids and non-essential amino acids.

Keywords:
Watermelon, rind,
seed, nutrient composition

INTRODUCTION

Aquaculture production is a major industry (FAO, 2014) and in Nigeria, it continues to grow as the demand for fish products increases while the supply from the wild decreases. Nutrition plays a critical role in intensive aquaculture due to its influence on production cost, fish growth, health and waste production (Gatlin, 2002).

The importance of artificial feeding in aquaculture cannot be over-emphasized (Gabriel, *et. al.*, 2007), however, the high cost of fish feed and feed ingredients have significantly affected the development of this sector. This can be mitigated through the use of cheaper non- conventional feed ingredients in fish feed production.

Watermelon (Citrullus lanatus) belonging to the family Cucurbitaceae is a common fruit in Nigeria, known for its sweet and juicy pulp (Renner *et.al.*, 2014). The rind and the seed of this fruit are mostly discarded after consumption of the juicy pulp, thus constituting solid waste with its potential adverse implications on environmental and public health (Egbuonu, 2015). Therefore, the incorporation of watermelon rind and seed will not only solve this environmental waste problem, but will also provide cheap and readily available source of nutrients for fish nutrition, thereby lowering the cost of fish feed and ultimately reducing fish production cost.

This work was aimed at providing baseline information on the proximate composition and amino acid profiles of ripe and unripe watermelon rind and seed for the assessment of watermelon rind and seed as potential feedstuff.

MATERIALS AND METHODS

Collection and preparation of samples

Watermelon (Kaolak) fruits were purchased from railway market, Makurdi, Benue State. The fruits were brought to the nutrition lab of the department of fisheries and Aquaculture, University of Agriculture, Makurdi. The fruits were washed, cut open and the seeds and rind were removed. The rind and the seeds were weighed, oven dried at 600C to a constant weight and milled separately as T1 (ripe rind), T2 (unripe rind), T3 (ripe seed), T4 (unripe seed) and stored in airtight containers for further use.

Determination of proximate composition.

The moisture content was obtained by the difference between the fresh and dry weight of the samples, dried at 1050C to a constant weight. Protein was determined using the kjedahl method, fat by soxhlet method and Ash was obtained by incineration at 5500C according to the method of AOAC (2005).

Determination of Amino acid profile

In determination of amino acids, rind and seed samples were dried to a constant weight, defatted, hydrolysed, evaporated and loaded unto an amino acid analyzer as given by Benitez (1989).

Data Analysis

Data was analysed using R version 4.0 (R-Core-team 2020). Descriptive statistics were obtained using Rmisc package in R (Hope 2013). Data was subjected to a one-way ANOVA in R (R-Core-team 2020) and means seperation was achieved using the Turkey HSD method implemented in Multicomp package (Hothorn, *et.a*l., 2008).

RESULT AND DISCUSSION

The proximate compositions of ripe and unripe watermelon rind and seeds is shown in table 1. The results reveals that all parameters differed significantly ($P<0.05$) between treatments. Crude protein was highest in T3 (17.95) and lowest in T2 (10.21). Similarly, Ether extract was highest in the T3 (15.42) and lowest in T2 (4.12). Ash content also showed statistical difference between treatments, ranging from 3.11 in T3 to 12.61 in T2. crude fiber ranged from 13.36 (T4) to 18.20 (T2) with significant differences ($P<0.05$) between treatments.

Comparing between the seed and the rind, notwithstanding the stage of their ripeness, the seed possessed higher crude protein and ether extract values than the rind. When considering, ripening stage, ripening seems to affect the nutritional quality of the feed materials as ripe materials (seed and rind) portrayed higher crude protein and ether extract content than the unripe ones.

Proteins are among the most important constituents of all living cells and fish are able to derive more metabolizable energy from the breaking down of proteins than from carbohydrates (Tacon, 1987).

Although all the experimental materials (rind and seeds) can be properly classified as energy supplements due to their crude protein content of less than 20% and fiber content of less than 18% (NRC,1993), they

have a substantial amount of crude protein and other nutrients that can aid fish growth.
Lipids serve as an important source of dietary energy for all fish (NRC, 2011). Ether extract shows the fraction of crude lipid in the materials, thus a high ether extract content in the seeds predicts the use of watermelon seeds as oil seeds and in meeting the lipid requirement of fish.
Ash represents the mineral elements and other inorganic residue in the material analyzed (Harris and Marshall, 2017), thus a higher ash content in the rind than the seeds predict a higher mineral content in the rind than the seeds.
This study is in line with the reports of Solomon et.al., (2023), Abdulazeez, et.al., (2020), Gav et.al., (2019), Zubairu,et.al.,(2018) who reported in their various works that the seeds of watermelon contained higher levels of crude protein and lipids than the rind.

Table 1: Proximate compositions of Ripe and Unripe watermelon Rinds and Seeds.

Treatments	T1	T2	T3	T4	P-Value
Crude protein %	13.85 ± 0.04^{b}	10.21 ± 0.20^{a}	17.95 ± 0.56^{c}	14.41 ± 0.40^{b}	0.0005
Ether Extract %	4.30 ±0.10^{a}	4.12 ± 0.03^{a}	15.42 ± 0.13^{c}	12.99 ± 0.10^{b}	2.4×10^{-7}
Ash %	10.87 ± 0.41^{b}	12.61 ± 0.03^{c}	3.11 ± 0.04^{a}	3.13 ± 0.06^{a}	9.77×10^{-6}
Crude Fiber %	17.48 ± 0.42^{c}	18.20 ±0.20^{c}	15.55 ± 0.16^{b}	13.36 ± 0.12^{a}	0.0006
Moisture %	9.51 ± 0.09^{b}	6.90 ± 0.09^{a}	5.36 ± 0.10^{a}	6.65 ± 0.60^{a}	0.0031
NFE %	43.99 ±0.78^{ab}	47.95 ± 0.32^{bc}	42.60 ± 0.42^{a}	49.46 ± 1.17^{c}	0.0083

*Means on the same row with different superscript differ significantly ($P < 0.05$).
Key: T1 = Ripe Rind; T2= Unripe Rind; T3= Ripe Seed; T4 = Unripe Seed; NFE = Nitrogen Free Extract

Table 2 shows the essential amino acid profile of ripe and unripe watermelon rinds and seeds. From the results, it was observed that all the essential amino acids differed significantly ($P<0.05$) between treatments. The results showed that T1 recorded the highest levels of arginine, histidine, methionine and valine (11.65, 2.58, 1.57 and 4.36 respectively). T3 recorded the highest levels of leucine, phenylalanine, threonine and tryptophan (6.43, 4.55, 3.98 and 1.17 respectively). T2 had the highest value of lysine (6.06) while T4 had the highest level of isoleucine (4.10). Table 2 also indicated that T4 had the least values for histidine, leucine, methionine, phenylalanine, threonine, tyrosine and valine (2.12, 4.60, 1.27, 1.52, 1.12, 0.73 and 3.55 respectively). This result indicates that the ripe rind and ripe seeds recorded the highest values in 4 essential amino acids each. This result also reveals that unripe seed had the least score of essential amino acids with the lowest values for 7 out of the 10 essential amino acids. This indicates that ripening may improve nutritional quality of the watermelon fruit, as ripe rind and seed gave better essential amino acids score than the unripe counterparts. This trend may vary depending on the type of fruit tested. For instance, Rajan, et.al., (2014) observed that unripe kundang fruit (Plum mango) possessed higher crude protein, lipid, crude fiber and essential amino acids contents than the ripe fruits.
The present study is similar to the work of Solomon et.al., (2023) who summized that both watermelon rinds and seeds are good sources of protein, fat and essential and non-amino acids. This result is also in line with the report of Ojogba and Uduma (2019) who concluded that watermelon seeds from different varieties tested, were good sources of essential and non-essential amino acids.
However, the result of this study is at variance with the reports of Egbuonu, (2015) who recorded a

Table 2: Essential Amino Acid Profile of Ripe and Unripe watermelon Rinds and Seeds in g/100g protein.

Amino Acid g/100g	T1	T2	T3	T4	P-Value
Arginine	11.65 ± 0.05c	8.96 ± 0.01^{a}	11.03 ± 0.01^{c}	9.64 ± 0.00^{b}	7.28×10^{-7}
Histidine	2.58 ± 0.03^{c}	2.44 ± 0.01^{b}	2.51 ± 0.02^{c}	2.12 ± 0.01^{a}	0.0003
Isoleucine	3.85 ± 0.05^{a}	3.97 ± 0.02^{ab}	3.95 ± 0.01^{ab}	4.10 ± 0.01^{b}	0.0144
Leucine	5.70 ± 0.10^{b}	4.70 ± 0.03^{a}	6.43 ± 0.01^{c}	4.60 ±0.01^{a}	4.55×10^{-5}
Lysine	3.58 ± 0.04^{a}	6.06 ±0.01^{d}	3.78 ± 0.01^{b}	4.94 ± 0.01^{c}	3.26×10^{-7}
Methionine	1.57 ±0.02^{b}	1.35 ± 0.01^{a}	1.53 ± 0.01^{b}	1.27 ± 0.01^{a}	0.0005
Phenylalanine	4.50 ±0.02^{b}	1.73 ± 0.04^{a}	4.55 ± 0.15^{b}	1.52 ±0.01^{a}	1.61×10^{-5}
Threonine	3.32 ± 0.03^{b}	1.26 ± 0.01^{a}	3.98 ± 0.03^{c}	1.12 ±0.01^{a}	1.19×10^{-7}
Typtophan	1.07 ±0.01^{d}	0.80 ± 0.01^{b}	1.17 ± 0.03^{c}	0.73 ±0.03^{a}	3.10×10^{-6}
Valine	4.36 ± 0.01^{b}	3.90 ±0.01^{a}	4.34 ±0.01^{b}	3.55 ±0.25^{a}	0.0272

*Means on the same row with different superscript differ significantly ($P < 0.05$).
Key: T1 = Ripe Rind; T2= Unripe Rind; T3= Ripe Seed; T4 = Unripe Seed

Table 3 reveals the non-essential amino acid profile of ripe and unripe watermelon rinds and seeds. The results indicates that all non-essential amino acids varied significantly between treatments. Proline, cystine, glutamic acid, serine and aspartic acid were highest in T3 (3.26, 1.42, 17.80, 3.78 and 8.96 respectively). T2 had the highest levels of alanine and glycine (6.25 and 5.74 respectively) while T1 gave the highest value of tyrosine (3.90).
T4 gave the the least values of proline, tyrosine, cystine, glutamic acid and serine (1.02, 2.60, 0.86, 13.94 and 2.02 respectively).
The results reveals that most (5 out of 8) of the non essential amino acids were highest in the ripe seeds and lowest in the unripe seeds.

Table 3: Non-Essential Amino Acid Profile of Ripe and Unripe watermelon Rinds and Seeds in g/100g protein.

Amino Acid g/100g	T1	T2	T3	T4	P-Value
Proline	3.03 ± 0.02^{c}	1.14 ± 0.01^{b}	3.26 ± 0.00^{d}	1.02 ± 0.00^{a}	4.65×10^{-8}
Tyrosine	3.90 ± 0.01^{d}	2.76 ± 0.01^{b}	3.75 ± 0.03^{c}	2.60 ± 0.03^{a}	3.15×10^{-6}
Cystine	1.23 ± 0.01^{b}	0.86 ± 0.01^{a}	1.42 ± 0.03^{c}	0.86 ± 0.01^{a}	6.17×10^{-5}
Alanine	4.30 ± 0.10^{a}	6.25 ± 0.05^{c}	4.75 ± 0.05^{b}	5.93 ± 0.01^{c}	6.30×10^{-5}
Glutamic acid	16.79 ± 0.02^{c}	14.64 ± 0.01^{b}	17.80 ± 0.01^{d}	13.94 ± 0.00^{a}	1.49×10^{-8}
Glycine	3.20 ± 0.01^{a}	5.74 ± 0.01^{d}	3.72 ± 0.01^{b}	5.54 ± 0.00^{c}	2.61×10^{-8}
Serine	3.40 ± 0.10^{b}	3.23 ± 0.01^{b}	3.78 ± 0.00^{c}	2.02 ± 0.01^{a}	6.55×10^{-5}
Aspartic acid	7.70 ± 0.01^{c}	5.56 ± 0.01^{a}	8.96 ± 0.03^{d}	6.58 ± 0.0^{b}	8.55×10^{-8}

Figure 1 shows the proximate compositions of the Ripe and Unripe watermelon Rinds and Seeds in comparison to that of Maize meal. The graph reveals that all the watermelon rind and seed tested, had better crude protein, lipid, ash and crude fibre than maize meal.

Figures 2 and 3 show the essential and non-essential amino acids of the Ripe and Unripe watermelon Rinds and Seeds in comparison to that of Maize meal respectively. The result reveals that all the watermelon samples had higher values of arginine, isoleucine and lysine than maizemeal and comparable values of histidine, isoleucine, methionine and tryptophan with maizemeal.

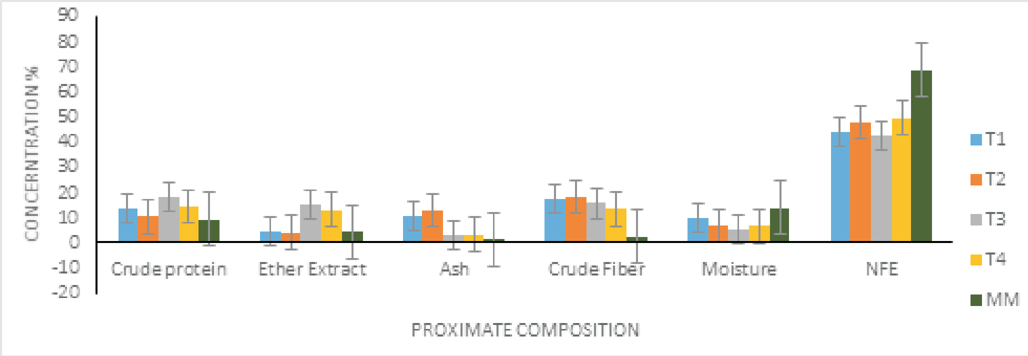

Figure 1: Graphical comparison between the proximate compositions of Maize meal (Heuzé et.al., 2017) and Ripe and Unripe watermelon Rinds and Seeds

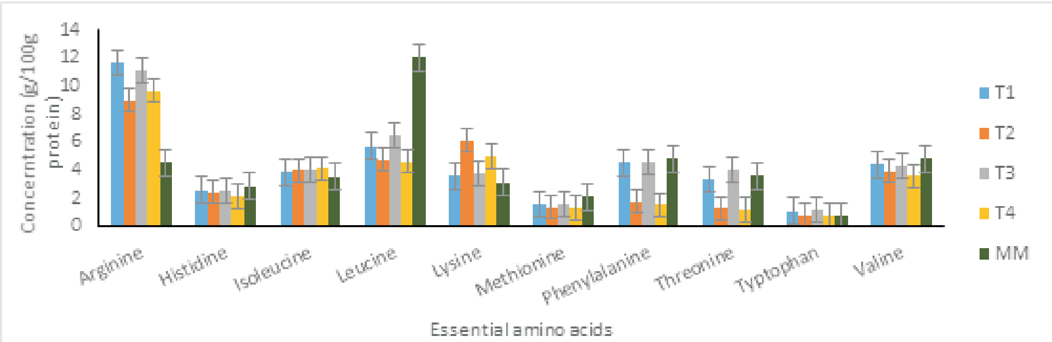

Figure 2: Graphical comparison between the Essential Amino Acids of Maize meal (Heuzé et.al., 2017) and Ripe and Unripe watermelon Rinds and Seeds

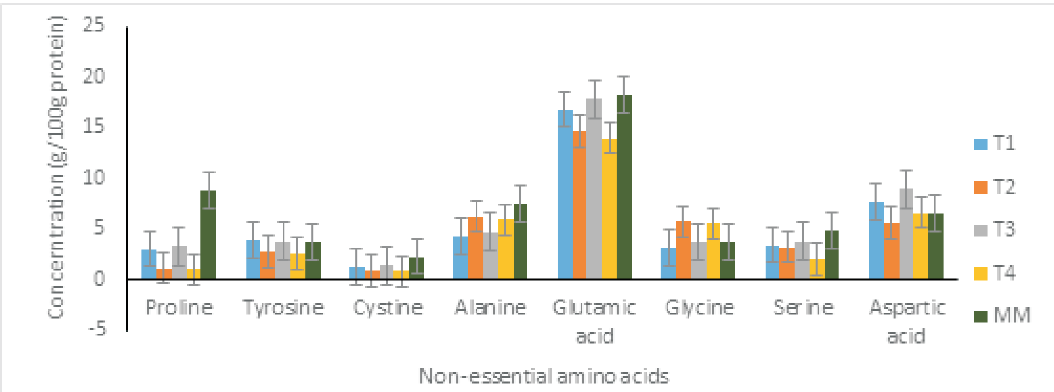

Figure 3: Graphical comparison between the Non-Essential Amino Acids of Maize meal (Heuzé et.al., 2017) and Ripe and Unripe watermelon Rinds and Seeds

CONCLUSION

All the feed materials under study (unripe and ripe seeds and rinds) can be properly classified as energy supplements due to their crude protein content of less than 20% and fiber content of less than 18%. This study concludes that although all the 4 tested feed materials are viable sources of nutrients, ripe rinds and ripe seeds are recommended for best results in feed formulation and production. This recommendation is however subject to further investigations including, determination of anti-nutritional factors and feeding trials to ascertain the acceptability and digestibility of the feedstuff.

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REFERENCES

Abdulazeez A., Abdullahi U., Audu S.S., Ibrahim I.L, Kwokwu S.I., Gimba A., Umaru M.T., Babatunde J., and Uthman A. (2020) Proximate composition of rind and seed of watermelon (Citrullus lanatus L). African Journal of Environment and Natural Science Research 3 (1), 24-31pp

AOAC (Association of Official Analytical Chemists International) (2005) Official Methods of Analysis. 18th Edition, Maryland, USA.

Benitez, L.V. (1989) Amino Acid and fatty acid profiles in aquaculture nutrition studies, pp 23-35 In: De Silva, S. S. (edited), Fish Nutrition Research in Asia, Proceedings of the Third Asian Fish Nutrition Network Meeting, Asian fish Society Special Publication, Asian Fisheries Society, Manila Philippines 4: 166pp

Egbuonu, A. C. C. (2015). Comparative Assessment of some Mineral, Amino Acid and Vitamin Compositions of Watermelon (Citrullus lanatus) Rind and Seed. Asian Journal of Biochemistry, 10, pp 230-236.

FAO (2014) The State of World Fisheries and Aquaculture: Opportunities and challenges. Fisheries and Aquaculture Department, Rome p223.

Gabriel, U. U., Akinrotimi, O. A., Bekibele, D. O., Onunkwo, D. N., and Anyanwu, P. E. (2007) Locally produced fish feed: potentials for aquaculture development in subsaharan Africa," African Journal of Agricultural Research, 2 (7), pp 287-295.

Gatlin, D.M. (2002) Nutrition and Fish Health. In: Halver, J.E. and Hardy, R.W. (Eds), Fish Nutrition, 3rd Edition, Academic Press, London, pp671-702.

Gav, B. L., Anyanwu, S. N., Oloruntoba, S. O., and Tor, R. (2019). Proximate and mineral analysis of water melon sold at North Bank Market Makurdi Nigeria. Global Journal of Science Frontier Research, 19(1), pp34-40.

Harris, G. K., and Marshall, M. R. (2017). Ash analysis. Food analysis, pp 287-297.

Heuzé, V., Tran, G. and Lebas, F. (2017) Maize grain. Feedipedia, a programme by INRAE, CIRAD, AFZ and FAO. http://www.feedipedia.org/node/556. Last updated on September 7, 2017, 14:29. Retrieved on August 2, 2024

Hope, R. M. (2013). Rmisc: ryan miscellaneous. R package version, 1(5), p5

Hothorn, T., Bretz, F., and Westfall, P. (2008). Simultaneous inference in general parametric models. Biometrical Journal: Journal of Mathematical Methods in Biosciences, 50(3), pp346-363

NRC (National Research Council) (1993) Nutrient Requirements of Fish. National Academy of Sciences, Washington, DC, USA. p114

NRC (National Research Council) (2011) Nutrient Requirements of Fish and Shrimp. National Academies press. Washington, DC, USA p138

Ojogba, J. A., and Uduma, A. U. (2019). Comparative study of amino acid composition in the different varieties of watermelon (Citrullus vulgaris) seeds sold in kano metropolis, Nigeria. FUDMA Journal of Sciences, 3(3), pp621-625.

Rajan, N. S., Bhat, R., and Karim, A. A. (2014). Preliminary studies on the evaluation of nutritional composition of unripe and ripe 'Kundang'fruits (Bouea macrophylla Griffith). International Food Research Journal, 21(3), pp985-990.

R-Core-team. (2020). RA language and environment for statistical computing, R Foundation for Statistical. Computing.

Renner, S. S., Chomicki, G., and Greuter, W. (2014). Proposal to conserve the name Momordica lanata (Citrullus lanatus) (watermelon, Cucurbitaceae), with a conserved type, against Citrullus battich. Taxon, 63(4), p2313

Solomon, S.G., Jackson, U.J., Obatanmi, S.W., Kwaghvihi, O.B., Dauda, A. B., Ikhwanuddin M. and Okomoda, V.T. (2023). Proximate and Amino Acid Profiles of Seed and Rind of Three Varieties of Watermelon and their Implications For Fish Nutrition. Nigerian Journal of Fisheries. 20, pp2708 - 2717.

Tacon, A. G. J (1987) The essential nutrients-Proteins and Amino acids. In: The nutrition and feeding of farmed fish and shrimp - a training manual 1. Fisheries and Aquaculture Department, Food and Agriculture Organization of the United Nations. Brasilia, Brazil.p.117.

Zubairu, A., Gimba, A. S., Mamza, W. J., and Highina, B. K. (2018). Proximate analysis of dry watermelon (Citrullus lanatus) rind and seed powder. Journal of Scientific and Engineering research, 5(3), pp473-478.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

FISHERIES POSTHARVEST TECHNOLOGY, PRODUCT DEVELOPMENT AND VALUE ADDITION (FPTV)

EFFECT OF PICKLE CURING ON HETEROCLARIAS *(Clarias gariepinus ♀ × Heterobranchus bidorsalis♀)* DURING AMBIENT STORAGE

[1]Ayeloja, A. A., [1]S. A. Ismaila and [2]O. O. Bakinde

[1]Department of Fisheries, Aquaculture and Wildlife, Faculty of Agriculture, University of Abuja PMB 117 Abuja Nigeria
[2]Department of Aquaculture and Fisheries, Faculty of Agriculture, University of Ilorin, PMB 1515 Ilorin, Kwara State Nigeria

Corresponding Author:
ayeloja2@gmail.com, ayeloja.ahmed@uniabuja.edu.ng, 0000-0002-1978-1762

ABSTRACT
Effect of pickle curing on Heteroclarias during ambient storage was studied. Muscle pH, conductivity, fish weight and microbiological quality changes that occured during pickle curing when stored at ambient temperature (27+3°C) were assessed. Samples of fish were collected on Day 15, 29, 43, 57, 71 and day 84. The conductivity of pickle cured Heteroclarias increased significantly ($p<0.05$) within the first 28 days of storage after which an irregular pattern was observed while no significant change ($P>0.05$) was observed in the average weight of the fish for 84 days. However, the microbial quality of the pickle cured fish showed that it was good for human consumption throughout the period of storage (84 days). Pickle curing method of fish preservation is therefore recommended for elongation of the shelf-life of fish, especially in communities where steady electricity supply is a challenge.

Keywords:
Fish preservation,
Pickle curing, Heteroclarias,
Ambient storage

INTRODUCTION

Global fish consumption has increased in recent years. While 88% of global fish output is consumed by man, 44% of these fishes are consumed in fresh or frozen form (Umer *et al.*, 2022). High consumption rate of fish could be due to its easy accessibility and affordability (Adeyeye *et al.*, 2015). Ayeloja (2019), reported that fish is an important food in the world today due to its high-quality protein, presence of polyunsaturated fatty acids, vitamins, minerals, fats, and it is highly digestible. Despite the usefulness of fish, it is a highly perishable food product, its quality deteriorates rapidly during handling and storage thereby limiting the shelf life of the product (Sallam, 2007). Fish freshness is lost shortly after death due to autolytic and microbial spoilage (Ayeloja *et al.*, 2020; Dehghani *et al.*, 2018). In tropical regions, conservation of fresh fish remains a problem because of the lack of adequate infrastructures environmental and climatic conditions that contribute to its spoilage within few hours (Anihouvi *et al.*, 2012). To prevent fish spoilage and reduce postharvest losses, various preservation methods including: frying, fermentation, drying, salting, and smoking are used (Ayeloja *et al.*, 2021; Ikutegbe and Sikoki, 2014). Salting as a means of fish preservation is gaining more popularity in recent times due to lack of social amenities such stable electricity in many developing countries (Alsaban et al., 2014). Thorarinsdottir *et al.* (2011), on the other hand define salting as a traditional method that uses osmotic pressure to cause cell rupture of bacteria in order to inhibit or kill pathogenic and spoilage bacteria. It is used to maintain food quality and prolong the shelf-life of food, such as fish that are difficult to preserve and easily spoilt. Giuffrida *et al.* (2017), also stated that salting is one of the oldest, most frequently used preservative; and fish preservation method used worldwide. The technique impact positively on fish taste, it is less costly and it requires little technical knowhow. However, there is dearth of information on the use of pickle curing method of fish preservation in elongating the shelf life of heteroclarias which is one the fish that is mostly cultured in the study area thus the need for this study which is aimed at providing baseline information on the effect of pickle curing on fish stored at ambient temperatures.

MATERIALS AND METHODS

Sample collection

Thirteen (13) samples of Heteroclarias were collected by dragging with a drag net from an earthen pond at Asa-Dam Road, Ilorin, Kwara State Nigeria. The samples were then conveyed using sterile polythene nylon to the Faculty of Agriculture Central Laboratory, University of Ilorin, Ilorin Kwara state within 48 minutes.

At the laboratory, the fish were gutted by opening the belly and remove the intestine and washed under running water after which the initial microbial load of the samples were assessed for the microbial analysis carried out includes Total viable count, Total fungal count, Total coliform count, Total mesophilic count, Total psychrophilic count following standard experimental procedures as described by Olutiola *et al.* (1991); Fawole and Osho (1995). Thereafter, Pickle curing (wet salting) method of fish preservation was done by collecting 7 litres of clean water which was put in a clean plastic container, after which 13 heteroclarias were put in the water. Thereafter, a muslin cloth containing 7kg of salt (making 1:1 water to salt) which allows free flow of water to create an isotonic solution of a high salt-water concentrate was inserted; the salt dissolved till saturation in the container was done while the remaining salt remain in the muslin clothe till the end of the experiment. The fish was kept in this state at ambient temperatures (27+3 oC) throughout the period of this study (84 days).

Sample Collection:

Samples were collected at every fortnight (0, 14, 28, 42, 56, 70 and 84 days) for 84 days for physicochemical (pH, conductivity and average weight) and microbiological quality changes (Total volatile count (TVC), Total mesophilic bacteria count (TMBC), Total psychrophilic bacteria count (TPBC), Total coliform count (TCC) and Total fungal count (TFC).

Statistical Analysis

Microbiological data obtained were logarithmically transformed (log cfu/g) and then subjected to Analysis of Variance (ANOVA) while means of the significantly different indices were separated using Duncan Multiple Range Test (DMRT) at $p < 0.05$.

RESULTS AND DISCUSSION

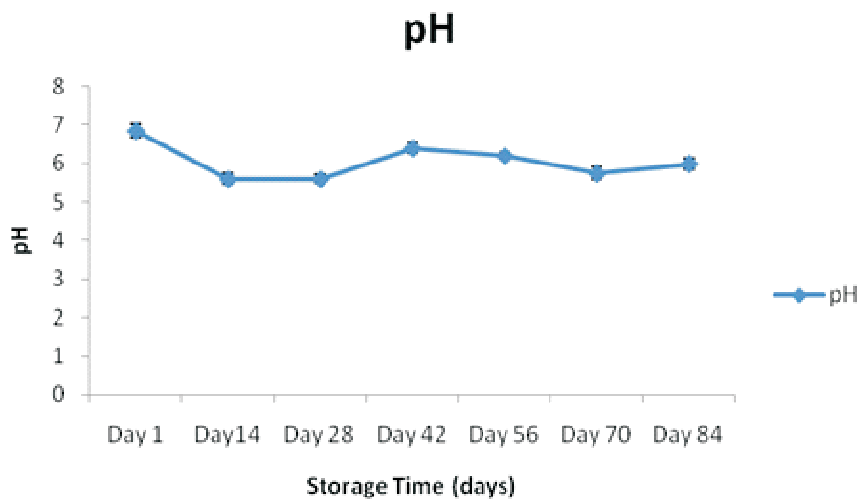


Fig 1: pH of pickle curing (wet salting) on Heteroclarias during ambient storage

The pH of wet salted fish (Fig. 1) did not follow a regular pattern. similar result was observed by Binici and Kaya (2018), who reported that there was no regular increase or decrease in the pH measurements of chub (Squalius cephalus) when brine and dry salting methods of preservation were adopted. The pH range observed in this study (5.6 - 7.0) is similar to that reported by Al-Asous and Al-Harbi (2016) who reported a pH range of 5.6 to 6.2 for salted fish that was stored at ambient temperature. pH value is used as an indicator of degree of freshness or spoilage of a fish. In the case of a fresh fish, the pH is close to neutral, while it decreases as the level lactic acid formation increases due to the conversion of glycogen present in the fish muscle into lactic acid in the absence of oxygen (fish muscle enzymes are responsible for these activities).

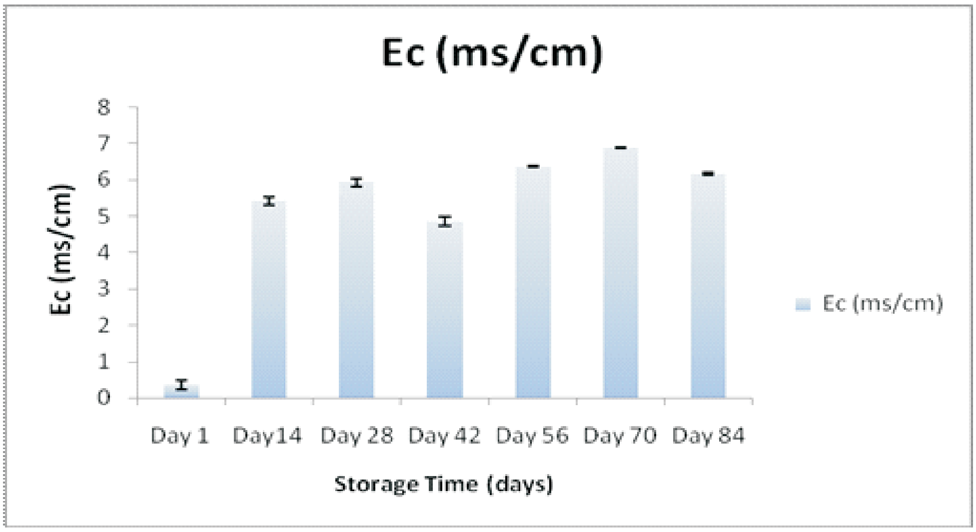


Fig 2: Conductivity (Ec) of pickle cured (wet salting) Heteroclarias during ambient storage

The study also indicated that the conductivity of pickle cured heteroclarias increased significantly ($p<0.05$) within the first 28 days of storage (Fig. 2) after which an irregular pattern was observed. The initial increase in the conductivity could be as a result of the absorption of salt molecule by the fish flesh during the early stage of wet salting preservation, this is in line with the opinion of Wiroonsri *et al.* (2022) who opined that there is correlation between increase in salt content and electrical conductivity of fish. Shi *et al.* (2014) also stated that the electrical conductivity of food will change as the ionic concentration and ionic properties of the food changes. Therefore, the higher the ionic concentration of the fish muscle, the higher the conductivity value that will be observed on the fish muscle.

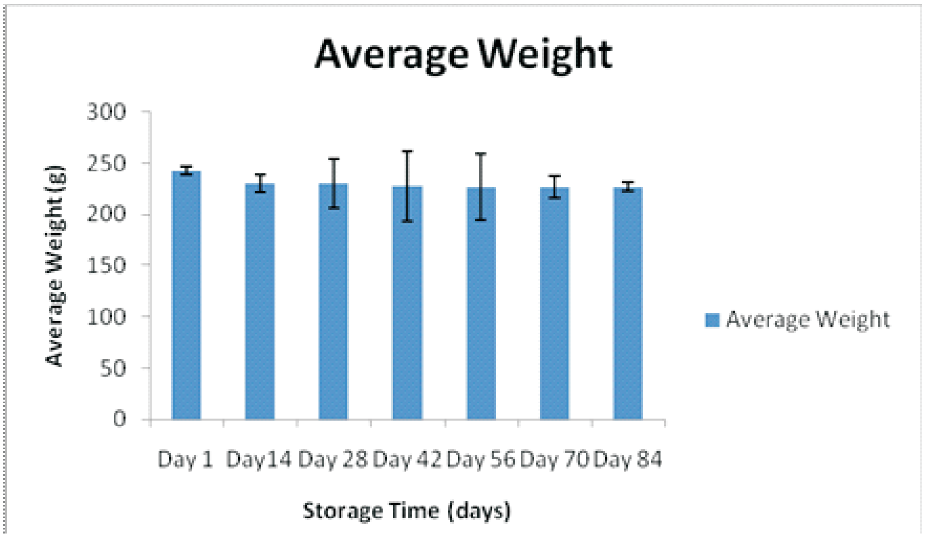


Fig 3: Average Weight (g) of wet- salted Heteroclarias during ambient storage

No significant change ($P>0.05$) was observed in the average weight of the fish throughout the period of this study

Table 1: Effect of pickle curing on the microbiological quality of Heteroclarias during ambient storage

Microbial load	Day 1	Day 14	Day 28	Day 42	Day 56	Day 70	Day 84
TVC (log Cfu/g)	$2.739{\pm}0.06^{g}$	$3.504{\pm}0.04^{f}$	$3.845{\pm}0.02^{e}$	$3.973{\pm}0.01^{d}$	$4.900{\pm}0.02^{c}$	$4.978{\pm}0.01^{b}$	$6.035{\pm}0.03^{a}$
TMBC (log Cfu/g)	ND	$3.016{\pm}0.09^{d}$	$3.078{\pm}0.05^{d}$	$3.484{\pm}0.03^{c}$	$4.657{\pm}0.03^{b}$	$4.707{\pm}0.02^{b}$	$5.505{\pm}0.02^{a}$
TPBC (log Cfu/g)	ND	$2.753{\pm}0.21^{d}$	$2.827{\pm}0.18^{d}$	$3.311{\pm}0.05^{c}$	$4.462{\pm}0.12^{b}$	$4.562{\pm}0.09^{b}$	$5.332{\pm}0.01^{a}$
TCC (log Cfu/g)	ND	$2.628{\pm}0.21^{d}$	$2.724{\pm}0.17^{d}$	$3.188{\pm}0.06^{c}$	$4.385{\pm}0.09^{b}$	$4.467{\pm}0.07^{b}$	$5.175{\pm}0.04^{a}$
TFC (log Cfu/g)	ND	ND	ND	ND	ND	ND	ND

Values with different superscript in the row indicates significant difference at $P<0.05$

TVC Total volatile count
TMBC Total mesophilic bacteria count
TPBC Total psychrophilic bacteria count
TCC Total coliform count
TFC Total fungal count
ND No detection

Log Logarithm The Total volatile count (TVC) recorded in pickle cured Heteroclarias (Table 1) ranged between 2.739±0.06 - 6.035±0.03 log cfu/g during the period of storage while the total mesophilic bacteria count (TMBC) ranged between 3.016±0.09 and 5.505± 0.02 log cfu/g . The microbial load increased significantly ($P < 0.05$) as the period of storage increases in line with the observation of Ayeloja et al. (2011) on fresh Clarias gariepinus kept unpreserved at ambient temperatures but the result of microbial load observed in this study exceeded the maximum recommended bacterial counts for marginally acceptable products which is 107 (7log10 Cfu/g) according to the International Commission on Microbiology Safety for Foods, ICMSF, (1986). This indicate that wet salting (pickle curing) is effective to keep fish quality for longer time, similar opinion was expressed by Tsai et al. (2022) who reported that treating fish fillet with brine salting is capable of reducing microbial load on the fish immediately due to the ability of brine to release bacteria attached to the surface of fish flesh, wet salting also bacteriostatic and bactericidal effects on fish fillet. The microbial load observed on pickle cured fish in this study is similar to that observed by other scientist that worked on wet salting preservation of fish such as Gassem (2019) as well as Binici and Kaya (2018).

CONCLUSION

This study established that pickle curing method of fish preservation have bactericidal and bacteriostatic effect on fish microorganisms as the microbial load is still within recommended value for marginally acceptable products by International Commission on Microbiology Safety for Foods, ICMSF. The salting method employed in this study keep the fish quality to still be wholesome for human consumption up till the last day of storage under dry salting condition (84th day). Pickle curing method of fish preservation is therefore recommended to elongate fish shelf life in villages and other environments that lack steady electricity supply without it having any significant effect ($P>0.05$) on the fish weight.

REFERENCE

Adeyeye, S. A. O., Oyewole, O. B., Obadina, A. O. and Omemu, A. M. (2015). Microbiological assessment of smoked silver catfish (Chrysichthys nigrodigitatus). African Journal of Microbiology Research, 5, 18-21.

Al-Asous, A. O. and Al-Harbi, A. H. (2016). Microbiological and physicochemical quality of salted bluespot mullet (Valamugil seheli) stored at different temperature. Journal of Food Safety, http://dx.doi.org/10.1111/jfs.12291.

Alsaban, W. A, Abou - El-Hawa, S. H., Manal, A. M H. and AbdEL-Rahman, M.A (2014). Effect of salting and storage on chemical Composition of some fish species. Journal of Food and Dairy Science, 5(6), 451–458.

Anihouvi, V. B., Kindossi, J. M. and Hounhouigan, J. D. (2012). Processing and quality characteristics of some major fermented fish products from Africa: A critical review. International Research Journal of Biological Sciences, 1, 72–84.

Ayeloja, A. A. (2019). Sensory quality of smoked Clarias gariepinus (Burchell, 1822) as affected by spices packaging methods. International Journal of Food Properties, 22(1), 704–713. https://doi.org/10.1080/10942912.2019.1597880

Ayeloja, A.A., Dauda T.O., George F.O.A. and Jimoh W.A. (2020): Statistical analysis of consumers acceptance and proximate composition of minced fish using different packaging materials. Journal of Food Processing and Preservation, 44(7), e14543

Ayeloja, A.A., Jimoh, W.A., Omotoye, T., Abegunde, E. and Yusuf, Y. (2021). Effect of post-slaughter time interval (PSI) on the sensory, histology, biochemical and microbial qualities of Heterotis niloticus. Journal of Food Processing and Preservation, 46(2),e16277. https://ifst.onlinelibrary.wiley.com/toc/17454549/2022/46/2

Ayeloja, AA, George, FOA, Obasa, SO, Sanni, LO, Ajayi, AA (2011). Effects of length of delay after slaughter (LODAS) on raw catfish Clarias gariepinu. J. Amer. Sci., 7(6), 508 – 512.

Binici, A. and Kaya, G. K. (2018). Effect of brine and dry salting methods on the physicochemical and microbial quality of chub (Squalius cephalus Linnaeus, 1758). Food Science Technology Campinas, 38(1), 66-70. https://doi.org/10.1590/1678-457X.15717

Dehghani, S., Hosseini, S. V. and Regenstein, J. L. (2018). Edible films and coatings in seafood preservation: A review. Food Chemistry, 240, 505–513. 10.1016/j.foodchem.2017.07.034

Fawole, MO and Osho, BA (1995). Laboratory manual of microbiology. Shalom prints Ibadan Nigeria. Pp25 – 30.

Gassem, M. A. (2019). Microbiological and chemical quality of a traditional salted-fermented fish (Hout-Kasef) product of Jazan Region, Saudi Arabia. Saudi Journal of Biological Sciences, 26,137–140.

Giuffrida, A., Giarratana, F., Valenti, D., Muscolino, D., Parisi, R., Parco, A., Marotta, S., Ziino, G. and Panebianco, A. (2017). A new approach to predict the fish fillet shelf-life in presence of natural preservative agents. Italian Journal of Food Safety, 6(2), 88-92.

ICMSF (1986). Microorganisms in foods 2: sampling for microbiological analysis. Principles and specific applications. 2nd ed. Oxford: Blackwell Science

Ikutegbe, V. and Sikoki, F. (2014). Microbiological and biochemical spoilage of smoke-dried fishes sold in West African open markets. Food Chemistry, 161, 332–336. 10.1016/j.foodchem.2014.04.032

Jittinandana, S., Kenney, P.B., Slider, S.D. and Kiser, R.A. (2006). Effects of Brining Conditions on Weight Gain in Herring (Clupea harengus) Fillets. Journal of Food Science, 70(7):e418 - e424. https://doi.org/10.1111/j.1365-2621.2005.tb11470.x.

Olutiola, PO, Famurewa, O, Sonntag, HG (1991). An introduction to General Microbiology: A Practical Approach. Heidelberger Verlagsanslait Druckerei, Heidelberg Germany. Pp112 – 175.

Sallam, K.I., 2007. Chemical, sensory and shelf life evaluation of sliced salmon treated with salts of organic acids. Food Chem, 101, 592–600.

Shi, C., Lu, H., Cui, J., Shen, H. and Luo, Y. (2014). Study on the predictive models of the quality of silver carp (Hypophthalmichthys molitrix) fillets stored under variable temperature conditions. Journal of Food Processing, 38, 356-363.

Thorarinsdottir, K. A., Arason, S., Sigurgisladottir, S., Gunnlaugsson, V. N., Johannsdottir, J. and Tornberg, E. (2011). The Effects of Salt-curing and Salting Procedures on the Microstructure of Cod (Gadus Morhua) Muscle. Food Chemistry. 126, 109–115. DOI: 10.1016/j.foodchem.2010.10.085.

Tsai, Y. H., Kung, H. F., Lin, C. S., Hwang, C. C., Lou, S. S., Huang, C. Y. and Lee, Y. C. (2022). Combined effect of brine salting and high-hydrostatic-pressure processing to improve the microbial quality and physicochemical properties of milkfish fillet. International Journal of Food Properties, 25(1), 872–884. https://doi.org/10.1080/10942912.2022.2066120

Umer, A. M., Fayaz, A., Ibraq, K. and Rasy, F. C. W. (2022). Isolation and Identification of Pathogenic Bacterial

Flora from Native Freshwater Fish of Kashmir Himalaya. Egyptian Journal of Aquatic Biology and Fisheries, 26(1), 299 – 311.

Wiroonsri, P., Wattanachant, S. and Youravong, W. (2022). Correlation between Electrical Conductivity and Salt Content in Tuna Meat. In Proceedings of the 16th ASEAN Food Conference (16th AFC 2019) - Outlook and Opportunities of Food Technology and Culinary for Tourism Industry, pages 256-262. Published by Science and Technology Publications, Lda.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

INFLUENCE OF HEAT SOURCES ON ORGANOLEPTIC QUALITY AND MICROBIAL LOAD OF SMOKED *Clarias gariepinus*

[1]Hafsat, I.O., [2]S.A. Okunsebor, [2]I.M. Danwali, [1]F.K. Abubakar, [1]H.D. Mudi, [3]U.G. Ibrahim, [4]A.S. Ibrahim. and [4]A.J. Bunu

[1]Department of Fisheries Technology, College of Agriculture, Science and Technology, Lafia, Nasarawa State, Nigeria.
[2]Department of Aquaculture and Fisheries Management, Faculty of Agriculture (Shabu-Lafia Campus), Nasarawa State University Keffi, Nigeria.
[3]Department of Natural Sciences, College of Education Billiri, Gombe State, Nigeria.
[4]Department of Fisheries and Aquaculture Technology, Federal University of Technology Owerri, Imo State, Nigeria.

Corresponding Author:
ibrahimhafsat644@gmail.com, +2348169568933

ABSTRACT
The study on the organoleptic assessment and microbial load of *Clarias gariepinus* smoked using three heat sources (gas, firewood and charcoal) was carried out for three (3) months. The smoking process was carried out at the fish processing unit of the Department of Aquaculture and Fisheries Management, Faculty of Agriculture, Shabu-Lafia Campus, Nasarawa State University, Keffi. Twenty seven kilogram (27kg) of *Clarias gariepinus* were used for the 3 heat sources each consisting of nine kilogram (9kg) fish with three (3) replicates (making 3kg fish per replicate. 5 hedonic scale were used to rate the quality of the fish product with a decision mean between 2.95 and above 3.0. Data obtained were subjected to Descriptive Statistics (mean, median, mode, frequency and percentage). The result of the study revealed that mean values of organoleptic parameters were above the decision mean value for taste (3.68), flavor (3.75), skin color (3.65), texture (3.66) and appearance (3.64). Fish smoked using Gas and Charcoal sources of heat yielded the best in terms of overall appearances. Microbial analysis showed Gas-smoked fish had the least microbial load and could be effectively used to achieve smoked fish product. The study recommend that Charcoal Smoking Kiln (CSK) and Gas Smoking Kiln (GSK) should be used as the method of smoking fish. Also, more research should be conducted to ascertain the proximate composition of fish product using the same heat sources.

Keywords:
Gas, Firewood, Charcoal, Organoleptic, Clarias gariepinus.

INTRODUCTION
The demand for fish and its products has consistently increased during the recent years since fish protein is a major animal protein consumed in many parts of the world. Fish is a very perishable product and processing is therefore necessary to assure safety and prolonged shelf life of fish (Blackwell, 2014). Though perishable, fish is an important food stuff, especially in the developing countries, due to its high protein content and nutritional value of unsaturated fatty acids and affordability by the masses when compared with beef, poultry, pork and egg (FAO, 2016).

Fish undergoes spoilage as soon as it is harvested. Once spoilage sets in, the odor/flavor, texture, color and chemical composition changes (Omoruyi *et al.*, 2016). One-third of fish produced worldwide was estimated to be wasted (Affognon *et al.*, 2015). To prevent economic losses, the processing and preservation of the fish is of critical importance.

Fish smoking is one of the oldest methods of preservation, giving a characteristic flavour and colour to the product and increasing its shelf life (Blackwell, 2014). Fish smoking originated naturally along the coastal fishing communities, with the aim of preserving the catch for a longer period (Omoruyi *et al.*, 2016). It is a very popular processing method in Africa and other continents where smoked fish is a delicacy (Ayofemi and Adeyeye, 2018. Fish smoking combines the effects of drying, salting and heating. It has received great attention because of its acceptance among consumers. The acceptance of smoked fish is based primarily on the sensory characteristics and its impact on the fish (Ghaly *et al.*, 2020). Fishermen usually subject their fish to smoking rather than selling it fresh because it generates more income (Magawata and Musa, 2015). Fish smoking plays a pivotal role in terms of reducing post-harvest losses, employment creation, poverty alleviation, food security, income generation, and foreign exchange earnings as well as improving the fisheries sector of a country's economy (Olagbemide, 2015; Asiedu *et al.*, 2018). Smoking is frequently employed to address this concern. Smoking improves organoleptic characteristics, induces water loss, and reduces the microbial load of food (fish) due to heat and the presence of bactericidal and aromatic substances (Chakroborty and Chakraborty, 2017). The objective of this study is to assess organoleptic and microbial load of smoked Clarias gariepinus using three different heat sources (gas, firewood and charcoal).

MATERIALS AND METHOD

Study Area

The experiment was conducted at the Fish Processing unit of the Experimental Fish Farm of the Department of Aquaculture and Fisheries Management, Faculty of Agriculture, Nasarawa State University Keffi, Shabu- Lafia Campus. Lafia is situated at latitude 8° 35IN, longitude 8° 32IE, 181.53 m above sea level, with an average temperature of 34°C, relative humidity ranging from 40 to 86%, and 9 to 12 hours of daylight on a typical day (NIMET, 2011).

Smoking Procedure

To attain a consistent level of dryness, smoking was done using red-hot charcoal for 12 hours, firewood for 24 hours, and gas for 9 hours. The fish were smoked, allowed to cool, and then wrapped in polythene bags labelled A, B, and C, according to the order in which they were handled.

Sensory (Organoleptic) Assessment

Samples from the smoked fish products were exposed to a sensory evaluation. A panel of one fifty (50) assessors, comprising both University Staff and Students. Questionnaire were administered to the panels, and scoring took place every two weeks. To lessen bias, the samples were blind coded. Organoleptic parameters assessed include flavor, skin colour, appearance, texture and taste. A 5 hedonic scale ranging from Like extremely, Like moderately, Like very much, Like slightly, Neither like nor dislike, were adopted for each quality parameter. The mean decision value was calculated using $5+4+3+2+1 = 15/5 = 3.0$ at 5% and the range determined below 2.95 was considered not important, mean above 2.95 was considered important while mean value above 3.0 and above was considered very important.

Bacteria Load

The number of bacteria present were counted using the spread plate method. Fish homogenate dilutions containing ten grams of sample were mixed with ninety milliliters of saline water, spread out on plate count of 12ml agar, and incubated for 24-48 hours at 37°C. The colonies counted for total plate counts were expressed as Colony Forming Units per gram (CFU/g), bearing in mind the factors of dilution (Maturin and Peeler, 2001). The manufacturer's instructions were followed for preparing each medium utilized for microbiological examination. Isolation and identification of Staphyloccus aureus using plate count agar (PCA) were carried out by the method described by Gutierrez *et al.* (2012) and Bacillus subtilis according to AOAC (2010) method. Escherichia coli were isolated using MacConkey agar medium. Colonies with pinkish red growth having a metallic sheen or reflection confirmed the presence of E. coli (AOAC 2010).

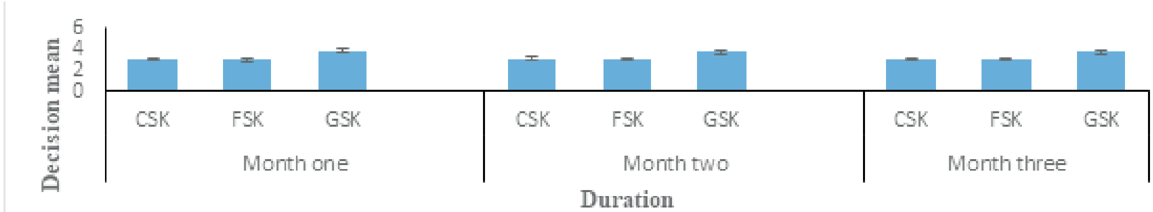
Fungal Load

Fungi isolation was done using Rose Bengal Chloramphenicol (RBC) agar.. 25 grams of the sample was weighed into 225 millilitres of 0.1% peptone water and homogenized, 0.1 milliliters of the suitable dilutions, were spread out over the medium's surface and incubated for 5 days at room temperature (28±1°C) (Immaculate *et al.*, 2013).

Data Analysis

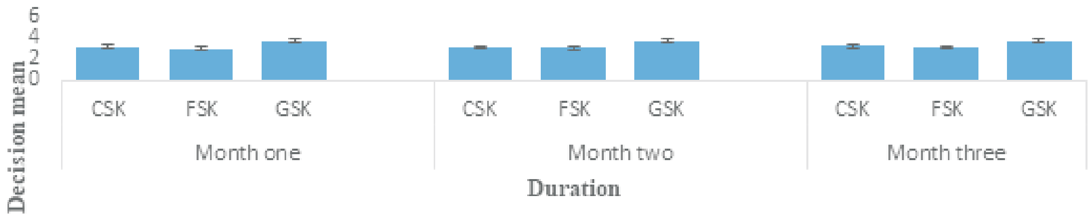
Data collected on the shelf-life and organoleptic characteristics of smoked fish were subjected to descriptive statistics (mean, median, mode, frequency, and percentage) and one way ANOVA using SPSS statistical tool, version 20.0.

RESULTS AND DISCUSSION



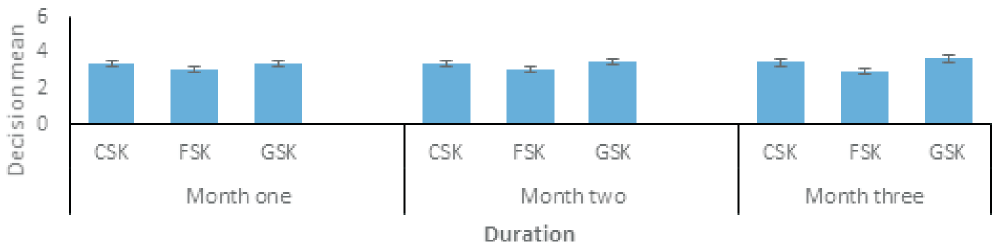
GSK = Gas Smoking Kiln, CSK = Charcoal Smoking Kiln, FSK = Firewood Smoking Kiln

Figure 1: Decision mean of Clarias garipinus on flavor assessed from three heat sources



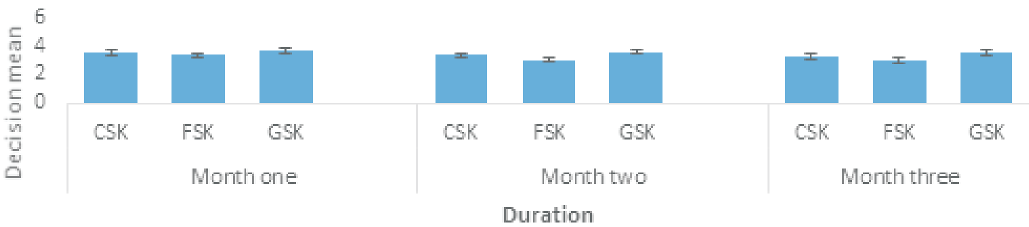
GSK = Gas Smoking Kiln, CSK = Charcoal Smoking Kiln, FSK = Firewood Smoking Kiln

Figure 2: Decision mean of Clarias garipinus on taste assessed from three heat sources



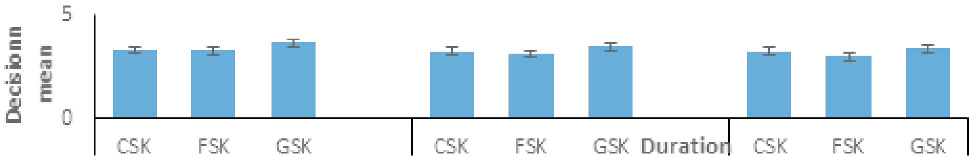
GSK = Gas Smoking Kiln, CSK = Charcoal Smoking Kiln, FSK = Firewood Smoking Kiln

Figure 3: Decision mean of Clarias garipinus on texture assessed from three heat sources

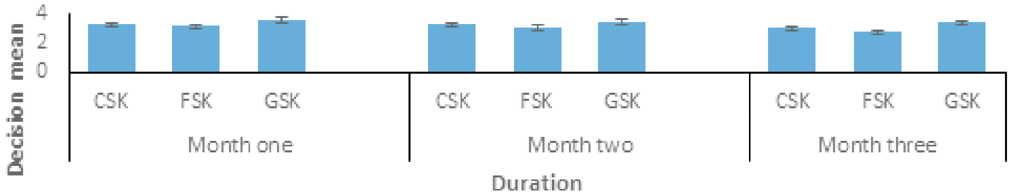


GSK = Gas Smoking Kiln, CSK = Charcoal Smoking Kiln, FSK = Firewood Smoking Kiln

Figure 4: Decision mean of Clarias garipinus on appearance assessed from three heat sources



GSK = Gas Smoking Kiln, CSK = Charcoal Smoking Kiln, FSK = Firewood Smoking Kiln
Figure 5: Decision mean of *Clarias garipinus* on skin colour assessed from three heat sources



GSK = Gas Smoking Kiln, CSK = Charcoal Smoking Kiln, FSK = Firewood Smoking Kiln
Figure 6: Decision mean of *Clarias gariepinus* on overall acceptability assessed from three heat sources

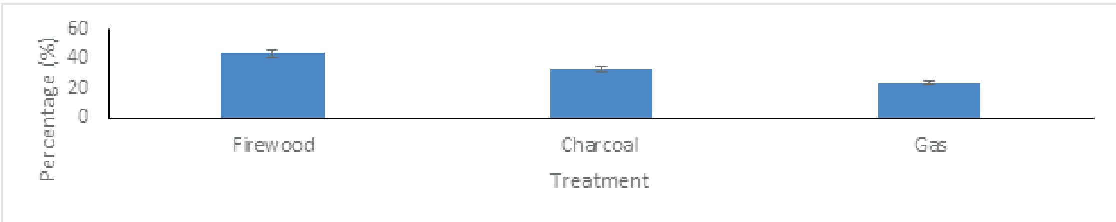


Figure 7: Percentage Bacterial count of *Clarias gariepinus* stored for three (3) Months using different heat sources

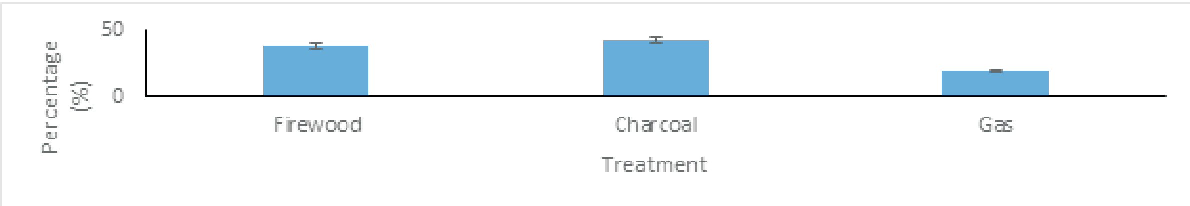


Figure 8: Percentage fungal count of Clarias gariepinus stored for three (3) months using different heat sources

Organoleptic Assessment of *Clarias gariepinus* Smoked-Dried using Three Heat Sources

The results of organoleptic assessment showed that fish smoked using gas smoking kiln is more preferred than charcoal and firewood smoking kilns in terms of flavor, taste, texture, appearance, and skin color, while on the overall acceptability, people rated the gas smoking kiln the best over charcoal and firewood smoking kilns, and during this period, organoleptic parameters were above the range value used for judgment by the panelists. This study agrees with the results of Giullén and Manzanos (2022) who reported mean scores of sensory qualities of smoked Clarias gariepinus above average.

Concerning color and appearance, fish smoked dried using charcoal gives a golden brown color and that of firewood produced a dark brown color, while those of gas smoking kiln gives pale brown color. This observation disagree with that of Umar *et al.* (2018) who attributed brown color to fish product smoked using firewood while dark brown color to fish smoked using melon briquettes. The reason for dark and brown color produced during smoking of fish could be attributed to the report of Nahid *et al.* (2016) who stated that fish color can be affected by interaction of carbonyls with amino components on the flesh surface and also as a result of phenolic and hemicellulose compounds produced from smoke of incomplete combustion of carbon. Consumers often evaluate quality of products by its color and appearance and color serve as an indication as to how food is well cooked (Umar *et al.*, 2018).

On the texture of fish, the study revealed that fish smoked using gas smoking kiln were better than those smoked using charcoal and firewood and this observation could be attributed to the amount of heat supplied during smoking process. Rahman,(2017) stated that shrinking of myofibrillar protein of fish muscles as a result of heat leads to firmer and harder texture. It was observed in the study that heat produced in the charcoal and firewood smoking kiln tempered with the fish flesh texture but those produced in gas smoking kiln maintain their texture throughout the smoking hours. Taste which is considered as important factor for consumers' acceptance of smoked fish was ranked the best in fish smoked using gas smoking kiln and the result disagree with the assertion of Toldra, (2020) who stated that smoke from firewood produced during pyrolysis consist of compounds that adds flavor and improve taste of fish products. In the case of overall acceptability, fish smoked using gas smoking kiln was ranked 1st throughout the period of study and more of consumers' preferences were towards gas smoking due to its palatability, tender flesh and uniform heat distribution during smoking.

Microbial Load of Clarias gariepinus Smoked Using Three Sources of Heat

Result of microbial load revealed that the highest total viable (Bacteria) count was observed in month 3 (9.7 x 105) for firewood treated fish and the least was observed in month 1 with the mean count (8.6 X 105) which disagree with the study of Nahid et al. (2016) who stated that The low level of pathogen including S. aureus from the study of the smoked catfish may be due to the presence of low moisture content in the smoked catfish. For fungal count, the maximum count was also observed in month 3 (4.4 x 103) while the least fungal count was observed in month 1 (3.2 x103). However, Adeyeye et al. (2015) stated that the occurrence of Escherichia coli may serve as the presence of indicator organisms for faecal contamination of foods which precipitates from non-adherence to good management practices (GMPs). Furthermore the highest viable (bacteria) mean count was observed in charcoal treated fish with the mean value (6.3 x105) while least bacteria mean count is also observed in month 1 (5.1 x105). The same trend was observed in fungal count with the highest fungal count (2.7 X103) and the lowest fungal account observed (2.0 x 103) in month 1. The result from gas treated fish showed that the highest mean viable (bacterial) count observed in month 3 (2.4 X104) and the least bacterial count also observed in month 1 (1.8 x 104) and the fungal count observed, the highest mean observed in month 3 (2.1 x102) and the least is also observed in month 1 (1.5 x10 2).

CONCLUSION

This study has revealed the presence of bacteria and fungi in the three samples under study. High population of bacteria was recorded more on fish sample smoked with firewood with Staphylococcus spp found most. Also, fungal loads were higher in smoked fish with charcoal heat source having Yeast most. The result of the study also showed that mean values of organoleptic parameters (flavour, taste, texture, colour and appearance) were above the decision mean value.

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REFERENCES

Adeyeye, S. A. O., Oyewole, O. B., Obadina, A. O. and Omemu, A. M. (2015) “Evaluation of Microbial Safety and Quality of Traditional Smoked Bonga Shad (Ethmalosa fimbriata) Fish from Lagos State, Nigeria”. Pacific Journal of Science and Technology, 16 (1): 286-294.

Affognon, H., Mutungi, C., Sanginga, P. and Borgemeister, C. (2015). Unpacking postharvest losses in sub-Saharan Africa: a meta-analysis. World development. 66. 49-68.

Asiedu, B., Failler, P., and Beygens, Y. (2018). Ensuring food security: an analysis of the industrial smoking fishery sector of Ghana. Agriculture Food Security. 7. 1-11.

Association of Official Analytical Chemists (AOAC) 2010. Official Methods of Analysis of the Association of Official Analytical Chemists. Vol. I and 2, (18th ed.). Association of Analytical Chemists, Washington DC.

Ayofemi, S. and Adeyeye, O. (2018). Smoking of fish: a critical review Journal of Culinary Science and Technology. 17(6): 559-575.

Blackwell, W. (2014). Seafood Processing Technology, Quality and Safety. Chichester, UK: Institute of Food Science and Technology. P. 41-45

Chakroborty, T. and Chakraborty, S. C. (2017). Effect of Storage Temperature on the Quality and Microbial Content of Salt-Smoke-Dried shoal (Ophiocephalus striatus). J Fisheries Livestock Production. 2017: 5:1

FAO (2016). The state of world fisheries and aquaculture. Rome, FAO. 105 pp.

Ghaly, A. E., Dave, D., Budge, S. and Brooks, M. S. (2020). A review of fish spoilage mechanisms and preservation techniques. American Journal of Applied Sciences. 7:859–877. https://doi.org/10.3844/ajassp.2010.859.877

Giullén, M. D. and Manzanos, M. J. (2022). Study of the volatile composition of an aqueous oak smoke preparation. Food Chemical. 79. 283- 292.

Gutiérrez, D. Delgado, S., Vázquez-Sánchez, D., Beatriz Martínez, López Cabo, M., Rodríguez, A., Herrera, J. and García, P. (2012). Incidence of Staphylococcus aureus and Analysis of Associated Bacterial Communities on Food Industry Surfaces. Applied Environment Microbiology. 78(24): 8547-8554.

Immaculate, K., Sinduja, P., Velammal, A. and Jamila, P. (2013). Quality and shelf-life status of salted and sun-dried fishes of Tuticorin fishing villages in different seasons. International Food Resources Journal. 20(4): 1855- 1859.

International Commission on Microbiological Specifications for Foods (ICMSF) (2002). Microorganisms in foods. Microbiological testing in Food Safety Management. Kluwer Academic/Plenum Publishers, New York, 199pp.

Magawata, I. and Musa, T. (2015). Quality characteristics of three Hot-Smoked fish species using locally fabricated Smoking kiln. International Journal of Fisheries and Aquatic Studies. 2015. 2(5): 88-92 ISSN: 2347-5129

Maturin, L. and Peeler, J. T. (2001). Aerobic Plate Count. In: Food and Drug Administration (FDA), Bacteriological Analytical Manual Online, 8th Edition, Silver Spring, Berlin, 1998.

Nahid, M. N., Latifa, G. A., Chakraborty, S. C., Farid, F. B. and Begum, M. (2016). Shelf life quality of smoke-dried freshwater SIS fish; Chapila (Gudusia chapra, Hamilton Buchanan 1822) kakila (Xenentodon cancila, Hamilton-Buchanan; 1822) stored at laboratory condition (26-310C). Journal of Agriculture and Veterinary Science. 9. 23-32.

NIMET (2011). Nigerian Metrological Agency. Synoptic office, Nasarawa State, Nigeria.

Olagbemide, P. T (2015). Nutritional Values of Smoked Clarias gariepinus from Major Markets in Southwest, Nigeria. Global Journal of Science Frontier Research: Agriculture and Veterinary. 15(6): 2249-4626.

Omoruyi, K., Owolabi, K. E. and Oghoje, A. E. (2016). Comparative analyses of fish processing, marketing and distribution in Warri-South and Sapele Local Government Areas of Delta State, Nigeria. P. 23-27.

Rahman, S. (2017). Resistant starch in cereals: exploiting genetic engineering and genetic variation. Journal of Cereal Science. 46. 251– 260.

Sajib Al-Reza, S. K., Mahmudul Hasan, S. R., Riadul, H. and Nannur, R. (2015). Effect of traditional fish processing methods on the proximate and microbiological characteristics of Laubuka dadiburjori during storage at room temperature. Journal of Fisheries and Aquatic Sciences. 10(4): 232-243.

Toldrá. F. (2020). Handbook of Meat Processing. 2121 State Avenue, Ames, Iowa 50014- 8300, USA. 584.

Toldrá. F. (2020). Handbook of Meat Processing. 2121 State Avenue, Ames, Iowa 50014- 8300, USA. 584.

Umar, F., Oyero, J. O., Ibrahim, S. U., Maradun, H. F. and Ahmad, M. (2018). Sensory evaluation of African catfish (Clarias gariepinus) smoked with melon shell briquettes and firewood. International Journal of Fisheries and Aquatic Studies. 6(3): 281-286

Yakubu, M.M. and Ngueku, B.B. (2015). Quality assessment of smoked-dried fish from five different markets in Lafia, Nigeria. International Journal on Fishing and Aquatic Studies. 2. 135-139.

EFFICACY OF DIFFERENT PLANT EXTRACTS FOR THE CONTROL OF ARTHOPOD PESTS IN DRIED BONGA SHAD

[1]Asinde P. J and [2] A. P Inyang –Etoh

[1]Ministry of Livestock, Aquaculture and Fisheries Development, Cross River State Calabar, Nigeria.
[2]Depatment of Fisheries and Aquaculture University of Calabar, Nigeria.

Corresponding Author:
patriciajamesasinde@gmail.com +2348027416130

ABSTRACT

This study investigates the efficacy of three plants extract (neem, moringa and garlic) in controlling arthropod pests in dried Bonga Shad. In the experimental setup, each plant extracts consists of five concentrations in triplicate of (20g/ml, 40g/ml, 60g/ml, 80g/ml, 100g/ml.. After the application of plant extracts, the experiment yielded significant results, showing a substantial reduction in pest infestation across treatment groups. The results revealed a significant positive correlation ($P<0.05$) between the concentration of plant extracts and percentage efficacy in all treatment groups. The dose dependent analysis revealed a distinctive relationship between concentration and effect, identifying optimal concentrations of 31.54g/ml, 65.08g/ml and 75.48g/ml for neem, moringa and garlic respectively. Notably, Neem demonstrated the highest efficacy, resulting in 31.58% to 100% mortality across concentrations, surpassing Moringa and Garlic, which exhibited mean mortalities of 50.09±9.93%, and 71.04±10.91%, respectively. In conclusion, Garlic, Moringa, and Neem extracts are potent agents for pest control in dried Bonga Shad. These findings contribute valuable insights for sustainable pest control practices in the fish processing industry, emphasizing practical observations alongside significant quantitative results.

Keywords:
infestation, mortality preservation, processing, Bonga Shad

INTRODUCTION

Dried fish occupies a central position in Nigeria's culinary traditions, being highly esteemed for its significant contribution to the local diet as a rich source of protein and essential nutrients (Ojedokun and Akinyode, 2023). Fish has long been a staple food, and the practice of drying fish has served as a traditional preservaktion method for centuries. The drying process allows fish to be stored for extended periods without the need for refrigeration, making it a convenient food choice in areas where reliable electricity and refrigeration facilities are limited (Okafor, 2017). However, the storage and preservation of dried fish can be challenging due to potential infestations by arthropods. Arthropods, such as cigarette beetles (Lasioderma serricorne), flour beetles (Tribolium spp.), drugstore beetles (Stegobium paniceum), Indian meal moths (Plodia interpunctella), Mediterranean flour moths (Ephestia kuehniella), rice weevils (Sitophilus oryzae), granary weevils (Sitophilus granarius), fish mites (Lepidoglyphus destructor), grain mites (Acarus siro), silverfish (Lepisma saccharina).

Infestations by arthropods can occur during processing, transportation, and storage, resulting in physical damage to the product and potential contamination with excrement, body parts, and microorganisms, posing risks to consumers health (Obasi and Danladi, 2023). Traditional methods of arthropod control, such as using insecticidal compounds, have been effective but r there are concerns about potential toxicological effects and environmental impacts. Consequently, there is a growing interest in exploring sustainable and environmentally-friendly methods for arthropod pest control. This includes the use of natural repellents and a compounds derived from plants and other natural sources (Garcia *et al.*, 2019). These extracts contain insecticidal compounds that act as natural repellent to pests. Neem, for example, contains azadirachtin, a well-known insecticidal compound that disrupts the growth and development of pests (Smith and Johnson, 20u22). Garlic contains compounds such as asallicin and diallyl disulfide that have demonstrated repellent effects on arthropod pests. Moringa is another plant that exhibits insecticidal properties and has shown promise in pest management. The bioactive compounds found in moringa, such as isothiocyanates and flavonoids, have been reported to have insecticidal activity (Kumari *et al.*, 2019). Therefore, this study was conducted to investigate the efficacy of three plants extract (Neem, Moringa and Garlic) in controlling arthropods pests in dried Bonga Shad.

MATERIALS AND METHOD

Study sites

Calabar Metropolis is located in south-south Nigeria near the coast of the Gulf of Guinea. Its coordinates are latitudes 4°54'30"N & 4°95'00"N and longitudes 8°19'30"E & 8°21'00"E. The city lies along the Calabar River., (The study sites are Marian and Watt Markets, Calabar.

Laboratory studies

Samples of dry Bonga shad were bought from fish sellers at Marian and Watt Markets. Leaves of Neem and moringa, as well as garlic bulbs were also sourced from local markets in Calabar Metropolis. To ensure their purity, the plants were cleaned using distilled water. Subsequently, the plant samples were subjected to oven drying at temperatures ranging from 50 to 70 °C for a duration of 24 hours. Following the drying phase, the plants were finely ground into powder using a mortar and pestle This powdered material, in a 1:5 w/v ratio (200g per liter), served as the basis for the extraction process. The extracts were immersed in 1000mL of distilled water and allowed to stand for 24 hours to facilitate thorough extraction. The extraction was carried out using the maceration technique as published by AOAC international (2016, Official Methods Of Analysis.

The prepared plant extracts were then dispensed into five different concentrations (20 g/ml, 40 g/ml, 60 g/ml, 80 g/ml, 100 g/ml)., The control group (0g/ml) were not treated with any plant extract.

The experimental setup followed a completely randomized design in triplicates, including a control group. The samples were kept in a room temperature for 48 hours to allow for natural infestation of insect prior to the application of plant extracts. The application of different concentrations (0 g/ml, 20 g/ml, 40 g/ml, 60 g/ml, 80 g/ml, 100 g/ml) of plant extracts was carried out using a plastic spray bottle. At the end of 96 hours of applying the plant extracts, total number of dead insects was recorded to evaluate the efficacy of each plant extract. This entire process was replicated for each plant extract. After 30days, the specimens were evaluated to determine the efficacy of the plant extracts in controlling insect infestation.

STATISTICAL ANALYSIS

Data was subjected to Analysis of Variance (ANOVA) using Statistical Product for Service Solution (SPSS ver. 20) at P = 0.05.

RESULTS AND DISCUSSION

RESULTS

Efficacy of plant extracts in controlling arthropod pests

The efficacy of various plant extracts at different concentrations in controlling arthropod pests infesting dried Bonga shad is as shown in Table 1. In the control group (0 g/l), a mean mortality of 17.78% was observed, serving as a baseline for evaluating the impact of plant extracts on arthropod pests. Neem(100g/ml) extract exhibited 100% insect mortality, followed by moringa at (100g/ml) with mortality of 85% while garlic (100g/ml) extract had 73% mortality.

Table 1: Efficacy of plant extracts in controlling arthropod pests

Plant Extract	Conc. (g/ml)	Total no. of live insects	Total no. of dead insects	Total no. of survivors	Mean Mortality (%)
Control	0	18	3	15	17.78
Neem	20	19	6	13	31.58
Neem	40	21	12	9	57.14
Neem	60	17	13	4	76.47
Neem	80	20	18	2	90.00
Neem	100	20	20	0	100.00
Moringa	20	24	5	19	20.83
Moringa	40	25	9	16	36.00
Moringa	60	22	10	12	45.45
Moringa	80	19	12	7	63.16
Moringa	100	20	17	3	85.00
Garlic	20	19	2	17	10.53
Garlic	40	21	7	14	33.33
Garlic	60	25	9	16	36.00
Garlic	80	24	13	11	54.17
Garlic	100	26	19	7	73.08

DISCUSSION

The results from this study revealed a dose-dependent effect of neem to cause mortality on arthropod insects. The mortality ranged from 31.58% to 100%, and is similar to the 35% to 89% reported by Canazart *et al.* (2021) against insect pests in stored grains and fish. This shows the efficacy of neem as a potential natural pest control agent. This study identified neem as the most effective extract, achieving complete pest control (100%) by the end of the experiment. This efficacy may be attributed to the presence of Azadirachtin (a well-known active ingredient in pesticides). The varying effect of neem and other plant extracts in different studies suggests the need for further exploration into combining different extracts to understand their synergetic effects.

This study demonstrated the effect of Moringa's extract on arthropod pests (mortality of 20.83% to 85.00%). This result is similar to the report of Irfan *et al.*, (2022) who reported the mortality range between 25% and 78%. Despite slightly lower effectiveness compared to neem in the present study, Moringa remains a promising natural pest control option for dried fish. To optimize its efficacy, further research is required to explore differences in extract preparation, target pest species, and environmental factors influencing efficacy.

Garlic extract displayed moderate efficacy against arthropod pests in this study, with results ranging from 10.53% to 73.08% mortality. It is also similar to the 15% to 85% mortality reported by Hanash (2023). While affirming neem's potential as a pest control option, our results indicate lower efficacy of garlic compared to neem. Similar to Moringa, garlic's effectiveness may vary based on method of extract preparation, target pest species, and environmental factors. Further investigation into optimal conditions for garlic extract application and its efficacy against specific pests is advocated.

CONCLUSION

In conclusion, the study provides insights into the efficacy of plant extracts for arthropod pest control in dried Bonga Shad. Neem, Moringa, and Garlic extracts demonstrated varying degrees of effectiveness, with Neem standing out as the most potent. The optimal concentrations identified for each extract, considering both efficacy in controlling arthropods pests; offer practical guidelines for implementing plant-based pest control methods.

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REFERENCES

Canazart, D. A., Daquila, B. V., Schneider, L. C. L., Silva, C. V. D., Gigliolli, A. A. S., Ruvolo-Takasusuki, M. C. C. and Conte, H. (2021). Insecticidal effect of garlic essential oil on Diatraea saccharalis (Fabricius, 1794) (Lepidoptera: Crambidae) eggs. Revista Ibero-Americana De Ciências Ambientais, 12(7), 434–447.

Garcia, M., Johnson, A., Thompson, L., and Davis, E. (2019). Natural Repellents and Deterrents for Arthropod Pest Control: A Comprehensive Review. Pest Management Science, 65(4), 356-370.

Hanash, A. A. R. (2023). Estimation insecticidal action of Abamectin and Neem oil against Tuta absoluta insect (Lepidoptera: Gelechiidae). Wasit Journal for Pure Sciences, 2(4), 131–135.

Isman, M. B. (2006). Botanical insecticides, deerrents, and repellents in modern agriculture and an increasingly regulated world. Annual Review of Entomology, 51, 45-66.

Kumari, P., Sharma, S., Lal, P., and Sharma, R. (2019). Moringa oleifera: A review on nutritive importance and its medicinal application. Food Science and Human Wellness, 8(3), 204-210.

Obasi B. C., and Danladi G. (2023). Evaluation of microbiological quality and organoleptic properties of smoked dried fish sold in Wukari Markets Taraba State, Nigeria. Magna Scientia Advanced Biology and Pharmacy, 9(1), 087–093

Obeten, B. U., Ayua, B. A., Aneshie, L. N., Etta, C. A., Obun, M. E., Ojong, A. A. and Onnoghen, N. U. (2024). Wildlife conservation society's activities and biodiversity conservation in protected areas in Cross River State, Nigeria. Journal for Nature Conservation, 78, 126575. https://doi.org/10.1016/j.jnc.2024.126575

Ojedokun and Akinyode, Akinyode, A.(2023). Economic Analysis of Dried (CAT) fish marketing in Ooyo Sstate Nigeria. Internal Journal of Agriculture and Earth Science, 9(4) 47-57.

Okafor, C. (2017). Cultural significance of dried fish in Nigerian cuisine. Food and Culture Review, 25(2), 112-126

Smith, D., and Davis, E. (2022). Potential of Biological Control Agents for Arthropod Pest Management in Fish Products: A Review. Aquaculture Journal, 105(3), 189-202.

Smith, D., and Johnson, A. (2022). Plant-Derived Essential Oils for Arthropod Pest Control in Agricultural and Food Storage Settings: A Meta-Analysis. Journal of Applied Entomology, 99(3), 201-215.

White, S. (2023). Control of Arthropod Pests in Dried Fish Products, including West African Ilisha (Ilisha africana): A Potential Area for Future Investigation. Journal of Pest Control and

Management, 42(1), 30-42.
Williams, L. (2022). Silverfish infestations in dried fish: Occurrence and prevention measures. Journal of Food Quality and Preference, 29(3), 201-216.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

EFFECT OF GINGER AND PEPPER ON PROCESSING AND PRESERVATION QUALITY OF AFRICAN BONY TONGUE *Heterotis niloticus* (CUVIER,1829)

Dambatta M. A[1], M.A Haruna [2],Panda M. S[1], A. A Muhammad[1]

[1]Department of Fisheries and Aquaculture, Kano University of Science and Technology Wudil, Kano State, Nigeria
[2] Department of Fisheries and Aquaculture, Federal University Dutse, Jigawa State, Nigeria
[3]Department of Fisheries and Aquaculture, Federal University Dutsin-Ma, Katsina State, Nigeria

Corresponding author:
mansirfish12@gmail.com

ABSTRACT
Improvement of consumer's palatability of Heterotis niloticus was investigated by value addition with natural spices and salt to improve its palatability and shelf-life. The major problem of H. niloticus is its poor taste, hence low demand and poor consumer's acceptability which affects the market value. The objective of this study was to improve the palatability and shelf-life of *H. niloticus* using ginger and pepper. The study was conducted at Teaching and Research Laboratory of the Department of Fisheries and Aquaculyure, Aliko Dangote University of Science and Technology, Wudil, Kano State. Ten samples of Heterotis niloticus with a total weight of 24kg were purchased from the fishermen at Galadima Market, Sabon Gari, Kano and conveyed down to Teaching and Research Laboratory of the Department of Fisheries and Aquaculture, ADUST Wudil. The experiment was factorial experiment having two factors (lemon grass and mint leaf) arranged a completely randomized design three treatments replicated thrice. The Heterotis niloticus were scaled, gutted and washed severally and then chunked into 48 pieces as each spice was replicated into three places. Proximate compositions of the processed fish product were analyzed for Crude Protein, Moisture, Ash, Crude Lipid, Crude fiber, and Nitrogen free extract (digestible carbohydrate). Standard method of the Association of Official Analytical Chemist AOAC (2005), was used for determination. Data collected were analyzed using simple percentages, descriptive analysis and ANOVA. The results of proximate composition of the fish sample as affected by the different ginger and pepper shows that the proximate composition were not significantly ($p > 0.05$) influenced by the different solution of the spices. The result indicated highest crude protein (69.41 %) is from ginger spiced, followed by pepper spiced, 68.39% and ginger spiced 67.40%.

Keywords:
ginger; pepper, processing, preservation, Heterotis niloticus

INTRODUCTION
Fish is one of the protein foods that need careful handling (Eyo, 2004). This is because fish spoils easily after capture due to the high tropical temperature which accelerates the activities of bacteria, enzymes and chemical oxidation of fat in the fish. Due to poor handling, about 30 – 50% of fishes harvested are

wasted in Nigeria. These losses could be minimized by the application of proper handling, processing and preservation techniques (Bate and Bendall, 2010). The purpose of processing and preserving fish is to get fish to an ultimate consumer in good, usable condition. The steps necessary to accomplish this begin before fishing expedition starts, and do not end until the fish is eaten or processed into oil, meal or a feed (Karube *et al.*, 2001). Fish begin to spoil as soon as it is caught, perhaps even before it is taken out of the water. (Gopakumar, 2000).

MATERIALS AND METHOD

Study Area

The study was conducted at Teaching and Research Laboratory of the Department of Fisheries and Aquaculture, Aliko Dangote University of Science and Technology, Wudil, Kano State. Wudil is located within the Sudan Savannah region of Nigeria. The experimental site is located on the latitude 110 37'N and longitude 80 58'E and at an altitude of 403 m above sea level.

Sample Collection

Ten samples of *Heterotis niloticus* with a total weight of 24kg were purchased from the fishermen at Galadima Market, Sabon Gari, Kano and conveyed down to Teaching and Research Laboratory of the Department of Forestry, Fisheries and Wildlife, Aliko Dangote University of Science and Technology, Wudil, Kano State in an ice-filled plastic bowl covered with a sack bag to prevent deterioration.

Experimental Design

This experiment is a factorial experiment having two factors (pepper and ginger spices) arranged a completely randomized design of the preservation inclusion. There are three treatments replicated thrice which are salt treated, ginger treated and pepper treated. Ginger (Zigiber officinala), Cameroon pepper (Capsicum chinese) were obtained from a Wudil local market, Kano State.

Preparation of the Samples

The *Heterotis niloticus* were scaled, gutted and washed severally and then chunked into 48 pieces as each spice was replicated into three places. The three spices used; were ginger and pepper grinded into powder using grinding machine (Manual Multi-function Grinder Machine, Model JR 10). The spices were placed in 1.0 Litre of water and 50g each was weighed using a sensitive scale (Atom A 122 Electronic Kitchen Digital Weighing Scale, Model SF: 400A). Each spice was added 10g of salt and mixed with 1.0 liter of water. The fish samples were soaked in the prepared spice extract for 1h, allowed to dipped for 20 minutes, then placed on smoking trays, tagged and placed into smoking kiln.

Fish Processing

The treated samples were replicated three times . The drying of the fish samples was done using a charcoal fired. They were subjected to heat and allowed to dry for 12h with turning at intervals to achieve a uniformly dried product. The fish samples were cooled, removed from smoking kiln and tagged as; Salt only (Control), Ginger, and Pepper. The samples were smoked dried according to the methods described by Omojowo and Ibitoye (2009)

Organoleptic Evaluation

A taste panel of ten members made of staff and students of Aliko Dangote University of Science and Technology, Wudil. They rate the samples for color, texture, taste and overall acceptability using a hedonic scale of 1 – 5 with 5 representing “like much” ad 1 representing “dislike much” (Afolabi *et al.*, 1984). This was done immediately after smoking the fish and after preserved for 6 weeks.

STATISTICAL ANALYSIS

Data collected were analyzed using simple percentages, descriptive analysis and ANOVA. Data that are significant at 5% are subjected to post hoc tests. SAS was used for the analysis

RESULT AND DISCUSSION

Weight Loss during Fish Processing

The weight loss during the fish processing using the different spices showed that, the fish sample containing Salt recorded a high drying rate followed by fish sample containing the ginger and least by pepper in the drying efficiency

Proximate Composition of the Smoked Fish Sample

The proximate composition of the fish sample as affected by the different spices shows that the proximate composition were not significantly (p> 0.05) influenced by the different solution of the spices. The result indicated highest crude protein (69.41 %)is from ginger spiced, followed by pepper spiced, 68.39% and salt spiced 67.40% (Table 1.)

Table 1.0: Proximate Composition of smoked *Heterotis niloticus* Processed using Salt, Ginger and Pepper Preservation.

Preservative agents	Crude Protein %	Crude Lipid %	Crude Fibre %	Ash %	Nitrogen Free Extract %	Dry Matter%
Salt	67.40±6.07	7.58±2.71	5.44±0.21	8.02±3.39	0.50±0.21	92.25±2.01
Ginger	69.41±6.02	9.05±3.64	4.89±0.08	8.21±4.14	0.18±0.14	93.88±1.93
Pepper	68.39±5.22	8.63±2.37	4.68±0.82	8.35±4.26	0.36±0.89	92.64±1.25

All the means of data on the same column are not significantly different (p>0.05)

Table 2 Proximate Composition of smoked *Heterotis niloticus* Processed Ginger and Pepper at six weeks.

Preservative agents	Crude Protein %	Crude Lipid %	Crude Fibre %	Ash %	Nitrogen Free Extract %	Dry Matter%
Salt	66.90±6.07	8.58±2.71	8.44±0.21	8.02±3.39	2.50±0.21	89.25±2.01
Ginger	68.56±6.02	8.05±3.64	3.89±0.08	8.21±4.14	1..18±0.14	88.88±1.93
Pepper	68.01±5.22	8.63±2.37	5.68±0.82	8.35±4.26	2.36±0.89	89.64±1.25

Mean of Data are no significantly different (p>0.05)

There was no significant difference (p>0.05) in proximate composition of the H. niloticus at the end of the preservation period of six weeks

Table 3: Organoleptic Assessment of the smoked and processed *Heterotis niloticus*.

	Appearance	Taste	Colour	Aroma	Over all acceptability
Salt	3.6	3.6	3.8	3.2	3.55
Pepper	4	4.1	4	4	4.03
Ginger	4.6	4.9	4.4	4.6	4.63

Table 3 showed that Heterotis niloticus when processed weeks recorded highest overall acceptability was recorded in Ginger treated followed by pepper and salt.

Table 4: Organoleptic Assessment of the smoked and processed *Heterotis niloticus* after six weeks

Preservative agents	Appearance	Taste	Colour	Aroma	Over all acceptability
Salt	3.667	2.8	3.8	2.43	3.18
Pepper	3.87	3.57	3.93	3.43	3.7
Ginger	3.93	4	3.93	4.33	4.05

Table 4 showed that *Heterotis niloticus* preserved for 6 weeks recorded highest overall acceptability in Ginger treated followed by pepper and salt

DISCUSSION

Fish Moisture and Pressure Efficiency

Weight loss showed that the fresh fish sample used during processing using the different spices, indicated lost in moisture content due to dehydration during smoking which varies 10-12 hours depending on the final constant weight obtained on the final product .Time and temperature change with high losses, these may be attributed to the type of specie, weight which is in line with Chukwu (2009), who observed that the principle of fish smoking is the removal of water just as the same principles with salting and drying as a result of heat production from smoking.

Proximate Composition of the Processed and Preserved Heterotis niloticus

Protein content of the processed fish species indicated significant difference within the species used and between the different methods. Omojowo and Ihuani (2006) mentioned that proximate composition of fish varies with species, body size, season, environmental factors and nutritional status. The increase of the protein content may be due to product dehydration which concentrated the protein during the heat treatment of the fish, thus increasing the nutritive value of the fish.

Crude lipid content increase could be as a result of heat produced by smoking kiln which result in moisture content losses, increasing the concentration of nutrient in the remaining mass of fat as related to lipid oxidation, which produced volatile compounds known to be unsaturated and very prone to oxidation (Salan *et al,*(2006). Moisture content differences could be due to certain factors such as genetic makeup, feed intake, metabolic efficiency, size, sex, and season of the year. These observation is in line with the findings of Olayemi *et al.*, (2011) who reported that the moisture content of smoked reduces during heat treatment which differs with species. Nitrogen free Extract te content of the fish samples where within the recommended range 0.0 to 3.0% which shows that the species could be source of dietary carbohydrate these agrees with Daramola *et al*, (2013), who reported that carbohydrates contents in fish generally low and practically zero. Ash content was also significant which could be attributed to the fish species, season, sex, and food availability similar findings was also reported by Bilgrin *et al.*, (2008) who observed significant difference in ash content of some nutritional composition of smoked Gilthead seabream.

SUMMARY

The study was conducted to improve the palatability and shelf-life of H. niloticus using ginger and pepper. Improvement of consumer's palatability of Heterotis niloticus for the period of six weeks was investigated by value addition with natural spices and salt to improve its palatability and shelf-life. The study was conducted at Teaching and Research Laboratory of the Department of Forestry, Fisheries and Wildlife, Aliko Dangote University of Science and Technology, Wudil, Kano State. Ten samples of Heterotis niloticus with a total weight of 24kg were purchased from the fishermen at Galadima Market, Sabon Gari, Kano and conveyed down to Teaching and Research Laboratory of the Department of Forestry, Fisheries and Wildlife, ADUST Wudil. The experiment was factorial experiment having two factors (lemon grass and mint leaf) arranged a completely randomized design three treatments replicated thrice. The *Heterotis* *niloticus* were scaled, gutted and washed severally and then chunked into 48 pieces as each spice was replicated into three places. Proximate compositions of the processed fish product were analyzed for Crude Protein, Moisture, Ash, Crude Lipid, Crude fiber, and Nitrogen free extract (digestible carbohydrate). Standard method of the Association of Official Analytical Chemist AOAC (2005) was used for the proximate analysis. Data collected were analyzed using simple percentages, descriptive analysis and ANOVA. The results of proximate composition of the fish sample as affected by the different spices shows that the proximate composition were not significantly ($p > 0.05$) influenced by the different solution of the spices. The result indicated highest crude protein (69.41 %)is from ginger spiced, followed by pepper spiced, 68.39% and salt spiced 67.40%. Sensory assessment as judged by panelist presented in the table above reveal that fish smoked with Lemon grass and Mint leaf was found to be better in terms of, appearance and taste.

CONCLUSION

This study demonstrated the effectiveness of natural spice addition in improving consumer's palatability and controlling microbial population and pathogens in Heterotis niloticus by predicting the microbial safety and quality of smoked H. niloticus. The study shows that ginger plus ginger is an efficient and effective spice for pre-treating fish (H. niloticus) before smoking for production of high quality, palatable and safe smoked-dried products. It was also evident from this study that the application of ginger plus pepper and good/hygienic handling procedures adopted greatly improved consumer's palatability of the fish (H. niloticus) and control microbial population.

RECOMMENDATIONS

- The most effective of the ginger and pepper are recommended for the protection of smoke-dried *Heterotis niloticus* fish against insect pest infestation, as good alternatives to synthetic insecticides.
- Further studies should be conducted to obtain information regarding the practical effectiveness of the ginger and pepper under natural conditions. Also, further studies on ginger and pepper on other stored product pests is recommended

REFERENCES

Allision E.H. (2011). Aquaculture, fisheries, poverty and food security. World fish Centre, 62-65

Amponsah S.K., Ofori-Danson P.K. and Nunoo F.K. (2016). Study of the population parameters of the big eye grunt, Brachydeuterus auritus (Valenciennes, 1831) in Ghanaian coastal waters and its implications for management. Int. J. Fisheries Aquatic Studies, 4,413-419

AOAC. Association of Official Analytical Chemists. Official Methods of Analysis 14th Edition, Washington D.C. 1984

Bate, E.C and Bendall, J.R. (2010). Changes in fish muscle after death. British Medical Bulletin, (12): 2305.

Bate, E.C and Bendall, J.R. (2010). Changes in fish muscle after death. British Medical Bulletin, (12): 2305.

Burt, J.R. (2003) Hypoxanthine a biochemical index of fish quality. Process Biochemistry, 11(10): 23-25.

Emmanuel O., Chinyere A., Oluwatobi A. and Peter K. (2014). Review of aquaculture production and management in Nigeria. Am. J. Exp. Agric., 49, 1137-1151

FAO (2014). The state of world fisheries and aquaculture. Rome, 223

Gopakumar, K. (2000). Enzymes and Enzyme products as Quality Indices. Seafood Enzymes, pp 337-363. Harrd N.F and Simpspn, B.K., (Eds). Marcel Dekker, Inc.New York, Basel, U.S.A.

Harrigan WF, McCance ME. Laboratory Methods in Food and Dairy Microbiology. Academic Press, London. 1976.

Karube, I., Marouka, H., Suzuki, S., Watanabe, E and Toyana, K. (2001). Journal of Agriculture and Food Chemistry, 32: 314-319.

Lima Dos Santos, C.A.M., James, D and Teutscher, F (2011). Guidelines for chilled fish storage experiments. FAO Fisheries Technical paper, No 210. FAO, Rome.

Longwe P, Fannuel K.(2016) Nutritional Composition of Smoked and Sun dried Pond raised Oreochromis karongae (Trewavas, 1941) and Tilapia rendalli (Boulenger, 1896). American Journal of Food and Nutrition.;4(6):157-160.

Maiduguri, Nigeria. Pp12-24. Eds. I. Nkama and P. Sopade. 1990.

Mazrouh MM. Effects of freezing storage on the biochemical composition in muscles of Saurida undosquamis (Richardson,1848) comparing with imported frozen. International Journal of Fisheries and aquactic Science. 2015;3(2):295-299.

Negbenebor C.A. Raw material supply for fishand animal processing Industries. In Proceedings of a workshop organized by the N/E Chapter of NIFST,

Nelson, J., Paetz, S., M and Joseph, R.T. (2004). The Fishes of Alberta, University of Alberta, p.654.

Olofin, E. A. Nabegu, A.B and Dambazau, A. M (2008).Wudil within Kano zone Geographical synthesis, 1st edition, Adamu Jojipublisher. Department of Geography Kano University of Science and Technology, Wudil.

Omojowo FS, Omojasola PF, Idris GL, Ihuahi JA. Evaluation of Citric Acid and Potassium Sorbate as Preservatives on the Safety and Shelf-Life of Smoked Catfish. In: Nature and Science Journal, 2009a Vol. 7(11):1-8.

Oparaku, Nkiruka Francisca, Nwaka FC. (2013) Effect of processing on the nutritional qualities of three fish species (Synodontis clarias, Trachurus trecae and Clarias gariepinus). International Journal Of Biology and Biological Sciences. 2014;2:143-149.

Pasqualino M.M., Thilsted S.H., Phillips M.J. and Koroma A.S. (2016). Food and nutrition security in Sierra Leone with a focus on fish in Tonkolili District. Penang, Malaysia. World Fishery Program Report, 23, 30-34

Pearson D. Chemical Analysis of Foods. 6th Ed. (198)1, Pp 33-120. New-York, Church-hill Livingstone.

Putro, S. (2005). Better on board handling of oil sardines in the Bali Strait using chilled sea water. Infofish Marketing Digest, 86(1): 33-35.

Reza SA, Karmaker S, Hasan M,. (2015).Effect of Traditional Fish Processing Methods on the Proximate and Microbiological Characteristics of Laubuka dadiburjori During Storage at Room Temperature. Journal of Fisheries and Aquatic Science. 2015).;10(4):232-243.

Smida MAB, Bolje A, Ouerhani A, (2014). Effects of Drying on the Biochemical Composition of Atherina boyeri from the Tunisian Coast. Food and Nutrition Sciences. 2014;5(14):1399-1407.

Steel RGD, Torrie JH. Principles and procedures of Statistics. McGraw-Hill Book Co.Inc. 1980. New York.

BACTERIOLOGICAL ASSESSMENT OF SOME FROZEN FISHES SOLD AT BUKURU MARKET, JOS SOUTH METROPOLIS PLATEAU STATE NIGERIA

[1]Jesse J. Gaude, [1]Chalya R. Shedrach, [2] Rotimi A. Ogunmokun, [1]Ibrahim Y.

[1]Department of Fisheries Technology, Federal College of Animal Health and Production Technology, Vom, Jos, Plateau State.
[2]Department of Fisheries Technology, Federal College of Land Resources Technology, Kuru, Jos, Plateau State.

Corresponding Author Email: jjgaude9@gmail.com

ABSTRACT
The bacteriological assessment of frozen Shawa (Ethmalosa fimbriata), Croaker (Pseudotolithus senegalensis), and Scumbia (Scomber japonicas) fish sold in Bukuru Market, Jos South Metropolis, Nigeria, revealed significant levels of contamination. Bacillus species were the most prevalent bacteria identified across all the (3) three fish species, with Scumbia recording the highest bacterial load (210.38±91.11 CFU/g). Shawa followed with a bacterial load of 163.50±64.42 CFU/g, and Croaker had the lowest load at 144.80±126.6 CFU/g. The study also found that the Mean Total Bacterial Count (TBC) was highest in Shawa (2.904 x 106 CFU/g), followed by Scumbia (2.305 x 106 CFU/g) and Croaker. The Total Coliform Count (TCC) showed alarming levels, with Shawa (197,200.00 CFU/g) and Scumbia (1.01821 x 106 CFU/g) exceeding the permissible limits for food safety, while Croaker had a lower count (35,500.00 CFU/g) but still above recommended levels. The results from this research call for better handling and storage practices to reduce the health risks associated with consuming these frozen fish products.

Keywords:
Bacteriological assessment, Frozen fish contamination, Food safety, Bacillus species, Total Coliform count

INTRODUCTION

Nigeria is a major importer of fish and fishery products in Africa, a situation likely driven by the need to fulfill domestic fish demand shortfalls (Okon *et al.*, 2024). Fish is one of the most affordable sources of animal protein across the continent. It has been a staple in human diets for centuries and continues to be a key dietary component in numerous countries due to its digestibility and high nutritional value (Bessada *et al.*, 2019) . Fish species are found in both freshwater and saltwater environments. Specific organisms such as Aeromonas species and others like Staphylococcus aureus, Salmonella, Vibrio parahaemolyticus, Listeria monocytogenes, Shigella, Yersinia, and Pseudomonas are known to potentially cause food-borne illnesses when present in ready-to-eat seafood (Omara *et al.*, 2024). Fish, with its high water content, typically freezes at temperatures between 0°C and 3°C, while freezing can kill some bacteria, others can survive and resume growth once the fish thaws. Bacteria such as Pseudomonas species, Moraxella species, Alcaligenes species, and Flavobacterium species can endure freezing temperatures and grow again when the temperature is favorable. Certain Clostridium botulinum species may survive freezing and potentially produce toxins (Bilska *et al.*, 2024). Fish may become contaminated either after capture or during transportation to retail markets, and if microbial contamination occurs, it can lead to spoilage and food-borne infections or food intoxication. In Nigeria, frozen fish accounts for 45% of fish consumption. Given the increasing population and the need for food storage and transportation, effective food preservation is crucial for maintaining nutritional value, texture, and flavor and safety. This study aimeds to evaluate the microbial load of three imported frozen fish species.

MATERIALS AND METHODS

Sample Collection

Fifteen (15) different frozen fish species namely: Shawa (Ethmalosa fimbriata), Croaker (Pseudotolithus senegalensis) and Scumbia (Scomber japonicas) were collected. Five each of the fish samples were randomly purchased at different periods from retailers in Bukuru Market of Jos South Local Government Area; and transported to the Central Diagnostic Laboratory of the National Veterinary Research Institute (NVRI), Vom, Plateau State. The samples were collected over a period of two weeks

Sample Processing

Upon collection, the frozen fish samples were transported to the laboratory under controlled temperature conditions to prevent thawing. Each sample was then thawed at 4°C for 24 hours. After thawing, the fish samples were aseptically dissected, and the flesh and skin portions were separated for bacteriological analysis according to (Nwaogu and Afolabi, 2022).

Bacteriological Analysis

Media Preparation: Nutrient Agar (for total bacterial count) and MacConkey Agar (for coliform detection), were prepared according to standard protocols and sterilized at 121°C for 15 minutes.The flesh and skin portions of each fish sample were separately homogenized in a sterile saline solution according to (Chukwudi and Okechukwu, 2022). Serial dilutions were prepared, and aliquots of appropriate dilutions were plated on selective and differential media for the enumeration and isolation of bacterial pathogens such as Escherichia coli, Salmonella spp., and Staphylococcus aureus. The plates were then incubated at appropriate temperatures for 24-48 hours (Igwe et al., 2023). Colonies with characteristic morphological features were subjected to biochemical tests, including catalase test, oxidase test, indole test, and coagulase test for the identification of bacterial species (Lawal et al., 2021). Additionally, molecular techniques such as polymerase chain reaction (PCR) were employed for the confirmation of bacterial species (Abubakar and Mohammed, 2022).

Data Analysis

Data obtained from the bacteriological analysis were subjected to descriptive statistical analysis to determine the mean prevalence and counts of bacterial pathogens (Eze and Adamu, 2023). Statistical significance was assessed using appropriate tests, and p-values <0.05 were considered statistically significant (Oladimeji and Adebayo, 2021).

RESULTS AND DISCUSSION

Table 1shows the frequency of occurance of bacterial isolates from the three frozen fish samples. For Shawa, Escherichia coli had the highest occurrence with 6 isolates (11.11%), followed by Coagulase-Negative Staphylococci (CoNS) and Bacillus species, each with 5 isolates (9.26%).
In Croaker, Bacillus species were the most prevalent with 5 isolates (9.26%), while Micrococcus luteus, and CoNS, each had 1 isolate (1.85%). For Scumbia, Bacillus species had 6 isolates (11.11%), followed by Escherichia coli with 5 isolates (9.26%) and Klebsiella aerogenes with 4 isolates (7.41%). Bacillus species were the dominant bacteria across all three fish species with a total of 16 isolates, while Aeromonas hydrophila and Micrococcus luteus were the least common, each with 1 isolate (1.85%) .

Table1: Frequency of occurrences for bacterial isolated from frozen fish

Fish species	Isolated Bacterial	No (%)
Shawa	Coagulase Negative *Staphylococcus* species	5(9.26)
	Escherichia coli	6(11.11)
	Staphylococcus aureus	1(1.85)
	Bacillus species	5(9.26)
	Aeromonas hydrophyla	1(1.85)
	Klebsiella aerogenes	1(1.85)
	Bacillus circulans	2(3.70)
Croaker	*Streptococcus* species	1(1.85)
	Klebsiella aerogenes	2(3.70)
	Bacillus species	5(9.26)
	Escherichia coli,	3(5.56)
	Staphylococcus aureus	1(1.85)
	Bacillus circulans	1(1.85)
	Micrococcus luteus	1(1.85)
	CoNS,	1(1.85)
Scumbia	*Escherichia coli*	5(9.26)
	Bacillus species	6(11.11)
	Klebsiella aerogenes	4(7.41)
	CoNS,	1(1.85)
	Bacillus circulans	2(3.70)
Total		54(100)

Key: CoNS= Coagulase Negative Staphylococcus species

Table 2 Shows the result of bacteriological investigation of the frozen fish samples. Scumbia has the highest raw count 210.38±91.11 of bacterial follows by Shawa 163.50±64.42 while croaker has the lowest raw count of 144.80±126.6. The highest total bacterial count (TBC) was observed in Shawa 2.904 x 106 while the lowest (144.80±126.6) was observed in Croaker. The lowest Mean of raw Count (TCC) was observed in Croaker 35,500.00 while the highest was found in Shawa 197,200.00a.The total coliform count (TCC), was highest in Scumbia followed by Shawa while Croaker had the lowest coliform count (1.01821 x 106a, 6.13 x 105 and 3.5 x 104).

Table 2: Bacteriological Assessment of some selected frozen fish bought from Bukuru Market Jos South Metropolis

Parameters	Shawa	Croaker	Scumbia	S E M	P-Value
Raw Count (10^{-4}) TBC	163.50±64.42	144.80±126.6	210.38±91.11	14.27	0.105^{NS}
Total Bacterial Count (CFU/g)	2.904×10^{6a}	1.448×10^{6b}	2.305×19^{6a}	1.68287×10^{5}	0.007*
Raw Count (10^{-3}) TCC	$197{,}200.00^{a}$	$35{,}500.00^{b}$	$153{,}400.00^{a}$	13.14	0.000*
Total Coliform Count (CFU/g)	6.13×10^{5ab}	3.5×10^{4b}	1.01821×10^{6a}	12.2132×10^{5}	0.001*

KEY: a, b, c Means in the same row with different superscripts are significantly different (P<0.05)
S E M = Standard Error of Mean, N S = Not Significant (P>0.05)

DISCUSSION

The bacterial isolates identified from the frozen fish samples in this study align with findings from other research, although some differences were observed. The high prevalence of Bacillus species (11.11%) across all the three fish types is to the findings of Adeyemi et al. (2023), who reported a dominance of Bacillus species from frozen fish samples in Oyo State and that of Olayinka et al. (2022) who found 13.2% in frozen catfish sold in Ibadan markets. The presence of Escherichia coli (9.26%) as the second most prevalent bacterium in this study, is higher than the report of Bello et al. (2021), who observed (10.8%) of E. coli in frozen tilapia across three Nigerian states. suggesting better handling practices in that region. The high bacterial count in Scumbia (210.38±91.11) is in agreement with findings of Kumar et al. (2022), who reported higher bacterial loads in fish with higher fat content. This suggests that Scumbia's higher fat content supports greater bacterial growth. However, Croaker's lower bacterial count aligns with Santos et al. (2021), who noted that fish with lower fat content tend to have fewer bacteria. According to the report by Nwosu and Nwachukwu (2020), who investigated frozen Mackerel in Enugu and recorded a TBC of 3.1 x 106 CFU/g and a TCC of 6.8 x 105 CFU/g. He observed that the TBC in Mackerel is higher than in Shawa and Scumbia, 2.904 x 106 CFU/g, 2.305 x 106 CFU/g this shows more significant bacterial load. The TCC is, however, lower in Scumbia but higher than in Shawa and Croaker, concluded that Mackerel may pose greater public health risks. Scumbia being second highest supports the idea that bacterial loads can vary significantly among species, which is in cord with the findings of Ahmed et al. (2022).The higher coliform count in Shawa (197,200.00) and Scumbia 1.01821 x 106 CFU/g, compared to Croaker (35,500.00) agreed with the findings of Nair et al. (2021), who reported higher coliform contamination in frozen fish and associated it with poor handling practices. However, the TCC in Shawa (197,200.00) and Scumbia (1.01821 x 106) far exceed the recommended maximum limit of 100 CFU/g for ready-to-eat fish products permissible level, raising significant food safety concerns, Codex Alimentarius (2020).

CONCLUSION

The results revealed significant bacterial contamination, with Scumbia and Croaker frozen fish. This observation called for stricter hygiene practices and regulatory compliance in the handling and storage of frozen fish to safeguard public health.

REFERENCE

Abubakar, M., and Mohammed, R. (2022). Molecular techniques in bacterial identification: Advances and applications. Journal of Bacteriology Research, 14(2), 45-58. https://doi.org/10.5897/JBR2022.0107

Adeyemi, A. O., Fadeyi, T. E., and Ojo, T. T. (2023). Prevalence of Bacterial Contaminants in Frozen Fish from Markets in Oyo State, Nigeria. Journal of Food Safety and Hygiene, 9(2), 112-119.

Ahmed, M. I., Rahman, A. S., and Begum, A. (2022). Variation in bacterial contamination among different species of frozen fish. Fisheries and Aquatic Sciences, 25(3), 459-466. https://doi.org/10.1016/j.fshs.2022.09.005

Bello, K. Y., Salihu, L. A., and Abdullahi, S. I. (2021). Incidence of Escherichia coli in Frozen Tilapia Fish from Three States in Nigeria. Journal of Applied Microbiology, 131(4), 1256-1264.

Bessada, S. M., Barreira, J. C., and Oliveira, M. B. P. (2019). Pulses and food security: Dietary protein, digestibility, bioactive and functional properties. Trends in Food Science & Technology, 93, 53-68.

Bilska, A., Wochna, K., Habiera, M., and Serwanska-Leja, K. (2024). Health Hazard Associated with the Presence of Clostridium Bacteria in Food Products. Foods, 13(16), 2578.

Chukwudi, C.I., and Okechukwu, L.N. (2022). Microbial assessment of frozen fish: Techniques and outcomes. International Journal of Microbiology, 20(2), 89-97. https://doi.org/10.1155/2022/6574356

Codex Alimentarius (2020). Code of practice for fish and fishery products (CAC/RCP 52-2003). FAO/WHO Codex Alimentarius Commission. Retrieved from https://www.fao.org/fao-who-codexalimentarius/en/

Eze, C. N., and Adamu, M. A. (2023). Prevalence of bacterial pathogens in frozen fish from selected Nigerian markets. Journal of Food Protection, 86(2), 307-314.

Igwe, K.A., Nwafor, J.E., and Okoro, C. (2023). Enumeration and isolation of bacterial pathogens in fish products. Journal of Microbiological Methods, 19(2), 134-140. https://doi.org/10.1016/j.mimet.2023.05.008

Kumar, R., Kumar, S., and Sharma, M. (2022). Bacterial load in relation to fat content in fish species: A comprehensive study. Fisheries Research, 245, 106905. https://doi.org/10.1016/j.fishres.2022.106905

Lawal, O., Ibe, E., and Emeka, C. (2021). Biochemical characterization of bacterial isolates in fish. Journal of Applied Bacteriology, 15(4), 211-220. https://doi.org/10.1111/jab.2021.456

Nair, P. P., Prasad, R., and George, T. (2021). Coliform contamination in frozen fish: A study on the influence of handling practices. Food Control, 132, 108352. https://doi.org/10.1016/j.foodcont.2021.108352

Nwaogu, T., and Afolabi, F. (2022). Bacteriological examination of fish: Methods and practices. Journal of Aquatic Food Product Technology, 28(2), 147-155. https://doi.org/10.1080/10498850.2022.127942

Nwosu, C. K., and Nwachukwu, I. S. (2020). Bacteriological quality of frozen Mackerel (Scomber scombrus) in Enugu markets. Nigerian Food Journal, 38(1), 45-53.

Okon, E. M., Okocha, R. C., Folowosele, D. O., Oluwafemi, P. T., and Falana, B. M. (2024). Aquatic food resources in tropical Africa: a comprehensive analysis. Frontiers in Sustainable Food Systems, 8, 1252119.

Oladimeji, A., and Adebayo, K. (2021). Statistical analysis in bacteriological studies. Journal of Statistical Research, 18(2), 98-105. https://doi.org/10.1080/00949655.2021.1002447

Olayinka, O. S., Oke, O. A., and Ademola, T. M. (2022). Microbial Quality of Frozen Catfish in Selected Markets in Ibadan, Nigeria. African Journal of Microbiology Research, 16(5), 245-252.

Omara, S. T., and Eljakee, J. A. K. E. E. N. (2024). Microbiological Assessment of Various Ready-To-Eat Foods in Cairo, Egypt, and Studying the Possible Antibacterial Effects of Garlic and Cumin Oils as Food Additives. Egyptian Journal of Veterinary Sciences, 55(1), 243-257.

Santos, J. P., Carvalho, C. M., and Sousa, R. (2021). Correlation between fish fat content and bacterial contamination in commercially available frozen fish. Journal of Applied Ichthyology, 37(4), 543-550. https://doi.org/10.1007/s11676-021-01354-4

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

EFFECT OF PRE-TREATMENT ON SENSORY AND PROXIMATE COMPOSITION OF *Oreochromis niloticus*

[1]Umar, K. A., [2] I. M. Danwali, [1] J. K. Yusuf, [1] G. J. Kwala, [1] M. I. Ramalan and [3] U. S. Muhammad

[1]Department of Fisheries and Aquaculture, Federal University of Lafia, Lafia, Nasarawa State, Nigeria.
[2]Department of Aquaculture and Fisheries Management, Nasarawa State University Keffi, Shabu-Lafia Campus. Nasarawa State, Nigeria.
[3]Department of Agricultural Technology, Federal Polytechnics, Nasarawa State, Nigeria

Corresponding Author:
gudakaltume1@gmail.com, +2348035973192

ABSTRACT
The effects of blanching (A), salting (B), and sugaring (C), as a pre-treatment on sensory and proximate composition of smoked Tilapia *(Oreochromis niloticus)* were assessed with fish samples without any form of pre-treatment as the control (D). Tilapia samples of 13kg were used for the study. Organoleptic test was conducted using a 10-point hedonic scale ranging from highly acceptable to highly unacceptable for each quality parameter. The results indicated that Texture had the highest score of 9.00+1.70 and 9.00+1.41 in B and C and lowest 7.00+1.70 in A; taste had highest (8.60+1.89) in C and lowest (7.20+2.70) in D. Flavour was highest with 9.00+1.70 and 9.00+1.4 in B and C and lowest (7.00+1.70) in A. Odour was highest with 8.60+1.89 in C, while was lowest (7.20+2.70) in D. Acceptability mean value was highest with 9.00+1.05 in D and lowest (8.60+1.35) in A. There was no significant difference in organoleptic attributes of B and C while both had better organoleptic attributes D and A; however, proximate composition of the differently smoked tilapia changes after 21 days of storage; therefore, salting, and sugaring pre-treatments are recommended for better organoleptic qualities for short storage period.

Keywords:
Oreochromis niloticus, blanched-smoked, salted-smoked, sugared-smoked, organoleptic test.

INTRODUCTION

Fish can contribute to the food and nutrition status of the world population through a variety of ways that range from direct supply of nutrients to consumers to providing income to fish dealers who sell the fish. Fish provides excellent protein, and several macro- and micronutrients (FAO, 2014). Fish has been suggested to be a useful key component for a healthy diet in humans. Fish has high food potential and could be expected to give relief to humans from malnutrition especially in countries with low-income earners and with high protein demand (FAO, 2005; Ashraf *et al*., 2011). For short time storage of dry fish that is safe from moulds and bacteria infestation, the moisture content must well below 30% (Idah and Nwankwo, 2013). Fish is usually preserved by many processes such as drying, canning, and smoking among others. Dry fish is a major form of fish preservation in many countries of the tropics, especially Nigeria. An average of about 30% of the world fish catch is consumed in the dried, salted, smoked forms or combination of these processes (Aliya *et al.*, 2012). Some of these preservation methods have various effects on the physical and nutritional quality of fish (Oparaku and Mgbenka, 2012).

Tilapias reproduce easily, and very palatable for consumption, most grow in brackish water, and some will adapt to full strength sea water; these characteristics make Tilapia well adapted to the environmental conditions of Africa and most developing countries (Aliya *et al.*, 2012). which motivated this research. A larger percentage of consumers do eat fish because of its availability, flavour, and palatability while fewer percentages do so because of its nutritional value. This research is aimed at assessing different pre-treatments of smoked Oreochromis niloticus based on palatability, sensory evaluations, and proximate analysis. This research will give options to patient with hyper/hypo sugar and blood pressure.

MATERIALS AND METHODS

Study Area

The experiment was carried out at the Fish processing unit of the Experimental Farm of the Department of Aquaculture and Fisheries Management (DAFM) of the Faculty of Agriculture, Nasarawa State University Keffi, Shabu- Lafia Campus. Lafia is located on latitude 8° 35'N, longitude 8° 32'E, altitude 181.53m above sea level with a mean temperature of 34°C, relative humidity of 40-86% and average day light of 9-12h (NIMET, 2011).

Source of Fish Samples

Thirteen (13) kg of O. niloticus fish samples were used for the study. The fish samples were purchased from fish sellers in Doma, Nasarawa State, Nigeria, and were conveyed to the DAFM of laboratory with ice water crystals and was subjected to immediate processing to prevent spoilage.

Fish Sample Preparation

Upon conveyance of the fish samples to the laboratory, the fish were thoroughly washed in clean water and degutted after which the fish was washed again in clean water and then drained briefly (about 20 min) in clean perforated containers to remove most of the resulting water. Thereafter, the fish was divided into four subgroups randomly while ensuring that each of the parts of the fish were represented in each pre-treatment before applying the treatments.

Application of Treatments

Blanching: Fish sample was dipped in 5 litres of boiling water (100°C) for about 5 minutes. The fish was removed and arranged on trays for about 30 minutes to remove all surface water from the fish before arranging them on the drying trays in the smoking kiln.

Salting: Fish sample was dipped into salt solution (250 g of salt to 5 litres of water) for about 30 minutes. They were removed and arranged on a tray and left for about 30 minutes to allow the surface water to be removed.

Sugaring: Fish sample was dipped into sugar solution (250 g of sugar to 5 litres of water) for about 30 minutes.

Control: The fish samples (without any form of pre-treatment) for control was just arranged on the trays for about 30 minutes to allow removal of surface water before drying.

Drying of Fish Samples

Fish samples were smoked using red flame from charcoal for 12 hours.

Sensory Evaluation

Samples from the freshly prepared dried fish products were subjected to sensory evaluation immediately after processing to obtain data for the selection of the best out of the differently dried fish samples before storage. A 10-member taste panel consisting of Staff and Students at the University was constituted. The samples were blind coded to reduce bias. Organoleptic parameters assessed include texture, taste, flavour, and general acceptability in accordance with Post et al. (1991). A 10-point hedonic scale ranging from highly acceptable to highly unacceptable was adopted for each quality parameter. Pencils, tissue paper and water was provided to the judges.

Proximate Analysis

Proximate analysis was done according to AOAC (2000).

Data Analysis

Data generated was subjected to One-Way Analysis of Variance (ANOVA) using SPSS version 20. Duncan Multiple Range test at the 5% level of significance was used to determine differences in means of all treatments.

RESULTS AND DISCUSSION

The results of effect of different pre-treatment (blanching, sugaring, and salting) on sensory properties of O. *niloticus* is presented in Table 1. Texture was highest 9.00+1.70 and 9.00+1.41 in salted and sugared O. *niloticus* and lowest 7.00+1.70 in blanched O. *niloticus* but were significantly different ($p<0.05$) among other treatments. Taste mean value was highest 8.60+1.89 in sugared O. *niloticus*, followed by 8.20+2.02 in salted O. *niloticus* while it was lowest 7.20+2.70 in the control. Taste was not significantly different ($p>0.05$) among salted and sugared O. *niloticus*. Flavour mean values was highest 9.00+1.70 and 9.00+1.4 in salted and sugared O. *niloticus* and lowest 7.00+1.70 in blanched O. *niloticus*. Flavour was not significantly different ($p>0.05$) among salted and sugared O. *niloticus* but were significantly different ($p<0.05$) among other treatments. Odour mean value was highest 8.60+1.89 in sugared O. *niloticus*, followed by 8.20+2.02 in salted O. niloticus while it was lowest 7.20+2.70 in the control. Taste was not significantly different ($p>0.05$) among salted and sugared O. *niloticus* but were significantly different ($p<0.05$) among other treatments. Acceptability mean value was highest 9.00+1.05 in the control and lowest 8.60+1.35 in blanched O. *niloticus*. Results of acceptability showed no significance difference ($p>0.05$) among the treatments. Tables 2 and 3 are proximate composition analysis.

Organoleptic attributes of smoked Tilapia

Sensory assessment as judged by the panellist as presented in Table 1 revealed that salted and sugared O. *niloticus* were found to be the best in terms of texture, taste, flavour, and odour with average scores of 9.00, 8.60, 8.20, 9.00, 8.60 and 8.20 respectively. This result is in line with the results of Abolagba et al. (2015) who reported mean values of 8.95, 8.11, 8.21, 8.95 and 8.0 for taste, flavour, colour, appearance, and texture of smoked cultured *Clarias gariepinus* in Delta and Edo States. There was no significant difference ($p>0.05$) in the appearance measured in this study. However blanching and the control had no significant difference ($p>0.05$) in all the sensory attributes assessed. In all the sensory qualities examined, the differently processed smoked O. *niloticus* scored above average, which indicates that are all acceptable after smoking. This agreed with findings of Bilgin *et al.* (2008) and Kumolu-Johnson *et al.* (2010), who reported that in terms of flavour, texture, appearance, odour and taste, the smoked fish scored above average which indicated that they might still be acceptable 21 days after smoking

Table 1: Effect of different pre-treatment (blanched, sugared and salted) on sensory properties of Oreochromis niloticus.

Parameter	Samples			
	TA	TB	TC	TD
Texture	8.00 ± 2.66^{b}	9.00 ± 1.70^{a}	9.00 ± 1.41^{a}	7.00 ± 1.70^{c}
Taste	7.20 ± 2.70^{b}	8.20 ± 2.20^{a}	8.60 ± 1.89^{a}	7.80 ± 2.20^{b}
Flavour	8.00 ± 2.66^{b}	9.00 ± 1.70^{a}	9.00 ± 1.41^{a}	7.00 ± 1.70^{c}
Odour	7.20 ± 2.70^{b}	8.20 ± 2.20^{a}	8.60 ± 1.89^{a}	7.80 ± 2.20^{b}
Appearance	9.00 ± 1.05^{a}	8.80 ± 1.03^{a}	8.80 ± 1.39^{a}	8.60 ± 1.35^{a}

Mean with different superscript along the row are significantly different ($p<0.05$)

Table 2 Initial Proximate Composition of the differently Smoked Tilapia.

Parameters	Treatment ±SD			
	TA	TB	TC	TD
%MD	5.84 ± 0.55^{a}	4.43 ± 0.10^{b}	3.32 ± 0.10^{c}	5.46 ± 0.11^{a}
% ASH	14.27 ± 0.95^{a}	10.40 ± 0.60^{c}	12.09 ± 0.02^{b}	10.65 ± 0.49^{c}
%CP	47.61 ± 0.55^{b}	48.45 ± 0.59^{b}	48.57 ± 0.08^{b}	50.64 ± 0.58^{a}
% EE	25.43 ± 0.52^{b}	25.97 ± 0.64^{ab}	26.88 ± 0.61^{a}	27.03 ± 0.99^{a}
% CF	1.25 ± 0.06^{ab}	1.14 ± 0.03^{b}	1.37 ± 0.21^{a}	1.13 ± 0.02^{b}
%NFE	6.41 ± 0.10^{c}	9.77 ± 0.08^{a}	8.41 ± 0.15^{b}	5.44 ± 0.49^{d}

Mean with different superscript along the row are significantly different ($p<0.05$)

Table 3 Final Proximate Composition of the differently Smoked Tilapia

Parameters	Treatment ± SD			
	TA	TB	TC	TD
%MD	4.25±0.63[c]	5.29±0.61[b]	4.78±0.05[bc]	6.88±0.11[a]
% ASH	13.30±0.70[a]	9.62±0.10[c]	11.51±0.61[b]	9.41±0.06[c]
%CP	42.77±0.67[b]	43.89±0.61[b]	43.45±0.61[b]	45.67±0.76[a]
%E. E	21.09±0.49[c]	22.84±0.55[b]	22.45±0.55[b]	24.42±0.55[a]
%CF	1.62±0.57[a]	1.36±0.10[a]	1.28±0.05[a]	1.26±0.06[a]
%NFE	17.57±.55[a]	17.86±0.55[a]	17.28±0.61[a]	13.21±0.61[b]

Mean with different superscript along the row are significantly different ($p<0.05$)

Proximate composition of smoked Catfish and Tilapia

The measurements of some proximate profiles (Tables 1 and 3) are often necessary to ensure that they meet the requirements of food regulations and commercial specifications. The moisture content obtained in this study for differently processed tilapia was between 3.20 - 6.88, ash content was between 9.62 -14.7, crude protein content was between 42.77. -50.64, ether extract was between 21.09 - 27.03, crude fibre 1.14 - 1.62 and NFE 5.44 -17.86. The values obtained in this study are in range with 10.4, 31.50, 25.83 and 16.27 for moisture, crude protein, lipid and NFE in smoked Tilapia as obtained by Ande et al. (2012). Fapohunda and Ogunkoya (2006) reported 14.64 ash content in smoked Tilapia zilli. Olopade *et al.* (2013) reported crude protein of smoked O. niloticus to be between were 47.69 and 50.12 and 10.21 as fact content. There was a decrease in crude protein content of the differently smoked fish. The decrease in the crude protein content could be because of loss of nutrient in the fish after 21 days of storage. Salted fish recorded the lowest crude protein level 34.56 – 51.63. Reduction in the percentage crude protein of the fish during the period of storage could be due to gradual degradation of the initial crude protein to more volatile products such as Total Volatile Bases (TVB), Hydrogen sulphide and Ammonia. Changes observed in protein content during storage may also have been due to leaching out of some extractable soluble protein fraction (Daramola et al., 2007). High susceptibility of fish to oxidative rancidity resulted from the high degree of unsaturation in the form of multiple double bonds in fatty acids Obemeata *et al.* (2011).

There was reduction in crude fat (Ether Extract) content in most of the smoked fish from the initial stage to the final stage (week 0-21 days). The reduction in crude fat content of both the differently processed fish may be due to oxidation and crude fat break down into other components. That is, oxidation of poly-unsaturated fatty acids (PUFA) contained in the fish tissue to products such as peroxides, aldehydes, ketones, and the free fatty acids as reported by Daramola *et al.* (2007). Fish oil has been found to be more liable to spoilage than other oils due to their greater number of unsaturated fatty acids as shown by the lower specification number and higher iodine value. The greater the degree of instauration, the greater would be the tendency for fat oxidation (rancidity). There might be high risks of rancidity during prolonged storage conditions due to the fatty nature of fish; the increase in the crude fibre content of differently processed fish during the period of assessment in this study could be accounted for by the fact that in these samples, there had been oxidation of their poly-unsaturated fatty acids (PUFA) components, contained in their tissues to products such as peroxides, aldehydes, ketones, and free fatty acids (Daramola *et al.*, 2007).

CONCLUSION

The result of the study showed that there was no significant difference in organoleptic attributes of salted and sugared-smoked Tilapia, and both had better organoleptic attributes than the control and the blanched smoked one. However, the proximate composition of the differently smoked tilapia changed after 21 days of storage, therefore, storage significantly affects the proximate composition of differently smoked tilapia upon prolong storage.

RECOMMENDATION

From the results, it is therefore recommended that fish processors should process their fish by salting or sugaring for better organoleptic qualities and that fish processed by only salting or sugaring should not be stored for long period to prevent loss of nutrients.

REFERENCES

Abolagba, O. J., Omoruyi, K. and Ajiwoni, K. M. (2015). Effects of smoking on the nutritional qualities of wild Synodontis clarias and cultured Clarias gariepinus in Delta and Edo State.

Aliya, G., Humaid, K., Nasser, A., Sami, G., Aziz, K., Nashwa, M. and Ponnerassery, S. S. (2012). Effect of the freshness of starting material on the final product quality of dried salted shark. Advance Journal of Food Science and Technology. 4(2): 60-63pp.

Ande, S., Leke, L., Eneji, I. and Yakubu, S. (2012). Proximate analysis of smoked and unsmoked fish (cat and tilapia) in Ombi River Lafia Nasarawa State Nigeria. Elixir International Journal of Food Science. 52 (2012): 11801-11803.

Ashraf, M. A., Zafar, A. R., Shahib, M. and Maureen A. Q. (2011). Nutritional value of wild and cultivated silver carp (Hypophthalmicthys molitrix) and Grass carp (Ctenoppharyngodon idella). International Journal of Agriculture and Biology. 13: 210-214pp.

Association of Official Analytical Chemist (AOAC) (2000). Official Methods of Analysis of the AOAC International. (17thedn), The Association, Gaithersburg, MD, USA.

Bilgin, S. M., Untusayin, L. I. and Gunlu, A. (2008). The determination of the shelf life and some nutritional components of gilthead seabream (Sparus aurata L. 1758) after cold and hot smoking. Turkish Journal of Veterinary Animal Science, 32 (1): 49–56.

Daramola, J. A., Fasakin, E. A. and Adeparusi, E. O. (2007). Changes In Physicochemical And Sensory Characteristics of Smoke-Dried Fish Species Stored at Ambient Temperature. African Journal of Food Agriculture Nutrition and Development: 7 (6). www.biolone.org.br/nd

FAO. (2008). Securing regional supply in aquatic products: prospects from the FAO postharvest loss assessment case studies. Paper presented at the Committee for Inland Fisheries and Aquaculture of Africa, Fifteenth Session. Lusaka, Zambia

FAO. (2014). The State of World Fisheries and Aquaculture: Opportunities and challenges. Rome 2014

Fapohunda, O.O. and Ogunkoya, M. (2006). Effect of smoke-drying on the proximate composition of Tilapia zilli, Parachanna obscura and Clarias gariepinus obtained from Akure, Ondo State, Nigeria. Animal Research International 3 (2): 478-480.

Idah, P. A. and Nwankwo, I. (2013). Effects of smoke-drying temperatures and time on physical and nutritional quality parameters of Tilapia (Oreochromis niloticus). International Journal of Fisheries and Aquaculture. 5(3), 29-34pp.

Kumolu- Johnson, C.A., Aladetohun, N. F. and Ndimele, P.E. (2010). The effects of smoking on the nutritional qualities and shelf life of Clarias gariepinus (Burchell, 1822). African Journal of Biotechnology, 9:(1) 073- 076.

Obemeata, O., Nnenna, F.P. and Christopher, N. (2011). Microbiological assessment of stored Tilapia guineesis. Afr. J. Food Sci., 5: 242-247.

Olopade, O.A., Taiwo, I.O. and Agbato, D.A. (2013). Effect of traditional smoking method on nutritive values and organoleptic properties of Sarotherodon gelilaeus and Oreochromis niloticus. International Journal of Applied Agricultural and Apicultural Research. 9 (1&2): 91-97.

Oparaku, N. F. and Mgbenka, B. O. (2012). Effects of electric oven and solar dryer on a proximate and water activity of Clarias gariepinus Fish. European Journal of Science Research. 81(1):139 -144pp.

Poste, L.M., Mackie, D.A. and Butler, G. (1991). Laboratory methods for sensory analysis of food. Ottawa. Res. Branch Agric., Canada Publication. p. 90.

ANALYSIS OF POLYCYCLIC AROMATIC HYDROCARBONS (PAHS) IN SMOKED *Clarias gariepinus* AND *Merluccius merluccius* MARKETED IN EKITI STATE, NIGERIA

[1]Fabusoro, A.A., [1]O.H. Tope-Jegede, [1]T.O. Ariyomo, [1]J.O. Jimoh, [1]J.S. Kelau, [1]E.O. Awelogun, [1]M.O. Ayanniyi, [1]J.W. Odetoso, [1]D.O. Kolade, and [1]Z.A. Lawal

[1]Department of Fisheries and Aquaculture, Federal University Oye Ekiti

Corresponding Author:
abiola.fabusoro@fuoye.edu.ng, +2348066576516, 0000-0002-4484-5350

ABSTRACT

Polycyclic Aromatic Hydrocarbons (PAHs) are environmental pollutants with potential carcinogenic, mutagenic, and teratogenic effects on humans, formed primarily during the incomplete combustion of organic matter. In Ekiti State, Nigeria, smoked fish, including *Clarias gariepinus* (African catfish) and *Merluccius merluccius* (European hake), are commonly consumed, raising concerns about food safety due to the presence of PAHs. This study aims to analyze the levels of PAHs in smoked *Clarias gariepinus* and *Merluccius merluccius* and assess the associated health risks to consumers using the recognized European Commission Standard limit of 12μg/kg for carcinogenic PAH4. Smoked fish samples were collected from three federal constituencies in Ekiti State and analyzed using Gas Chromatography-Mass Spectrometry (GC-MS). *Clarias gariepinus* had BaP concentrations ranging from 1.92±0.60 μg/kg to 2.19±0.19 μg/kg, slightly exceeding regulatory limits of 2 μg/kg, whereas *Merluccius merluccius* had lower BaP levels (0.11±0.01 μg/kg to 0.41±0.23 μg/kg). PAH4 concentration ranges from 3.15 μg/kg to 3.52 μg/kg for C. *gariepinus* and 0.94 μg/kg to 1.53 μg/kg for M. merluccius all noted to be within safety standards. The results indicated that *Clarias gariepinus* exhibited PAH levels near to slightly above regulatory limits across the sample location, suggesting a higher carcinogenic risk compared to *Merluccius merluccius*, which remained within acceptable safety standards. These findings underline the need for regular monitoring, improved processing practices, and regulatory interventions to minimize PAH exposure and protect public health.

Keywords:
Polycyclic Aromatic Hydrocarbons, Clarias gariepinus, Merluccius merluccius, Food Safety, Fish Processing

INTRODUCTION

Polycyclic Aromatic Hydrocarbons (PAHs) are a class of organic compounds that are formed primarily during the incomplete combustion of organic matter (Abdel-Shafy & Mansour, 2016). They are known to be environmental pollutants with potential carcinogenic, mutagenic, and teratogenic effects on humans. PAHs are found in various food items, particularly in smoked and grilled foods due to the methods of preparation that involve direct exposure to smoke (Adeyeye & Ashaolu, 2022).

Smoked fish is a popular delicacy in many parts of the world, including Nigeria. In Ekiti State, *Clarias gariepinus* (African catfish) and *Merluccius merluccius* (European hake) are commonly smoked and consumed. However, the smoking process, which imparts flavor and extends the shelf life of the fish, can also lead to the formation of PAHs. Given the widespread consumption of these fish species in Ekiti State, it is crucial to understand the levels of PAHs present in these products and assess their potential health risks to consumers.

The increasing consumption of smoked fish in Ekiti State, particularly in this period of economy downturn raises concerns about food safety, particularly in relation to the presence of PAHs. The traditional smoking methods employed by local processors may contribute to the formation of significant levels of PAHs in the smoked fish, posing a potential health risk to consumers (Asamoah et al., 2021). Despite the popularity of smoked *Clarias gariepinus* and *Merluccius merluccius* in the region, there is a lack of comprehensive studies that analyze the PAH content in these products. This gap in knowledge necessitates a detailed investigation into the PAH levels in smoked fish products to ensure public health safety.

Given the carcinogenic nature of some PAHs and the high consumption rates of smoked fish in Ekiti State, it is imperative to assess the levels of these compounds in smoked *Clarias gariepinus* and *Merluccius merluccius*. Therefore, this research seeks to analyze the levels of Polycyclic Aromatic Hydrocarbons (PAHs) in smoked *Clarias gariepinus* and *Merluccius merluccius* processed in Ekiti State with a view to assessing the potential health risks associated with their consumption. The findings of this study will provide valuable insights into the extent of PAH contamination in smoked fish and will inform both consumers and regulators about potential health risks. Moreover, the results can guide the development of safer smoking practices that minimize PAH formation, ultimately contributing to better food safety standards in the region.

MATERIALS AND METHOD

Study Area and Sampling Locations

The study was conducted across three federal constituencies in Ekiti State: Ekiti North, Ekiti Central, and Ekiti South. Within each constituency, one local government area was selected, and in each local government area, a major market was chosen as the sampling location. The selected markets were intended to represent the diversity of fish species in the region, although traditional processing methods were predominantly observed. This method is widely used in the region and is known for its potential to produce Polycyclic Aromatic Hydrocarbons (PAHs) due to the direct exposure of the fish to smoke.

Sample Collection

Smoked fish samples of *Clarias gariepinus* (African catfish) and *Merluccius merluccius* (European hake) were purchased from each selected market within the selected local government. For each fish species, three samples were collected per market, leading to a total of nine samples per species across the entire study area. These samples were categorized by their respective constituencies, providing three replicates for each species per constituency as follows:

- Ekiti Central: Ado Local Government (Sample A)
- Ekiti South: Ikere Local Government (Sample B)
- Ekiti North: Oye Local Government (Sample C)

Laboratory Analysis of PAHs

The smoked fish samples were transported to the Department of Chemical and Petroleum Engineering at Afe Babalola University for PAH analysis. The analysis was performed using a Varian GC-MS 4000/3800 gas chromatograph (Agilent Technologies, Palo Alto, CA) equipped with an HP-1MS (Cross-linked PH ME siloxane) column. The procedure followed the standard method described by Wretling et al., (2010). The gas chromatograph-mass spectrometer (GC-MS) was calibrated using standard solutions containing the 16 target PAH compounds.

Statistical Analysis

The data obtained from the PAH analysis were subjected to a one-way analysis of variance (ANOVA) using Statistical Package for the Social Sciences (SPSS) software, version 25. Significant differences were determined at a 5% level of significance using Duncan's Multiple Range Test. The results were further compared with the recognized European Commission Standard limit for processed fish and meat products to evaluate the potential health risks associated with the consumption of these smoked fish.

RESULTS AND DISCUSSION

The concentrations of polycyclic aromatic hydrocarbons (PAHs) in Clarias gariepinus and Merluccius merluccius samples are presented in Table 1. A total of sixteen PAHs were measured, including Naphthalene (NAP), Acenaphthylene (ACY), Acenaphthene (ACE), Fluorene (FLU), Phenanthrene (PHEN), Pyrene (PRY), Fluoranthene (FLTH), Anthracene (ANTH), Benzo[k] fluoranthene (Benzo[k]), Benzo[a]pyrene (B[a]P), Chrysene (CHRY), Benzo[a]anthracene, [1,2,3-cd]pyrene, Benzo[b]fluoranthene (Benzo[b]), Dibenzo[a,h]anthracene (Dibenzo[a,h]), and Benzo[g,h,i]perylene.
The analysis of Polycyclic Aromatic Hydrocarbons (PAHs) in smoked C*larias gariepinus* and *Merluccius merluccius* highlights the variability in contamination levels between these species, which may directly impacts the potential health risks associated with their consumption.

Table 1: PAHs Concentration in fish samples commonly marketed in Ekiti State

	Clarias gariepinus			*Merliccius merliccius*		
Compounds	Sample A (µg/kg)	Sample B (µg/kg)	Sample C (µg/kg)	Sample A (µg/kg)	Sample B (µg/kg)	Sample C (µg/kg)
Naphthalene (NAP)	0.41±0.25[a]	0.46±0.23[a]	0.61±0.19[a]	0.33±0.03[a]	0.22±0.01[a]	0.64±0.15[b]
Acenaphthylene (ACY)	1.92±0.08[a]	1.86±0.16[a]	1.98±0.10[a]	ND	ND	ND
Acenaphthene (ACE)	0.67±1.16[a]	0.35±0.61[a]	0.72±1.25[a]	ND	ND	ND
Fluorene (FLU)	1.50±0.35[a]	1.45±0.35[a]	1.65±0.32[a]	ND	ND	ND
Phenanthrene (PHEN)	0.43±0.75[a]	0.40±0.69[a]	0.46±0.80[a]	0.08±0.01[a]	0.12±0.02[a]	0.40±0.16[b]
Pyrene (PRY)	0.62±1.07[a]	0.60±1.10[a]	0.63±1.10[a]	0.96±0.03[b]	0.62±0.02[a]	0.70±0.15[a]
Fluoranthene (FLTH)	2.79±3.80[a]	2.77±3.72[a]	2.86±3.80[a]	0.72±0.03[b]	0.43±0.02[a]	0.67±0.16[b]
Anthracene (ANTH)	2.00±2.21[a]	1.90±2.12[a]	2.05±2.22[a]	0.13±0.02[a]	0.34±0.02[ab]	0.52±0.26[b]
Benzo[k]fluoranthene (B[k]F)	ND	ND	ND	0.12±0.01[a]	0.13±0.02[a]	0.43±0.21[b]
Benzo[a]pyrene (B[a]P)	1.92±0.60[a]	2.19±0.19[a]	2.09±0.73[a]	0.11±0.01[a]	0.11±0.02[a]	0.41±0.23[b]
Chrysene (CHRY)	0.22±0.25[a]	0.15±0.14[a]	0.32±0.32[a]	0.77±0.02[a]	0.77±0.04[a]	0.68±0.18[a]
Benzo[a]anthracene (B[a]A)	1.01±0.78[a]	1.01±0.76[a]	1.11±0.83[a]	ND	ND	ND
Indeno[1,2,3-cd] pyrene	1.25±0.56[a]	1.20±0.68[a]	1.41±0.64[a]	ND	ND	ND
Benzo[b]fluoranthene (B[b]F)	ND	ND	ND	0.06±0.01[a]	0.16±0.02[a]	0.44±0.12[b]
Dibenzo[a,h]anthracene ((D[ah]A))	0.07±0.12[a]	0.08±0.13[a]	0.08±0.14[a]	0.33±0.03[a]	0.21±0.02[a]	0.63±0.22[b]
Benzo[g,h,i]perylene (B[ghi]P)	ND	ND	ND	ND	ND	ND

ND: Not Detected. Mean ± S.D with different superscripts across rows are significantly different

The European Commission has set maximum allowable levels for certain PAHs in food to protect public health. Specifically, the limit for Benzo[a]pyrene (BaP), a known carcinogen, is 2 µg/kg, while the combined limit for four PAHs (PAH4: Benzo[a]anthracene, Chrysene, Benzo[b]fluoranthene, and Benzo[a]pyrene) is 12 µg/kg (Iwegbue et al., 2015).
In C*larias gariepinus*, the BaP concentrations ranged from 1.92±0.60 µg/kg to 2.19±0.19 µg/kg, which is at and slightly above the regulatory limit. In contrast, *Merluccius merluccius* had significantly lower BaP levels, ranging from 0.11±0.01 µg/kg to 0.41±0.23 µg/kg, well within the acceptable limit. These findings indicate that *Merluccius merluccius* poses a lower carcinogenic risk compared to C*larias gariepinus* marketed in Ekiti State.
The PAH4 concentrations in C*larias gariepinus* did not exceed the European Commission's threshold

of 12 μg/kg, with values for individual PAH compounds such as Chrysene and Benzo[a]anthracene remaining within safe limits. Merluccius merluccius also demonstrated compliance with safety standards, with Chrysene levels ranging from 0.68±0.18 μg/kg to 0.77±0.04 μg/kg and Benzo[b]fluoranthene levels from 0.06±0.01 μg/kg to 0.44±0.12 μg/kg.

Table 2: PAH4 Concentration in fish samples commonly marketed in Ekiti State

Compounds	*Clarias gariepinus* Sample A (µg/kg)	Sample B (µg/kg)	Sample C (µg/kg)	*Merliccius merliccius* Sample A (µg/kg)	Sample B (µg/kg)	Sample C (µg/kg)
Benzo[a]pyrene (B[a]P)	1.92±0.60[a]	2.19±0.19[a]	2.09±0.73[a]	0.11±0.01[a]	0.11±0.02[a]	0.41±0.23[b]
Chrysene (CHRY)	0.22±0.25[a]	0.15±0.14[a]	0.32±0.32[a]	0.77±0.02[a]	0.77±0.04[a]	0.68±0.18[a]
Benzo[a]anthracene (B[a]A)	1.01±0.78[a]	1.01±0.76[a]	1.11±0.83[a]	ND	ND	ND
Benzo[b]fluoranthene (B[b]F)	ND	ND	ND	0.06±0.01[a]	0.16±0.02[a]	0.44±0.12[b]
TOTAL	**3.15**	**3.35**	**3.52**	**0.94**	**1.04**	**1.53**

ND: Not Detected. Mean ± S.D with different superscripts across rows are significantly different

The total PAH concentrations (∑16 PAHs) observed in this study align with findings from other research. Iwu *et al.,* (2024) reported mean concentrations of PAH markers B[a]P and PAH4 exceeding EU limits in smoked and grilled fish species in Nigeria. Similarly, Tongo et al., (2017) recorded high levels of PAH, particularly B[a]P, above recognized limits in smoked Clarias gariepinus examined in Southern Nigeria which can be as a result of the high fat content. Studies from various regions have documented differing PAH concentrations, highlighting the widespread presence of these pollutants in processed products.
The presence of PAHs in C*larias gariepinus* and *Merluccius merluccius* underlines the need for regular monitoring and swift change to modern processing methods while adhering to food safety regulations. While the concentrations found in *Merluccius merluccius* are generally within safe limits, the levels in C*larias gariepinus* warrant attention to minimize potential health risks.

CONCLUSION

The analysis highlights the urgent need for action to address the health risks associated with traditional fish processing methods. The findings emphasized the potential hazards of polycyclic aromatic hydrocarbon (PAH) exposure in smoked fish processed using traditional wood-smoking techniques, particularly in communities where such fish forms a dietary staple. As a result, there is a critical need for the introduction and adoption of modern smoking kilns, which have proven to significantly reduce PAH levels. Additionally, empowering fish traders through training and subsidies to transition to these improved technologies is essential. Governmental regulatory oversight and structured intervention programs must be established to ensure widespread adoption of safer processing techniques. Future research should focus on refining smoking methods to balance efficiency, cost, and safety while regular surveillance is conducted to monitor adherence to food safety standards, ensuring consumer health protection.

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REFERENCES

Abdel-Shafy, H. I., and Mansour, M. S. (2016). A review on polycyclic aromatic hydrocarbons: source, environmental impact, effect on human health and remediation. Egyptian journal of petroleum, 25(1), 107-123. https://doi.org/10.1016/j.ejpe.2015.03.011

Adeyeye, S. A. O., and Ashaolu, T. J. (2022). Polycyclic aromatic hydrocarbons formation and mitigation in meat and meat products. Polycyclic Aromatic Compounds, 42(6), 3401-3411. https://doi.org/10.1080/10406638.2020.1866039

Asamoah, E. K., Nunoo, F. K. E., Addo, S., Nyarko, J. O., and Hyldig, G. (2021). Polycyclic aromatic hydrocarbons (PAHs) in fish smoked using traditional and improved kilns: Levels and human health risk implications through dietary exposure in Ghana. Food Control, 121, 107576.

Iwegbue, C. M., Tesi, G. O., Overah, L. C., Bassey, F. I., Nwadukwe, F. O., and Martincigh, B. S. (2015). Concentrations and profiles of polycyclic aromatic hydrocarbons in some popular fish species in Nigeria. Journal of food protection, 78(3), 554-560. https://doi.org/10.4315/0362-028X.JFP-14-432

Iwu, G.I., Lajide, L., Madu, P.C. and Isah I.A (2024). Assessment of polycyclic aromatic hydrocarbon (PAH) profiles in heat-processed meat and fish: a study on health risk evaluation. Discov Food 4, 46. https://doi.org/10.1007/s44187-024-00116-5

Tongo, I., Ogbeide, O., and Ezemonye, L. (2017). Human health risk assessment of polycyclic aromatic hydrocarbons (PAHs) in smoked fish species from markets in Southern Nigeria. Toxicology reports, 4, 55-61. https://doi.org/10.1016/j.toxrep.2016.12.006

Wretling, 1. S., Eriksson, A., Eskhult, G. A., and Larsson, B. (2010). Polycyclic aromatic hydrocarbons (PAHs) in Swedish smoked meat and fish. Journal of food composition and analysis, 23(3), 264-272. https://doi.org/10.1016/j.jfca.2009.10.003

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

SENSORY EVALUATION OF SMOKED *Clarias gariepinus* USING BRINE, GARLIC, GINGER, TURMERIC AS PRESERVATIVE AND VALUE-ADDED ENHANCER

[1]YUSUF J.K., [2]S.A OKUNSEBOR and [2]S. OMEJI

[1] Department of Fisheries and Aquaculture, Federal University of Lafia
[1] Department of Aquaculture and Fisheries Management, Nasarawa State University
[2] Department of Fisheries and Aquaculture, Joseph Sarwuan Tarka University Makurdi.

Correspondence email:
khadijat2050@gmail.com, 08148538323

ABSTRACT
The sensory/organoleptic quality of smoked *Clarias gariepinus* was studied after curing with spices; salt, ginger, garlic, turmeric, a combination of ginger and garlic, ginger and turmeric and garlic and turmeric at different concentration (10g, 20g and 30g) respectively. One hundred and five kilogram (105 kg) of fresh C. *gariepinus* was distributed at 15kg per treatments and cut into chunks of near equal sizes each. The study comprised of seven (7) treatments T1 (Salt cured), T2 (Ginger cured), T3 (Garlic cured), T4 (Turmeric), T5 (Ginger and garlic cured) T6 (Ginger and turmeric cured) and T7 (Garlic and turmeric cured) C. *gariepinus* respectively. Salt cured C. gariepinus scored the highest mean for appearance at 20g concentration (4.08) followed by Ginger cured at 20g (3.88); for texture, ginger-cured recorded the mean sensory value (4.16) at 20g concentration followed by garlic and turmeric cured C. *gariepinus* at 20g concentration (4.08) respectively. Ginger cured treatment recorded the highest mean sensory value for taste (4.22) at 20g concentration followed by ginger and garlic cured treatment (4.1) at 30g concentration while the highest sensory mean value for flavour was the garlic and turmeric cured treatment (3.96) at 10g concentration followed by ginger turmeric (3.92) at 20g concentration. Conclusively, to increase the shelf life of smoked C. *gariepinus*, it is recommended that mixed spices of ginger and garlic, ginger and turmeric and or garlic and turmeric be used before smoking.

Keywords:
Sensory-evaluation, smoked, Clarias gariepinus, ginger, garlic, turmeric, preservative.

INTRODUCTION

Smoked fish product is considered a delicacy in Nigeria; however its quality is of concern to consumers who most often trust fish handlers like the fishermen, processors and traders with the healthy condition of the fish that they consume. Smoking, drying, marinating, and salting are the most common traditional methods of preservation (Taherzadeh-Shalmaei *et al.*, 2021).

Like all food products, fish, is composed of biological raw materials which inherently spoil and deteriorate overtime (Ahmad *et al.*, 2021). Fish processing is done to ensure a longer shelf life and convert the raw fish into a form that will still be acceptable to the consumers. In addition to increasing the shelf life of fishery products, processing is carried out to increase value and product quality. Processing activities are aimed at increasing the added value of a fishery product and the launch of various types of processed products that are more valuable and appealing to domestic as well as the international market (Indrajit *et al.*, 2022).

Reports have it that spices are commonly used as curing agents in a variety of food products as; anti-inflammatory, anti-cancer and anti-microbial agents. Many spices including cloves, cinnamon, black pepper, turmeric, ginger, garlic and onions exhibit oxidative activities and inhibit the microbial growth in a variety of foods (Al-Jalay *et al.*, 1987; Jurdi Haldeman *et al.*, 1987).

MATERIALS AND METHODS

Experimental setup/sample preparation

One-hundred and five kilogram (105 kg) samples were divided into seven (7) treatments in three (3) concentrations including a control; each treatment consisted of 15kg making a total of 105kg table size *Clarias gariepinus*. Each group of fish (5kg) were gutted and cut into chunks of near equal sizes and washed thoroughly under clean tap water to remove fish slime, sand and fish visceral.

The test spices (ginger, garlic, and turmeric) were crispy dried, ground into powder, and placed in containers separately in preparation for the study and thereafter 10g, 20g, and 30g of each of the ground spices were weighed using a sensitive scale (Atom A 122 Electronic kitchen digital weighing scale, model SF: 400A). Each of the weighed spices was mixed in a litre of water) separately and thereafter each fish treatment samples were immersed in the solution for two hours respectively and tagged. Smoking was carried out at the processing unit of the Department of Aquaculture and Fisheries Management, Nasarawa State University, Shabu Campus Lafia. The tagged cured fish were smoked in a gas kiln for nine hours (9 hours) under low heat to reduce the water activity after which the smoked fish products were left to cool inside the smoking kiln for two hours (2h); and thereafter the cooled smoked product was packed and labelled respectively.

The first sample treated with brine solution served as the control.

Sensory evaluation

The smoked fish products were subjected to sensory evaluation using descriptive test based on 5-point hedonic scale modified from Sadasivam and Manickam (1996) to evaluate for appearance, texture, taste and flavour.

One hundred panellists were drawn in clusters from Staff and Student of Faculty of Agriculture Nasarawa State University, Keffi, Shabu campus and College of Agriculture Science and Technology Lafia, Nasarawa State Nigeria for the evaluation. Fish samples were given out with questionnaires for the panellists to evaluate and fill the products score based on how it appealed to their senses as indicated above, using the five (5) scale rating: in the following order 5 (like extremely), 4 (like very much), 3 (like moderately) 2 (like slightly) 1 (neither like nor dislike). The mean obtained from the evaluation was calculated by weighing the various hedonic modes, accordingly in the following order; $5+4+3+2+1 = 15/5 = 3$. Using the interval of 0.05, the upper limit was $3.00 + 0.05 = 3.05$, while the lower limit was $3.00 - 0.05 = 2.95$.

Decision rule: the following decision rule was used to determine the acceptability of the product or not; any mean of sensory parameter score equal or less than 2.95 were considered not important while mean equal or greater than 3.00 were considered very important.

RESULT

Table 1: Comparative evaluation of the sensory mean values recorded for the various treatments

Parameter	Treatments	Mean Sensory score	Ranking	Remark
Appearance	T1	4.08 (20g)	1	Accepted
	T2	3.86 (20g)	3	Accepted
	T3	3.68 (30g)	5	Accepted
	T4	3.74 (20g)	4	Accepted
	T5	3.58 (30g)	6	Accepted
	T6	3.88 (20g)	2	Accepted
	T7	3.68 (10g)	5	Accepted
Texture	T1	3.76 (30g)	4	Accepted
	T2	4.16 (20g)	1	Accepted
	T3	3.8 (10g)	3	Accepted
	T4	3.8 (10g)	3	Accepted
	T5	3.66 (10g)	5	Accepted
	T6	3.62 (10g)	6	Accepted
	T7	4.08 (20g)	2	Accepted
Taste	T1	4 (20g)	3	Accepted
	T2	4.22 (20g)	1	Accepted
	T3	3.6 (10g)	6	Accepted
	T4	3.78 (20g)	4	Accepted
	T5	4.1 (30g)	2	Accepted
	T6	3.78 (20g)	4	Accepted
	T7	3.68 (30g)	5	Accepted
Flavour	T1	3.78 (30g)	3	Accepted
	T2	3.78 (10g)	3	Accepted
	T3	3.7 (20g)	4	Accepted
	T4	3.54 (10g)	5	Accepted
	T5	3.48 (30g)	6	Accepted
	T6	3.92 (20g)	2	Accepted
	T7	3.96 (10g)	1	Accepted

Keys: TI (salt cured), T2 (ginger cured), T3 (garlic cured), T4 (Turmeric cured), T5 (ginger and garlic cured), T6 (ginger turmeric cured), T7 (garlic turmeric cured), Acceptable decision rule: mean below 2.95 were considered (not important) and rejected while mean 2.95-3.05 were considered (very important) and accepted

DISCUSSION

The results on sensory (organoleptic) evaluation showed a high acceptance of the C. *gariepinus* smoked product treated with different concentrations of ginger, garlic and turmeric as well as samples treated with salt among the respondents. This study showed that the spices have effects on consumer's acceptance of smoked C. *gariepinus*. Ginger, garlic and turmeric have some anti-oxidative effects of smoked C. *gariepinus*

There was also a high acceptance of the ginger, garlic and turmeric cured samples as shown in all the sensory parameters except for 30g concentration of combined garlic and turmeric whose mean sensory

score falls below the acceptable range. Generally, the sensory mean value fluctuates as the concentration of the spices increases.
The high mean values recorded for ginger in this study for texture and taste at 20g respectively agrees with the findings of Kumolu-Johnson and Ndimele (2011) as well as Jerimoth et al., (2021) where panellists rated the sensory values of C. *gariepinus* treated with ginger better than untreated sample for all parameters except for texture where the findings in this work disagrees with that of Jerimoth *et al.*, (2021) where panellists rated ginger treated sample low for texture. The high sensory mean recorded in this study is also generally attributed to the addition of spices which have been proven to increase sensory value of foods, this agrees with Agbontale *et al.*, (2020), who opined that natural flavoured smoked catfish taste better.

CONCLUSION

To prevent post-harvest losses, effectiveness of salt, ginger, garlic and turmeric as preservatives on the proximate, microbial and sensory quality of smoked C. *gariepinus* were investigated initially after treatments finally after storage for two months, with a view to extend its shelf life as well as consumer acceptance.
The result on sensory evaluation report by 100 member panellist showed highest mean sensory acceptance values for appearance, texture, Taste and flavour from the various spices used in the various treatment samples.

RECOMMENDATIONS

Based on the findings in this study, the following recommendation are made
Combination of natural spices should be used in fish curing during fish post-harvest handling based on consumers' preference.
Awareness programme on beneficial uses of these spices for public use should be funded by the Government through the extension officers in government parastatals or non-governmental organisation (NGOs)
The preservation and processing of fishes should be taken seriously by fish handlers so as to prevent postharvest and economic losses.
Further research should be carried out on the phyto-chemical and medicinal properties of these spices on fish postharvest handling as well as investigation of factors and their combinations in order to achieve stable quality of smoked fish.

REFERENCE

Al-Jalay, B. Blank, G. McConnell, B. and Al-hayat, M. (1897). Antioxidant activity of selected spices used in fermented meat sausage. J.food protect. 50:25-27

Agbontale, A. O., Okorafor, P. U., Ogbu, U. M., Isegbe, E. I. & Adisa T. A. (2020). Consumers' Perception On Indigenous Spiced Smoked Catfish (Clarias gariepinus) Among Households In Oyo State. International Journal of Innovative Agriculture & Biology Research 8(1):7-14, www.seahipaj.org ISSN: 2354- 2934.

Ahmad, B., Ali, A., DiNaz, S., Raziq, Khan, A., Abdul, A., Ullah, F., Ahmad, S., Ul Haq, A., Ullah, I., Khan, I. and Ishaq, M. (2021). Biochemical composition of fish and changes during processing and storage: A review. Bioscience Research, 18 (2), 1903–1913. https: / / www.isisn. org / BR18(2) 2021 / 1903 - 1913 - 18(2) 2021BR21-244.pdf

Indrajit W; Rita N. and Suprehatin (2022). Value Chain Upgrading: Evidence from Smoked Fish Agribusiness In Central Java. AGRISEP Vol. 21 No. 1 March 2021 Page: 243 – 256. ISSN: 1412-8837, e-ISSN: 2579-9959.

Jerimoth K.E, Agatha A.N., Arnold E. N., Jane O. (2021) Spicing: A means of improving organoleptic quality and shelf life of smoked catfish – Journal of Scientific African 2021. https://www.sciencedirect.com/science/article/pii/S2468227621002349

Kumolu-Johnson, C. A., & Ndimele, P. E. (2011). Anti-Oxidative and Anti-fungal Effects of Fresh Ginger (Zingiber officinale Treatment on the Shelf Life of Hot-smoked Catfish (Clarias gariepinus, Burchell, (1822). Asian Journal of Bio logical Sciences, 4 (7), 532–539

Jurdi-Haldeman, D. MacNeil, J.H., and Yared, D.M. (1987).Antioxidant activity of onion and garlic juice in stored cooked ground lamb. J. food protect. 50: 411-413.

Kumolu-Johnson, C. A.; Ndimele, P. E. Anti-Oxidative And Anti-Fungal Effect of Garlic (Allium sativum) Treatment on The Shelf Life of Hot-Smoked Catfish (Clarias gariepinus, Burchell 1822). World Appl. Sci. J. 2011, 13(7), 1628–1634.

Sadasivam, S and A. Manickam (1996) Biochemical methods. New Age International (P) Ltd. Publishers, pp. 126-128.

Taherzadeh-Shalmaei, N., Sharifi, M. and Ghasemi-Mobtaker, H. K. (2021) A. Evaluating the energy use, economic and environmental sustainability for smoked fish production from life cycle assessment point of view (case study: Guilan Province, Iran) Environmental Science and Pollution Research. 28(38):53833–53846.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

INFLUENCE OF DIFFERENT SMOKE SOURCES ON THE NUTRITIONAL COMPOSITION OF AFRICAN CATFISH *(Clarias gariepinus)*

1Suleiman, A. M., 1 K. N. Shehu, 1A. Hassan, 1 M. U. Aminu, 1I. U. Muhd and 1 F. B. Abubakar
1 Department of Fisheries and Aquaculture, Bayero University, PMB 3011, Kano, Nigeria

Corresponding Author:
samohammed.faq@buk.edu.ng +234 7032867661, 0000-0001-8179-9915

ABSTRACT

This study investigated the effects of different smoke sources (corn husk, firewood, and charcoal) on the nutritional value of African catfish *(Clarias gariepinus)*. The research aimed to address the gap between fish demand and supply in Nigeria, primarily due to poor post-harvest handling practices. Catfish samples were smoked using different fuel sources namely; charcoal, firewood, cornhusk, electric oven (control), and then analysed for proximate composition and sensory attributes. Results showed significant differences ($P<0.05$) in moisture, crude protein, crude fat, ash content, crude fibre, and nitrogen-free extracts among the smoked catfish samples. The fish smoked with corn husks exhibited the highest protein content (54.55%) and lowest moisture content (6.97%), suggesting better preservation. Sensory evaluations revealed no significant differences ($P>0.05$) in colour, flavour, taste, and texture among samples smoked with corn husk, charcoal, and oven. However, firewood-smoked fish had significantly lower sensory scores. In conclusion, corn husks emerged as a promising smoking material for preserving African catfish while maintaining its nutritional value and sensory appeal. This study contributes to improving post-harvest handling practices and promoting sustainable fish production in Nigeria.

Keywords:
Aquaculture, Microbial, proximate Compositions and Sensory Evaluation

INTRODUCTION

Aquaculture is a fast-growing industry in Nigeria with the African Catfish *(Clarias gariepinus)* accounting for around 60% of Nigeria's aquaculture output (FCWC, 2022). It has over the years gained much popularity with fish farmers in Nigeria because of its Rapid growth rate and high selling price, good feed conversion ratio, resistance to disease infection, hardiness and ability to survive in adverse water conditions such as low dissolved oxygen concentrations and high turbidity (Oladipo and Bankole, 2013).

Generally, microbial activity is the primary cause of quality deterioration in fish products leading to changes in sensory characteristics and limiting shelf-life. Enzymatic autolysis initiates quality degradation immediately after catch (Shamshad *et al.*, 2022).The gap between the demand and supply of fish is widening due to poor post-harvest handling and lack of processing and storage facilities (Olufemi *et al.*, 2015). Spoilage is a metabolic process that causes food to be undesirable or unacceptable for human consumption due to changes in sensory and nutritional characteristics from the point of view of health because the food has become a medium for the growth of pathogenic microorganisms (Sofos, 2020). Fish begins deteriorating immediately after being caught although the rate of deterioration depends on storage temperature, under partial freezing (0°C), storage life ranges from 12 to 20 days; at tropical ambient temperatures (20°C to 30°C) storage life can be as short as 6 to 12 hours. Fish perishability is due to its high susceptibility to degradable organisms which are present in the slime, gills and intestine and on the surface of the fish (Oladipo and Bankole, 2013).

Both fresh and smoked catfish are relished and widely eaten across Nigeria either as main dishes or as flavouring ingredients. Nigerians are large consumers of catfish and it remains one of the main products consumed in terms of animal protein. It is cheap and highly acceptable, which gives it an advantage over pork or beef. Only about 50% of the demand for fish is currently being met by local supply (Aliyu *et al.*, 2024). Fish production contributes about 3.5% to Nigeria's total Gross Domestic Product (GDP) after the oil and gas industry (Tkaczewska *et al.*, 2020).

The aim of this research is to determine the effects of different smoke sources (corn husk, firewood and charcoal) on nutritional value of African catfish *(Clarias gariepinus)*.

MATERIALS AND METHODS

Experimental Site and Sample Collection: The study was conducted at the fish farm complex of the Department of Fisheries and Aquaculture, Bayero University, Kano, Nigeria (11.977616°N, 8.424571°E). Fresh African catfish *(C. gariepinus)* specimens, weighing approximately 0.25 kg each, were procured from Bae fish farm, Kankare, Kano State.

Experimental Design: A total of 8 kg of catfish was divided into four equal groups with 2 kg representing each group. The fish of Control Group were gutted, washed with clean water then oven-dried at 70°C for 24 hours using a Crown Star electric oven (MDL:MC-EO782A) while the fish of group A, B and C treatments were smoked Using firewood, charcoal and corn husks respectively.

Smoking Process: Fish samples for treatment groups were also gutted and washed thoroughly to remove impurities. Smoking was carried out in a modified drum kiln using the designated fuel source at a temperature range of 70oC to 80oC until constant weight was achieved. The smoked fish were then cooled and packaged in transparent polyethylene bags.

Sample Preparation for Analysis: Samples of each treatment group, including the control, were subjected to crushing using a Crown Star electric blender and the representative of each treatment group was placed in a labelled plastic container for subsequent proximate analysis.

Proximate Composition Analysis: The proximate compositions of the fish samples were determined according to the Association of Official Analytical Chemistry (AOAC) method of analysis (2010) and parameters such as moisture content, crude protein, crude fibre, ash content, crude lipid and nitrogen free extracts were determined.

Sensory Evaluation: A sensory evaluation was conducted on the smoked catfish products from various smoking sources to assess colour, taste, flavour, texture, and overall acceptability. A ten-member trained sensory panel evaluated the samples using a standardized scoring method adapted from Eyo (2001). Smoked catfish samples were presented on individual plates, labelled with unique codes, and divided into smaller pieces. Toothpicks and water were provided for palate cleansing between evaluations. Panel members assessed each sample, rinsing their mouths with water between evaluations (except for colour assessment). Sensory attributes were evaluated using the predetermined scoring criteria.

Statistical Analysis: results obtained were subjected to one-way analysis of variance and this was done to check the significant difference ($P<0.05$) between the means of proximate compositions parameters of the smoked catfish with different sources of fuel. Fisher SLD post hoc was used to find treatment pairs with significant difference. Kruskal-Wallis test was used as a nonparametric test to check the significant difference ($P<0.05$) between the sensory evaluation ranking of the fish treatment.

RESULTS AND DISCUSSION

The results for proximate compositions of the smoked catfish (C. gariepinus)are shown in Table 1. There were significant differences ($P<0.05$) in moisture, crude protein, crude fat, ash content, crude fibre and nitrogen free extracts of all the treatments. The protein content (54.55%) of the sample smoked with cornhusk was significantly higher ($P<0.05$) than that of fish from other fuel sources (charcoal and firewood) while charcoal was significantly ($P<0.05$) the lowest. However, the ranges of 42.50% to 54.55% protein contents recorded from this study were in disagreement with that of Aliyu et al. (2024) who used charcoal and gas as fuel sources to evaluate smoked C. *gariepinus* and Tilapia. This may be due to the intensity of the heat generated in the kiln which in turn caused reduction in moisture content, increased in the crude protein of the fish smoked with Corn husks than firewood and cornhusk, even though they were subjected to the same length of smoking period as similarly observed by Ogbonnaya and Ibrahim (2009). Significant increase in protein level in smoked dried Catfish may lead to decrease in moisture content which might have been lost during smoking process and this finding agrees with that of Aliyu *et al.* (2024). Electric oven dried samples retained lower lipid content than smoking kiln dried samples which indicate that the fat loss phenomenon in electric oven was more intensive than in smoking kiln this statement is in contrary with the report of Ogbonnaya and Ibrahim (2009).

The mean scores obtained for sensory evaluations of catfish smoked with oven (control),charcoal and corn husk did not show significant difference ($P>0.05$) in colour, flavour, Taste and Texture while significance differences ($P<0.05$) are shown in the fish smoked with firewood as in Table 2. These were in agreement with the report of Samuel (2016) whose results showed no significant difference ($P>0.05$) among mean scores of the three samples of the fish smoked with Corn husks that were Characterized by smoked in terms of colour and texture. However, Samuel (2016) reported that smoked dried fishes had the most attractive colour against oven and sun dried samples.

Table 1: Proximate Compositions of Catfish *(C. gariepinus)* **Smoked with Different Fuel Sources**

Parameter (%)	Charcoal (Mean±SEM)	Firewood (Mean±SEM)	Corn husk (Mean±SEM)	Oven (Mean±SEM)
Moisture	7.387 ± 0.081^{b}	8.26000 ± 0.081^{a}	6.967 ± 0.081^{c}	7.443 ± 0.081^{b}
Ash	7.587 ± 0.012^{b}	7.303 ± 0.012^{c}	7.273 ± 0.012^{c}	9.580 ± 0.012^{a}
Fat	16.067 ± 0.026^{a}	12.587 ± 0.026^{c}	15.167 ± 0.026^{b}	10.310 ± 0.026^{d}
CP	42.500 ± 0.109^{d}	47.127 ± 0.109^{c}	54.550 ± 0.109^{a}	48.743 ± 0.109^{b}
CF	1.317 ± 0.015^{b}	1.507 ± 0.015^{a}	1.227 ± 0.015^{c}	1.307 ± 0.015^{b}
NFE	25.143 ± 0.169^{a}	23.217 ± 0.169^{b}	14.817 ± 0.169^{d}	22.583 ± 0.169^{c}

Means in the same row having similar superscripts are not significantly different ($p>0.05$) from each other

Table 2: Results of the sensory attribute of the C. *gariepinus* **Smoked with the Different Fuel Sources**

Parameter	Charcoal	Firewood	Corn husk	Oven	Chi Square value
	Mean Rank	Mean Rank	Mean Rank	Mean Rank	
Colour	20.3500^{a}	17.9500^{a}	23.5000^{a}	20.2000^{a}	1.2492
Taste	23.5000^{a}	5.1111^{b}	29.0000^{a}	20.9000^{a}	23.4585
Flavour	24.0500^{a}	8.5500^{b}	30.3500^{a}	19.0500^{ab}	19.7447
Texture	22.3000^{a}	12.9000^{a}	25.8000^{a}	21.0000^{a}	7.2521
Acceptability	24.0000^{ab}	7.4000^{c}	31.6000^{ab}	19.0000^{bc}	23.8220

Means in the same row having similar superscripts are not significantly different ($p>0.05$) from each other

CONCLUSION

The results from this study have shown that Corn husks is a good smoking material and its utilisation can help in preventing deterioration of fresh fish. Nutritionally, fish smoked with cornhusk has the highest crude protein composition. Findings from this study also revealed that Corn husks is better for smoking African catfish because it reduces the moisture content of the fish that could enhance spoilage. Corn husks also provide a good taste and promote appealing colour of the smoked African catfish. Above all, it promotes or raises the protein content of the smoked fish.

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REFERENCES
Aliyu, H. M., Ubwa, S.T., Obochi, G. O., James, S. and Nwokocha, L. (2024). Nutrient Evaluation of Charcoal and Gas Smoked Clarias gariepinus (Burchell, 1822) and Sarotheredon gallilious (Linnus, 1758) from Bauchi River (Gubi Dam). FUDMA Journal of Sciences.8 (3): 379-385

AOAC. (2010). Official Method of Analysis 18th Edition, Association of Official Analytical Chemists, Washington, D.C. U.S.A.

Eyo, A. A. (2001). Fish Processing Technology in the Tropics. A publication of National Institute for Fresh water Fisheries Research (NIFFR).PMB 6006, New Bussa, Nigeria.

FCWC (Fisheries Committee for the West Central Gulf of Guinea). (2022). Report on Aquaculture in the FCWC Region: Prospects and Challenges.

Ogbonnaya, C. and Ibrahim, M. S. (2009). Effects of Drying Methods on Proximate Compositions of Catfish (Clarias gariepinus). World Journals of Agricultural Sciences. 5 (1): 114 - 116.

Oladipo, I. C. and Bankole, S. O. (2013). Nutritional and Microbial Quality of Fresh and Dried Clarias gariepinus and Oreochromis niloticus. International Journal of Applied Microbiology and Biotechnology Research. 1-6

Olufemi, S. A., Adekunle, O., Agunbiade, J. A. and Abimbola, O. (2015). Growth Performance, Apparent Nutrient Digestibility, Intestinal Morphology and Carcass Traits of Broilers chickens Fed Dry, Wet and Fermented-Wet Weed. Journal of livestock Science. 177

Samuel, A. O. A. (2016). Traditional Fish Processing in Nigeria: A Critical Review. Nutrition and Food Science. 46 (6): 321- 335

Shamshad, H., Bakri, R. and Mirza, A. Z. (2022). Dihydrofolate Reductase, Thymidylate Synthase and Serine Hydroxy Methyltransferase: Successful Tergets Against Some Infectious Diseases. Molecular Biology Reports. 49: 6659-6691.

Sofos, J. N. (2020). Introduction to food spoilage microbiology and preservation strategies. In Food Microbiology and Biotechnology (pp. 1-21). CRC Press.

Tkaczewska, J., Jamróz, M., Kulawik, P., Morawski, M., Szczurowska, K., and Zajac, M. (2020). Native Polish Traditionally Smoked Fish: Past, Present and Future. A Review. Foods, 9(3), 340.

BIOCHEMICALS AND SAFETY INDEX OF MINERALS IN CUTTLEFISH, Sepia officinalis: IMPLICATION FOR SEAFOOD SAFETY APPLICATION

[1]Moruf, R. O., [2]A.O. Lawal-Are, and [3]E. Asamoah

[1]Department of Fisheries and Aquaculture, Bayero University, Kano, Kano State- Nigeria
[2]Department of Marine Sciences, University of Lagos, Akoka, Lagos State- Nigeria
[2]Department of Marine and Fisheries Sciences, University of Ghana, Ghana

Email: tunjimoruf@gmail.com, +234022429983, 0000-0002-0459-0621

ABSTRACT

Cuttlefish is one of the most important demersal marine invertebrates, rich in taste and has few inedible parts. This study evaluates the nutrients, non-nutritional factors, oleic acid, cholesterol, and mineral safety index (MSI) of raw and processed (fried) Sepia officinalis (cuttlefish) using standard methods. Raw cuttlefish had higher moisture, protein, and mineral levels (calcium, phosphorus, magnesium, iron, and manganese), while processed samples had increased fat, cholesterol, and oleic acid content. Processing reduced anti-nutritional factors like trypsin inhibitor, phytate, and oxalate. The calcium-to-phosphorus ratio exceeded the ideal range of 1.5–3.6 in both raw and processed samples, while other mineral ratios were within acceptable limits. All minerals had MSI values below tabulated standards, with positive percentage differences ranging from 7.8% to 99.55%. These findings suggest that consumption of S. officinalis from the study area poses no risk of mineral overload and highlight its nutritional value.

Keywords:
Biochemical Composition, Mineral Safety Index, Cuttlefish, Seafood Safety, Toxicological Implications

INTRODUCTION

Sepia officinalis (cuttlefish) is an important demersal marine invertebrate found on the continental shelf, with global annual catches ranging from 11,000 to 15,000 tons (Santi et al., 2019). Mediterranean countries are the leading exporters of frozen cuttlefish. Its connective tissue is highly developed, and its lipid content is low, with omega-3 polyunsaturated fatty acids comprising the majority of the lipids. Nutrient composition in cuttlefish varies due to factors like species, size, sex, season, and processing methods such as boiling, frying, roasting (Gökoglu, 2021). Since fish is rarely consumed raw, these methods impact nutrient content, texture, and flavor. While data on raw Sepia species is available, limited information exists on processed cuttlefish. This study investigates the biochemicals and safety index of minerals of raw and processed Sepia officinalis in Nigeria to highlight its nutritional significance for human health.

MATERIALS AND METHODS

Study Site

Cuttlefish samples were obtained from Ajeloro Fish Market, Apapa, Lagos, Nigeria. The fish was washed, cut into 50 g pieces, and rinsed again with distilled water. Samples were divided into two parts: one was analyzed raw, while the other part was deep-fried in vegetable oil at 240°C for 15 minutes. No additional ingredients were used during processing. All samples were homogenized before analysis.

Laboratory Analysis

Proximate analysis followed standard procedures (AOAC, 2000). Moisture content was measured by drying fish muscle samples at 102-105°C for 24 hours. Ash content was determined by incinerating 5 g samples at 600°C for 8 hours. Crude fat was assessed using the Soxhlet extraction method with n-hexane.

Protein content was estimated by multiplying nitrogen content by 6.25, and total carbohydrates were calculated by subtracting the sum of moisture, protein, lipids, and ash percentages from 100%.
The estimation of anti-nutritional contents was by the colorimetric procedure, cholesterol was measured with Liebermann-Burchard reagent, and free fatty acids were analyzed following the modified methods by Enujiugha and Olagundoye (2001). Mineral analysis involved wet-ashing samples, dissolving the ash in de-ionized water and hydrochloric acid, and using Atomic Absorption Spectrophotometry. Phosphorus was determined using the Vanado Molybdate method. All determinations were performed in triplicate.

Statistical Analysis

The result was analyzed using Microsoft Excel and STAT 7.0 statistical package.

RESULTS AND DISCUSSION

Biochemical Composition

The summary of the biochemical compositions is shown in Figure 1. The moisture and crude protein contents for raw sample of cuttlefish were significantly higher ($P < 0.05$) than that of the processed sample, whereas, the crude fat was significantly higher in the processed sample (22.39±0.54%) than the raw sample (16.24±0.10%). The raw sample had higher ash content than the processed form due to the degradation of minerals under heat, which reduced ash content in the fried product. Crude fibre was not detected in the cuttlefish samples. The cholesterol (1.037±0.02 mg/100g) and oleic acid (4.47±0.10%) contents increased during processing due to lipid absorption from the frying oil, which enhanced their concentrations in the fried product. Frying decreases the moisture content and results in desirable nonenzymatic browning reactions but increases the crude fat content of the cuttlefish. Ash, a measure of the mineral content of food item indicates that the cuttlefish is a good source of minerals. The significant crude protein decrease in the processed sample is in agreement with the report of Okpanachi et al. (2018) and suggested protein leaching and denaturation. The amount of carbohydrate obtained in this study was higher than the amount reported for Sepia esculenta (Lee *et al.*, 2019), which might be due to genetical factors as well as extrinsic factors (such as feeding regimes, change in some structural and flesh quality parameters of the two cuttlefish species). On the cholesterol and oleic contents, similar observation was reported by Ozogul *et al.* (2015) that frying process significantly reduces the sterol content of some selected mollusc except for common cuttlefish.
The antinutrient content was significantly higher in raw sample than the fried sample, it is likely that frying plays a role in reducing the levels of oxalate (20.27), phytate (3.4) and trypsin inhibitor (9.71) available in cuttlefish. Farinde et al. (2018) indicated a significant reduction in phytate and trypsin inhibitor contents after cooking, which is in agreement with this research. Generally, processing reduced the level of all the antinutrients analyzed to their permissible levels.

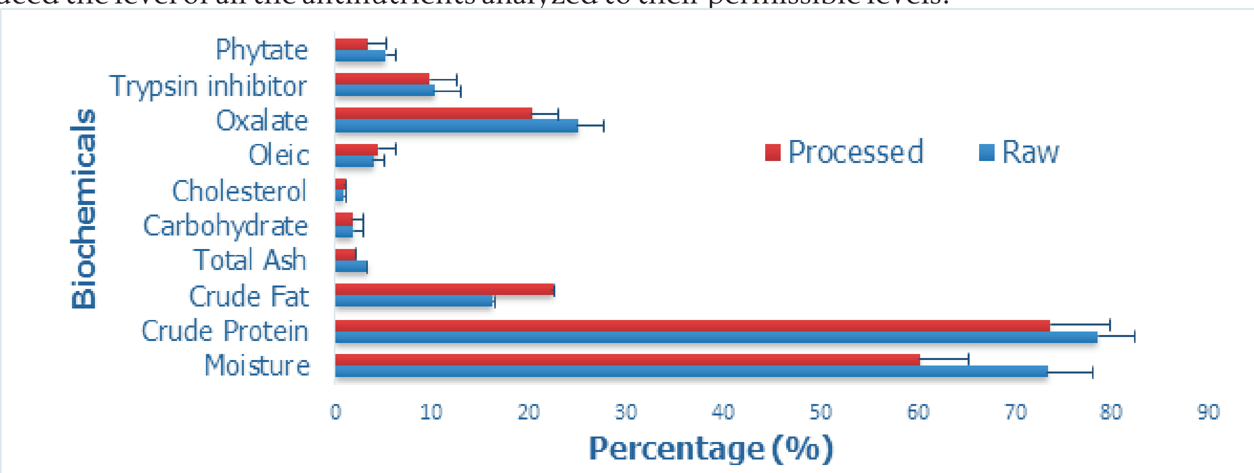

Fig. 1: Biochemical composition of raw and processed Common Cuttlefish (Sepia officinalis)

Mineral Ratio and Safety Index

The ratio of the minerals in the common cuttlefish is shown in Table 1. Ca/P was higher than the ideal range of 1.5–3.6 in both samples, while other ratios were within and below the appropriate ideal range, as reported in the raw and grilled meat of C. amartum (Moruf *et al.,* 2021). The above ideal range result could result from a naturally high calcium content in cuttlefish tissue relative to phosphorus. This imbalance may also be influenced by the retention of calcium during frying, which concentrates its levels due to moisture loss and the relatively stable nature of calcium compared to phosphorus under heat processing. The interaction of sodium and potassium (whose ratio is also below the appropriate ideal range), is integral to maintaining healthy blood. According to McDonough *et al.* (2017), raising the dietary potassium to sodium ratio to the recommended level helps reduce heart and kidney disease.

Table 1: Mineral Ratio in the Common Cuttlefish, Sepia officinalis

Parameter	Reference value	Acceptable ideal range	Raw	Processed	Mean	SD	CV%
Ca/Mg	7	3 to 11	0.93	0.98	0.95	0.04	4.01
Ca/K	4.2	2.2 to 6.2	5.26	3.49	4.88	6.21	78.80
Ca/P	2.6	1.5 to 3.6	5.95	5.77	5.96	0.19	0.31
Na/K	2.4	1.4 to 3.4	3.07	2.60	3.24	0.90	27.79
Na/Mg	4	2 to 6	0.29	0.73	0.51	0.31	60.60

Keys: Standard deviation (SD), Coefficient of variation per cent (CV %). Source for Reference value: Watt (2010).

The values of the mineral safety index (MSI) in the common cuttlefish are shown in Table 2. The standard MSI tabulated for the investigated minerals are Ca (10), Mg (15), P (10) and Na (4.8). In this study, all the minerals had MSI calculated values lower than the MSI tabulated, thereby showing positive percentage differences, ranging from 7.8 to 99.52 and 18.58 to 99.55 for raw and processed samples respectively. The result indicates that the consumption of the common cuttlefish from the study area will not cause mineral overload. This result corroborates the report of the caridean species, Macrobrachium macrobrachion from the same region, where its consumption would not constitute mineral overload (Moruf and Akinwunmi, 2022).

Table 2: Mineral Safety Index (MSI) in the Common Cuttlefish, Sepia officinalis

Mineral	RAI (mg)	MSItv	Raw		Processed		Mean	SD	CV%
			MSIcv	%D	MSIcv	%D			
Ca	1200	10	2.85	71.49	2.66	73.35	2.76	0.13	4.79
Mg	400	15	13.83	7.8	12.21	18.58	13.02	1.14	8.78
P	1200	10	0.05	99.52	0.04	99.55	0.05	0	5.1
Na	500	4.8	1.04	78.39	2.29	52.31	1.66	0.89	53.23

Keys: MSIcv= Calculated value of Mineral Safety Index, MSItv= Tabulated value of Mineral Safety Index, SD= Standard deviation, %D= Percentage Difference, CV%= Coefficient of variation

CONCLUSION

This study demonstrates that Sepia officinalis (cuttlefish) is a nutritionally valuable marine species, offering high levels of protein, essential minerals, and beneficial fatty acids, particularly in its raw form. While frying increases fat and cholesterol content, it also reduces anti-nutritional factors such as trypsin inhibitor, phytate, and oxalate. The mineral safety index (MSI) values for all tested minerals were below tabulated standards, indicating no risk of mineral overload from consuming cuttlefish. These findings underscore the species' potential as a healthy food source, particularly in processed food applications.

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REFERENCES

AOAC (2000). International 17 th Ed. Published by the Association of Official Analytical Chemists International, Suite 4002200 Wilson Boulevard, Arlington, Virginia USA.pp. 22201-3301.

Enujiugha, V. N. and Olagundoye, T. V. (2001). Comparative nutritional characteristics of raw fermented and roasted African oil bean (Pentaclethra macrophylla Benth) seed. Revista italiana delle sostanze grasse, 78: 247- 250.

Farinde, E. O., Olanipekun, O. T. and Olasupo, R. B. (2018). Nutritional composition and antinutrients content of raw and processed lima bean (Phaseolus lunatus). Annals. Food Science and Technology, 19(2): 250-264.

Gökoglu, N. (2021). Shellfish processing and preservation. Springer Nature.

Lee, D. J. (2019). Comparison of Broadband Acoustic Scattering Characteristics Between Japanese Flying Squid Todarodes pacificus and Golden Cuttlefish Sepia esculenta. Korean Journal of Fisheries and Aquatic Sciences, 52(6): 709-718.

McDonough, A. A., Veiras, L. C., Guevara, C. A. and Ralph, D. (2017). Cardiovascular benefits associated with higher dietary K+ vs. lower dietary Na+: evidence from population and mechanistic studies. American Journal of Physiology-Endocrinology and Metabolism, 312: 348–356.

Moruf, R. O. and Akinwunmi, M. F. (2022). Compositional energy values, macro and trace elements in the caridean species, Macrobrachium macrobrachion (Herklots, 1851). Food and Environment Safety Journal, 21(1): 39- 46.

Moruf, R. O., Taiwo, M. A. and Adebayo, Q. (2021). Nutritional and functional attributes of raw and grilled crabmeat. Agricultural Science and Technology, 13(1): 83–90.

Okpanachi, M. A., Yaro, C. A. and Bello, O. Z. (2018). Assessment of the effect of processing methods on the proximate composition of Trachurus trachurus (mackerel) sold in Anyigba Market, Kogi State. American Journal of Food Science and Technology, 6(1): 26-32.

Ozogul, F., Kuley, E. and Ozogul, Y. (2015). Sterol content of fish, crustacea and mollusc: effects of cooking methods. International Journal of Food Properties, 18(9): 2026-2041.

Santi, A., Metusakach, D. G., Genisha, D. and Mahendradatta, M. (2019). Proximate and mineral composition of cuttlefish (Sepia sp.). International Journal of Scientific Research in Science and Technology, 6: 130-137.

Watts D. L. (2010). HTMA Mineral Ratios. A brief discussion of their clinical importance. Trace Elem Newsletter, 21: 1-3.

COMPARATIVE STUDY OF PROXIMATE AND MINERAL PROFILE OF TWO COMMERCIAL MARINE FISH SPECIES *Scomber scombrus* and *Pseudotholitus typus*

Ogunbambo, M. M.

Department of Marine Sciences, University of Lagos, Akoka, Lagos State- Nigeria

Email: mutiat.ogunbambo@gmail.com, +2348035737463, 0000-0002-9589-3408

ABSTRACT
The proximate and mineral compositions of Scomber scombrus and Pseudotholitus typus in Lagos were investigated using standard techniques. The moisture content was 58.12±0.37% in *S. scombrus* and 75.28±1.22% in *P. typus*. Crude protein content showed no significant difference, with S. scombrus at 15.01±0.60% and *P. typus* at 13.87±1.38%. The highest crude fat was found in *S. scombrus*. Crude fiber was detected only in *S. scombrus* (2.04±0.02%), while ash was similar between the species. Carbohydrate content was significantly higher in *S. scombrus* (7.42±0.56%) and *P. typus* (7.29±1.28%). Total metabolisable energy was higher in S. scombrus with the value of 149 kcal 100g-1. The highest proportion of energy contribution was from protein in both S. scombrus and P. typus at 60 kcal 100g-1 and 55 kcal 100g-1 respectively. P. typus had the highest total macro element content (790.23 mg 100g-1). Mineral content followed the pattern: K > P > Na > Mg > Ca in both species. The study highlights the positive relationship between proximate composition and mineral content in these marine fish species.

Keywords:
Biochemical profile, marine fish, mineral element, Lagos Lagoon, Nigeria

INTRODUCTION

Marine fish are a vital source of nutrients, especially in coastal areas where they are a staple in the local diet. According to Ogundiran (2014), the marine fish is generally cheaper and more abundant when compared with fresh water fishes, which are relatively more expensive in Nigeria. Understanding the nutritional composition of commercially available marine fish is important for public health and food security. *Scomber scombrus* (Atlantic mackerel) and *Pseudotolithus typus* (Longneck croaker) are widely consumed in Nigeria due to their availability and affordability. Nutritional value of fish can vary between species, influenced by factors such as habitat, feeding habits, and environmental conditions (Ahmed *et al.*, 2022).

Despite the widespread consumption of these marine fishes, there is limited comprehensive data on their proximate and mineral compositions, which are crucial for informed dietary choices and nutrition planning (Abimbola, 2016; Opeyemi, 2020; Ogbe and Omada, 2020). Given the importance of fish in addressing protein deficiency and malnutrition in Nigeria, a detailed comparative analysis of these species is necessary. This study aims to fill the knowledge gap by evaluating and comparing the proximate and mineral profiles of these two commercially significant fish species- S. scombrus and P. typus, providing valuable insights into their nutritional benefits, guide consumers choices, and support the fisheries industry.

MATERIALS AND METHODS

Study Site

The fish samples (S. scombrus and P. typus) were obtained from Makoko Jetty of the Lagos Lagoon. The lagoon lies between latitudes 6º 26' and 6º 39' N and longitudes 3º 29' and 3º 50' E. The Lagos

Lagoon is a part of a continuous system of lagoons and creeks' lying along the coast of Nigeria and it is an open tidal estuary situated within the low-lying coastal zone of Nigeria (Moruf and Lawal-Are, 2017). The samples were transported in a 20 L bucket to the laboratory and processed within 4 hours of the collection. The fresh samples were identified using Identification Guides (Schneider, 1990)

Laboratory Analysis

Proximate analysis followed standard procedures (AOAC, 2006). Moisture content was measured by drying fish muscle samples at 102-105°C for 24 hours. Ash content was determined by incinerating 5 g samples at 600°C for 8 hours. Fat was assessed using the Soxhlet extraction method with n-hexane. Protein content was estimated by multiplying nitrogen content by 6.25, and total carbohydrates were calculated by subtracting the sum of water, protein, lipids, and ash percentages from 100%. Mineral analysis involved wet-ashing samples, dissolving the ash in deionized water and HCl, and using Atomic Absorption Spectrophotometry. Phosphorus was determined using the Vanado Molybdate method. Determinations were performed in triplicate.

Statistical Analysis

The result was analyzed using Microsoft Excel and STAT 7.0 statistical package.

RESULTS AND DISCUSSION

Proximate Composition

The summary of the proximate composition is shown in Table 1. The percentage protein (15.01±0.6), crude fat (16.57±1.05), crude fibre (2.04±0.02) and carbohydrate (7.42±0.56) content were higher in S. scombrus while P. typus had higher total ash content (1.20±0.61). However, these values were higher to that reported by Lawal-Are *et al.* (2018) for the whole body (69.55 ± 2.93 %) of Squilla aculeata calmani from the same habitat. The crude protein contents for both S. scombrus (15.01±0.60 %) and P. typus (13.87±1.38 %) are similar to that reported for raw (16.02±2.24 %) and grilled (14.98±1.12 %) Cardisoma armatum by Moruf *et al.* (2021a). The protein content of the studied fish species showed no significance difference (P > 0.05) when compared. Crude fibre was only detected in S. scombrus with the value of 2.04±0.02 % similar to 2.47 % reported for flesh of Panulirus regius from Lagos Atlantic Ocean (Moruf *et al.*, 2021b).

Table 1: Proximate composition of two commercial marine fish species *Scomber scombrus* and *Pseudotholitus typus* in Lagos, Nigeria

Parameters (%)	*Scomber scombrus*	*Pseudotholitus typus*	*P*-Value
Moisture	58.12 ± 0.37^a	75.28 ± 1.22^b	0.04*
Protein	15.01 ± 0.6^a	13.87 ± 1.38^a	0.10
Crude Fat	16.57 ± 1.05^a	2.35 ± 0.55^b	0.03*
Crude Fibre	2.04 ± 0.02^a	0.00 ± 0.00^b	0.04*
Total Ash	0.85 ± 0.06^a	1.20 ± 0.61^a	0.13
Carbohydrate	7.42 ± 0.56^a	7.29 ± 1.28^a	0.51

*: Significant difference (P < 0.05)

Table 2 shows the result of the percentage energy contribution by nutrients. Total metabolizable energy was higher in *S. scombrus* with the value of 149 kcal 100g-1. The highest proportion of energy contrition was from protein (PEP) in both S. scombrus and P. typus at 60 kcal 100g-1 and 55 kcal 100g-1 respectively. kJ) with 5.12 CV%. The trend of energy contribution, PEP > PEF > PEC is comparable to the pattern in the Royal Spiny Lobster, *Panulirus regius* (Moruf *et al.*, 2021b).

Table 2: Compositional energy values in two commercial marine fish species *Scomber scombrus* and *Pseudotholitus typus* in Lagos, Nigeria

Parameter	Unit	*Scomber scombrus*	*Pseudotholitus typus*	Mean	SD	CV%
Total Energy, E	kcal $100g^{-1}$	149	106	127.32	30.45	23.91
PEF	% (kcal $100g^{-1}$)	16.3 (59)	6.0 (21)	11.15	7.34	65.83
PEC	% (kcal $100g^{-1}$)	8.2 (30)	8.2 (29)	8.21	0.01	0.13
PEP	% (kcal $100g^{-1}$)	16.6 (60)	15.6 (55)	16.11	0.68	4.2
UEDP%	kcal	10	9.4	9.66	0.41	4.2

Keys: SD= Standard deviation, CV%= Coefficient of variation

Mineral Profile

The result of the mineral content is presented in Table 3. The highest total macro element was recorded in P. typus (790.23 mg $100g^{-1}$). Potassium was the most concentrated mineral in S scombrus and P. typus, with respective values of 371.72±1.06 mg $100g^{-1}$ and 328.61±0.61 mg $100g^{-1}$. The mineral content pattern in both fish speacies was Potassium > Phosphorus > Sodium > Magnesium > Calcium. Phosphorus was significantly higher ($P<0.05$) in P. typus. This result aligns with Ogundiran (2014), highlighting marine fish species in southwestern Nigeria as a good source of macro minerals for human health.

Table 3: Mineral profiling of some selected commercial marine fin fish species in Lagos, Nigeria

Parameters (mg $100g^{-1}$)	*Scomber scombrus*	*Pseudotholitus typus*	*P*-Value
Calcium	12.43±3.18^{a}	12.96±3.30^{a}	0.08
Magnesium	78.31±1.6^{a}	86.31±1.52^{a}	0.10
Potassium	371.72±1.06^{a}	328.61±0.61^{a}	0.13
Phosphorus	215.11±3.55^{a}	267.21±2.24^{b}	0.04*
Sodium	89.17±27.97^{a}	95.14±15.51^{a}	0.13
Total	766.74	790.23	0.51

*: Significant difference

Tables 4 and 5 display the correlation matrices between the proximate and mineral compositions of *S. scombrus* and *P. typus*. In both cases, there were nearly perfect positive relationships between proximate and mineral components. In *S. scombrus,* crude fiber exhibited strong correlations with calcium (0.99), magnesium (1.00), potassium (0.95), phosphorus (1.00), and sodium (0.97) at the 0.05 significance level, which was similar for ash content. In *P. typus,* fat and carbohydrate contents showed positive correlations with all minerals, except for potassium (-0.11). These findings align with the report on macro and micro-nutrients in the flesh of C. amnicola from Southwest Nigeria (Moruf *et al.*, 2019).

Table 4: Correlation coefficient between the proximate and mineral compositions in *Scomber scombrus*

	Moisture	*Protein*	*Fat*	*Fibre*	*Ash*	*NFE*	*Ca*	*Mg*	*K*	*P*	*Na*
Moisture	1										
Protein	0.94	1									
Crude Fat	-0.92	-0.72	1								
Crude Fibre	0.12	-0.24	-0.5	1							
Total Ash	0.74	0.46	-0.95	0.75	1						
NFE	-0.02	-0.37	-0.37	0.99	0.65	1					
Ca	-0.04	-0.39	-0.36	0.99	0.64	1	1				
Mg	0.2	-0.16	-0.57	1	0.8	0.98	0.97	1			
K	0.41	0.07	-0.74	0.95	0.91	0.9	0.9	0.97	1		
P	0.07	-0.28	-0.46	1	0.72	1	0.99	0.99	0.94	1	
Na	0.36	0.02	-0.7	0.97	0.89	0.92	0.92	0.98	1	0.96	1

Table 5: Correlation coefficient between the proximate and mineral compositions in *Pseudotholitus typus*

	Moisture	*Protein*	*Fat*	*Ash*	*NFE*	*Ca*	*Mg*	*K*	*P*	*Na*
Moisture	1									
Protein	-0.55	1								
Fat	-0.93	0.82	1							
Total Ash	0.95	-0.78	-1	1						
NFE	-0.42	-0.53	0.05	-0.11	1					
Ca	0.85	-0.9	-0.99	0.97	0.12	1				
Mg	0.82	-0.93	-0.97	0.96	0.17	1	1			
K	0.95	-0.78	-1	1	-0.11	0.97	0.96	1		
P	0.89	-0.87	-0.99	0.99	0.05	1	0.99	0.99	1	
Na	0.85	-0.91	-0.98	0.97	0.13	1	1	0.97	1	1

CONCLUSION

Scomber scombrus and *Pseudotholitus typus* demonstrate valuable nutritional profiles, particularly in protein and mineral content, making them significant contributors to a healthy diet. Their distinct compositions and energy contributions emphasize their potential for diverse dietary applications.

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REFERENCES

Abimbola, A. O. (2016). Proximate and mineral composition of Pseudotolithus senegalensis and Pseudotolithus typus from Lagos Lagoon, Nigeria. Food and Applied Bioscience Journal, 4(1): 35-40.

Ahmed, I., Jan, K., Fatma, S. and Dawood, M. A. (2022). Muscle proximate composition of various food fish species and their nutritional significance: A review. Journal of Animal Physiology and Animal Nutrition, 106(3): 690-719.

AOAC (2006). Association of Official Analytical Chemists. Official Methods of Analysis (17th ed.), Washington D.C. 21-447pp.

Lawal-Are, A. O., Moruf, R. O. and Afolayan, O. A. (2018). Proximate composition, mineral profile and cholesterol level in whole and fillet of the Guinean Mantis Shrimp, Squilla aculeata calmani (Holthuis, 1959) (Crustacea: Stomatopoda). Albanian J. Agric. Sci., 17(3): 160–165.

Moruf, R. O, Saba, A.O., Chukwu-Osazuwa, J. and Elegbede, I.O. (2019). Seasonal variation in Macro-Micronutrient compositions of the flesh and shell of the Portunid Crab, Callinectes amnicola (De Rochebrune, 1883) from the coastal waters of Southwest Nigeria. Agricultura, 102 (1-2): 200-209.

Moruf, R. O. and Lawal-Are, A. O. (2017). Size composition, Growth pattern and Condition factor of two Portunid crabs, Callinectes amnicola (De Rochebrune) and Portunus validus (Herklots) off Lagos coast, Nigeria. Nigerian Journal of Fisheries and Aquaculture, 5(1): 15 – 21.

Moruf, R. O., Taiwo, M. A. and Adebayo, Q. (2021a). Nutritional and functional attributes of raw and grilled crabmeat. Agricultural Science and Technology, 13 (1): 83-90.

Moruf, R. O., Afolayan, O.A., Taiwo, M.A. and Ogunbambo, M. M. (2021b). Estimation of nutritional energy values, mineral ratio and mineral safety index in the Royal Spiny Lobster, Panulirus regius (De Brito Capello, 1864). Croatian Journal of Food Science and Technology, 13 (1): 105-110.

Ogbe, K. U. and Omada, O. I. (2020). Comparative Studies on the Proximate Composition of the Various Body Part of Clarias gariepinus and Scomber scomrus. Journal of Applied Sciences and Environmental Management, 24(4): 615-618.

Ogundiran, M. A., Adewoye, S. O., Ayandiran, T. A. and Dahunsi, S. O. (2014). Heavy metal, proximate and microbial profile of some selected commercial marine fish collected from two markets in south western Nigeria. African Journal of Biotechnology, 13(10): 1147-1153.

Opeyemi, I. E. (2020). Proximate Analysis and Mineral Composition of Some Fish Species in Ero Reservoir Ikun Ekiti, Nigeria. Global Advanced Research Journal of Agricultural Science, 9(1):1-9.

Schneider, W. (1990). Field guide to commercial marine resources of the Gulf of Guinea. Food and Agricultural organization of the United, Rome, Italy. 186pp.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

COMPARATIVE STUDY OF THE PHYSICOCHEMICAL PROPERTIES AND FATTY ACID COMPOSITION OF FISH OIL FROM *Clarias anguillaris*, *Synodontis membranacea* AND *Mormyrus rume*

[1],3Olugbenga, B. O., [1]*M. T. Yakubu, and [2]O. D. Owolabi,

[1]Department of Biochemistry, University of Ilorin, P.M.B 1515, Ilorin, Nigeria;
[2]Department of Zoology, University of Ilorin, P.M.B. 1515Ilorin, Nigeria;
[3]National Institute for Freshwater Fisheries Research, P.M.B. 6006, New-Bussa.

Corresponding author:
yamt@unilorin.edu.ng, +2348033754437

ABSTRACT

Fish oils contain essential fatty acids which are of benefits to human's health and aquaculture. The physicochemical properties and fatty acid composition of *Clarias anguillaris* oil (CAO), *Synodontis membranacea* oil (SMO) and *Mormyrus rume* oil (MRO) were determined in this study. Wet rendering method of extraction was used to obtain oil form the three fish species. The peroxide (1.95-3.15 Meq/kg), iodine (126.39-146.96), total oxidation (7.96-10.30), vitamin A (1.15-3.09 μM) and vitamin E (17.60-23.32 μg/ml) values for CAO, SMO and MRO were within the CODEX standard; with omega 3 fatty acid constituent of 21.57%, 15.53% and 2.58% respectively. The major saturated fatty acids (SFA) in CAO, SMO and MRO was Palmitic acid (C16:0). Oleic acid was the major monounsaturated fatty acids (MUFA) in CAO and SMO while in MRO; palmitoleic and oleic acid. The highest polyunsaturated fatty acids (PUFA) in CAO are eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) while DHA and arachidonic acid in SMO and MRO respectively. CAO contains the highest percentage of unsaturated fatty acids (UFA), MUFA and omega-3 fatty acid.

Keywords:
Freshwater fish,
CODEX Standard,
Peroxide value,
PUFA, MUFA

INTRODUCTION

Fish oil is an extractable product from marine fish and freshwater fishes' tissues and wastes (fish by-catches, fins, heads, bones, skin, and viscera that are not edible and underutilized) (Marak *et al.*, 2020; Hashim *et al.*, 2021; Mgbechidinma *et al;* 2023). The fatty acid composition of fish lipids are saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA) (Marak et al., 2020; Bawlan and Saba, 2021) and it is highly recommended in human diet due to its richness in long chain omega 3 polyunsaturated fatty acids (LC ? -3 PUFA); eicosapentaenoic acid (EPA) and docosahexaenoicacid (DHA) (Bawlan and Saba, 2021). These are essential fatty acids (EFA) obtainable in human diet from fatty fishes, fish products or fish oil supplements. Humans cannot synthesize them de novo but depend on dietary sources for their uptake (Gladyshev *et al.*, 2012; Phung et al., 2020; Marak *et al.*, 2020).The main dietary sources are the flesh of fatty fish such as sardine, herring, mackerel, menhaden, salmon, the liver of cod and the blubber of marine mammals such as seals and whales and over-the-counter fish oil supplements (Jairoun *et al.*, 2020; Bawlan and Saba, 2021). Fish oil/supplements are currently highly valued for their prophylactic and therapeutic properties in nutritional and human health fields (Bonilla-Méndez and Hoyos-Concha, 2018). Studies have revealed the role of long chain omega-3 PUFAs is the treatment of cardiovascular diseases, hypertension, diabetes, arthritis, depression, migraines, skin diseases like psoriasis, eczema and other inflammatory and autoimmune disorders as well as cancer (Parvarthy *et al.*, 2016).

The chemical composition and quality of fish oils depend on both the production process and quality of the raw material (EFSA, 2010). In recent times, the focus of research due to the market demand for nutraceutical (such as oils rich in omega-3 fatty acids) in pursuit of a healthier life is targeted at the production of these functional foods. Since population studies suggest regular consumption of small amounts of fatty fish or fish oil to promote health and the importance and applicability of fish oil in aquaculture, cosmetics, value added foods, biodiesel, pharmacological and other biotechnological industries have been overemphasized (Jayasinghe *et al.*, 2013; Alfio *et al.*, 2021; Amorim *et al.*, 2021; Delgado et al., 2021; Karsli, 2021) there is need to investigate into fish of different species to evaluate their physicochemical properties and fatty acid composition. However, many of these researches are mainly on fish oils and fish oil supplements from marine fishes in temperate regions but there exist dearth of information on oils from fishes of freshwater origin, particularly from the tropics, hence the rationale to extract oil from *Clarias anguillaris*, *Synodontis membranacea* and *Mormyrus rume*. *Clarias anguillaris*, *Synodontis membranacea* and *Mormyrus rume* are species of freshwater fishes of the tropics belonging to the family Clariidae, Mochokidae and Mormyridae. They are widely distributed in water bodies in African and can be found in the Niger and Benue river systems in Nigeria. The aim of this study was to determine the physicochemical properties and fatty acid composition of oils extracted from *Clarias anguillaris*, *Synodontis membranacea* and *Mormyrus rume*.

MATERIALS AND METHODS

Fish Samples

Clarias anguillaris (Plate 1a), *Synodontis membranacea* (Plate 1b) and *Mormyrus rume* (Plate 1c) were used for this research. *Mormyrus rume*, *Synodontis membranacea* were purchased from fisher folks at Kainji Lake Dam while *Clarias anguillaris* was purchased from Abdulsalam Fish Farm in Kainji and identified at the Fish Biology Section of the National Institute for Freshwater Fisheries Research, New- Bussa, Niger State using the taxonomic keys provided by Reeds et al. (1967).

Chemicals

The chemicals used in this study were of analytical grade.

Extraction of fish oil from the freshwater fishes

Fish oil was extracted from *Clarias anguillaris*, *Synodontis membranacea* and *Mormyrus rume* fish using the wet rendering method described by Okoth et al. (2015) with slight modification. The fishes were thoroughly washed with clean water, de-headed, de-gutted and chopped with knife into smaller pieces. The pieces were rinsed to remove blood, strained and put to boil at 96 oC for 15 minutes. The cooked mass was poured into net sack to strain and loaded onto screw press machine to obtain the oil-water fraction and the press-cake. The oil-water fraction was sieved using clean Muslin cloth. The oil was further separated by decantation and evaporation methods. The oil was then sieved with Whatman No. 1 Paper and stored in air-tight bottles.

Plate 1:*Clarias anguillaris*, *Synodontis membranacea* and *Mormyrus rume* fish and oils extracted

Physicochemical Properties and Fatty Acids Composition Analysis

The physicochemical properties of the oils from *Clarias anguillaris*, *Synodontis membranacea* and *Mormyrus rume* were determined according to the following methods. The percentage oil yield (Gopakumar and Rajendranathan Nair, 1972), peroxide value (AOCS 2003), free fatty acid, density of the oil, acid value (AOCS, 1998), saponification value (AOCS, 1993), iodine value (AOCS, 1992). p-Anisidine value (AOCS, 2004), vitamin E content, Vitamin A content (Rutkowski *et al.*, 2007), total oxidation (AOCS, 1998), Refractive index (AOAC, 2000), viscosity (Sathe and Salunkhe, 1981) and melting point (Regost *et al.*, 2003).

Oil from *Clarias anguillaris*, *Synodontis membranacea* and *Mormyrus rume* were transesterified into fatty acid methyl ester (FAME). Fatty Acid Methyl Esters (FAME) were identified and quantified with Gas Chromatography-mass spectrometry (GC-MS) (Park and Goins, 1994).

Statistical analysis

The results were analyzed statistically and data were expressed as mean ± SEM of three determinations or as percentages. Data were analysed with one way analysis of variance and Duncan multiple range test (IBM SPSS statistics, 2020). Results were also compared with Codex (2017) fish oil standards.

RESULTS AND DISCUSSION

The physicochemical properties of the oils from Clarias anguillaris, Synodontis membranacea and Mormyrus rume are revealed in Table 1. The peroxide value, acid value, free fatty acid, p-anisidine value and total oxidation value of the extracted oils were within the CODEX standards for fish oil (FAO/WHO 2017). The chemical and physical properties of the fish oils are used to determine their economic value and shelf-life quality (Endo, 2018). Fish oil consists of three major categories; saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) (Salih et al., 2021). According to Zhang et al. (2020) Palmitic acid (C16:0) contribute approximately 65% of the total saturated fatty acids in marine fish oils. In this study, the main saturated fatty acids in oils from *Clarias anguillaris*, *Synodontis membranacea* and *Mormyrus rume* was palmitic acid (C16:0) consisting of 57.47%, 57.93% and 53.39% of the total saturated fatty acids respectively (Table 2). The highest MUFA content in *Clarias anguillaris* and *Synodontis membranacea* oil was oleic acid (C18:1) with 21.42% and 27.59% of the total fatty acid respectively, while palmitoleic (C16:1) with 15.96% and oleic acids (C18:1) with 15.80% were highest in *Mormyrus rume* oil. In this study, the percentage monounsaturated fatty acid in Clarias anguillaris oil compared favourably with the report of Guil-Guerrero et al. (2011) on the Mediterranean Hake oil (Merluciusmerlucius Mediterraneus) and Loftsson et al. (2016) on Cod (Gadus morhua) liver oil. The major PUFA content in *Clarias anguillaris* oil are Eicosapentaenoic acid, (EPA) with 9.16% and docosahexaenoic acid (DHA) with 9.42%; docosahexaenoic acid in Synodontis membranacea oil and arachidonic acid in *Mormyrus rume* oil with 7.31 and 2.43% respectively.

Synodontis membranacea oil had the highest saturated fatty acid proportion while *Clarias anguillaris* oil had the highest percentage proportion of unsaturated fatty acid, omega-3 fatty acid and EPA + DHA and the smallest percentage proportion of omega-6 fatty acid (Figure 2). The difference in the fatty acid composition of the three fish species could be attributed to their feeding habits (Robert et al., 2014).

Table 1: Physicochemical properties of oil from *Clarias anguillaris*, *Synodontis membranacea* and *Mormyrus rume*

Physicochemical parameters	*Clarias anguillaris* oil	*Synodontis membranacea* oil	*Mormyrus rume* oil	CODEX Standards
Peroxide value (meqO_2/kg)	2.77 ± 0.18^{b}	3.15 ± 0.01^{a}	1.95 ± 0.00^{c}	„
Acid Value (mg/KOH)	0.2 ± 0.01^{a}	0.17 ± 0.01^{a}	0.27 ± 0.00^{a}	≤ 3
Anisidine value (AnV)	4.52 ± 0.13^{a}	4.00 ± 0.09^{a}	4.06 ± 0.08^{a}	≤ 20
TOTOX (2PV+AnV)	10.06 ± 0.49^{a}	10.30 ± 0.11^{a}	7.96 ± 0.08^{a}	≤ 26
Free Fatty Acid (FFA)	0.10 ± 0.01^{a}	0.08 ± 0.01^{a}	0.13 ± 0.00^{a}	≤ 1.13
Iodine value (gI_2/100g)	126.39 ± 8.44^{a}	146.96 ± 11.06^{b}	140.24 ± 5.41^{b}	
Saponification value	243.97 ± 4.75^{a}	249.67 ± 10.40^{a}	233.27 ± 13.06^{ab}	
Refractive index	$> 1.4^{a}$	$> 1.4^{a}$	$> 1.4^{a}$	
Viscosity (%)	73.0 ± 0.00^{a}	74.5 ± 0.01^{a}	73.5 ± 0.01^{a}	
Specific gravity	0.92 ± 0.00^{a}	0.89 ± 0.00^{a}	0.91 ± 0.00^{a}	
Density (g/L)	920.00 ± 0.00^{a}	923.08 ± 0.00^{a}	916.92 ± 0.00^{a}	
Melting point (°C)	$35 - 40^{c}$	$35 - 52^{a}$	$35 - 42^{b}$	
Vitamin A (µM)	3.09 ± 0.00^{a}	2.43 ± 0.00^{b}	1.15 ± 0.00^{c}	
Vitamin E (µg/ml)	17.6 ± 0.00^{a}	18.35 ± 0.00^{b}	23.32 ± 0.00^{a}	

Data are expressed as mean ± SEM of three determinations. Values with superscripts a, b, c are significantly different ($P > 0.05$) across the row. TOTOX - Total Oxidation

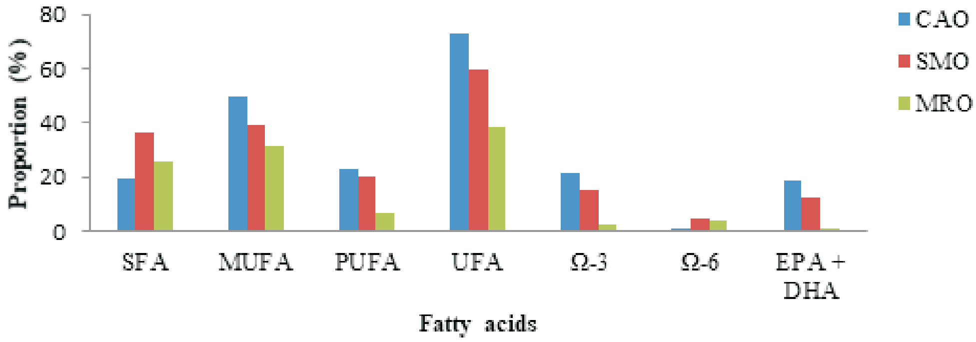

Figure 1: Percentage proportion of fatty acids in oils from Clarias anguillaris, Synodontis membranacea and Mormyrus rume

CAO-Clarias anguillaris oil, SMO- Synodontis membranacea oil, Mormyrus rume oil, SFA- saturated fatty acids, MUFA- monounsaturated fatty acids, PUFA-Polyunsaturated fatty acids, UFA-Unsaturated fatty acids,∑-3- Omega 3 fatty acids, ∑-6- Omega 6 fatty acids, EPA-Eicosapentaenoic acid, DHA- Docosahexaenoic acid

Table 2: Fatty acid composition of oil extracted from Clarias anguillaris, Synodontis membranacea and Mormyrus rume

Fish Specie	Saturated Fatty Acid (SFA) (%)							
	C14:0	**C15:0**	**C16:0**	**C17:0**	**C18:0**			∑ SFA
CAO	5.41	-	11.00	-	2.73			19.14
SMO	3.81	2.02	21.14	1.64	7.88			36.49
MRO	5.18	-	13.86	-	6.92			25.96
	Monounsaturated Fatty Acid (MUFA) (%)							
	C16:1 ∑7	**C18:1 Ω9**	**C20:1 Ω7**	**C22:1 Ω9**				**Ω PUFA**
CAO	9.38	21.42	10.65	8.54				49.99
SMO	8.45	27.59	3.21	-				39.25
MRO	15.96	15.80	-	-				31.76
	Polyunsaturated Fatty Acid (PUFA) (%)							
	C18:2 Ω6	**C18:4 Ω3**	**C20:4 Ω6**	**C20:4 Ω3**	**C20:5 Ω3**	**C22:5 Ω3**	**C22:6 Ω3**	**Ω PUFA**
CAO	1.49	2.99	-	-	9.16	-	9.42	23.06
SMO	2.53	-	2.48	1.10	4.79	1.95	7.31	20.16
MRO	1.79	-	2.43		-	1.16	1.42	6.80

CONCLUSION

Globally, with the increasing demands for PUFA -enriched oils due to their health benefits, freshwater fish species should be exploited. Clarias anguillaris oil had the relatively highest level of eicosapentaenoic acid and docosahexaenoic acid than the other two fish species from the Kainji dam. Thus, more of Clarias anguillaris may be consumed to obtain high amount of EPA and DHA.

REFERENCES

Alfi,o V. G., Manzo, C. and Micillo, R. (2021). From fish waste to value: An overview of the sustainable recovery of Omega-3 for food supplements. Molecules 26:1002. https://doi.org/10.3390/molecules26041002

Amorim, T. L, de la Fuente M. A, de Oliveira M. A. L, and Gómez-Cortés P. (2021). ATR-FTIR and Raman spectroscopies associated with chemometrics for lipid form evaluation of fish oil supplements: A comparative study. ACS Food Science and Technology1:318–325. https://doi.org/10.1021/acsfoodscitech.0c00122

AOCS (1992). Official methods and recommended practices of the American Oil Chemists Society (4th ed.), Champaign, American Oil Chemists' Society,USA.

AOCS (1993). Official Methods and Recommended Practices of the American Oil Chemists' Society, AOC Press. Washington, DC

AOCS (1998). Free fatty acids in: Official methods and recommended practices of the American oil chemists society. Vol. 5a. 5th ed. Champaign (US): AOCS Press.

AOCS (2003). Official Method Cd 8-53 Peroxides in fats and oils. American Oil Chemists Society, Champaign, Illinois, USA.

AOCS. (2004). Official methods and recommended practices of the American Oil Chemists' Society. Champaign: American Oil Chemists' Society.

Balwan, W. K. and Saba, N. (2021). Study of Role of Fish Oil in Human Health. Global Academic Journal of Medicine and Science; Vol-3(1), : 14-18. http://dx.doi.org/10.36348/gajms.2021.v03i01.002

Bonilla-Méndez, J. R. and Hoyos-Concha, J. L. (2018). Methods of extraction, refining and concentration of fish oil as a source of omega-3 fatty acids. Corpoica Cienc Tecnol Agropecuaria, Mosquera (Colombia), 19(3):645-668. https://doi.org/10.21930/rcta.vol19_num2_art:684

Delgado, E., Valles-Rosales, D. J., Flores, N. C and Reyes-Jáquez, D. (2021). Evaluation of fish oil content and cottonseed meal with ultralow gossypol content on the functional properties of an extruded shrimp feed. Aquaculture Reports;19:100588, 1 - 6. https://doi.org/10.1016/j.aqrep.2021.100588

Endo, Y. (2018). Analytical methods to evaluate the quality of edible fats and oils: the JOCS standard methods for analysis of fats, oils and related materials (2013) and advanced methods. Journal of Oleo Science, 67(1), 1-10. https://doi.org/10.5650/jos.ess17130

European Food Safety Authority (2010). Scientific opinion on fish oil for human consumption. Food Hygiene, including rancidity. European Food Safety Authority (EFSA) Journal. 8, 1–48. https://doi.org/10.2903/j.efsa.2010.1874

FAO WHO. (2017). Standard for Fish Oil CXS 329 2017 Codex Alimentarius Commission. Report of the Twenty Forth Session of the CODEX Committee on Fats and Oils. Joint FAO/WHO Food Standards Programme Codex Alimentarius Commission.

Gladyshev, M. I., Lepskaya, E. V., Sushchik, N. N., Makhutova, O. N., Kalachova, G. S., Malyshevskaya, K. K., and Markevich, G. N. (2012). Comparison of polyunsaturated fatty acids content in filets of anadromous and landlocked sockeye salmon Oncorhynchus nerka. Journal of food science, 77(12), C1307–C1310. https://doi.org/10.1111/j.1750-3841.2012.02998.x

Gopakumar, K., and Rajendranathan Nair, M. (1972). Fatty acid composition of eight species of Indian marine fish. Journal of the science of food and agriculture, 23(4), 493–496. https://doi.org/10.1002/jsfa.2740230409

Guil-Guerrero, J. L., Venegas-Venegas, E., RincónCervera, M. Á. and Suárez, M. D. (2011). Fatty acid profiles of livers from selected marine fish species. Journal of Food Composition and Analysis, 24(2), 217–222. https://doi.org/10.1016/j.jfca.2010.07.011

Hashim, N. A., Mudalip, S. K. A., Sulaiman, S. Z. and Shaarani, S. (2021). Nutritional values and microencapsulation techniques of fish oil from different sources: A mini review. Material Today Proceedings, 42:222–228. https://doi.org/10.1016/j.matpr.2020.11.849

Jairoun, A. A., Shahwan, M., & Zyoud, S. H. (2020). Fish oil supplements, oxidative status, and compliance behaviour: Regulatory challenges and opportunities. PloS one, 15(12), e0244688. https://doi.org/10.1371/journal.pone.0244688

Jayasinghe, P., Adeoti, I. and Hawboldt. K. (2013). A study of process optimization of extraction of oil from fish waste for use as a low-grade fuel. Journal of American Oil Chemistry Society, 90:1903– 1915. http://dx.doi.org/10.1007/s11746-013-2321-1

Karsli B. (2021) Comparative analysis of the fatty acid composition of commercially available fish oil supplements in Turkey: Public health risks and benefits. Journal of Food Composition and Analysis, 103:104105. https://doi.org/10.1016/j.jfca.2021.104105

Marak, N. R., Baruah, U and Bhattacharya, R. (2020). Fish Oils in Health and Disease. International Journal of Current Microbiology and Applied Science, 9(11): 1337-1343. https://doi.org/10.20546/ijcmas.2020.911.157

Mgbechidinma, C. L., Zheng, G., Baguya, E. B., Zhou, H., Okon, S. U., and Zhang, C. (2023). Fatty acid composition and nutritional analysis of waste crude fish oil obtained by optimized milder extraction methods. Environmental Engineering Research, 28(2). https://doi.org/10.4491/eer.2022.034

Okoth, M.W., Imungi, J.K., and Aloo, J.O. (2015). Physico-chemical Characteristics of Refined Lake Victoria Nile Perch (Lates niloticus) Viscera Oil. Food Science and Quality Management, 46, 44-54.

Park, P. W. and Goins, R. E. (1994).In Situ Preparation of Fatty Acids Methyl Ester for Analysis of Fatty Acids Composition in Food. Journal of Food Science, 59: 1262-1266. https://doi.org/10.1111/j.1365-2621.1994.tb14691.x

Parvarthy, U., Jeyakumari, A., Murthy L. N., Visnuvinayagam, S., and Ravishankar, C. N. (2016). Fish oil and their significance to human health. Everyman's Science. 4, 258-261.

Phung, A. S., Bannenberg, G., Vigor, C., Reversat, G., Oger, C., Roumain, M., Galano, J. M., Durand, T., Muccioli, G. G., Ismail, A., and Wang, S. C. (2020). Chemical Compositional Changes in Over-Oxidized Fish Oils. Foods (Basel, Switzerland). 9(10), 1501. https://doi.org/10.3390/foods9101501

Regost, C., Arzel, J., Cardinal, M., Rosenlund, G. and Kaushik, S.J. (2003). Total replacement of fish oil by soybean or linseed oil with a return to fish oil in turbot (Psetta maxima) 2. Flesh quality properties. Aquaculture, 220(1-4): 737-747. https://doi.org/10.1016/S0044-8486(02)00655-5

Robert, A., Mfilinge, P., Limbu, S. M. and Mwita, C. J. (2014). Fatty Acid composition and levels of selected polyunsaturated Fatty acids in four commercial important freshwater fish species from lake victoria, Tanzania. Journal of lipids, 712134. https://doi.org/10.1155/2014/712134

Rutkowski, M. and Grzegorczyk K. (2007). Modifications of spectrophotometric methods for antioxidative vitamins determination convenient in analytic practice. Acta Scientiarum Polonorum Technologia Alimentaria. 6 (3), 17-28

Salih, A. W., Najim, S. M. and Al-Noor, J. M. (2021). Some physical, chemical and sensory properties of fish oil extracted from fish wastes by physical and chemical methods. BiologicalandApplied Environmental Research.Vol. 5(1): 152-162. https://doi.org/10.51304/baer.2021.5.1.152

Sathe, S. K. and Salunkhe, D. K. (1981). Functional properties of great northern bean (Phasolus vulgaris) protein: Emulsion, foaming, viscosity, and gelation properties. Journal ofFood Science, 46(1): 71-81. https://doi.org/10.1111/j.1365-2621.1981.tb14533.x

Zhang, X., Ning, X., He, X., Sun, X., Yu, X., Cheng, Y., Yu, R.Q. and Wu, Y. (2020). Fatty acid composition analyses of commercially important fish species from the Pearl River Estuary, China. PLoS ONE, 15(1). https://doi.org/10.1371/journal.pone.0228276

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

EFFECT OF TIME ON QUANTITY OF OIL PRODUCED From *Bagrus bayad* (Forskal, 1775).

[1]Abidang, I. F., [2]J. O. Ed-Idoko, [3]J. O. Apochi, [4]N. P. Xolani, and [5]A. O. Tanimowo

[1] Department of Fisheries, Faculty Of Agriculture, University Of Maiduguri
[2] Fisheries and Aquaculture Department, Federal University of Agriculture, Makurdi (Joseph Sarwuantarka University Makurdi), Benue State
[3] Mediatrix Integrated Agricultural Limited, Abuja.
[4] Department of Ichthyology and Fisheries Science, Rhodes University, Grahamstown South Africa
[5] Department of Fisheries and Aquaculture Technology, School of Agriculture and Agricultural Technology, Federal University of Technology, Akure, Ondo State

Corresponding author:
edidoko.john@gmail.com, +2348061216970, 0000-0002-1311-6526

ABSTRACT

This study used eight (8) kilograms of fresh *Bagrus bayad* purchased, beheaded, degutted, fins removed and washed with clean water (to remove any sand and blood) prior to cooking, for the experiment on effect of time on quantity of oil produced. Fire was generated using charcoal. The first treatment of two (2kg) was cooked for 30 minutes, the second treatment (2kg) was cooked for 60 minutes, the third treatment (2kg) of prepared fish was cooked for 90minutes and lastly the fourth treatment (2kg) of prepared fish was cooked for 120 minutes at a boiling point of 95°C - 100°C. Each treatment was replicated twice. The data obtained from the study was subjected to one way analysis of variance (ANOVA) and the difference in mean were separated using LSD at 95% confidence level ($P<0.05$). Quantity of oil produced was highest (27.00ml) in quantity of oil produced at 30minutes followed by quantity of oil produced at 90minutes with a value of 23.50ml. Quantity of oil produced at 120 minutes had a value of 21.75ml while least value of 20.75ml was produced at 60 minutes. Highest value of Residues (635.00g) was recorded in the oil produced at 30 minutes followed by the values of 620.00g and 525.00g in oil produced at 60 and 90 minutes while least value was observed in 120 minutes with a value of 450.00g. This study recommends time exposure of 30 mins as seen from Treatment 1, for use of in fish oil extraction as it gave the best results of more pure oil extracted from *Bagrus bayad*.

Keywords:
Extraction, processing, treatment, cooking, evaporation, residues.

INTRODUCTION

Fish is a vital source of food for people. It is man's most important single source of high-quality protein, providing 16% of the animal protein consumed by the world's population, according to the Food and Agriculture Organisation (FAO) of the United Nations (1997). The FAO estimates that about one billion people world-wide rely on fish as their primary source of animal protein (FAO, 2000).

Apart from the fish tissues (flesh) as food, other value can be derived from the other parts of fish, such as fish oil from the fatty glands of fish. For example, fish processing offcuts such as heads, viscera and skin are frequently discarded without realising its potential except some low level of value-addition in limited fields..

Fish oil was originally consumed to get enough vitamin A and vitamin D, which for many years have been known to be important micro-nutrients for the body's normal functions (homeostasis). Fish oil is derived from the tissues of oily fish. It is recommended for a healthy diet because it contains the ? - 3 fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), precursors to eicosanoids that reduce inflammation throughout the body as reported by Sargent (1997). Fish oils are required to be added in minute quantities for optimum health benefit, cellular metabolism and normal physiological functions (Sau and Paul, 2004). Scientists came to know about many benefits of fish oils in the early 1970s when Danish physicians observed that Greenland Eskimos had an exceptionally low incidence of heart disease and arthritis despite the fact that they consumed a high-fat diet. Intensive research soon discovered that two of the fats that they consumed in large quantities, EPA and DHA, were actually highly beneficial. Fish oil has numerous beneficial effects to human body. It prevents atherosclerosis, angina, heart attack, congestive heart failure, arrhythmias, stroke, and peripheral vascular disease. Clinical trials have shown that it is also effective in the treatment of many disorders including rheumatoid arthritis, diabetes, cancer etc, (Connor and William, 2000).

There are different methods of fish oil extraction, however, some of these methods are linked to several drawbacks, e.g., chemical solvent extraction still contains traces of hazardous chemicals, and the extraction process is not eco-friendly. Cold press renders a very low oil yield. Enzymatic and supercritical fluid extraction is associated with higher capital expenditures and, hence, is not cost-effective. Due to this reason, the present research is focused on solvent-free, eco-friendly, and cost-effective methods for recovering fish oil (Ivanous *et al.*, 2017, Ciriminna *et al.*, 2019). In this regard, wet rendering is gaining interest, which involves cooking fish biomass in water or steam to break the complex tissue and release the oil in free form. This oil is easily separated from the water and other fish solids. Cooking time and temperature can affect the yield and quality of fish oil during wet rendering (Nasir *et al.*, 2017).

The bagrid catfish *(B. bayad)* have been identified as model species that could be used to not only understand biogeography, but also are important commercial fisheries species and candidates for aquaculture development in Africa. These species have high economic importance and market acceptability, in addition their wide distribution across the continent (Alhassan and Ansu-Darko, 2011).

The genus Bagrus belongs to the family Bagridae (bagrid catfishes) and known to comprise seven species; three species *Bagrus bayad* (Forsskal 1775), B. docmac (Forsskal 1775) and B. degeni occur in Africa (Boulenger, 1907). These species are observed to have a wide range of natural distribution in all principal river-systems of Africa. They were reported in the Nile River, Lakes Albert and Turkana, Lake Chad, Niger. The habitats and habits of Bagrus fish are fairly similar to those of the Nile perch.

The bagrid catfishes are widely distributed in African and Asian freshwaters. About 100 species occur in African freshwaters (Lowe-McConnell, 1987), widely distributed in the basins of Gambia, the Nile system, Chad, Niger, Senegal, the Volta and most of the East African rift lakes (Risch, 1986; Golubtsov *et al.*, 1995).

STATEMENT OF THE PROBLEM

Fishes are highly important in the development of Nigeria both economically and health wise as source of protein with low cholesterol level in the diets of many populace. Bagrus bayad is a common indigenous fish whose economic importance has not been fully harnessed nor commercialized despite the fact that they are readily available, abundant and cheap.

JUSTIFICATION OF THE STUDY

There is need to understand that the use of indigenous fish can provide oil in quantities that can even be commercialized. The extraction of oil from imported fish is high, expensive, scarce and sometimes not available. Production of oil from indigenous fish (Bagrus bayad) can increase the availability of fish oil, reduce the cost of production and improve the income of the local fisher folk.

SCOPE OF THE STUDY

This research covers the Extraction of oil from Bagrus bayad (Forskal, 1775).

OBJECTIVE OF THE STUDY

The objective of this research are;

i. Extraction of oil from Bagrus bayad

ii. To know the quantity of oil produced with time

MATERIALS AND METHODS

STUDY AREA

This study was carried out at the Department of Fisheries Fish Preservation and Post harvest Unit, University of Maiduguri, Borno State, Nigeria.

PROCEDURAL METHODOLOGY

Eight (8): kilograms of fresh sample of Bagrus bayad, clean tap water, plastic bowls, knife, cooking pot, charcoal, weighing balance, strainer, spoon, mesh, packaging bottles.

Eight (8) kilograms of fresh Bagrus bayad were purchased from custom market (Gomboru) in maiduguri, Borno State. The fresh fish were kept at room temperature for subsequent experiment.

Prior to the cooking of fresh fish for oil extraction, the fish was beheaded, degutted, the fins removed and washed with clean water to remove any sand and blood. The prepared fish was transferred into a clean cooking pot containing clean water for proper cooking after weighing.

The prepared fish was weighed and transferred into a clean cooking pot filled with one liter of clean tap water. Local method of oil extraction was adopted in this study. Fire was generated using charcoal.

OIL EXTRACTION METHOD

The Eight (8) kilograms of the prepared fish were cooked separately that is the first treatment of two (2kg) was cooked for 30minutes, the second treatment (2kg) of prepared fish was cooked for 60minutes, the third treatment (2kg) of prepared fish was cooked for 90minutes and lastly the fourth treatment (2kg) of prepared fish was cooked for 120minutes at a boiling point of 95°C - 100°C. Each treatment was repeated twice.

After cooking of the fish for some minutes, oil start forming at the surface and the fish settles at the bottom of the cooking pot. This process continued until when the carcass stops producing oil. The oil on the surface was collected using spoon into another cooking pot. The collected oil was heated again to remove (evaporate) any moisture in it. The packaging bottles was sterilized for 20minutes and the extracted oil was allowed to cool before measuring and pouring it into the packaging bottles.

DRYING OF RESIDUES

After the oil have been extracted from each treatment, the Residues collected were sun-dried for a day. The sun-dried Residues was weighed based on each treatment using a weighing balance.

DATA ANALYSIS

The data obtained from the study was subjected to one way analysis of variance (ANOVA) and the difference in mean were separated using LSD at 95% confidential level ($P<0.05$).

RESULTS

Table 1 shows the effect of time on oil production in *Bagrus bayad*. The weight of Fish used for the extraction of the oil were one (1g) gram for each treatment. No significant variation ($P<0.05$) was observed in all the time used in the Extraction.

Quantity of oil produced was higher 27.00ml in quantity of oil produced at 30minutes followed by quantity of oil produced at 90minutes with a value of 23.50ml. Quantity of oil produced at 120minutes has a value of 21.75ml while least value of 20.75ml was produced at 60minutes. No Statistical difference ($P<0.05$) was recorded in the quantity of oil produced in the different time intervals.

Higher value of Residues of 635.00g was recorded in the oil produced at 30minutes followed by the values of 620.00g and 525.00g in oil produced at 60 and 90 minutes while least value was observed in

120minutes with a value of 450.00g. No Significant difference were seen in all the four treatments.

Table. 1: Effect of time on oil production in Bagrus bayad

	Time (minutes)				
	30	60	90	120	SEM
Weight of Fish(Kg)	1.00[a]	1.00[a]	1.00[a]	1.00[a]	0.00[ns]
Quantity of Oil (ml)	27.00[a]	20.75[a]	23.50[a]	21.75[a]	5.69[ns]
Residues(g)	635.00 [a]	620.00 [a]	525.00 [a]	450.00 [a]	149.58[ns]

DISCUSSION

The results of the present findings indicates that, one (1g) gram of *Bagrus bayad* was used for the Extraction of oil in each treatment. This one (1g) gram used differ with the findings of Suleiman (2022), who used 0.5g in oil extraction from three different species of fish (Hydrocynus forskali, *Clarias gariepinus* and *Mormyrops rume*). The difference in the weight of the fish used could be attributed to the availability of the fish.

The higher quantity of oil obtained from this study which is 27.00ml was lower than the findings of Abdullahi (2021), who produced oil from two species of fish (Hydrocynus forskali and Brycinus nurse) and obtained the highest quantity of 420ml from Brycinus nurse. The lower value of oil produced from this study could be as a result of the difference in the time of the oil extraction.

Similar research carried out on the Extraction of oil from two wild species of Catfishes *Clarias angularis* and Hetebranchus longifilis reported that the quantity of oil produced from both Heterobranchus longifilis and Clarias angularis as 15.33 and 14.83ml was lower than the quantity of oil produced in the recent findings (Chigbo *et al.*, 2018). This could be attributed to the difference in the specie of the fish.

Higher value of Residues of 635.00g was observed in the oil produced in 30minutes. The least value of 450.00g was observed in oil produced at 120 minutes. The least value of Residues obtained from this study could be attributed to the high percentage of oil than flesh in that treatment.

CONCLUSION

Fish oil can be produced from whole fish, fish trimmings or other fish by-products resulting from fish processing and extraction procedures.

The duration of extracted fatty glands from fish, under high temperature affects the quantity of oil that could be extracted. The best result is obtainable from the process in treatment one (exposing the oil to cook for 30 minutes before sedimentation, decantation and evaporation procedures).

RECOMMENDATION

This study recommend that the use of time in fish oil extraction is very important as it provides information on the best timing for heat exposure of 30 mins to our fish species for more oil extraction. This enables one understand the best timing to be adopted when extracting oil from Bagrus bayad.

REFERENCES

Adeniyi, O. R., Omitoyin, S. A. and Aderibigbe, H. I. (2010). Profitability of Aquacultural practices: empirical experience from fish farmers in Epe Local Government Area of Lagos State. Nigerian Journal of Fisheries. 7(1&2): 117-125.

Alhassan, E., and Ansu-Darko, M. (2011). Food and feeding habits of a potential aquaculture candidate, the black Nile catfish, Bagrus bajad in the Golinga reservoir.

Boulenger, G.A. (1907). Zoology of Egypt. The Fishes of the Nile. Hugh Rees Ltd., London.

Chigbo C. M, Lukong C. B. and Okechukwu A. (2018). "Comparative analysis of the oil extracted from two different species of wild catfish in Otuocha River, Anambra State Nigeria". Environmental Science. DOI:10.25240/TJANS.2018.2.2.11

Ciriminna R, Scurria A, Avellone G, and Pagliaro M. A. (2019) Circular economy approach to fish oil extraction. Chem Select.;4(17):5106–9. [Google Scholar]

El-Drawany, M., and Elnagar, W. (2015). Growth, food and feeding habits of Bagrus bayad and Bagrus docmac inhibiting muess channel, Sharkia Province, Egypt. Journal of Aquaculture Research & Development, 6, 1

Falaye, A. E. and Jenyo-Oni, A. (2009). Aquatic biodiversity and the implication in artisanal fishing production. African journal of livestock extension, 7: 39-43.

Fasakin, K. (2006). Fish farming (aquaculture) made easy. LUSIJ Publications Lagos. 33

FAO and NACA (Network of Aquaculture Centres in Asia-Pacific). (2000). Asia regional technical guidelines on health management for the responsible movement of live aquatic animals and the Beijing consensus and implementation strategy. FAO Fisheries Technical Paper No. 402. Rome.

Ivanovs K, and Blumberga D. (2017). Extraction of fish oil using green extraction methods: A short review. Energy Procedia. 128:477–83. [Google Scholar]

Lowe-McConnell, R.M. (1987). Ecological studies in Tropical Fish Communities. Cambridge University Press, Cambridge.

Melgosa R, Sanz MT, Beltrán S. (2021) Supercritical CO2 processing of omega-3 polyunsaturated fatty acids–Towards a biorefinery for fish waste valorization. J Supercrit Fluid. 69:105121. [Google Scholar]

Nazir N, Diana A, Sayuti K. (2017). Physicochemical and fatty acid profile of fish oil from head of tuna (Thunnus albacares) extracted from various extraction method. Int J Adv Sci Eng Inf Technol. 7(2):709–15. [Google Scholar]

Risch, L.M. (1986). Bagridae. In: J. Daget, J.-P. Gosseand D.F.E. Thys van den Audenaerde (eds.) Checklist of the freshwater fishes of Africa (CLOFFA).ISNB, Brussels; MRAC, Tervuren; and ORSTOM, Paris., 2: 2-35.

Tsikliras, A.C., Dinouli, A., Tsiros, V.-Z. and Tsalkou, E., (2015). The Mediterranean and Black Sea fisheries at risk from overexploitation. PLoS ONE 10, e0121188.

Zhou, S., Smith, A.D.M., Punt, A., Punt, A.E., Richardson, A.J., Gibbs, M., Fulton, E.A.,Pascoe, S., Bulman, C., Bayliss, P., and Sainsbury, K.J., (2010). Ecosystem-based fisheries management requires a change to the selective fishing philosophy. Proc. Nat. Asso. Sci. USA 107, 9485–9489.

CHEMICAL COMPOSITION OF GARABIYA FORTIFIED WITH CATFISH ROE PROTEIN CONCENTRATES (CRPC)

[1]Mustapha F. A., [2]A. Mohammed, [3]A.G. Shehu, [3]I. G. Musa, [1]R.E. Nyako, and [4]A. I. Maijalo.

[1]National Institute for Freshwater Fisheries Research, Maiduguri Zonal Station, Maiduguri, Borno State
[2] Department of Veterinary Public Health and Preventive Medicine, University of Maiduguri
[3]National Institute for Freshwater Fisheries Research, New Bussa, Niger State
[4]Department of Food Science and Technology, University of Maiduguri

Corresponding Author:
fulaimah@gmail.com, +2348034633367 https://orcid.org/0009-0005-9828-3284

ABSTRACT
Roes are considered as abundant and underutilized fish by-product in Nigeria. The production of roe protein concentrate (RPC) is expected to increase the economic value and potency of their usage. A protein concentrate was produced using catfish roes, and the concentrates (CRPC) were used to fortify a rice based snack garabiya using four different ratios of rice to protein concentrates (90:10; 85:15; 75: 25 and 70:30). The results of the proximate composition ranges from 1.68±0.03 to 2.89±0.04, 6.65±0.06 to 14.42±0.73, 22.01±0.57 to 26.12±0.18, 0.45±0.07 to 0.60±0.02, 2.10±0.13 to 2.52±0.04, and 53.61±0.11 to 63.12±0.35mg/g for moisture, protein, ash, fibre and carbohydrate. The 100% rice garabiya recorded lower moisture, protein and ash contents, and significant (P=0.05) amount of carbohydrate. The results of mineral analysis of the samples indicated significant differences (P=0.05) in the mineral composition. Sodium and Potassium were the most abundant minerals and the highest value was observed in garabiya with CRPC15%. Among the garabiya samples also, the results of amino acid profile indicated leucine and lysine being the most predominant essential amino acids recorded. The results of the sensory evaluation of the garabiya were significantly different (P=0.05). Roe protein concentrates contained high amounts of protein, fat and ash, as well as minerals and amino acid contents. A highly nutritious garabiya has been produced through fortification with catfish protein concentrate (CRPC).

Keywords:
snacks, muscle, proximate

INTRODUCTION

Roe is the term used to describe fish eggs (oocytes) gathered in skeins (Mahmoud *et al.*, 2008). Furthermore, roe has a high content of nutritive lipids, particularly phospholipids and long chain unsaturated fatty acids (LCUFAs) (Mahmoud et al., 2008). Fatty acids, such as cis-5,8,11,14,17-Eicosapentaenoic acid (EPA; C20:5 n-3) and cis-4,7,10,13,16,19-docosahexaenoic acid (DHA; C20:6 n-3) have been reported to play many important roles in the reduction of the risk of coronary heart disease and prevention of Alzheimer's disease and they also have anti-inflammatory properties (Sahena et al., 2009). Garabia, is a sweetened snack that is produced from rice, sugar, groundnut oil and spices (ginger, cloves, and pepper). It is a "Royal snack" that is mainly prepared by the Kanuris and Shuwa Arabs of Yobe and Borno States (Kyari, 2002). The major ingredient used in garabiya production is rice flour. Rice is the seed of the grass species Oryza sativa (Asian rice) or Oryza glaberrima (African rice).

As a cereal grain, it is the most widely consumed staple food for a large part of the world's human population, especially in Asia. It is the Agricultural commodity with the third-highest worldwide production, after sugarcane and maize (FAOSTAT, 2012). Rice is a good source of staple food in many parts of the world, but it is not regarded as a complete protein, it does not contain all of the essential amino acids in sufficient amounts for good health, and should be combined with other sources of protein, such as nuts, seeds, beans, fish, or meat (Jianguo et al., 2003). This study is therefore limited for the production of roe protein concentrate and fortifying a rice based snack (garabiya), and evaluating its chemical and sensory properties.

MATERIALS AND METHODS

Sample acquisition and preparation

Fish samples were purchased directly from fish dealers from Gamboru Market, rice and other ingredients were purchased from Maiduguri Monday market, Borno State. Protein concentrates and the fortified Garabiya were processed at the Food Processing Laboratory, Department of Food Science and Technology. Standard methods were used (AOAC, 2006) in all the chemical analysis (protein, fat, ash, and moisture); and the analyses were carried out in the National Agency for Food and Drug Administration and Control laboratories (NAFDAC), Maiduguri Branch, Borno State.

Preparation of Catfish Roe Protein Concentrates (CRPC)

Roe protein concentrate (RPC) was prepared according to the method used by Narsing et al., (2012). Fresh roes were separated manually from skins and blood vessels of the fish. The roe was homogenized using a high-speed mixer, and dried at 45±2°C for about 10 hours in a cabinet tray drier. The dried roes were ground and defatted using isopropanol maintaining a solid to solvent ratio of 1:3 (w/v) at ambient temperature of 28±2°C for two hours, with occasional stirring. The solvent was decanted and the extraction was repeated for three times to ensure maximum removal of lipid. The residue was dried in a vacuum drier 45±2°C for a period of eight hours. The defatted and dried roes were ground to powder using a mixer, and then sieved through a 180μ mesh (the kitchen sieve was used for this study) to obtain roe protein concentrates. Fish protein concentrate (FPC) from fish muscle were also prepared using the above technique.

Garabiya Production

Garabiya was produced using the method described by Kyari (2002). The fortified Garabiya was also compared with the traditionally manufactured Garabiya to determine their organoleptic and chemical properties. The major ingredients used in Garabiya production are rice flour, sugar, groundnut oil, ginger, cloves and pepper. The ingredients were made into flour, mixed in appropriate proportion and the resulting dough is then shaped using finjal cups and dry-fried in a local pan known as "ngaya" for 10-15 minutes.

Proximate Analysis

The proximate composition (Moisture Content, Protein, Fat, Fibre, and Carbohydrates) of the fortified Garabiya and the locally processed Garabiya were determined following the guidelines outlined in AOAC (2006).

Amino Acid Analysis

The Amino Acid profile in the known sample was determined using methods described by Benitez (1989). The known sample was dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Applied Biosystems PTH Amino Acid Analyzer.

Mineral analysis

Mineral content of Garabiya was determined using atomic absorption spectrophotometer (AOAC, 2006). The minerals examined were; Potassium, Iron, Sodium, Calcium, and Phosphorus.

Sensory Evaluation

The sensory evaluation test was conducted by a team of 20 panellist that were drawn from staff and students of Department of Food Science and Technology, University of Maiduguri, who have good experience of the quality characteristics of good quality Garabiya. The samples were rated for test, colour, texture and overall acceptability based on a 9-point hedonic scale with 9 representing "like extremely" and 1 "representing dislike extremely" (Ihekoronye and Ngoddy, 1985).

RESULTS AND DISCUSSION

Proximate Composition of the Fortified Garabiya

Table 1 shows the proximate composition of the fortified Garabiya. There was a significant difference in the proximate composition except the fat content among the fortified Garabiya and the 100% rice Garabiya. The protein content varies significantly among the Garabiya samples, and increased with increase in the protein concentrates and samples containing 30% protein concentrates had the highest protein content. Sathivel et al., (2009) reported catfish roe protein powder possessing a protein content of 67%. 100% rice Garabiya had lowest moisture, protein and ash. There was no significant difference in the ash content of the Garabiya (0.22 to 1.35%) and the least was recorded in 100% rice Garabiya. The moisture content in the Garabiya recorded in this study is similar to that obtained by Badau et al (2013) in Garabiya fortified with cowpea. The fat content is however higher, but lower in protein and carbohydrate contents. This result also indicated that rice-fish Garabiya is a rich source of energy and capable of supplying the daily energy requirements of the body. Although snacking is often considered bad habit because it contains high energy and may facilitate hyperphagia while providing insignificant qualities of valuable nutrients due to choice of low quality snacks, nutritionists still agreed that since human bodies need re-fueling every 3-4 hours, healthy snack like Garabiya may provide energy burst and help keep hunger under control so one is not tempted to over eat later (Drummond et al., 1996).

Table 1. Proximate Composition of the Fortified Garabiya

CONCENTRATES*	MOISTURE (%)	PROTEIN (%)	FAT (%)	ASH (%)	FIBRE (%)	CHO (%)	ENERGY (KJ)
CRPC10%	2.89±0.04^{d}	6.65±0.06^{a}	24.52±0.29^{c}	0.60±0.02^{c}	2.30±0.13^{b}	63.06±0.21^{c}	499.44±2.04^{b}
CRPC15%	2.58±0.13^{c}	9.17±0.11^{b}	22.01±0.57^{b}	0.61±0.02^{c}	2.52±0.04^{c}	63.12±0.35^{c}	487.21±3.29^{a}
CRPC25%	1.68±0.03^{b}	9.66±0.36^{b}	24.99±0.25^{c}	0.79±0.02^{d}	2.10±0.13^{a}	60.79±0.54^{b}	506.69±1.59^{c}
CRPC30%	2.30±0.11^{c}	14.42±0.73^{c}	26.12±0.18^{d}	0.45±0.07^{b}	2.44±0.11^{c}	53.61±0.11^{a}	507.18±4.12^{c}
100%Rice	1.30±0.02^{a}	4.71±0.28^{a}	25.28±0.40^{a}	0.22±0.11^{a}	2.69±0.27^{d}	65.82±0.26^{d}	509.58±1.45^{d}

Mineral Composition of the processed Garabiya

Table 2 presents the mineral composition of the Garabiya. Significant variation occurred in the calcium content which ranged from 1.00 to 4.00mg/g. Sodium, the most abundant (248.31±9.09 to 359.41±1.39) mineral in all the garabiya samples, varied significantly and the least was recorded in the 100% rice Garabiya (174.00mg/g). Little variation of phosphorus level was observed (CRPC25%, 1.50mg/g). Iron level ranged from 1.10 to mg/g and varied significantly at $p=0.05$. Potassium was the second most abundant mineral and the highest was recorded in CRPC15% (64.00mg/g). Badau et al., (2013) observed that rice Garabiya fortified with cowpea contained 0.235 to 1.031mg/g Iron, 6.293 to 7.800mg/g Potassium and 0.891 to 1.432mg/g Zinc, respectively. Their findings are in agreement with those recorded in this study. Galla (2014) analyzed higher amount of calcium and phosphorus, and lower iron (37.0, 1.32 and 948mg/100g) in Cyprinus carpio and Epinephelus tauvina roe protein concentrates than in this study.

Table 2 Mineral composition of the processed Garabiya fortified (mg/g)

CONCENTRATES	CALCIUM	SODIUM	PHOSPHORUS	IRON	POTASSIUM
CRPC10%	2.10±0.01^{b}	253.10±9.75^{b}	1.70±0.01^{a}	1.10±0.00^{a}	22.00±0.14^{b}
CRPC15%	2.00±0.01^{b}	248.31±9.09^{b}	2.30±0.02^{b}	1.35±0.01^{a}	64.00±3.11^{e}
CRPC25%	1.70±0.06^{a}	306.45±0.91^{c}	1.50±0.02^{a}	1.10±0.01^{a}	52.50±0.21^{d}
CRPC30%	2.20±0.03^{b}	359.41±1.39^{d}	1.80±0.04^{a}	1.70±0.10^{b}	30.00±2.55^{c}
CONTROL	4.00±0.01^{c}	174.00±1.18^{a}	2.50±0.01^{c}	1.25±0.01^{a}	15.40±0.37^{a}

Essential Amino Acid of the processed Garabiya

The amino acid profile (essential) of the Garabiya were analyzed and presented in table 3. The results obtained showed that leucine and lysine were the most abundant (8.07 and 6.28g/100g) essential amino acids recorded in CRPC10%. Highest isoleucine was recorded in CRPC15% (4.52g/100g sample) and the lowest in the 100% rice Garabiya (3.15g/100g sample). Phenylalanine showed significant variation with the highest value CRPC25% (4.09g/100g) and the lowest in CRPC 30% (3.01g/100g sample). Tryptophan as the least essential amino acid ranged from 0.90 to 1.20g/100g recorded in 100% rice and CRPC10%. Least valine content was observed in the CRPC30%. There was no significant difference in the methionine. There was a significant difference in the histidine among the Garabiya and CRPC10% had the highest value. Shirai et at., (2006) reported that composition of fish roe depends on the type of roe and the method of processing. They are regarded as high-quality foods since they include important amounts of protein and amino acids. The lipid from fish roe products has presented as a useful food source for maintaining human health (Shirai et al., 2006).

Table 3 Amino Acid Profile (Essential) of the Garabiya (g/100g protein)

CONCENTRATES	LEUCINE	LYSINE	ISOLEUSINE	PHENYLALANINE	TRYPTOPHAN	VALINE	METHIONINE	HISTIDINE	THREONINE	TEAA
CRPC 10%	8.07 ± 0.10^{e}	6.28 ± 0.00^{d}	4.25 ± 0.00^{d}	4.09 ± 0.12^{c}	1.20 ± 0.00^{b}	3.93 ± 0.01^{b}	2.19 ± 0.00^{a}	2.51 ± 0.39^{b}	4.44 ± 0.10^{c}	36.92^{c}
CRPC 15%	7.88 ± 0.01^{d}	5.60 ± 0.07^{c}	4.20 ± 0.01^{d}	3.64 ± 0.12^{b}	1.05 ± 0.07^{a}	4.00 ± 0.00^{b}	2.10 ± 0.13^{a}	2.21 ± 0.01^{b}	4.07 ± 0.02^{b}	34.75^{b}
CRPC 25%	7.30 ± 0.01^{c}	5.30 ± 0.00^{b}	3.94 ± 0.03^{c}	3.58 ± 0.04^{b}	0.98 ± 0.01^{a}	4.02 ± 0.02^{b}	2.18 ± 0.06^{a}	2.12 ± 0.12^{a}	3.83 ± 0.01^{b}	33.25^{b}
CRPC 30%	6.82 ± 0.07^{b}	5.02 ± 0.02^{a}	3.53 ± 0.04^{a}	3.01 ± 0.01^{a}	0.91 ± 0.01^{a}	3.43 ± 0.03^{a}	2.08 ± 0.01^{a}	2.10 ± 0.14^{a}	3.35 ± 0.01^{a}	30.16^{a}
CONTROL	6.29 ± 0.06^{a}	5.56 ± 0.03^{b}	3.15 ± 0.01^{a}	3.99 ± 0.00^{c}	0.90 ± 0.01^{a}	4.29 ± 0.00^{c}	1.32 ± 0.01^{a}	2.31 ± 0.01^{b}	3.28 ± 0.05^{a}	31.09^{a}

no Acid Profile (non-Essential) of the Garabiya produced

The non-essential amino acid of the fortified Garabiya was presented in table 4. Glutamic acid was the most abundant non-essential amino acid followed by aspartine, arginine, glycine, alanine, tyrosine and proline as recorded for the protein concentrates. Higher alanine content was observed in CRPC 10% (4.50g/100g) and the lowest was in AFPC 15% (3.24g/100g). The highest value of serine was observed in CRPC 10% and the lowest in CRPC 30%. Highest value of proline was observed in HRPC 25%, and the lowest in CRPC30%. Tyrosine was lower in CRPC25% and higher in MFPC30%. Glutamic acid content ranged from 11.59 to 13.17g/100g and the highest was observed in CRPC10%, and the least in 100% rice garabiya.

Table 4. Amino Acid Profile (non-Essential) of the Garabiya produced

SAMPLES	CYS	ALA	GLU	GLY	SER	ASP	PRO	ARG	TYR
CRPC10%	1.28 ± 0.01^{b}	4.50 ± 0.02^{d}	13.17 ± 0.00^{e}	3.98 ± 0.02^{c}	4.00 ± 0.01^{e}	8.81 ± 0.01^{c}	3.55 ± 0.00^{d}	5.94 ± 0.12^{d}	3.64 ± 0.04^{c}
CRPC15%	1.21 ± 0.00^{b}	4.20 ± 0.04^{c}	12.87 ± 0.00^{d}	3.57 ± 0.01^{a}	3.41 ± 0.01^{c}	8.26 ± 0.35^{b}	3.35 ± 0.00^{c}	5.50 ± 0.37^{c}	3.45 ± 0.01^{b}
CRPC25%	1.10 ± 0.01^{a}	3.98 ± 0.00^{b}	12.57 ± 0.01^{c}	3.58 ± 0.57^{a}	3.19 ± 0.01^{b}	8.20 ± 0.01^{b}	2.93 ± 0.02^{b}	5.50 ± 0.00^{c}	3.05 ± 0.06^{a}
CRPC30%	1.21 ± 0.00^{b}	3.80 ± 0.01^{b}	11.98 ± 0.02^{b}	3.80 ± 0.00^{b}	3.00 ± 0.00^{a}	7.84 ± 0.00^{a}	2.85 ± 0.01^{a}	5.18 ± 0.03^{a}	3.10 ± 0.01^{a}
CONTROL	0.92 ± 0.11^{a}	3.67 ± 0.04^{a}	11.59 ± 0.01^{a}	4.29 ± 0.02^{d}	3.71 ± 0.02^{d}	7.83 ± 0.01^{a}	3.55 ± 0.00^{d}	5.33 ± 0.24^{b}	3.88 ± 0.11^{d}

Sensory evaluation of the Garabiya

Table 5 presents the results of the sensory analysis of the Garabiya produced. There was a significant difference among the sensory attributes of the prepared sample. Garabiya produced with 10% CRPC was scored higher (liked moderately) in appearance, this might be due to the brighter color of the concentrates. Aroma is also one of the parameters used for roe protein concentrate quality determination. Good quality of Fish Protein Concentrate should have weak fishy odor (Nollet et. al., 2007). There was no significant difference in the texture of the Garabiya, samples containing catfish roe, while catfish roe fortified Garabiya was neither liked nor disliked. CRPC30% had the least value in terms of Overall Acceptability.

Table 5 Sensory Evaluation of the Prepared Garabiya

GARABIYA	APPEARANCE	TASTE	TEXTURE	COLOR	Overall Acceptability
CRPC 10%	7.25 ± 1.45^{d}	6.55 ± 1.73^{d}	6.40 ± 1.67^{d}	6.60 ± 1.93^{d}	6.65 ± 1.87^{d}
CRPC 15%	6.65 ± 1.87^{c}	5.85 ± 2.43^{a}	6.35 ± 1.95^{c}	6.55 ± 1.67^{c}	6.30 ± 2.00^{b}
CRPC 25%	5.80 ± 1.88^{b}	5.85 ± 1.98^{a}	6.10 ± 2.61^{a}	6.45 ± 1.93^{b}	6.55 ± 2.16^{c}
CRPC 30%	5.55 ± 2.01^{a}	5.80 ± 2.02^{a}	6.20 ± 2.02^{b}	6.10 ± 1.97^{a}	5.70 ± 2.15^{a}
CONTROL	6.65 ± 2.35^{c}	6.20 ± 2.21^{c}	6.75 ± 1.55^{e}	6.55 ± 2.14^{c}	7.25 ± 1.68^{e}

CONCLUSION

THIS study concludes that protein concentrates could be prepared from roes of different species of fish and that the protein concentrates could be used at different proportions to prepare rice snacks of higher nutritional and sensory qualities. CRPC produced were a rich source of protein, fat and ash. Sodium, Iron and potassium are the most abundant mineral recorded. In conclusion, protein concentrates made from catfish roe had higher nutritional value and can be used as an ingredient that can be incorporated in different formulas such as Garabiya and other snacks.

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REFERENCES

AOAC (2006). Association of Official Analytical Chemists. Official methods of analysis. 18th Edition, Washington; D. C., AOAC.

Badau, M.H., Ngozi, C. and Danbaba N. (2013). Quality of Garabiya (A Nigerian Traditional Snack) From Four Varieties of Rice as Affected by the Addition of Cowpea. Advanced Journal of Food Science and Technology 5(3). Pp: 249-254

Benitez, L.V. (1989). Amino Acid and fatty acid profiles in aquaculture nutrition studies. Proceedings of the Third Asian Fish Nutrition Network Meeting. Asian fish. Society Special Publication, 4. Pp 166..

Drummond, S.N. and Kirk, T.R. (1996). A critique of the effects of snacking on body weight status. Eur. J. Clin Nutr.50. Pp: 779-783.

FAOSTAT (2012): Production-Crops, data". Food and Agriculture Organization of the United Nations. 2014. http://faostat.fao.org/site/339/default.aspx

Galla, N.R. (2014). Physico-chemical, Functional, and Antioxidant Properties of Roe Protein Concentrates from Cyprinus carpio and Epinephelus tauvina. Journal of Food and Pharmaceutical Sciences, 2. Pp: 15-22.

Ihekoronye, A. I., and Ngoddy, P. O. (1985). Integrated Food Science and Technology for the Tropics. Macmillan Publishers, London.

Jianguo, G.W., Chunhai, S. and Xiaoming, Z. (2003). Estimating the amino acid composition in milled rice by near-infrared reflectance spectroscopy. Field Crops Research 75. Pp: 1.

Kyari, Y.F. (2002). Standardization of ingredients used in Garabiya production. B.sc. unpublished thesis of food science and technology. University of Maiduguri.

Mahmoud, K. A., Linder, M., Fanni, J., and Parmentier, M. (2008). Characterisation of the lipid fractions obtained by proteolytic and chemical extractions from rainbow trout (Oncorhynchus mykiss) roe. Process Biochemistry, 43(4). Pp 376–383.

Narsing, R.G., Balaswamy, K., Satyanarayana, A., and Prabhakara R. (2012). Physico chemical, amino acid composition, functional & antioxidant properties of roe protein concentrates obtained from Channa striatus & Lates calcarifer. Food Chemistry, 132. Pp 1171–1176.

Nollet, L.M.L., Boylston, F., Chen, P.C., and Coggins, M.B. Handbook of Meat, Poultry and Seafood Quality, Blackwell Publishing, USA, 2007.

Sahena, F., Zaidul, I.S., Saari, N., Jahurul, H. and Abbas K. A., (2009). PUFAs in fish: Extraction, Fractionation, Importance in Health. Comprehensive Reviews in Food Science and Food Safety, 8(2), 59–74.

Sathivel, Subramaniam, Huaixia, YinJoan, and M. King (2009). Physical and nutritional properties of catfish roe spray dried protein powder and its application in an emulsion system. Science Direct Navigation. Journal of Food Engineering, November 2009, Vol.95(1):76–81.

Shirai, N.; Higuchi, T.; Suzuki, H. Analysis of lipid classes and the fatty acid composition of the salted fish roe food products, Ikura, Tarako, Tobiko, and Kazunoko. Food Chem. 2006, 94, 61–67.

Sikorski, Z. E., and Naczk, M. (1981). Modification of technological properties of fish protein concentrate. Critical Reviews in Food Science and Nutrition, 14, Pp 201–230.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

COMPARATIVE ANALYSIS OF MOISTURE, NUTRIENT COMPOSITION AND SHELF-LIFE OF SMOKED *Lutjanus goreensis* USING NIOMR AND TRADITIONAL KILNS

1Quadri, O. N. and 1A. O. Osibona

1Department of Marine Sciences, University of Lagos, Akoka, Yaba, Lagos.

Corresponding Author:
quadrioyindamola123@gmail.com, +2349067144819

ABSTRACT

This research was carried out to determine the change in moisture, lipid, protein, ash content, peroxide value, iodine value, total volatile basic nitrogen and sensory properties of smoked Lutjanus goreensis using NIOMR and traditional smoking kilns during a six-month storage period. Fish was bought fresh, washed and smoked using the traditional and NIOMR smoking methods. The moisture, lipid, protein and ash content were determined according to the Association of Official Analytical Chemists (AOAC) methods while the peroxide, total volatile base and iodine value were determined according to Pearson's method. Sensory properties were assessed using six-members panel. Data obtained was subjected to Analysis of Variance (ANOVA) and independent sample T-test. Results for the moisture, lipid, protein and ash content of traditionally smoked *Lutjanus goreensis* ranged between 4.6%-10.7%, 15.28%- 16.36%, 20.23%-25.85% and 16.51%-18.56% respectively and for NIOMR smoked *Lutjanus goreensis* ranged between 4.06%-11.23%, 15.55%-18.22%, 18.67%-23.32% and 15.55%-16.41% respectively. The peroxide, total volatile base and iodine value for traditional ranged from 1.41meq/kg - 2.90meq/kg, 28.54mg/100g - 65.00mg/100g and 155.72mg/100g - 177.49mg/100g respectively and for NIOMR was 1.37meq/kg-2.79meq/kg, 28.78mg/100g -65.78 mg/100g and 157.44mg/100g-180.79mg/100g. The results showed no significant difference ($p>0.05$) in moisture, lipid, protein, ash content, peroxide value, iodine value and total volatile basic nitrogen of NIOMR and traditionally smoked *Lutjanus goreensis*. Sensory quality was not significantly different ($p>0.05$) in texture, appearance, aroma and overall acceptability between traditional and NIOMR smoked *Lutjanus goreensis*. Also, there is similarities in the moisture, lipid, protein, ash content and shelf life of *Lutjanus goreensis* smoked with traditional and NIOMR smoking kilns stored for six months.

Keywords:
Lutjanus goreensis, smoking kilns, biochemical compositions, sensory quality

INTRODUCTION

Fish are cold-blooded aquatic animals with scales and fins that breathe through their gills. They are an extremely nutrient-rich diet that is especially prized for its high-quality protein when compared to meat and eggs (Ojutiku *et al.*, 2009). They are high in proteins and other nitrogenous substances, low in carbohydrates, fats, minerals, and vitamins. They are also widely acceptable because of its high palatability, low cholesterol and tender flesh (Eyo, 2001). However, they are highly perishable because it provides a favourable medium for the growth of macro and microorganisms after death

(Ojutiku et al., 2009; Aliya et al., 2012; Babarinde et al., 2012; Oparaku and Mgbenka, 2012). Fish are highly susceptible to deterioration without any preservative or processing measures (Okonta and Ekelemu, 2005) and requires proper handling and preservation to increase its shelf life, quality, and nutritional value (Ye, 1999). Smoking is the most widely practiced method. Smoking combines the effect of the destruction of bacteria by compounds in the smoke, such as phenols, and the cooking of the fish, since high temperatures will be generated. Smoked fish products have a long shelf life, which has been attributed to the drying and cooking effects.

Gorean snapper is a member of the family Lutjanidae (Snappers). Lutjanus goreensis are important in both tropical and subtropical waters. Snappers are an excellent source of protein, omega-3 fatty acid, and essential vitamins and minerals including vitamin B12, Vitamin D, Selenium and phosphorus. Studies related to comparison of proximate composition and shelf-life of smoked Lutjanus goreensis using traditional and smoking kilns have not been documented. Therefore, the aim of this study is to determine the moisture, lipid, protein, ash content and shelf life of Gorean snapper (Lutjanus goreensis) smoked using the NIOMR and traditional smoking methods.

MATERIALS AND METHODS

Twenty (20) freshly caught fish samples of Gorean snapper (Lutjanus goreensis) were purchased from Better Life Fish Market, Makoko, Yaba Mainland Local Government Area, Lagos, Nigeria. It was placed in ice boxes and transported to the Botanical Garden, University of Lagos for smoking. The Fresh fish purchased were not gutted, but were thoroughly washed with clean water and placed in a sieve to drain, without salting. The fish were separated into two equal halves (10 each) before smoking using NIOMR smoking kiln and a traditional drum smoking kiln in the Botanical Garden, University of Lagos. After smoking, the fish were placed in open trays to cool and later transferred to plastic baskets for storage and to prevent rodent and insect infestation. They were then kept on benches in the kitchen cabinet at room temperature for the period of six (6) months. During storage period, the moisture, lipid, ash, protein, organoleptic assessment, peroxide value, total volatile bases and iodine values of NIOMR and traditionally smoked fish were assessed monthly for a period of six months. Every month, a fish each that was smoked using the NIOMR and traditional smoking kiln was taken to the laboratory. The whole fish was ground using an electric blender into a powdered form and was placed into well labelled container for proper identification. The analysis was carried out in duplicate. The moisture, lipid, protein, ash content, iodine value, peroxide value and total volatile base of the smoked samples were determined as described by Association of Analytical Chemist Method, (AOAC, 2005) and Pearson (1982) while the sensory analysis was carried out by a panel of six members from students of the Department of Marine Sciences, University of Lagos using the 9-point Hedonic scale. The data obtained during this study were subjected to One-way Analysis of Variance (ANOVA) and independent sample T-Test. Duncan multiple range test (DMRT) was used to separate means where differences exist at 95% confidence level ($p < 0.05$).

RESULTS AND DISCUSSION

The moisture, crude protein, lipid and ash content, iodine value, total volatile base and peroxide value for Lutjanus goreensis smoked using traditional and NIOMR smoking kilns and stored for a period of six months are shown on Tables 1 and 2. The result indicates that moisture, ash, lipid, protein, iodine, peroxide and total volatile content of Lutjanus goreensis smoked using traditional and NIOMR smoking kilns ranged between 4.6% -10.79% and 4.06% - 11.23%, 18.56%-16.51% and 16.51% - 15.5%, 16.36% -15.28% and 18.22% - 15.55%, 25.85% -20.23% and 23.32% - 18.67%, 177.49mg/100g - 155.7mg/100g and 180.79mg/100g - 157.44mg/100g, 1.41meq/kg - 2.90%meq/kg and 1.37meq/kg - 2.79meq/kg, 28.54mg/100g - 65mg/100g and 28.78mg/100g - 65.78mg/100g respectively. The highest moisture, peroxide and total volatile content was recorded on the sixth month of storage while that of ash, lipid, protein and iodine value recorded on the first month of storage. There was a significant difference of moisture, ash, lipid protein, iodine value, peroxide and total volatile base for the six months of storage and no significant difference between smoking methods except for lipid which had significant difference.The result for the organoleptic assessment (texture, aroma, appearance and overall acceptability) of Lutjanus goreensis smoked using traditional and NIOMR smoking kilns examined on a bi-weekly basis for six months ranged between 1.00-8.00 and 1.08-8.33, 1.25-7.33 and 1.41-8.43, 1.16-7.67 and 1.25-8.33, 1.00-8.33 and 1.00-8.67 respectively. There was a significant difference of texture, appearance, aroma and overall acceptability for the six months of storage and no significant difference between smoking methods.

Table 1: Mean moisture, protein, lipid, ash content, iodine value, total volatile base and peroxide of Lutjanus goreensis smoked using traditional smoking drum

Storage Period (months)	Moisture content (%)	Ash (%)	Lipid content (%)	Crude Protein (%)	Iodine value (mg/100g)	Total volatile base (mg/100g)	Peroxide value (meq/kg)
1	4.6±0.04^{a}	18.56±0.07^{c}	16.36±0.02^{a}	25.85±0.02^{a}	177.49±0.17^{a}	28.54±0.08^{a}	1.41±0.01^{a}
2	4.91±0.0.1^{b}	18.7±0.02^{cd}	16.84±0.02^{b}	24.24±0.03^{b}	175.9±0.03^{b}	31.901±0.04^{b}	1.62±0.01^{b}
3	6.3±0.01^{c}	18.77±0.03^{d}	17.39±0.02^{c}	22.9±0.03^{c}	170.54±0.04^{c}	37.041±0.04^{c}	1.81±0.01^{c}
4	7.36±0.04^{d}	17.54±0.04^{b}	17.00±0.00^{d}	22.95±0.04^{c}	163.59±0.03^{d}	48.33±0.06^{d}	2.31±0.02^{d}
5	7.87±0.03^{e}	17.51±0.03^{b}	16.61±0.04^{e}	20.03±0.03^{d}	157.37±0.04^{e}	60.97±0.03^{e}	2.73±0.02^{e}
6	10.79±0.04^{f}	16.51±0.03^{a}	15.28±0.02^{a}	20.23±0.02^{e}	155.72±0.03^{f}	65.00±0.00^{f}	2.90±0.00^{f}

Note: Means with different susperscripts along the same column are significantly different ($P<0.05$)

Table 2: Mean moisture, protein, lipid, ash content, iodine value, total volatile base and peroxide of Lutjanus goreensis smoked using NIOMR smoking kiln

Storage Period (months)	Moisture content (%)	Ash (%)	Lipid content (%)	Crude Protein (%)	Iodine value (mg/100g)	Total volatile base (mg/100g)	Peroxide value (meq/kg)
1	4.06±0.04^{a}	15.55±0.5^{c}	18.22±0.04^{c}	23.32±0.031^{d}	180.79±0.00^{a}	28.78±0.09^{a}	1.37±0.01^{a}
2	4.57±0.0.2^{b}	16.4±0.03^{d}	18.24±0.03^{c}	23.07±0.04^{d}	180.79±0.00^{b}	31.911±0.02^{b}	1.58±0.00^{b}
3	6.25±0.02^{c}	16.87±0.07^{b}	18.23±0.02^{c}	21.71±0.02^{c}	172.38±0.03^{c}	38.031±0.03^{c}	1.78±0.01^{c}
4	7.23±0.04^{d}	15.31±0.04^{ab}	15.14±0.04^{a}	20.7±0.04^{b}	165.26±0.05^{d}	48.54±0.0.02^{d}	2.39±0.02^{d}
5	7.65±0.05^{e}	15.21±0.03^{ec}	15.55±0.04^{b}	18.96±0.03^{a}	159.20±0.06^{e}	62.95±0.08^{e}	2.64±0.01^{e}
6	11.23±0.03^{f}	16.41±0.00^{a}	15.55±0.02^{ab}	18.67±0.03^{a}	157.44±0.07^{f}	65.78±0.04^{f}	2.79±0.01^{f}

Note: Means with different susperscripts along the same column are significantly different ($P<0.05$)

This gradual increase in moisture content is consistent with research by Okereke et al. (2014), which observed that smoked fish, especially in humid conditions, tends to acquire moisture from the environment during storage because it was kept in a basket with lid on a kitchen cabinet. The reduction in ash content could be as a result of increase in moisture and the drying conditions for both procedures, as proposed by Adeyeye and Adebiyi (2019). Reduction in lipid content could be attributed to oxidation of poly-unsaturated fatty acids (PUFA) contained in the fish tissue to products such as peroxides, aldehydes ketones and the free fatty acids as noted by (Horner,1992: Ajayi et al., 2017). The reduction in protein could be due to gradual degradation of the initial crude protein to

more volatile products such as Total Volatile Bases (TVB), Hydrogen sulphide and Ammonia (Eyo,2001). A decrease in unsaturated fatty acids over time is indicated by the pattern of declining iodine value for both smoking methods. At the beginning of the storage period, the modern method appeared to preserve unsaturated fats slightly better, but by the end, both methods had become similar. This is consistent with research by Samples (2013), who found that mild processing techniques can initially retain fish's fatty acid profile more effectively, but that these benefits may later be outweighed by oxidation processes that occur during storage. Lipid oxidation during storage is evident from the rising peroxide values seen in both methods. However, (Connel,1995) reported that when peroxide value is above 10-20, fish develop rancid taste and smell. The ratio of Volatile Basic Nitrogen to the Total Nitrogen has been recommended as a useful index of quality in fish (Huss, 1988). Pearson (1982) recommended that the limit of acceptability of fish is 20-30mg N per 100g. The rising TVB-N values seen in the two smoking methods show that protein breakdown occurs gradually over storage.
Sensory evaluation is a crucial part in food development because it determines how consumers will react towards a product (Bouzgarrou and Sadok, 2017). The sensory characteristics observed with the taste panel response revealed that people preferred fish smoked using modern smoking kiln over those smoked using traditional smoking drum. There was a decline in texture, appearance, aroma, and overall acceptability scores for both smoking methods over the 24-week. Extractives, present in low concentrations in fish contribute directly to the taste, aroma, texture and appearance of a particular fish species and cause differences in taste of various fish species. This demonstrates how chemical changes translate to sensory impressions and are consistent with changes seen in proximal composition and biochemical qualities.

CONCLUSION

This study showed that the moisture, peroxide and total volatile content of both NIOMR and traditionally smoked Lutjanus goreensis increased with increase in storage time while the percentage crude protein, crude lipid. Ash and iodine value reduced with increase in storage time. The taste panel scores recorded for appearance, aroma, overall acceptability and texture of Lutjanus goreensis smoked using NIOMR and traditional kilns decreased with increasing time storage. The results obtained from this study showed similarities in the moisture, lipid, protein, ash content and shelf life of Lutjanus goreensis smoked with traditional and modern smoking kilns stored for six months.

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REFERENCES

Adeyeye, S. A., and Adebiyi, O. A. (2019). Evaluation of nutritional and sensory properties of fish dried with different methods. African Journal of Food Science, 13(6): 118-125.

Ajayi, O. A., Adedeji, O. E., and Babatunde, B. O. (2017). Comparative analysis of proximate composition, mineral content, and fatty acid profile of fresh and smoked Nigerian fish species. Journal of Food Processing and Preservation, 41(6): 32-55.

Aliya, G., Humaid, K., Nasser, A., Sami, G., Aziz, K., Nashwa, M., and Ponnerassery, S. S. (2012). Effect of the freshness of starting material on the final product quality of dried salted shark. Advance Journal of Food bScience and Technology, 4(2):60-63.

AOAC. (2005). Official Methods of Analysis (18th edition) Association of Official Analytical, Chemists International, Maryland, USA, 95(5): 1392-1397.

Babarinde, S. A., Pitan, O. R., Adebayo, T. A., Akinyemi, A. O., Adesina, G. O., and Odumade, O. I. (2012). Susceptibility of 12 smoke-dried fish species to Dermestes frischii Kugelann, 1792 (Coleoptera:Dermestidae). African Entolmology, 20(1):171-176.

Bouzgarrou, O. and Sadok, S. (2017). Determination of Potential Health Hazards and Nutritional Attributes of the Fresh and Smoked Freshwater Thin-Lipped Grey Mullet (Liza Ramada). IOSR Journal of Business and Management (IOSR-JBM), 19(5): 60-73

Connell, J. J. (1995). Control of Fish quality. 4th Edition. Fishing News Books, Farnham. England. 234pp.

Eyo, A. A. (2001). Fish processing Technology in the tropics National Institute for Freshwater Fisheries Research. University of Ilorin press, 403pp.

Horner, W. F. (1992). Preservation of Fish by curing (drying, smoking and salting). Fish Processing Technology. 32-73pp.

Huss, H. M. (1998). Fresh fish quality and quality changes. FAO/DANIDA Training Programme on Fish Technology and Quality Control. FAO Fisheries Series, 68pp.

Ojutiku, R. O., Kolo, R. J., and Mhammed, M. L. (2009). Comparative study of sun drying and solar tent drying of Hyperopisus bebeoccidentalis. Pakistan journal of Nutrition, 8(7): 955-957.

Okonta, A. A., and Ekelemu, J. K. (2005). A preliminary study of micro- organisms associated with fish spoilage in Asaba Southern Nigeria. Proceedings of the 20th Annual Conference of the fisheries Society if Nigeria (FISON) Port Harcourt 14th – 18th November. Pp 557-760.

Okereke, A., Okpara, J., and Ogumuka, S. (2014). Comparative Nutritional Compositiion of Smoked Catfish (Clarias gariepinus) Produced from NIOMR Smoking Kilns and Local Cut Drum Oven. American Journal of Food Technology, 9(7), 377-381.

Oparaku, N. F., and Mgbenka, B. O. (2012). Effects of electric oven and solar dryer on a proximate and water activity of Clarias gariepinus Fish. European Journal of Scientific Research, 81(1):139-144.

Pearson D. (1982): The Chemical Analysis of Foods. Churchill Livingstone; Edinburgh, London and New York, 411-507pp.

Samples, S. (2013). Oxidation and antioxidants in fish and meat from farm to fork. Food Industry, pp 114-144.

Ye, Y. (1999). Historical consumption and future demand for fish and fishery products, exploration calculations for the years 2015, 2030. FAO Fisheries Circular No 949, Rome UNIFEM 1988, Fish processing, Food Cycle Technology, Source Book, 4:31 -56.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

QUALITY EVALUATION OF AFRICAN CATFISH SMOKED USING THREE SEASONINGS

[1]Habibu, A. K., [2]A. A. Sani, [1]A.H. Bichi, [1]I.M. Usman and [1]G.B. Hamid

[1]Department of Fisheries and Aquaculture, Federal University Dutsin-Ma Nigeria
[2]Department of Wildlife and Ecotourism Management, Binyaminu Usman Polytechnic Hadejia,Jigawa State

Corresponding Author:
ahkusada@fudutssinma.edu.ng, +2348062912907

ABSTRACT
This study evaluated the sensory qualities and proximate composition of African catfish smoked with three seasonings: salt, ginger, garlic, and pepper. Sensory attributes such as taste, appearance, texture, and aroma were assessed, alongside proximate composition including moisture, ash, crude protein, crude lipid nitrogen-free extract (NFE), and dry matter content. The sensory evaluation revealed that fish treated with ginger scored highest in taste and aroma, while garlic was most favoured for appearance. Ginger was identified as the best additive for enhancing overall sensory appeal. In the proximate analysis, salt-treated fish had the lowest moisture content (13.13%), supporting its role in dehydration and preservation. Pepper-treated fish exhibited the highest crude lipid content (8.10%), while garlic-treated fish had the highest protein content (56.88%). Ginger-treated fish recorded the highest nitrogen-free extract (NFE) value, hence, this study highlight the potential of using natural additives to enhance the quality of smoked fish products.

Keywords:
Clarias gariepinus, proximate analysis, sensory evaluation, smoking.

INTRODUCTION

Fish is an important source of high-quality protein, essential fatty acids, vitamins, and minerals. African catfish (Clarias gariepinus) is one of the fish species that is particularly valued in aquaculture across Africa and beyond (Adeoye *et al.*, 2020). However, fresh fish is highly perishable, making effective preservation methods necessary to reduce post-harvest losses and ensure food security. Smoking is one of the most traditional and widely adopted preservation methods, extending the shelf life of fish by reducing moisture content and imparting desirable sensory qualities such as taste, aroma, and texture (Ahmed *et al.*, 2021).

Fish smoking enhances the flavour and nutritional profile of the product, especially when combined with natural additives. Salt, a primary preservative, draws out moisture, inhibiting microbial growth and enzymatic spoilage (Olusegun *et al.*, 2022). Meanwhile, spices like ginger, garlic, and pepper have been increasingly used due to their antimicrobial, antioxidant, and flavour-enhancing properties. These spices not only improve the sensory appeal of smoked fish but also help retain essential nutrients such as proteins, fats, and minerals (Al-Juhaimi *et al.*, 2020). Despite these information, limited research has been done on the effect of these additives on African catfish, a species of economic importance, particularly in Africa. This study aims to evaluate the effects of salt, ginger, garlic, and pepper on the sensory attributes and proximate composition of smoked African catfish.

MATERIALS AND METHODS

Experimental Design

The experiment followed a completely randomized design (CRD), with the fish divided into four treatment groups with three replicates.

Procurement and Preparation of Samples

Fresh African catfish, each weighing between 500-700g, were sourced from Zobe reservoir Dutsin-Ma and immediately transported to the Fisheries and Aquaculture laboratory for processing. The fish were gutted and washed thoroughly with clean water to remove blood and impurities. They were weighed and divided into four groups, corresponding to the different treatments. The treatments were prepared in four different bowls, each bowl containing 1kg of fish. The spices were weighed accordingly; 3g of salt, ginger, garlic, and pepper was used. These spices were added into 2 liters of water and then the fish were added inside. They were also allowed to stay in the mixture for 10 minutes (Mosarrat *et al.*, 2017). The fish were removed from the solutions, drained, and prepared for smoking.

Sensory Evaluation

A panel of 10 trained assessors were recruited for the evaluation. Taste, appearance, texture, and aroma were evaluated using a 7-point hedonic scale (7- Excellent; 6-Extremely good; 5-Very good; 4- Good; 3- Poor; 2- Very poor; 1- Extremely poor) according to Sogbesan and Ibrahim (2017).

Proximate Composition Analysis

The proximate analysis of fish was determined according to standard methods (AOAC, 2019). Crude protein content was determined by the Kjeldahl method, crude fibre was determined using acid and alkali digestion, crude fat was by the Soxhlet extraction method, ash was carried out by incineration while dry matter and nitrogen free extracts were calculated.

STATISTICAL ANALYSIS

All data were expressed as means ± standard deviation (SD). One-way analysis of variance (ANOVA) was used to determine significant differences among the treatment groups for proximate composition while average was used for sensory evaluation. Duncan's Multiple Range Test (DMRT) was employed to compare the means at a significance level of $p < 0.05$. Statistical analyses were performed using SPSS version 25.

RESULTS AND DISCUSSION

Table 1 show the sensory evaluation of African catfish (Clarias gariepinus) smoked with different native seasonings. The catfish smoked with ginger had the highest taste score (9.73), followed by garlic and pepper. Salt alone had the lowest score (5.66), which suggests that spices like ginger and garlic significantly enhance the flavour of smoked catfish. Studies on the use of ginger in fish smoking have found that it improves flavour due to its pungency and mild spiciness. A study by Adeyemi and Alhassan (2019) showed similar results, where ginger was noted for significantly enhancing the taste profile of smoked tilapia. This may be as a result of gingers anti-inflammatory and flavor-enhancing properties which made it the most preferred additive in this study as well. Garlic-treated samples scored highest appearance (7.86), with ginger and pepper following closely. Salt alone again had the lowest score (5.40), which might indicate that spices influence the visual appeal of the fish, potentially through effects on colour or surface texture during smoking. Similar observations were made by Fawole et al. (2018), where garlic and pepper enhanced the appearance of smoked mackerel. Both ginger and pepper resulted in the highest texture scores (7.86), suggesting that these additives contribute to a desirable firmness or softness in the fish after smoking. Salt had the lowest score, possibly because it did not interact with the fish proteins to the same extent as the spices. Ginger has been known to tenderize meat due to the presence of proteolytic enzymes, which may explain the favourable texture scores here. Similar findings were reported in a study by Ogodo et al. (2021), where ginger enhanced the texture of smoked catfish more than other treatments. Ginger again led with the highest score for aroma (8.00), followed by garlic and pepper. Salt had the lowest aroma score (5.13), highlighting the strong aromatic compounds present in ginger and garlic.

Table 1: Sensory evaluation of smoked African catfish *(Clarias gariepinus)* with different seasonings

Features	Salt	Ginger	Garlic	Pepper
Taste	5.66	9.73	7.66	7.40
Appearance	5.40	7.73	7.86	7.53
Texture	5.53	7.86	7.20	7.86
Aroma	5.13	8.00	7.86	6.73

Studies on smoked fish generally show that lower moisture content enhances the shelf life and quality of the product. For example, Adeyemi and Alhassan (2021) found that fish smoked with lower moisture content tend to have longer storage potential. In this study as shown in Table 2, salt resulted in the lowest moisture content, which aligns with findings from other research where salt is often used to draw out moisture before smoking. The ash content here was highest in pepper-treated fish. This is similar to the findings of Fawole et al. (2018), where pepper increased mineral retention during the smoking process due to its high mineral content, especially calcium and potassium. Pepper yielded the highest lipid content, which contrasts with ginger having the lowest. Ogodo et al. (2021) observed similar results, where ginger reduced fat content in fish, likely due to its enzymatic activities. Garlic-treated fish showed the highest protein content, indicating that garlic might be preserving protein structures during smoking. This agrees with earlier research by Ikujenlola and Fesobi (2020), where garlic's antioxidant properties helped reduce protein degradation in smoked fish. Ginger-treated fish had the highest NFE, indicating higher carbohydrate content which may be as a result of gingers natural sugars and fibres.

Table 2: Proximate composition of smoked African catfish (Clarias gariepinus) treated with different seasonings

Treatment	Moisture (%)	Ash (%)	Crude lipid (%)	Crude protein (%)	NFE (%)	Dry matter (%)
T1	13.13±0.09^{a}	9.57±0.60^{a}	6.40±0.05^{b}	55.14±0.16^{a}	12.18±0.08^{b}	83.89±0.76^{c}
T2	16.22±0.14^{d}	11.61±0.17^{b}	5.62±0.06^{a}	51.94±0.78^{a}	14.60±0.89^{c}	83.78±0.14^{a}
T3	14.54±0.01^{b}	9.71±0.09^{a}	7.10±0.00^{c}	56.88±0.00^{a}	11.76±0.00^{b}	85.45±0.98^{bc}
T4	15.51±0.19^{c}	12.65±0.45^{b}	8.10±0.00^{d}	49.06±6.23^{a}	8.78±0.71^{a}	84.49±0.19^{ab}

Key: Means with different subscript within a column are statistically different at $p<0.05$
NFE= Nitrogen free extract, salt (T1), ginger (T2), garlic (T3), and pepper (T4)

CONCLUSION

Result from sensory evaluation revealed that ginger consistently scored the highest across most attributes, making it the most effective additive for sensory enhancement of smoked African catfish. Garlic and pepper also performed well, particularly in appearance and texture. Salt, though commonly used in fish preservation, did not enhance the sensory qualities as effectively as the spices. The proximate composition results indicate that each additive had a different impact on the nutritional quality of smoked catfish. Salt generally reduced moisture, making it ideal for preservation. Garlic was effective in maintaining high protein content, and pepper contributed to higher fat retention and ash content.

REFERENCES

Adeoye, B. F., Ojo, S. O. and Jimoh, A. O. (2020). Aquaculture practices and challenges in Africa: The case of African catfish (Clarias gariepinus). Journal of Fisheries and Aquatic Sciences, 15(2), 156-162.

Adeyemi, A. A. and Alhassan, M. A. (2019). Effect of ginger on the sensory and nutritional quality of smoked tilapia. Nigerian Food Journal, 37(2), 92-98.

Adeyemi, A. A. and Alhassan, M. A. (2021). Influence of natural additives on the preservation and sensory qualities of smoked fish: A review. Journal of Food Science and Technology, 58(8), 2335-2344.

Ahmed, O. M. Ibrahim, R. M. and Abba, S. I. (2021). Influence of smoking and additives on the quality and shelf-life of fish: A review. Food Science and Technology Research, 27(5), 341-350.

Al-Juhaimi, F. Y., Özcan, M. M., Ghafoor, K. and Babiker, E. E. (2020). Effect of different types of spices on the proximate and mineral composition of smoked fish. Journal of Food Processing and Preservation, 44(9), e14636.

AOAC (2019). Official Methods of Analysis of AOAC International, 21st Edition. Association of Official Analytical Chemists, Gaithersburg, MD, USA.

Fawole, O. O., Ogundiran, M. A., Ayandiran, T. A. and Olagunju, O. F. (2020). Comparative effects of garlic and pepper on sensory and nutritional quality of smoked fish. African Journal of Food Science and Technology, 12(2), 114-121.

Ikujenlola, A. V. and Fesobi, O. O. (2020). Assessment of the effect of garlic and ginger on the sensory and chemical properties of smoked mackerel fish. Journal of Food Science and Nutrition Research, 7(3), 98-106.

Mosarrat, N.N, Dr.Gulshan, A.L., Dr.Shubbash, C.C., Farzan, B.F. and Mohajira, B. shelf life study of salt and garlic treated smoked dried Mastacembeluspancalus (balm) during different storage condition. International journal of advanced research 3(9), 78-81

Ogodo, A. C., Udeh, S. O. and Obi, S. K. (2021). Effect of ginger on the proximate composition and sensory properties of smoked catfish (Clarias gariepinus). Journal of Aquatic Food Product Technology, 30(6), 617-630.

Olusegun, M. T., Fakayode, S. B. and Adeniran, O. A. (2022). Salt curing and smoking techniques in fish preservation: Effects on nutritional quality and microbial load. African Journal of Food Science, 16(1), 23-32.

Sogbesan, O.A. and Ibrahim, P. (2017). Assessment of Smoked Fish Quality using two smoking kilns and hybrid solar dryer on some commercial fish species in Yola, Nigeria. Journal of Animal Research and Nutrition 2(1), 6.

LARVICIDAL EFFECT OF *Albizia lebbeck* SEED OIL AGAINST *Dermestes maculatus*, PEST OF SMOKE-DRIED *Clarias gariepinus*

Akpotu Onoriode Joseph

Dennis Osadebay University, Asaba Delta State.
Department of Fisheries and Aquaculture, Dennis Osadebay University, Asaba, Delta State

Corresponding Author:
joseph.akpotu@dou.edu.ng, +2347064506985, 0000-0003-1274-0973

ABSTRACT
This study was designed to investigate the larvicidal effect of the seed oil of *Albizia lebbeck* on the larvae of *Dermestes maculatus*. Soxhlet extraction technique was used to obtain the oil from the seeds. The physicochemical property of the oil was determined by standard procedure. The fatty acid composition of the oil was also determined by GCMS procedure. 30 late instar larvae each were randomly distributed to fish treated with different concentrations of the oil (0.003ml/g, 0.009ml/g, 0.027ml/g, 0.081ml/g and 0.243ml/g) for the definitive test. Each treatment was replicated thrice. The repellency effect was high at 0.081ml/g and 0.243ml/g. The mortality of *D. maculatus* larvae increased with increasing concentration which was also time dependent implying that Albizia lebbeck seed oil could be considered as an effective tool in the control of *D. maculatus* pest of smoke-dried fish.

Keywords:
Repellency, Larvicidal, Dermestes Larvae, Mortality

INTRODUCTION

A total of 90.3 million tonnes of fish were reportedly captured globally in 2020 comprising of 78.8 and 11.5 million tonnes from marine and inland waters respectively (FAO, 2022). Despite a 5.1 percent decline from 2019 due to COVID-19 pandemic, global catches in inland waters, estimated at 11.5 million tonnes, remained at a historically high level, largely attributed to improved reporting by the producing countries. Asia produced almost two-thirds of total inland fisheries, followed by Africa – inland catches are important for food security in both these regions (FAO, 2022).

Live, fresh or chilled forms still represented the largest share of aquatic food (excluding algae) for direct human consumption, followed by frozen, prepared, and preserved and cured. In Asia and Africa, the share of aquatic food production preserved by salting, smoking, fermentation or drying is higher than the world average (FAO, 2022).

These processing and preservation techniques remain vital as they help to lengthen the shelf-life of the fish and maintain their consumptive quality. Several tools are being explored by researchers globally against destructive insect pests of dried fish as well as spoilage microorganisms. Among the reported are extracts of plant parts- leaves, fruits and seeds, because of their eco-friendly nature.

Albizia lebbeck, a deciduous woody tree of the family Mimosaceae, is one of such plants that grow abundantly in the savannah regions of sub-saharan Africa. It is traditionally used for treating asthma, colds, coughs, and other allergic diseases (Zia-Ul-Haq et al., 2013). Therefore, the focus of this study is to examine the larvicidal potential of the seed oil extract against *Dermestes maculatus*, pest of smoke-dried *Clarias gariepinus*.

MATERIALS AND METHODS

Study Area

The experiment was conducted in the Fisheries Research Laboratory of the Department of Biological Sciences, Ahmadu Bello University, Samaru, Zaria, Kaduna State, Nigeria at ambient temperature of between 25 - 30°C.

Sources of Plant Materials

The seeds of A. lebbeck used for this study were collected from fruiting trees within the Main Campus of Ahmadu Bello University, Samaru, Zaria. They were properly identified and authenticated at the herbarium unit of Biological Sciences Department, Ahmadu Bello University, Zaria.

Processing of plant materials

Seeds of A. lebbeck were removed from their pods, sun-dried for 17 days after which they were pulverized using a mortar and pestle. The pulverized seeds were sieved and stored in pre-labeled new cellophane bags.

Extraction of oil by soxhlet extraction method

40g of A. lebbeck seed powder was weighed into separate muslin cloth and introduced separately into the soxhlet chamber for the oil extraction. In the round bottom flask, 350ml of n – hexane was introduced as extraction solvent. The extraction was done at 60 - 80° C until the solvent in the soxhlet chamber became transparent. The soxhlet apparatus was dismantled and the content of the round bottom flask were transferred to a rotary evaporator which was used to evaporate excess solvent from the oil. The extracted seed oils were stored in separate labeled bottles in a cool place until used for bioassay.

Collection and Treatment of Insects

Insects belonging to D. maculatus taxon were obtained from infested fish pieces purchased from Sabon – Gari market (11°13'N and 07°52'E), Zaria. Their larvae were properly identified under X40 magnification of a stereo microscope using the pictorial keys of Haines (1991). The larvae were acclimatized for 24 hours in the laboratory before being subjected to bioassay.

Collection of Smoke – Dried Fish

Smoked catfish, *Clarias gariepinus* specimen weighing between 17 – 20g, were purchased from Sabon – Gari market, Zaria.

Pilot Study

Range finding tests were conducted to determine the concentration range of A. lebbeck oil to be used for the definitive tests (bioassay). This was done by applying five nominal concentrations (0.001 to 0.234mlg-1 that is, preceding concentration multiplied by 3 gives the next concentration) of the oil to the heat sterilized fishes in triplicate and placing them singly in Kilner jars. Thirty (30) late instar larvae of D. maculatus were then introduced in triplicate into each jar. The set up were observed at 24, 48, 72 and 96 hours to establish total and zero mortality/minimal mortality range. Five concentrations between total and zero mortality observed in this study were chosen for the bioassay test.

Bioassay

The smoke – dried fishes were heat sterilized in the oven set at 60±2° C for one hour and then allowed to cool. After cooling to room temperature, each fish was weighed and tagged. From the pilot study conducted, the following application levels 0.003mlg-1, 0.009mlg-1, 0.027mlg-1, 0.081mlg-1, and 0.234mlg-1 of the oils were determined. Oil treated fishes were introduced into separate Kilner jars for the larvicidal test. Thirty (30) late instar larvae of D. maculatus were introduced into the jars and the entire set up were replicated. Observations were recorded at 24, 48, 72 and 96hours exposure time. The repellent effects of the oil were tested in triplicates using rectangular glass containers of 18cmx12cmx10cm dimension. A treated and an untreated fish were placed at opposite extremes in the container and 30 late instar larvae were introduced at the mid-point of it. The setup were left for 24 hours at which time larvae found within 1cm radius of the treated fish are considered repelled.

Determination of the Physico-Chemical Properties of the Seed Oil

The physico-chemical properties of A. lebbeck seed oil was determined using AOAC Standard Methods (Official Methods of Analysis, 1998; Oils and Fats, 2012). The GC-MS profile of the seed oil was determined using a Hewlett-Packard model: 6890NGC-MS system (Agilent Technologies) coupled to a mass-spectrometer model: HP5973.

Statistical Analysis

All repellent and mortality data were subjected to Analysis of Variance (ANOVA) at $p < 0.05$ to determine significant difference between treatments. Least Significant Difference (LSD) was employed to separate the means. Mortality data were subjected to Probit Analysis to determine their median lethal concentration (LC50) of the seed oil of A. lebbeck.

RESULTS AND DISCUSSION

Table I: Physico-chemical Properties of A. lebbeck seed oil

A. lebbeck Seed oil	Relative Density	Refractive Index	Saponification value	Peroxide value	Iodine value	Acid value
% Composition	0.92	1.47	196.30	4.49	114.00	5.14

Table II: Fatty Acid compositions(%) of A. lebbeck seed oil

Fatty Acids	Arachidic acid	Linoleic acid	Palmitic acid	Stearic acid
% Composition	1.54	40.95	13.40	4.59

Table III: Metabolite compositions (%) of A. lebbeck seed oil

Metabolites	Linolein	Linoleic acid chloride	Pentacosane	Tetracosane	Ethanone	Oxirane	2,2-Dimethylvaleraldehyde
% Composition	15.38	12.40	6.08	3.62	1.27	0.45	0.33

Table IV: Repellent effect of Albizia lebbeck seed oil against Dermestes maculatus larvae at 24 hours exposure period ($p<0.05$).

Application(ml) per 17g fish	Mean number of larvae on treated fish	Mean number of larvae on untreated fish	Repellency Rate (%)	Repellency Class (RC)
0.05(0.003mlg^{-1})	29.33	0.67 ± 0.33^{e}	-95.56	I
0.15(0.009mlg^{-1})	25.33	4.67 ± 0.33^{d}	-68.89	I
0.46(0.027mlg^{-1})	14.33	15.67 ± 0.67^{c}	4.44	II
1.38(0.081mlg^{-1})	3.33	27.67 ± 0.33^{b}	77.78	V

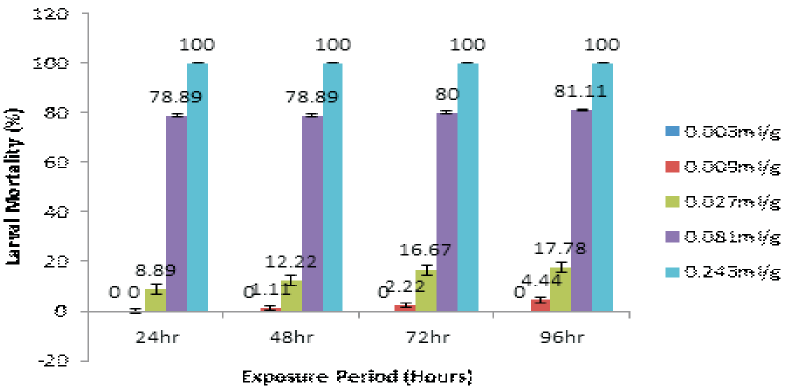

Fig. I:
Percentage Mortality effect of *Albizia lebbeck* seed oil on *Dermestes maculatus* larvae

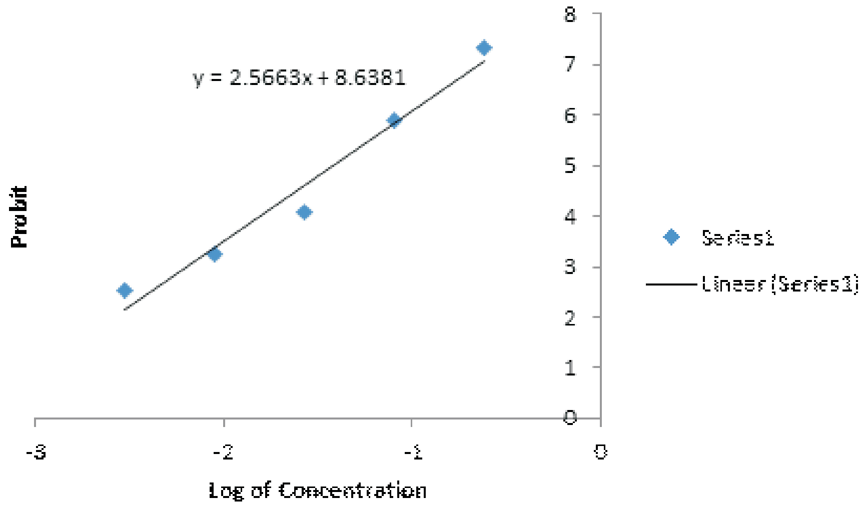

Fig. II: Probit graph use to determine the LC50 of Albizia lebbeck seed oil against *Dermestes maculatus* larvae (LC50 = 0.038mlg-1)

Albizia lebbeck seed oil is very rich in linoleic acid (Table II) which has been implicated in death recognition and death aversion (repellency) in cockroaches (Rollo et al., 1995). Other fatty acids worthy of note that is present in this seed oil is the palmitic acid and stearic acid which is believed to have worked synergistically with linoleic acid to produce the repellent as well as mortality effect on the larvae of D. maculatus observed in this study. According to Verónica Herrera-Mayorga *et al.* (2021), oleic acid, palmitic acid and stearic acid had strong insecticidal effect against Spodoptera frugiperda concluding that palmitic acid was the most active agent followed by oleic and stearic acid extracted from Carica papaya. Oxirane (Table III) otherwise known as Ethylene oxide detected in this oil could have contributed to its toxicity to the larvae of D. maculatus since it was in common use as a fumigant for grain, and by the 1950's, it was widely used in museums, libraries and archives for insect pest control (Ballard and Baer, 1986). Pentacosane and Tetracosane are alkanes and triterpenes detected in A. lebbeck seed oil and could have contributed to the toxicity to the larvae of D. maculatus. These alkanes were noted by Sanford and Satish (1998) to possess insecticidal properties and are used to kill insects that damage crops. It can therefore be deduced that these metabolites could have worked in a synergistic way with the fatty acid components of the oil to bring about the repellency and mortality of the larvae of D. maculatus observed in this study.

The seed oil of A. lebbeck excellently repelled the larvae of *Dermestes maculatus* from treated smoke – dried fish, *Clarias gariepinus* thereby preserving the fishes (Table IV). The repellency effect increased with increasing concentration of the oil. This view is largely supported by Stoll (2000) who reported repellence as a major mechanism by which plant products control insect damage to stored produce. Akinwumi et al. (2007) also reported in this light that extracts of Dennettia tripetala, Eugenia aromatica, Monodora myristica and Piper guineense exhibited repellency against D. maculatus.

Compounds like monoterpenes, diterpenes alcohol (phytol), triterpenes and volatile terpenoids (Table III) which are repellent to most insects as reported by Nerio et al., (2010) make up a notable proportion of this seed oil tested in this study and could likely have been responsible for the repellent effect observed against the larvae of D. maculatus. These repellent molecules could have interacted with the olfactory receptors and block the sense of smell compelling them to move away from the treated fish.

A. lebbeck seed oil tested in this study showed significant mortality ($p<0.05$) of D. maculatus larvae (Fig. I) exposing these oils as valuable products for the control of insect pests of smoke – dried African catfish. The seed oils are suspected to have a contact mode of action on the larvae since they were killed as a result of their transient contact with the treated fish. Lale (1995) reported that plant extracts are

highly lipophilic and could penetrate the cuticle of insects. The toxicity effect observed in this study can also be attributed to the various chemical ingredients present alongside the fatty acid compositions in the oils as agreed with Butterworth and Morgan (1968) who reported that toxicity of essential oils is associated with the presence of many chemical ingredients such as triterpenoids. Lu and Wu (2010) also suggested that various essential oils or their constituents cause symptoms that suggest a neurotoxic mode of action. Odeyemi et al. (2000) observed that cases of high mortality occur in larvae partly because of their inability to detoxify plant toxins when feeding actively, especially at the 1st to 4th instar larval stages. Okonkwo and Okoye (2001) reported 100 percent kill of larvae of D. maculatus when treated with extracts of D. tripetala and P. guineense at dosages lower than the powders which was similarly the case reported for A. lebbeck seed oil in the present study (0.243mlg-1).
The mortality effect of the oils in this present study could also be attributed to the oils coating the surface of the fish thereby causing the larvae to avoid the treated fish resulting in starvation and death. Adedire *et al.* (2011) suggested that the mode of action of the plant powder and oil could be as a result of the powder and oil coating the treated cowpea seeds which prevented contact between the seeds and the bruchid resulting in starvation. Again, the oils could have blocked the spiracles of the larvae in contact with the treated fish thereby resulting in their suffocation and eventual death (Adedire et al., 2011). LC50 value of Albizia lebbeck seed oil was computed to be 0.038mlg-1 as shown in Fig. II indicating that the oil is very effective in protecting the fish against the larvae of *D. maculatus*.

CONCLUSION

In conclusion, the seed oil of *Albizia lebbeck* showed commendable repellent and larvicidal activities on the larvae of *D. maculatus* and retain activities even at 96h exposure period, confirming the residual nature of the effect of the oil. Therefore, *Albizia lebbeck* seed oil could form the basis for a successful formulation and commercialization of biopesticides against *D. maculatus*. It could provide valuable alternative to the synthetic insecticides in the management of storage insect pests of smoke-dried fishes. However, further study is required to ascertain the palatability of smoke-dried fish treated with this seed oil extract.

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REFERENCES

Adedire, C.O., Obembe, O.O., Akinkurolele, R.O. and Oduleye, O. (2011). Response of Callosobruchus maculatus (Coleoptera: Chysomelidae: Bruchinae) to extracts of cashew kernels. Journal of Plant Diseases and Protection, 118 (2): 75 - 79.

Akinwumi, F.O., Fasakin, E.A. and Adedire, C.O. (2007). Toxic and repellence activities of four plant extracts to Dermestes maculatus Degeer on smoked African mud catfish, Clarias gariepinus Burchell. Journal of Entomology, 4(2): 149 – 154.

AOAC (1998).Official method of analysis, 16th edition.Association of Analytical Chemists, Arlington, VA.4: 1-45.

Ballard, M.W., and Baer, N.S. (1986). Ethylene Oxide Fumigation: Results and Risk Assessment, DOI: 10.1515/rest. 1986.7 .4. 143

Butterworth, J.H. and Morgan, E.D. (1968). Isolation of substance that suppresses feeding in locusts. Journal of Chemical Society, Chemical Communication, 1: 23 – 24.

FAO (2022). The State of the World Fisheries and Aquaculture. Food and Agricultural Organization. Fisheries and Aquaculture Department, Rome, 360pp.

Haines, C.P. (1991). Insects and Arachnids of tropical stored products: Their biology and Identification: A Training Manual. 2nd Edn., Natural Resources Institute, UK.

Lale, N.E.S.(1995). An overview of the use of plant products in the management of stored product coleoptera in the products. Post Harvest News Information, 6: 69N – 75N.

Lu, J. and S. Wu, (2010).Bioactivity of essential oil from Ailanthus altissima bark against 4 major stored-grain insects. African Journal of Microbiology Research, 4: 154 – 157.

Nerio, L.S., Olivero-Verbel, J. and Stashenko, E. (2010) Repellent activity of essential oils: a review. Bioresource Technology, 101: 372–378.

Odeyemi, O.O., Owoade, R.A. and Akinkurolere, R. (2000). Toxicity and population suppression effects of Parkia clappertoniana on dried fish pests, (Dermestes maculatus and Necrobia rufipes). Global Journal of Pure and Applied Sciences. 6(2): 191 – 195.

Oils and Fats (2012). Fssai Manual of Methods of Analysis of Food.Lab. Manual 2. Food Safety and Standards Authority of India, New Delhi, India.

Okonkwo, E.O. and Okoye, W.I.(2001). Insecticidal activity of Dennettia tripetala Baker f. and Piper guineense Schum.and Thonn against Dermestes maculatus Degeer (Coleoptera: Dermestidae) and Necrobia rufipes Degeer (Coleoptera: Cleridae) on dried fish. Nigerian Journal of Entomology, 18: 109 – 117.

Rollo, F., Sassaroli, S. and Ubaldi, M. (1995) Molecular phylogeny of the fungi of the Iceman's grass clothing. Current Genetics, 28:289–297.

Sanford, D. E. and Satish, K. P. (1998). Neonate Plutella xylostella responses to surface wax components of a resistant cabbage (Brassica oleracea). Journal of Chemical Ecology. 24(10): 1611 – 1627.

Stoll, G. (2000). Natural Crop protection in the tropics: Letting information come to life. 2 nd enlarged edition. Margraf Verlag 2000.Weikersheim p. 376.

Verónica Herrera-Mayorga, Francisco A. Paredes-Sánchez, Gildardo Rivera, Virgilio Bocanegra-García, Hadassa Y. Martínez-Padrón, Martín Berrones-Morales and Nohemí Niño-García (2021). Advances in Control Strategies against Spodoptera frugiperda. A Review. Molecules, 26(18): 5587.

Zia-Ul-Haq, M., M.S. Stankovic, K. Rizwan, V.D. Feo (2013). Grewia asiatica L., a food plant with multiple uses. Molecules, 18 (3), 2663-26682.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

PRODUCTION AND QUALITY EVALUATION OF FISH SAUCE

Diyaware, M. Y.[1], 1L. Salkushu, [2]F. A. Mustapha, [1]H.M. Shettima and [3]D.M. Umar

[1]Department of Fisheries, Faculty of Agriculture, University of Maiduguri, Nigeria
[2]National Institute for Freshwater Fisheries Research, Maiduguri Zonal Office, Nigeria.

Corresponding author:
mydiyaware@unimaid.edu.ng, +234 8034822858,
ORCID Number: orcid.org/0000-0002-9300-8946

ABSTRACT

The study aimed to evaluate the nutritional quality and organoleptic properties of fish sauce produced using low-market-valued fish flesh as a value addition to low-market-value fish. The fish sauce is composed of Heterotis niloticus flesh, sweet pepper, sesame, sugar, salt, ginger, and vegetable oil. The proximate composition and organoleptic properties of the sauce were conducted immediately after production and after six months of storage at room temperature. Data obtained from the proximate composition and microbial loads were subjected to a student's t-test, while data on organoleptic properties were subjected to descriptive statistics (percentage). The result showed that the crude protein, fat, moisture, crude fibre, ash and metabolisable energy of the sauce immediately after production were 28.77, 40.08%, 17.09%, 2.08%, 4.48 %, and 3969.76 (kg/cal.), respectively. In contrast, 27.66%, 42.50%, 16.95%, 2.00%, and 39.29.75 (kg/cal.) were the crude protein, fat, moisture, crude, and metabolisable energy, respectively, of the sauce after 6 months of preservation at room temperature. Fifty (50.7%) of the panellists liked the product very much, while 29.6%, 26.2%, and 32% liked the colour, flavour, and sweetness of the fish sauce very much. However, the majority of the panellists (52.1 and 50.5%) slightly disliked the flavour and saltiness of the fish sauce. Conclusively, fish sauce made from fish Heterotis niloticus flesh is nutritious, and the product can increase the market value and acceptability of the fish.

Keywords:
Fish sauce, nutritional quality, Proximate composition,
Value edition to fish

INTRODUCTION

Fish has a high nutritional value because it provides high-quality protein, is rich in essential amino acids, is a good source of complex B vitamins, and contains a wide variety of minerals, including phosphorus, magnesium, iron, zinc, and even iodine in marine fish (Arino *et al.*, 2013). Fish protein concentrate has been highly studied due to its nutritional characteristics and its potential for human consumption (Godoy et al., 2013). Fish protein also provides health benefits to the adult population. There is strong evidence that fish in particular oily fish, lowers the risk of coronary heart disease mortality by up to 3.6% due to a combination of Environmental Protection Agency and docosahexaenoic acid (FAO/WHO 2011).

Fish sauce is a brown to grey liquid with a unique aroma and flavor produced as the end product of fish. It is commonly used as a flavoring additive in cooking and often consumed as a condiment in daily meals (Montero et al., 2017). There has been a record of fish sauce consumption during the Roman and Athenian eras during the fifth century, namely Garum Aquerreta *et al.* (2002) as well as in ancient Greece, Aimeteon (Ishige, 1993). Fish sauces are known by different names throughout different

countries, such as Nam-pla (Thailand), Bagoong (Philippines), Bakasang (Indonesia), Shottsuru (Japan), Aekjot (Korea), Yu-lu (China), Colombo cure (India), Ngapi (Burma) and Budu (Malaysia) (Kuda & Miyawaki, 2010; Sim *et al.*, 2015). These varieties of fish sauce products have different fish species used as the primary raw material, salt concentrations, storage temperatures, storage containers, and processing techniques, resulting in a final product with unique characteristics of different smells, tastes, and colors (Lopetcharat et al., 2007). Fish sauce prepared using low-valued fish is a common menu among Asians, especially in China (Diyaware *et al.*, 2004).
The African bony tongue, Heterotis niloticus, belonging to the family Osteoglossidae, is a large fish that is widespread in many tropical rivers and freshwater lakes of western and central parts of Africa (Agbugui et al., 2021). It is found all year round in most Rivers and lakes, such as Benue and Chad, respectively, and Dams like Alau, Tiga, and Shiror) of Northern Nigeria. The H. niloticus is a scaly species that has good quality flesh enhanced by its high muscle-to-bone ratio, and its bones and cartilage pose less danger of choking to consumers. However, it does not command high market value compared to Clarias and Tilapia species due to its taste. Udo (201) reported that H. niloticus grows bigger, but due to its taste it is not attractive, hence commands low patronage. Its protein contents also tend to be lower than that of other fish species. According to Udo (2012), H. niloticus has 18.92 % crude protein, 51% moisture, 16.0% fat, 5% ash and 339.0 metabolisable energy. Sulieman and Omer (2021) reported 61.20, 5.5, 782.0, and 12.5% crude protein, ash, moisture, and fat, respectively, while 308.58 k/cal of metabolisable energy. He suggested an alternative way to convert the use of fish, especially into meals. Noor-E-Islami *et al.* (2015) produced fish sauce using low-value small fish.
Value addition refers to any process that enhances the value of fish products by increasing their shelf life, improving their quality and acceptability, or transforming them into more marketable or consumer-friendly forms. Adding value to fish that has less market value often results in higher prices, allowing producers and processors to earn more.
It is, therefore, imperative to enhance the nutritional and market value of the aim of increasing food and nutrition, especially among young children. Several values have been added to other fish species (fish fingers, fish pie, fish Jacky, etc., but none was done using Heterotis niloticus. The objective of the study, therefore, is to develop and evaluate the nutritional composition and organoleptic properties of fish sauce produced using H. niloticus flesh as a major raw material.

MATERIALS AND METHODS

Study Area

The study was carried out in the fish nutrition and postharvest technology of the Department of Fisheries, University of Maiduguri. The University of Maiduguri lies between latitude 11° 05'N and longitude 13°20'E. It has two distinct seasons: a rainy season with an annual rainfall of about 500mm from June to October and a hot, dry season from March to May. The dry season is preceded by a period of harmattan from November to February with very low temperatures (Duwa *et al.*, 2012).

Collection of Ingredients and Preparation of fish sauce

Fresh Heterotis niloticus of 4000g weight and 18-20 cm length each were procured from fishermen at Abbary landing site Lake. The fish was placed into an ice box containing crushed ice and transported to the Fish nutrition and postharvest technology laboratory. The fish were descaled, degutted, fins removed, beheaded, and washed. Dried sweet pepper, sesame, vegetable oil, sugar, ginger, and table salt were procured from Monday Market Maiduguri.

Table 1: Recipe for the Production of Fish Sauce with Heterotis niloticus

Ingredients	Inclusion level (%)
Heterotis niloticus flesh	22.80
Sweet pepper	2.80
Sesame	3.30
Ginger	17.30
Sugar	30.30
Salt	0.10
Vegetable oil	24.50

The sweet pepper and ginger were ground separately into a fine powder using an electric grinding machine. They were then sieved through a 0.2mm mesh sieve. The sesame was briefly soaked in tap water to remove chaff and dust and then toasted until the moisture was no longer visible. The fish was beheaded and steamed for 30 minutes, then allowed to cool to room temperature. The cold steamed H. niloticus was mashed using a wooden pestle and mortar. Each of the required ingredients and the fish were weighed (table 1) using an electric weigh balance. The weighed ingredients were mixed manually in a stainless-steel bowl. Hot vegetable oil was then gently added at once into the mixture (Fig. 1). The mixture was allowed to cool to warm before packaging.

Packaging

Four hundred mill (400ml) capacity used glass bottles were procured in the Maiduguri Monday market. The bottles were sterilized using an autoclave at 100oC for 15 minutes. The fish sauce was packaged in 400ml bottles and kept on the laboratory table until required.

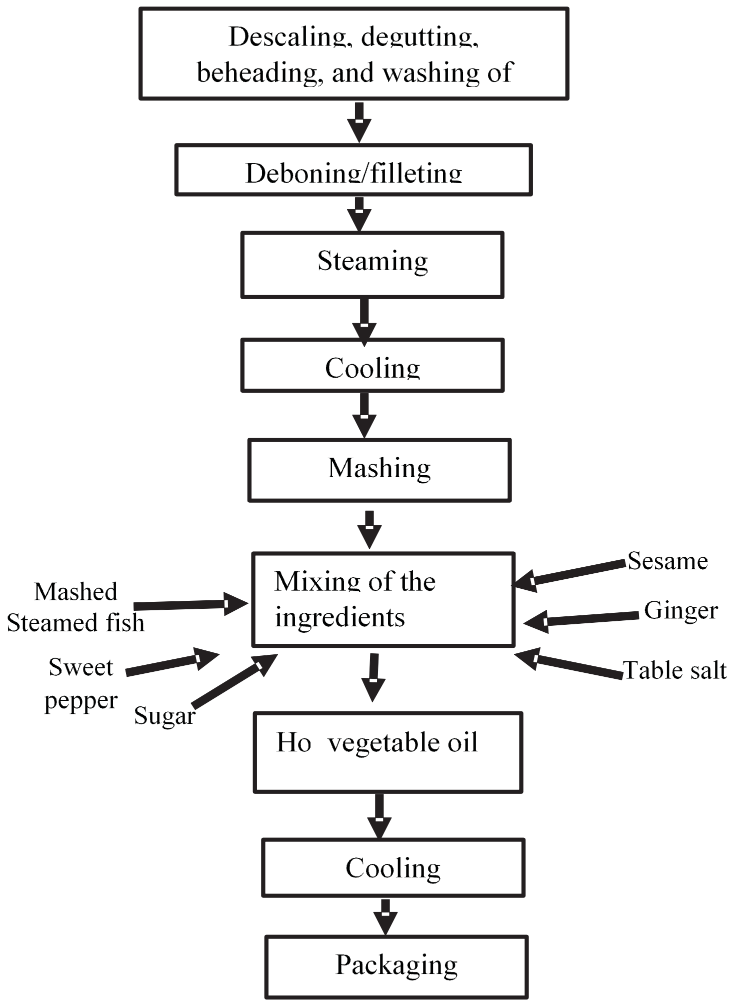

Fig. 1: Flow Chart for the production of fish sauce production.

Proximate Composition of Fish Sauce

One hundred (100 g) of freshly produced and 6 months of stored fish sauce were packed in 120 mil capacity bottles in replicates and shipped to the Animal care quality control laboratory for proximate analysis. The proximate was conducted using a digital Neared Infrared (NIR) Multi-Checker (Model: 21MC11309A06). Samples of the fish sauce were placed in the NIR multi-check static sample cup filled to three-quarters and placed back into the NIR Multi-check. The measurement bottom was then pressed, and the result (proximate composition) was displayed within 60 seconds. This was repeated three times using separate samples of both freshly produced and six-month preserved fish sauce.

Organoleptic Assessment

Organoleptic characteristics like colour, flavour, texture, taste, saltiness, sweetness, and general acceptability were evaluated by 50 panellists randomly selected from the University community using 5-scale Hedonic scales (Lawless & Heymann, 2010).

STATISTICAL ANALYSIS

Proximate composition data were subjected to a one-way analysis of variance. Differences between the means of the student t-tests were analyzed using Statistix 8.0.

RESULTS AND DISCUSSION

Table 1 shows the proximate composition of fresh and stored fish sauce. The crude protein of the fresh and preserved fish sauce was 28.77 and 27.66 %, respectively, while fat, moisture, crude fiber, dry matter, and metabolizable energy were 40.08 and 17.09. 2.08, 81.09 % 3969.76 (kg/cal.), and 42.50, 16.95. 2.0, 83.05% and 3926.75(kg/cal.), respectively. There were no significant differences between the nutrient composition of the freshly produced and the six months of stored fish sauce. However, ash content was significantly higher in the freshly produced fish sauce compared to the 6-month stored sauce. The crude protein content of fish sauce made from H. niloticus in this study was better than 18.92% of freshly caught H. niloticus observed by Udo (2012) and that of sundried (16.60%) and solar-dried (10.30%) H. niloticus reported by Oparaku et al. (2010). The variation in the crude protein might been caused by the presence of sesame, which is leguminous and has high protein (18 to 25%) contents (FAO, 2019: Abou-Gharbia et al., 2000: Seid and Mehari, 2022). Similarly, the fat content observed in this study was higher than the 16.0 % reported by Udo (2012). The variation in the fat could be due to the additional vegetable oil used for the production of the fish sauce.

Table 1: Proximate Composition of fresh and stored Fish Sauce

Nutrients	Immediately after Production	After 6 months of storage	SE (P=0.05)
Crude Protein	28.77	27.66	0.02
Fat	40.08	42.50	0.01
Moisture Content	17.09	16.95	7.07
Crude Fiber	2.08	2.00	0.02
Ash Content	4.48^{a}	2.00^{b}	0.34
Dry matter	81.09	83.05	0.02
Met. Energy (kg/cal.)	3969.76	3929.75	28.28

This means in the same row having the same superscript are not significantly different (p>0,05)

The organoleptic properties of fish sauce produced using H. niloticus and stored for 6 months are presented in Table 2. A majority (50.7%) of the panellists generally accepted (like very much), while 29.6, 26.2, and 32 liked the colour, flavour, and sweetness of the fish sauce very much. Additionally, 60.6, 70.4, 69, 21, and 28% of the panellists slightly liked the colour, taste, flavour, texture, saltness and sweetness, respectively. However, the majority of the panellists (52.1 and 50.5%) slightly dislike the flavour and saltness of the fish sauce. This indicates that the product is salty and likely to be not suitable for people with hypertension, as high sodium intake increases the risk of cardiovascular diseases, stroke, and kidney disease (He and MacGregor, 2009).

Table 2: The Organoleptic Properties of Fish Sauce after Storage for 6 Months

Statement	LVM	LS	NLND	SDL	DLV	Total (%)
Acceptability	50.7	30.6	10.2	1.3	7.2	100
Colour	29.6	70.4	-	-	-	100
Taste	26.2	60.6	4.6	3.2	4.0	100
Flavor	9.86	21.13	16.90	52.12		100
Texture	14.1	69.0	7.0	9.9	-	100
Saltness	12	21.4	6.0	50.5	4.1	100
Sweet	32.2	28.4	13	20.4	-	100

Key: LVM=like very much, LS=like slightly, NLND=Neither Like nor Dislike, SDL=Slightly Dislike, DLV=Dislike Very much.

Only a small number of panelists did not like the fish sauce. The fish sauce produced in this study is nutritious and can be stored at room temperature for 6 months without affecting its nutritional value and taste. Even though the fish sauce made using H. niloticus as the main raw material is nutritious, people with high blood pressure and diabetic patients are advised to avoid adding salt and sugar, respectively, when preparing fish sauce.

CONCLUSION

Conclusively, fish sauce made from Heterotis niloticus flesh is nutritious, tasty and acceptable, and it can increase the fish's market value and acceptability.

REFERENCES

Abou-Gharbia, H. A., Shehata, A. A. and Shahidi, F. (2000). Effect of processing on oxidative stability and lipid classes of sesame oil. Food Research International, 33(5), 331–340.

Agbugui, M. O. Egbo, H. O. and Abhulimen, F. E. (2021). The Biology of the African Bonytongue Heterotis niloticus (Cuvier, 1829) from the Lower Niger River at Agenebode in Edo State, Nigeria. International Journal of Zoology, Pp.13.

Aquerreta, I., Astiasarn, J. and Bello, F. (2002). Fish sauce consumption in ancient Greece: A comparative study of Garum and Aimeteon. International Journal of Food Studies, 9(3), 78-94.

Arino, A., Calvo M.A. and Gil A. (2013). Nutritional Value of Fish: Lipids, Proteins, Vitamins, And Minerals. In J.M. Lorenzo and F. Toldra (Eds.), Handbook of Seafood Quality, Safety and Health Applications. Wiley-Blackwell, pp.1-16

Duwa, H., Smith, J. and Johnson, A. (2012). The Effects of Harmattan on Weather Patterns. Journal of Climatology, 45(3), 78-92.

Diyaware, M.Y. and Yi, B.G. (2004). Production of Fish Sauce Using Low Market Value Fish. A Training Workshop for Fishers (focused on women) organised by the South-South Cooperation in collaboration with FAO at Plateau State Agricultural Development Programme, on 25th September 2004. Pp.4.

Eyo, A.A (2001). Fish Processing Technology in the Tropics. National Institute for Fresh Water Fisheries Research (FIFR), New Bussa, Nigeria.

He, F. J. and MacGregor, G. A. (2009). A Comprehensive Review on Salt and Health and Current Experience Of Worldwide Salt Reduction Programmes. Journal of Human Hypertension, 23(6), 363-384.

Ishige, N. (1993). Aimeteon: The ancient Greek fish sauce. Food Culture in Ancient Greece and Rome: A Companion to the Classical Cookbook, pp. 56–78.

Lawless, H. T. and Heymann, H. (2010). Sensory Evaluation of Food: Principles and Practices

Lopetcharat, K., Park, J. W. and Harte, B. (2007). Fish Sauce Products: History and Quality Characteristics. In Bechtel P.J. and R. E. Smiley (Eds.), Processed Seafood: Quality Evaluation, pp. 253–274.

Montero, P., Gomez-Guillen, M. C. and Borderias, A. J. (2017). Fish Sauces: Chemistry and Biochemistry. In Advances in Food and Nutrition Research, Academic Press, pp. 81:187-215.

Seid, F. and Mehari, B. (2022). Elemental and Proximate Compositions of Sesame Seeds and the Underlying Soil from Tsegede, Ethiopia.International Journal of Analytical Chemistry, Pp.7. ges https://doi.org/10.1155/2022/1083196.

Shori, A.B. (2017). Awareness and Knowledge about Food Spoilage and Principles of Food Preservation among Saudi Women in Jeddah. Journal of Food Microbial Safety and Hygiene 2: (120), 1-4.doi:10.4172/2476-2059.1000120.

Udo, P. J. (2012). The Proximate Composition and Mineral Contents of Two Economically Important West African Cichlids: Heterotis niloticus and Oreochromis niloticus (Pisces: Cichlidae). Pakistan Journal of Nutrition, 11: pp. 1087–1091.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

NUTRITIONAL PROFILE OF SMOKED AFRICAN CATFISH *(Clarias gariepinus)* USING ONION TUNIC *(Allium cepa)*

[1]Dasuki, A., [1]A. H Oladele and [1]M. M. Samuel

[1]Department of Fisheries and Aquaculture, Federal University Dutsin Ma

Correspondence Author:
adasuki@fudutsinma.edu.ng, 0000-0001-7056-4184

ABSTRACT
Consumer awareness of nutritious and healthy diets has led to the creation of functional foods. This study aimed to determine the nutritional profile of African catfish *(Clarias gariepinus)* by incorporating onion *(Allium cepa)* tunic infusion at varying levels: A (5%), B (15%), C (25%), and D (0%). The fish was assessed for the impact of onion tunic inclusion on its biochemical properties, chemical composition and sensory attributes of smoke-dried catfish. Inclusion of onion tunic significantly affected the proximate composition, with variations in moisture, ash, fat, and nitrogen-free extract. The highest moisture content (8.2%) was observed in the 15% inclusion sample, while the lowest (5.6%) was in the 25% group. Ash content increased with inclusion, peaking at 14.3% in the 25% sample. Fat content was highest at 19.1% in the 15% group, but protein content decreased with higher onion tunic inclusion, dropping to 54.1% in the 25% sample. Sensory evaluation showed no significant differences in most attributes ($p > 0.05$), except for mouthfeel ($p = 0.037$), where the control sample differed from those with onion tunic inclusion. Mineral analysis revealed that calcium and zinc levels decreased with higher onion tunic inclusion, while potassium and sodium concentrations increased significantly ($p < 0.05$). Copper levels were highest in the control (2.13 mg/100g), but decreased with onion tunic inclusion. The study suggests that onion tunic affects both the nutritional profile and sensory qualities of smoke-dried fish, with varying effects based on inclusion levels. Further research is needed to explore its impact on protein content and sensory attributes.

Keywords:
Clarias gariepinus,
functional food,
Nutritional profile,
Onion tunic,
sensory property.

INTRODUCTION

Fish spoilage in Nigeria is influenced to a large extent by high ambient temperatures, considerable distances of landing port to point of utilization and poor as well as inadequate infrastructure, post-harvest processing and landing (Saliu, 2008). Proper preservation starts the moment fish is harvested until it reaches the consumer's table (Oluborode *et al.*, 2010).

Fish is one of the cheap and fairly accessible animal protein sources; consumption of fish provides readily available dietary nutrients to a large number of the people worldwide and makes a very significant contribution to nutrition (Mufutau, 2012). According to Adesina *et al.* (2014), fish constitutes about 50% of animal protein intake in Nigeria which can be attributed to the increasing cost of beef; and owing to nutritional and health benefits of fish, accounts for its wide acceptability on the menu table of most Nigerians irrespective of socio -economic status, age and religious background.

Smoking is the most popular method of fish processing and among the several methods of long-term preservation of fish, smoking is perhaps the simplest method as it does not require sophisticated equipment or highly skilled workers (Kolawole, 2011). Fish smoking is one of the most widely used traditional fish-processing methods. Various species of fish are smoked depending on the availability. *Clarias gariepinus* specie is among the most commonly cultured and smoked fish in Nigeria (Akinola *et al.*, 2006). Quality and shelf life of fish and fish products are often enhanced by using various food additives during handling, processing and storage. Due to potential health hazards synthetic additives are replaced by their natural counter paths such as extracts containing bioactive compound isolated from various plant sources which have shown remarkable antioxidant and antimicrobial activities. Consumption of food containing natural aromatic plant extracts is expected to prevent the risk of many free radical mediated diseases according to Rahman (2007) and to enhance the nutritional value of consumed foods, researchers are exploring various natural plant-based ingredients, such as byproducts of agricultural processing due to their bioactive compounds and economic viability (Kumar et al., 2022b).

Onion (Allium Cepa), are edible allium among the oldest cultivated plants, and it belong to family of Alliaceae. Onion is commonly used the world over. Onion peel/skin contains bioactive compounds such as phytochemicals, total phenolic compounds, flavonoids, tannins, vitamins with quercetin and its derivates as major compounds. These bioactive substances have been proven to have various health benefits such as the prevention of lifestyle diseases such as obesity, cardiovascular diseases, diabetics and other therapeutic benefits such as anticancer and antimicrobial properties (kumar et al., 2022a). Studies have shown that the concentration of anthocyanins is higher in red when compared to white or yellow cultivar (Slimestad *et al.*, 2007).

Several synthetic antimicrobial compounds have been used to delay microbial proliferation and oxidative changes in fish processing and even though highly active, the metabolites of these synthetic preservatives have been reported to have toxicology effects (Naveena *et al.*, 2008; Manju *et al.*, 2012). Hence, interest in bio-preservation of food systems has increased because of the increase in bacterial resistance to synthetic antibiotics (Rahman, 2007). Therefore, it is very important to explore safe and inexpensive alternatives such as natural plants that have antimicrobial and antioxidants properties.

MATERIALS AND METHODS

Description of the Study Area

The experiment was carried out at the Department of Fisheries and Aquaculture Fish market, Faculty of Renewable Natural Resources, Federal University Dutsin-Ma, and Dutsin-Ma Local Government Area of Katsina State. Dutsin-Ma local government lies between latitude 12°27'14.11" North and longitude 7o 29' 50.03" East. The area is characterized by Sudan savannah a semi-arid climate with distinct wet and dry seasons.

Experimental Design

A complete randomized design was used for this experiment composing of three (3) treatment (A, B, C) and (D) as control.

Collection and Preparation of Materials

Method of Onion tunic (Allium cepa) Crude Extract

The onion tunic was sun dried, sorted to remove dirt and then milled into powder. The powdered onion tunic was measured corresponding to the different Samples (Sample A=5g; Sample B=15g; Sample C=25g and Sample D=0g onion powder as control) and was poured into different plastic container each and a solvent (water) of about 500ml was added to soak overnight for about 12hrs according to Kumolu-Johnson et al. (2010) methods as slightly modified. The container was kept in a cupboard with occasional shaking and left to infuse for 12 hours. The mixture was filtered using a

0.5mm strainer to get a clear infusion. This was stored in a beaker for further use.

Preparation of the African Catfish *(Clarias gariepinus)*

6 Kg of Clarias gariepinus with an average weight of 350g - 500g was purchased from Sauki Fish Farms in Katsina-State; the fish were chilled on ice and transported to the University Fish Market in Dutsin-Ma. The fish were divided into 4 groups of 1.5Kg fish/treatment. The fish was gutted, washed off its slime, brined (5% saline solution for 15 minutes) and then coiled into the traditional horse-shoe shape and allowed to drain.

Application of the Onion tunic *(Allium cepa)* Infusion

Each group of coiled fish was marinated with the different extracted infusion (Sample A - D) for 20minutes according to Latifa et al. (2014) methods as slightly modified and then drained and air dried for 1 hour prior to smoking process.

Smoking Process

The smoking was done using the Kainji smoking kiln, and the time taken to smoke-dry the fish sample to constant weight was observed. The source of heat was the Purple Orchid (Piliostigma reticulatum) 'Geza' wood due to its low Polycyclic Aromatic Hydrocarbon (PAHs) deposits (Dasuki *et al.*, 2022). The smoking chamber was preheated to a desired temperature with proper ventilation ensured. The fish samples were arranged on the smoking racks, leaving adequate space between each sample for smoke circulation, the smoking process was monitored closely to prevent overcooking or burning of the fish. On completion of this process, the fish were left to cool and subsequently packaged in a transparent polythene bag against microbial infections (Abolagba *et al.*, 2008).

Quality Evaluation

The quality attributes of the smoked Clarias gariepinus samples treated with onion tunic extract was assessed. The comparison was carried out in terms of organoleptic characteristics such as taste, texture, colour, odour, Appearance and overall acceptability/ general comment as described by Iwe (2002). A 9-point hedonic scale was used where, 9 would be "Like extremely" and a score of 1 would be "dislike extremely". 15 semi-trained panel from Department of Fisheries and Aquaculture, Faculty of Renewable Natural Resources, Federal University Dutsin-Ma Katsina State, made of staffs and students assessed.

Proximate Composition

The proximate analysis of the smoked fish was carried out according to the official methods of analysis described by the Association of Official Analytical Chemists (AOAC, 1990). This was analysed at the Biochemistry Lab of Federal University Dutse.

MINERAL CONTENT OF ANALYSIS

Mineral content analysis was carried out according to methods of AOAC (2000). Samples ash was achieved at 600°C for 2 hours and the weight was recorded. This was followed by sample digestion (residue) using 5cm3 of concentrated Nitric acid and then filtered using a filter paper in to 100ml volumetric flask and was diluted to the mark with distilled water. It was then transferred in to sampling bottle, ready for analyses. The procedure was repeated for all other samples. Calcium (Ca), copper (Cu), potassium (K), magnesium (Mg), sodium (Na), and zinc (Zn) were determined by atomic absorption spectrophotometer (AAS) an alpha four model atomic absorption spectrophotometer (PerkinElmer PinAAcle 900H USA), equipped with adequate digital read out system was used for the work; operating conditions as recommended by the manufacturer.

DATA ANALYSIS

The data obtained were subjected to simple descriptive statistics for the organoleptic assessment while Analysis of Variance (ANOVA) and a statistical significance was set at $p < 0.05$ least significance difference (LSD) using Statistical Packaged for Social Sciences (SPSS version 16.1) was made between Samples.

RESULTS AND DISCUSSION

The study investigated the effect of varying percentages of onion tunic inclusion on the chemical composition and sensory attributes of smoke-dried fish samples. The results (Table 1) showed that higher onion tunic inclusion significantly influenced the proximate composition. Moisture content was highest in Sample B (15% inclusion) at 8.203%, and lowest in Sample C (25% inclusion) at 5.619%. Ash content increased with onion tunic inclusion, peaking at 14.272% in Sample C, while the control (Sample D) had 9.686%. Fat content was highest in Sample B (19.113%) and lowest in the control (14.422%). Conversely, protein content was highest in the control (65.625%) and lowest in Sample C (54.141%), suggesting a dilution effect of onion tunic on protein concentration. The nitrogen-free extract content was highest in Sample C (7.7565%), indicating a higher contribution of non-protein, non-fat constituents from onion tunic.

Table 1: Results Showing Differences in Nutrient Composition of Smoked *Clarias gariepinus* treated with Onion tunic.

Different superscripts (a, b, c) within each row indicate significant differences between samples at the $p < 0.05$ level.

Parameters	Sample A 5% Onion Tunic Infusion	Sample B 15%Onion Tunic Infusion	Sample C 25% Onion Tunic Infusion	Sample D Control
% Moisture	5.788 ± 0.003^{c}	8.203 ± 0.004^{a}	5.620 ± 0.022^{b}	6.038 ± 0.053^{d}
% Ash	7.431 ± 0.038^{c}	8.697 ± 0.040^{b}	14.272 ± 0.068^{a}	9.686 ± 0.028^{d}
% Fat	15.567 ± 0.097^{c}	19.113 ± 0.016^{a}	18.211 ± 0.021^{b}	14.422 ± 0.047^{d}
% Protein	65.078 ± 0.774^{a}	59.596 ± 0.792^{b}	54.141 ± 0.774^{c}	65.625 ± 0.000^{a}
% Nitrogen Free Extract	6.137 ± 0.911^{b}	4.392 ± 0.740^{c}	7.757 ± 0.885^{a}	4.230 ± 0.129^{c}

The results for sensory evaluation (Table 2) revealed no significant differences ($p > 0.05$) in most sensory attributes such as colour, aroma, appearance, texture, taste, and general acceptability. However, mouth feel showed a significant difference ($p = 0.037$), with post-hoc analysis indicating that the control sample differed significantly from Samples A (5% inclusion) and B (15% inclusion).

Optimization of smoking conditions to enhance mineral retention and organoleptic properties was achieved by using Purple Orchid tree (Piliostigma reticulatum) wood for smoking as reported by Dasuki et al. (2022) in their works on different wood types used in smoking Bagrus bayad fish. The study's findings align with previous research, such as Hwang et al. (2011), who reported similar trends of increased ash and reduced protein content with the inclusion of dietary fibers, like apple pomace. The elevated fat content in the 15% onion tunic group contrasts with Talukder (2012), who found that fiber-rich carrot pomace generally reduced fat content. This discrepancy may result from the unique interaction of onion tunic fibers with the food matrix.

Table 2: Results of Sensory Evaluation of Smoked *Clarias gariepinus* treated with Onion tunic using Different inclusion levels

Sensory Attribute	Sample A 5g onion tunic inclusion	Sample B 15g onion tunic inclusion	Sample C 25g onion tunic inclusion	Sample D Control	p-value
Colour	7.5 ± 0.4	7.3 ± 0.5	7.6 ± 0.4	7.4 ± 0.3	0.831
Appearance	7.6 ± 0.3	7.5 ± 0.4	7.7 ± 0.3	7.6 ± 0.4	0.756
Aroma	7.4 ± 0.5	7.3 ± 0.4	7.5 ± 0.5	7.3 ± 0.4	0.628
Texture	7.8 ± 0.3	7.7 ± 0.4	7.9 ± 0.3	7.7 ± 0.4	0.534
Taste	7.7 ± 0.4	7.6 ± 0.5	7.8 ± 0.4	7.7 ± 0.3	0.119
General Acceptability	7.6 ± 0.4	7.5 ± 0.5	7.7 ± 0.4	7.6 ± 0.3	0.712
Mouth Feel	7.9 ± 0.2^{a}	7.8 ± 0.3^{a}	8.0 ± 0.2^{a}	7.4 ± 0.4^{b}	0.037

Different superscripts within each row indicate significant differences between samples at the $p < 0.05$ level

The importance of mouth feels in sensory perception, noted in this study, is consistent with Johnson and Thompson (2016), highlighting its critical role in overall sensory evaluation. Comparing these results with existing literature reveals that significant differences in sensory attributes, such as colour and appearance, typically require substantial visual changes (Zhang *et al.*, 2019). Similarly, Kim et al. (2018) found that aroma differences are only noticeable with major compositional changes. Texture and taste, although not significantly different here, align with the findings of Williams et al. (2017) and Lee et al. (2015), suggesting that substantial variations are necessary to influence sensory ratings. General acceptability followed similar patterns observed by Garcia and Martinez (2017), where overall trends are shaped by the combination of individual sensory attributes, emphasizing the central role of mouth feel in this context. Fish are also a good source of bionutrients, e.g., vitamins and minerals in diets according to Kiczorowska and Kiczorowski (2011) and the mineral contents of smoked African Catfish Clarias gariepinus treated with varying inclusion levels of onion tunic is presented in Table 3.

The Ca content of all samples in this study was significantly ($P < 0.05$) different. Samples A and B had higher Ca content while sample of 25% inclusion was lowest (592.9) when compared to the control. The results obtained in this work in smoked samples are in disagreement with the report of Tenyang et al. (2020) who noted an increase in Ca content in smoked C. Nigrodigitatus; similarly, it is lower than (976mg/100g) Tenyang et al. (2022) for smoked Polypterus bichir bichir.

Table 3: Mineral composition of smoked Clarias gariepinus (mg/100g)

Samples	Calcium	Copper	Potassium	Manganese	Sodium	Zinc
A	712.7 ± 1.08^{a}	1.28 ± 0.06^{b}	4083 ± 35.60^{c}	4.40 ± 0.03^{c}	851.5 ± 5.13^{c}	14.1 ± 0.05^{c}
B	712.5 ± 3.06^{a}	1.94 ± 0.03^{a}	6157 ± 31.70^{b}	5.78 ± 0.11^{b}	1394 ± 3.30^{b}	19.04 ± 0.07^{b}
C	592.9 ± 5.08^{ab}	1.44 ± 0.05^{b}	7867 ± 74.5a	3.94 ± 0.04^{c}	1551 ± 5.4^{a}	22.61 ± 0.01^{a}
D	698.9 ± 4.49^{a}	2.13 ± 0.03^{a}	4424 ± 19.10^{c}	8.24 ± 0.08^{a}	1233 ± 2.40^{b}	22.8 ± 0.06^{a}

Key: A = 5% onion tunic; B = 15% onion tunic; C = 25% onion tunic; D = control. Values represented as means ± standard deviation

Copper (Cu) content of Clarias gariepinus was highest 2.13mg/100g in the control while sample A (5%) inclusion recorded 1.28mg/100g the lowest value. The bioaccumulation of the microelements (Zn, Cu, Mn) in this study depends on several factors, such as the age of fish, its weight and body length (Farkas et al., 2003, Luczynska et al., 2009). These results were higher than 0.05 and 0.06mg/kg reported by Cieslik et al. (2017) for rainbow trot and Northern pike. Smoked Clarias gariepinus contains 4424mg/100g of potassium (K) in the control. The additive (onion tunic infusion) affected the K content and there was an increase significantly ($P<0.05$) across the Samples. The current study reveals a range of 4083 – 7867mg/100g which is higher than 3209.6 – 4300.8 reported by Cieslik et al. (2017).

The levels of sodium (Na) are presented in Table 3. This microelement is very important for muscle functioning. The data showed that their content increased exponentially as inclusion level increased. The control (Sample D) recorded 1233mg/100g. This is in disagreement with the report of Kiczorowska et al. (2019) who reported a lower content of 530 – 1120mg/100g for SFF to SMF. This could be associated with brining during the processing stage. The recommended daily dose of Na is 575 mg day-1 and a tolerable dose is 2350 mg day-1, thus any higher level of this element is unhealthy (if

eaten much and often), especially for consumers with cardiovascular problems, hypertension, etc. (Polak-Juszczak 2016) and results from this study revealed a tolerable content. The levels of zinc (Zn) of the African catfish revealed that as inclusion level increased, the levels of Zn also progressed. Results are higher than those for smoked Polypterus bichir bichir (6.84mg/100g) as reported by Tenyang *et al*. (2022). The lowest Zn (14.1mg/100g) was obtained in sample fortified with 5% powdered onion tunic infusion. The current study results are very low when compared to Cies lik *et al*. (2017) who reported a range of 7.86 – 12.59mg/Kg for common carp, rainbow trout and Northern pike.
Variation in mineral contents observed in the present work may be due to changes induced by inclusion level treatments. The differences observed in the concentration of various nutrients in the analysed fish species result from not only in the accumulation of mineral elements in tissues but may be due also to nutrient availability in the aquatic environment or feed as well as the ability to absorb and transform the compounds into essential nutritional components (Fawole *et al.,* 2007).

CONCLUSION

The findings highlight the potential of onion tunic as a functional ingredient in food products, enhancing certain nutritional properties while maintaining acceptable sensory qualities. Further research is needed to fully understand the mechanisms behind these effects and to optimize the use of onion tunic in various fish food applications.

REFERENCES

Abolagba, O. J., Enabueta, I. and Peter, D. O. (2008). Microbial load of smoked fish (Clarias gariepinus) marketed in Benin Metropolis, Edo State, Nigeria. Research Journal of Fisheries and Hydrobiology, 3(1), 33-37.

Adesina, B. A., Dongo, Jayeola, L. N. and Orisajo, S. B. (2014). Comparative quality assessment of fish (Clarias gariepinus) smoked with cocoa pod husk and three other different smoking materials. Journal of Food Technology, 6, 5-8.

Akinola, O. A., Akinyemi, A. A. and Bolaji, B. O. (2006). Evaluation of traditional and solar fish drying systems towards enhancing fish storage and preservation in Nigeria: Abeokuta local governments as case study. J. Fisheries Int., 1: 44-49. https://doi.org/10.3923/jfish.2006.44.49

AOAC, 1990. Official Methods of Analysis. 15th Edition, Association of official Analytical Chemists, Washington DC, 685-1298 pp.

AOAC. (2000). Official methods of analysis (15th ed.). Association of Official Analytical Chemists International, Maryland, USA.

Cieslik, I., Migdal, W., Topolska, K., Gambus, F., Szczurowska, K. and Cieslik, E. (2017). Changes in macro- and microelements in freshwater fish during food processing. Journal of Elementology, 22(2), 453-462. https://doi.org/10.5601/jelem.2016.21.1.1128

Dasuki, A. Abdullahi, A. B. and Adikwu, I. (2022). Characterization of polycyclic aromatic hydrocarbons concentrations in silver catfish (Bagarus bayad) smoked with different wood types. In: Kotos, A. A. (Editor), Book of Proceedings 37th Annual Conference of the Fisheries Society of Nigeria, land of Beauty 2022, held between 30th October and 4th November, 2022 at Federal College of Education, Yola, Adamawa State, pp 541 - 545.

Farkas, A., Salánki, J. and Specziár, A. (2003). Age- and size-specific patterns of heavy metals in the organs of freshwater fish (Abramis brama L.) populating a low-contaminated site. Water Research, 37, 959-964.

Fawole, O. O., Ogundiran, M. A., Ayandiran, T. A. and Olagunju, O. F. (2007). Mineral composition in some selected freshwater fishes in Nigeria. Journal of Food Safety, 9, 52-55.

Garcia, C. and Martinez, J. (2017). General acceptability in food products: Influence of sensory characteristics. Food Acceptance and Preference, 21(4), 567-580.

Hwang, K. E., Kim, C. J., Choi, Y. S., Kim, H. Y., Jeon, K. H., Park, J. H., ... and Choi, J. H. (2011). Effect of dietary fiber from apple pomace on the quality characteristics of meat products. Food Science and Biotechnology, 20(1), 223-228.

Iwe, M. O. (2002). Handbook on sensory methods and analysis. Rejoint Communications Services Limited.pg. 200 – 204.

Johnson, R. and Thompson, G. (2016). Impact of mouth feel on sensory evaluation. Journal of Sensory Science, 15(3), 210-223.

Kiczorowska, B. and Kiczorowski, P. (2011). Comparison of chemical composition and Mg, K, Na, Ca, Mn, Fe content in edible parts of chosen pear cultivars produced in Podkarpackie Province. Acta Scientiarum Polonorum-Hortorum Cultus, 10, 153-169.

Kiczorowska, B., Samoliniska,W., Grela, E. R. and Bik-Malodzinska, M. (2019). Nutrient and mineral profile of chosen fresh and smoked fish. Nutrients, 11(7), 1448

Kim, S., Garcia, M. and Lee, J. (2018). Aroma differentiation in food products: Compositional variations and consumer preferences. Food Chemistry, 17(5), 567-579.

Kolawole, O. M., Ajayi, K. T., Olayemi, A. B. and Okoh, A. I. (2011). Assessment of water quality in Asa River (Nigeria) and its indigenous Clarias gariepinus fish. International Journal of Environmental Research and Public Health, 8(11), 4332-4352.

Kumolu-Johnson, C. A., Ndimele, P. E. and Nwabueze, A. A. (2010). The effects of smoking on the nutritional qualities and shelf-life of Clarias gariepinus (Burchell 1822). African Journal of Biotechnology, 9(1), 73-76.

Kumar,M., Barbhai, M. D., Hasan,M., Punia, S., Dhumal, S., Radha, Rais, N., Chandran, D., Pandiselvam, R., Kothakota, A., Tomar, M., Satankar, V., Senapathy, M., Anitha, T., Dey, A., Sayed, A. A. S., Gadallah, F. M., Amarowicz, R. and Mekhemar, M. (2022a). Onion (Allium cepa L.) peels: A review on bioactive compounds and biomedical activities. Biomedicine and Pharmacotherapy, 146, 112498.

Kumar, M., Barbhai, M. D., Hasan, M., Dhumal, S., Singh, S., Pandiselvam, R., Rais, N., Natta, S., Senapathy, M. and Sinha, N. (2022b). Onion (Allium cepa L.) peels: A review on the extraction of bioactive compounds, its antioxidant potential, and its application as a functional food ingredient. Journal of Food Science, 87, 4289-4311. https://doi.org/10.1111/1750-3841.16297

Latifa, G. A., Chakraborty, S. C., Begum, M., Farid, F. B. and Nahid, M. N. (2014). Comparative study of quality-analysis of three different Bangladeshi smoke-dried lean fishes using salt and turmeric stored at refrigeration temperature (4 °C). American Journal of Food Science and Technology, 2(6), 209-215.

Lee, M., Garcia, C. and Martinez, J. (2015). Taste perception and its impact on sensory evaluation. Journal of Taste Research, 19(2), 345-358.

LuczyNska, J., Tonska, E. and Luczynski, M. (2009). Essential mineral components in the muscles of six freshwater fish from the Mazurian Great Lakes (northeastern Poland). Archives of Polish Fisheries, 17, 171-178. https://doi.org/10.2478/v10086-009-0015-y

Manju, A., Cruz, J. M., Franco, D., Dominguez, J. M., Sineiro, J., Dominguez, H., Nunez, M. J. and Parajo. (2012). Natural antioxidants from residual sources. Journal of Chemistry.

Mufutau, A. A. (2012). Evaluation of the efficacy of neem seed oil (NSO) extract for the control of Dermestes maculatus Degeer, 1774 (Coleoptera: Dermestidae) in Clarias gariepinus Burchell 1822 (Pisces: Clariidae). Munis Entomology and Zoology, 7(2), 1188-1194.

Naveena, B. M., Sen, A. R., Vaithiyanathan, S., Babji, Y. and Kondaiah, N. (2008). Comparative efficacy of pomegranate juice, pomegranate rind powder, and BHT in cooked chicken patties. Meat Science, 80, 1304-1308.

Oluborode, G. B., Omorinkoba, W. S. and Bwala, R. L. (2010). Development and construction of an electric furnace and control system for fish drying. African Journal of Engineering Research and Development, 3(2), 123-128.

Polak-Juszczak L. 2016. Effects of processing methods on the content of minerals in fish products. J. Elem., 21(2): 461-470. https://doi.org/10.5601/jelem.2015.20.3.890

Rahman, M. S. (Ed.). (2007). Handbook of food preservation. CRC Press.

Saliu, J. K. (2008). Effect of smoking and frozen storage on the nutrient composition of some African fish. Advances in Natural and Applied Sciences, 2(1), 16-20.

Slimestad, R., Fossen, T. and Vågen, I. M. (2007). Onions: A source of unique dietary flavonoids. Journal of Agricultural and Food Chemistry, 55, 10067-10080.

Talukder, S. (2012). Effect of dietary fiber from carrot pomace on the quality characteristics of meat products. Journal of Food Science and Technology, 49(2), 247-255.

Tenyang, N., Ponka, R. and Womeni, H. M. (2020). Effect of local hot smoking on proximate, lipid oxidation, fatty acid profile and minerals content of Chrischthys nigrodigitatus from Lake Maga in Cameroon. International Journal of Brain and Cognitive Sciences, 14(4), 1214-1227.

Tenyang, N., Mawamba, L. A., Ponka, R., Mamat, A., Tiencheu, B. and Womeni, H. M. (2022). Effect of cooking and smoking methods on proximate composition, lipid oxidation and mineral contents of Polypterus bichir bichir fish from far-north region of Cameroon. Heliyon, 8(10). https://doi.org/10.1016/j.heliyon.2022.e10921

Williams, A., Smith, J. and Lee, M. (2017). Texture variations in food products: Influences on sensory perception. Journal of Food Engineering, 28(3), 456-468.

Zhang, H., Kim, S. and Martinez, C. (2019). Sensory evaluation and consumer preferences: Insights into color and appearance. Journal of Consumer Science, 12(1), 45-57.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

INNOVATIVE POST HARVEST TECHNOLOGIES AND VALUE ADDITION IN FISHERIES: A REVIEW

Abasiubong, T. M.*[1], I. E. Okon[2] and J. P. Udoh[3]

Department of Fisheries and Aquatic Environmental Management, Faculty of Agriculture, University of Uyo, Nigeria;
tiandibotabasiubong@gmail.com[1], 001imaimaokon@gmail.com[2], jamesudoh@uniuyo.edu.ng[3].

Corresponding author:
tiandibotabasiubong@gmail.com, +234-8062504138

ABSTRACT
The fisheries sector is critical to Nigeria's economy, providing major employment and nourishment. However, problems persist in the post-harvest stage, where inefficiencies in handling and preservation result in significant losses and reduced product quality. Post-harvest technology ensures that fishery products are available where, when, and in the form necessary. Fish preservation and processing of value-added fish products requires current and enhanced post-harvest technologies. This review highlights the post-harvest technologies deployed in handling and preservation of fish and fish products in Nigeria. Drawing insights from diverse literature sources, the review underscores the impact of post-harvest technologies in the Nigerian fisheries sector and also elucidate the crucial role of product development and value addition in enhancing economic returns, expanding market opportunities, reducing waste, improving nutrition, and promoting food security. These advancements not only contribute to the reduction of post-harvest losses but also elevate the standards of fish products. New markets need be developed and a reliable supply of energy is essential.

Keywords:
Postharvest technology, product development, value addiction, food security

INTRODUCTION

Fish is one of the world's most traded food commodities, accounting for almost 10% of agricultural exports and having a higher global trade value than other animal goods (FAO, 2024). Fish are highly perishable, and their quality deteriorates quickly after harvest. Because of these qualities, fish have 50-60% higher postharvest losses (PHFL) than agricultural commodities (Keerthana et al., 2022).

Although Nigeria has an abundance of fish resources, post-harvest losses (PHL) from improper handling and preservation techniques continue to be a major problem (Abdul *et al.*, 2024). According to Kaminski *et al.* (2020), developing nations are more susceptible to fish post-harvest losses because they lack advanced processing techniques, sufficient facilities for processing fish, technical capacity, and adequate electricity and market infrastructure.

Fisheries are an essential source of food security, especially for the poor emerging countries. In low-income food deficient countries (LIFDCs), they account for 22% of total animal protein consumption (Demeke, 2013). Nigeria's fisheries sector is distinguished by a vast range of fish species, reflecting the natural diversity of its water bodies (Federal Ministry of Agriculture and Rural Development, 2017). The sector includes both artisanal and industrial fisheries, serving the diverse demands of a population that relies largely on fish as its principal source of animal protein (FAO, 2015). The fisheries industry, like any other food production sector, suffers from post-harvest losses. Thus, good post-harvest technology has a critical role in minimizing these losses, prolonging shelf life, enhancing hygiene, and adding value to fish and fish products (Abdul *et al.*, 2024).

There are several processing and preservation techniques accessible, ranging from basic conventional methods like smoking, drying, and salting to more advanced modern and improved technique such as destroying microbial DNA and pressure preservation (Sampels, 2015). Modern and enhanced post-harvest methods are required for fish preservation and processing into value-added fish products (Munguti *et al.*, 2021). Temperature-based preservation techniques, as well as conventional methods such as smoking and drying, are widely employed in many impoverished countries (Kyuleet *al.*, 2014; Munguti *et al.*, 2021). Traditional approaches, however, have limits, hence enhanced and modern technology are being recommended as a remedy to fish post-harvest losses (Keyombe *et al.*, 2018).

Fish post-harvest losses (Fig. 1) can be reduced through fish value addition, which has a variety of benefits such as opening up new marketing opportunities through product differentiation, increasing fish shelf life, maintaining fish quality, and improving the safety of fish products (Sampels, 2015). Various post-harvest technologies, such as improved fish solar driers, improved fish smoking kilns, and improved fish processing and value-addition equipment, have been developed and promoted among fish traders across the globe (Keyombe *et al.*, 2018).

The fish industry has progressed from traditional post- harvest practices to value - addition practices for many reasons (Magesa *et al.*, 2024). Value addition is essential for increasing financial gains, opening up new markets, cutting waste, boosting food security, and improving nutrition. Value is added to fish and fisheries products in Africa based on the demands of various markets. Live, fresh, frozen cured, canned, and smoked fish are all exchanged. In Nigeria, smoking is one of the finest techniques to enhance the value of catfish (Magesa *et al.*, 2024).

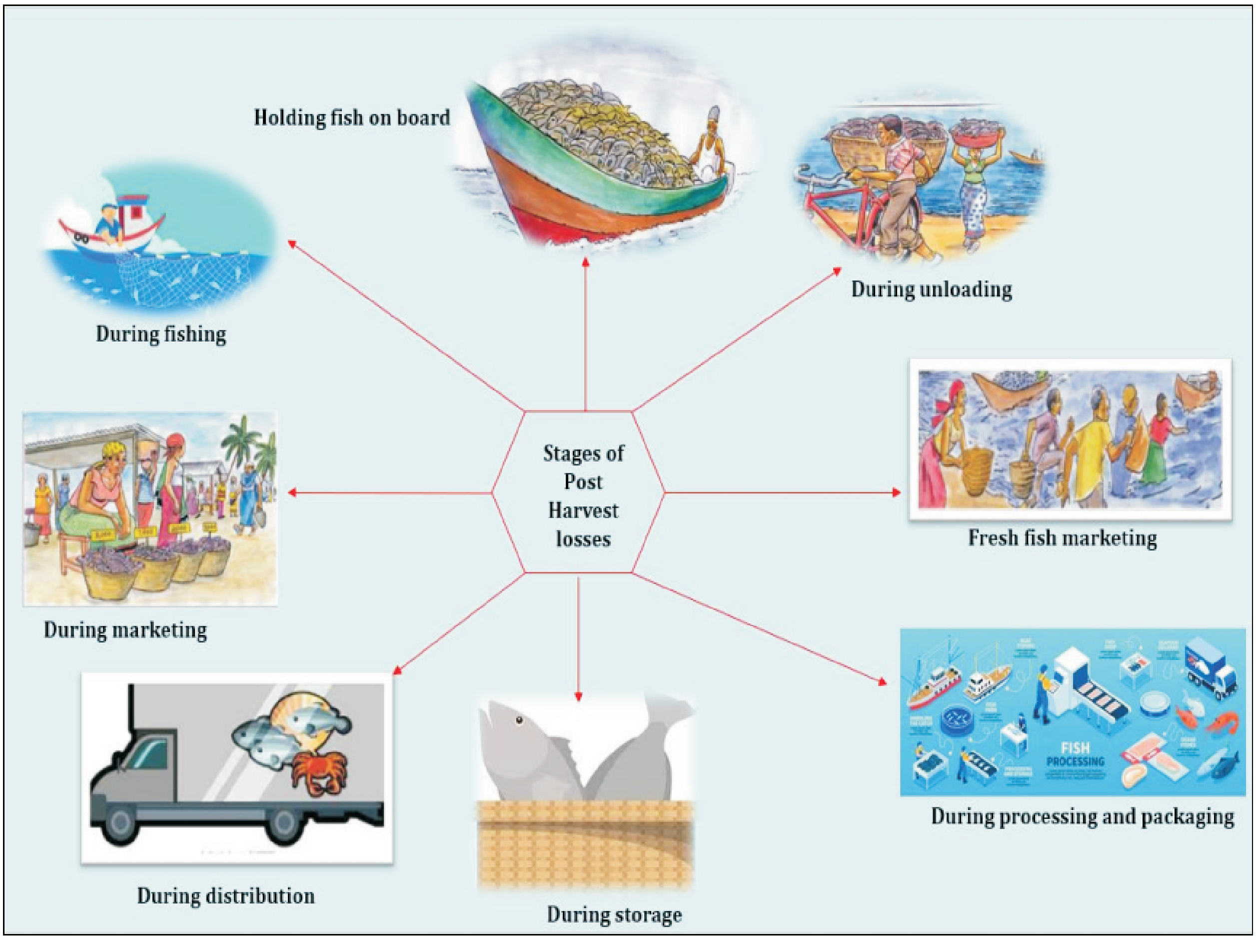

Figure 1: Stages of fish post harvest loss (Keerthana et al., 2022)

POST-HARVEST TECHNOLOGIES

This is an interdisciplinary "Science and Technique" applied to fisheries production after harvest for its preservation, conservation, processing, packing, distribution, marketing, and usage to meet the people's food and nutritional requirements in relation to their need. (https://www.slideshare.net/KarriRamarao). Post - harvest technologies encompass a broad spectrum, ranging from innovations in storage facilities and transportation to advancements in processing methods (FAO, 2015). They include the following:

Chilling and icing technology: This technology is critical for maintaining fresh fish quality during transit and marketing (Akande et al., 2017). Chilling involves the application of low temperatures just above freezing (0-4°C) without hardening fish. However, insufficient access to energy and ice infrastructure poses issues (World Bank, 2019).

Freezing technology: Freezing fish applies much lower temperature at sub-zero temperatures (-18°C or lower), to preserve fish for much longer time or even years. But it necessitates a significant investment in freezers and a steady power source (Ezenwa et al., 2012). Small-scale solar-powered refrigerators have intriguing applications in rural regions (Akaneme *et al.*, 2019).

Modified atmosphere packaging (MAP) technology: Uses regulated gas mixes to extend shelf life and retain freshness (Nnorom et al., 2018). This method necessitates specialized packaging materials and technical skills, limiting its use by small-scale processors (Adeyeye *et al.*, 2020).

Fish smoking technology: Smoking fish has evolved over many generations, mostly to fit the local environment, and is an effective technique of drying and preserving fish in areas where there is no cold storage for fresh fish (Keerthana et al., 2022). It is often used for oily fish species; the smoke prevents microbial development while also adding flavor (Adedeji *et al.*, 2018).

Fish drying technology: The fish's higher water activity and moisture content make it ideal for the growth of a variety of bacteria. As a result, lowering the moisture content of fish has an important role in preventing microbiological degradation, extending shelf life, and preserving nutrients (Abera et al, 2010). Fish drying technology is the most used traditional method, particularly in rural regions, because it is simple and inexpensive (Akinneye et al., 2012). However, it has slow drying times, uneven quality, and is susceptible to insects and pollution (FAO 2015). Improved smoking kilns, such as the Chorkor oven, increase efficiency and product quality (FAO, 2015). The most recent innovation in fish drying is the increasing use of dehydrators. Dehydrators offer several advantages over traditional sun drying or smoking methods. They preserve and help maintain the fish's nutritional value, texture and flavor (Jason, 2018), efficiently dry fish faster and more evenly (Raquel, 2020) and provide a clean and sanitized environment, minimizing the risk of contamination and spoilage (Sanches-Silva, 2014). Dehydrators can also help reduce water usage in fish processing, as they do not require water for drying (Raquel, 2020).

Fish Salting technology: This is a quick and easy way to preserve dry fish, especially along the seaside (Olagunju et al., 2019). However, using too much salt might have an adverse effect on nutritional value and flavor (Ojo et al., 2014).

Time temperature indicator (TTI) Technology: The time temperature indicator (TTI) is one of the most popular forms of intelligent packaging technique. A TTI is a tiny self-adhesive label that can be applied to shipping containers or individual items. When the TTI is subjected to adverse conditions, its color changes irrevocably. TTIs are also used as freshness indicators for the estimation of the shelf life of perishable products. The majority of intelligent or active systems, however, increase the package's cost. Therefore, packaging improvements need to provide a net positive impact that outweighs the additional costs associated with this technology (Panagiotis et al., 2016).

STORAGE AND PACKAGING TECHNOLOGIES

Novel storage technologies such as improved humidity packaging, ethylene absorbents, and irradiation are being investigated to improve the shelf life of perishables. Innovations in packaging and logistics, including as active and intelligent packaging, geospatial technology, and blockchain, are changing fresh product shipping. Active packaging methods such as oxygen scavengers and antimicrobial packaging aid in increasing the shelf life of perishables during transportation (Yildirim et al., 2018). Intelligent packaging with sensors and indicators can monitor product quality and safety in real time (Lee et al., 2015). Geospatial technology, such as GPS and GIS, offer real-time supply chain tracking and optimization (Aung and Chang, 2014). Blockchain technology is being researched to improve traceability, transparency, and trust in agri-food supply networkss (Kamilaris et al., 2019)

FISH PRODUCTS DEVELOPMENT AND VALUE ADDITION

Some advantages of post harvest technology on value addition include: Reduced post-harvest losses: Technology implementation can dramatically minimize losses, increasing food availability and income for fishermen and processors (Akintola *et al.*, 2017).

Improved product quality and safety: Proper preservation methods and hygienic handling procedures extend product shelf life and lower the danger of contamination and spoiling (Ogbonna *et al.*, 2018).

Value addition and market diversification: Processing techniques including filleting, smoking, and canning produce value-added products that increase market share and command higher prices (Ezenwa et al., 2012). Value addition increases the profitability of fishermen by lowering post-harvest losses, extending the shelf life of that specific fish product, and ensuring a steady supply of fish throughout the off-season (Kyule *et al.*, 2014).

Product development and value addition: Product development refers to the methods and actions used to bring new products to a market or modify the existing products to create new business. It comprises several steps from producing an idea till distributing the products to consumers (Fig. 2).

Figure 2: Stages of product development process (Santhakumar *et al.*, 2023)

Product development strategy is the process of bringing a new innovation to consumers from concept to testing through distribution (Santhakumar et al., 2023). The high levels of food loss and waste (FLW) in the fish value chain provide a strong case for development of fish products into globally acceptable forms such as fresh, sun-dried, smoked and fermented fish, as well as fish sauces and pastes. Other notable value-added fish products include: the popular fish fillets (where the fish is cut into firm pieces making it easier to cook and consume), canned fish, fish sticks and fish burgers made from fish paste.

Product development will raise the product's added value, giving it a competitive edge and helping it to dominate the market. A few strategies to sustain fisheries' contribution to food security include reducing fish postharvest loss; these include developing new and value-added products; enhancing the conventional methods of handling, processing, and preserving fish and its gear system; and creating and implementing new technologies.

Value addition is a change in the condition or form of fish through processing or further processing in order to increase its value and make it available to a wider consumer in order to increase producers' income or revenue. Value addition starts when a fish is caught, sorted, graded, peeled, gutted, sliced, etc. (Magesa *et al.*, 2024). According to Olusola (2017), value is added to fish and fisheries products in Africa based on the demands of various markets. Value addition for fish is a crucial tactic that can lessen the issue of post-harvest losses while increasing economic value and potentially expanding market performance (Kyule *et al.*, 2014; Mohamad *et al.*, 2011).

FAST-TRACKING THE PENETRATION OF AFRICAN FISHERY AND VALUE-ADDED PRODUCTS INTO THE GLOBAL MARKET

The overall production and market value of fisheries capture and value-added fish products is expected to continue growing in the coming years, with China leading in all fronts (FAO, 2024). Limited knowledge exists on trade and marketing of fisheries products within Africa and her export market. Several strategies for fast-tracking penetration into the global market include diversification of fishery products (e.g., fish fillets, canned fish, canned crabs, fish biscuits, and smoked fish) and exploration of new partnerships and markets for them. Attainment of international quality and safety standards require promotion and support of fishery business organizations to obtain ISO 9000 standard for optimal management system and performance. The hazard analysis and critical control point (HACCP) system of food safety program must be in place. Making enhanced market access and trade a critical government policy is also necessary. The capture of fisheries operations for instance, in blue economy and export processing zones will drive foreign direct investments; coupled with negotiating favorable trade agreements, reducing tariffs and non-tariff barriers, and improving logistics and transportation infrastructure. Promoting informal marketing, appropriate and affordable post-harvest technologies and storage to ensure year-round availability, accessibility and affordability of fish for consumers (Bavinck et al., 2023) is also essential. As well as promoting sustainable fishing practices such as traceability, eco-labeling and certification of product will drive the demand for African fishery products and improve market competitiveness. African countries can also strategically develop value chains and clusters richly supplied with fish processing infrastructure, improving cold chain logistics, and promoting public-private partnerships.

ENERGY AND ENVIRONMENTAL IMPACT

Sustainable Development Goal (SDG) 7 emphasis access to affordable, reliable, sustainable and modern energy for all. One of the limiting concerns in the application of postharvest technologies is availability and cost of the appropriate technology. Most of the technologies discussed in this paper require electricity, and can contribute to greenhouse gas emissions (Jason, 2018). FAO is promoting the uptake of renewable energy solutions in fisheries operations through raising awareness of good practices and providing technical guidance, technology transfer, innovation and design, capacity building; and empowerment of stakeholders. A Sri Lankan model is to employ solar energy to reduce FLW in small-scale fisheries (FAO, 2024; Rincon *et al.*, 2024).

CONCLUSIONS

Postharvest technology, value addition, and product development have enormous potential to change the aquaculture and fisheries industry, save waste, guarantee food security, and raise farmer incomes. Post-harvest technologies that are efficient in reducing losses, improving product quality, and adding value to fish products have the potential to completely transform the Nigerian fisheries industry. Nigeria can guarantee food security and minimize food waste by utilizing postharvest technologies and the value addition of fish products. This would also open up new doors for economic growth, job creation, and export competitiveness. New markets need be developed and a reliable supply of energy is essential.

REFERENCES

Abdul, I. M., Kamilu, M., Maiyanga, I. E., Yaji, I. L., Yerima, A. K. and Ibrahim, A. T. (2024). The role of post-harvest technologies in the handling and preservation of fish and fish products in Nigeria: A mini-review. Journal of Agriculture, Aquaculture, and Animal Science, 1(1), 1-4

.https://journals.stecab. com/index.php/jaaas/article/view/21
Abera, D. and Tesfaye, A. (2010). A comparative study on the three drying methods for better preservation. In: Proceeding of the second national conference of the Ethiopian Fisheries and Aquatic Sciences Association. 1: pp.117-122.https://www.ajol.info/index.php/eajbcs/article/view/221338/208864
Adedeji, O. A., Aletor, O.and Lawal, O. A. (2018). Comparative quality evaluation of smoked fish using traditional and improved smoking kilns. International Journal of Food Science and Technology, 53(8), 1806-1813. https://www.researchgate.net/publication/380721076_The_Role_of_Post-Harvest_Technologies_in_the_Handling_and_Preservation_of_Fish_and_Fish_Products_in_Nigeria_A_Mini-Review
Adeyeye, O. O., Adekanye, O. J. and Akintola, M. O. (2020). Challenges and opportunities for adopting modified atmosphere packaging technology in the Nigerian fish industry. International Journal of Food Science and Technology, 55(1), 217-228 from: https://www.researchgate.net/publication/380721076
Akande, K. O., Akintunde, F. O. and Adebayo, R. O. (2017). Effect of chilled and iced storage on the quality and shelf life of tilapia (Oreochromis niloticus) fillets. International Journal of Fisheries and Aquatic Sciences, 11(4), 465-474. https://www.researchgate.net/publication/380721076_The_Role_of_Post Harvest_Technologies_in_the_Handling_and_Preservation_of_Fish_and_Fish_Products_in_Nigeria_ A_ Mini-Review
Akaneme, F. N., Ogbonna, A. C. and Okorie, V. O. (2019). Solar powered cold chain systems for fish preservation in rural Nigerian communities. International Journal of Refrigeration, 103, 127-136. https://www.researchgate.net/publication/380721076_The_Role_of_Post-Harvest_Technologies_in_the_Handling_and_Preservation_of_Fish_and_Fish_Products_in_Nigeria_A_Mini-Review
Akinneye, J. O. and Akintunde, F. O. (2012). Factors affecting the adoption of improved fish drying technologies in Nigeria. International Journal of Sustainable Development, 5(8), 56-64.
Aung, M. M. and Chang, Y. S. (2014). Temperature management for the quality assurance of a perishable food supply chain. Food Control, 40, 198-207. 36. http://dx.doi.org/10.1016/j.foodcont.2013.11.016
Bavinck, M., Ahern, M., Hapke, H.M., Johnson, D.S., Kjelevold, M., Kolding, J., Overå, R. and Schut, T., eds. (2023). Small fish for food security and nutrition. FAO Fisheries and Aquaculture Technical Paper, No. 694. Rome, FAO. https://doi.org/10.4060/cc6229en
Demeke, T., (2013). Fish post-harvest technologies as a mean of food and nutrition security. International Journal of Fishery Science and Aquaculture 1(1), 024-027. http://www.advancedscholarsjournals.org/
Ezenwa, M. I., Nnanna, I. A. and Onyeacho, L. M. (2012). Feasibility and economic viability of using solar freezers for fish preservation in rural communities in Nigeria. International Journal of Refrigeration, 35(1), 21-27.
FAO (2015). Fish handling and processing practices in Africa. Food and Agriculture Organization of the United Nations.
FAO. (2024). The State of World Fisheries and Aquaculture 2024 – Blue Transformation in action. Rome. https://doi.org/10.4060/cd0683en
Federal Ministry of Agriculture and Rural Development. (2017). Aquaculture development plan for Nigeria 2016-2020. Nigerian Fisheries Society.
Food and Agriculture Organization, FAO (2015). Fish losses and waste in the post-harvest sector – A global estimate. FAO, Rome.
Jason, A. C. (2018). Dehydration of salmon: Effects on nutritional quality. Journal of Food Science, 83(5), S1448-S1456.
Kamilaris, A., Fonts, A. and Prenafeta-Bold, F. X. (2019). The rise of blockchain technology in agriculture and food supply chains. Trends in Food Science and Technology, 91, 640-652. http://dx.doi.org/10.48550/arXiv.1908.07391
Kaminski, A. M., Cole, S. M., Elizabeth, A. l., Haddad, R., Kefi, A. S., Chilala, A. D. (2020). Fish losses for whom? A gendered assessment of post-harvest losses in the Barotse floodplain fishery, Zambia.

Sustainability;12:10091.http://dx.doi.org/10.3390/su122310091

Keerthana, P. S., Soorya, G., Rubeena, R., Rinu, F., Kavya, S., Nisha, R., Pooja, U., Teena, E., Gifty, T. A., Das, N. H., Dinesh, K., Safeena, M. P. and Sreekanth, G. B. (2022). Post-harvest losses in the fisheries sector-facts, figures, challenges and strategies .International Journal of Fisheries and Aquatic Studies 2022; 10(4): 101-108. https://doi.org/10.22271/fish.2022.v10.i4b.2691

Keyombe, J. L. A., Bironga, H. C., Obiero, M. O., Malala, J. O., Olilo, C. O.and Aura, C. M. (2018). Monitoring the effectiveness of interventions of solar polyethylene dryer in reducing post-harvest losses in lake Turkana and share the findings. Mombasa: Kenya Marine and Fisheries Research Institute; 2018. Report No.: KMF/RS/2018/C2.1(i) https://www.researchgate.net/publication/ 328701662_Have_Innovative_Technologies_Reduced_Post-Harvest_Fish_Losses_in_Lake_Turkana _Case_Study_of_Polyethylene_Solar_Dryer

Kyule, D. N., Yongo, E., Opiyo, M. A., Obiero, K., Munguti, J. M. and Charo-Karisa, H. (2014). Fish product development and market trials of fish and fish products in Kenya: a case study of Kirinyaga and Meru counties. Livestock Research and Rural Development 26, 178-89. https://www.researchgate.net/publication/299868391_Fish_product_development_and_market_trials_of_fish_and_fish_prod ucts_in_Kenya_a_case_study_of_Kirinyaga_and_Meru_Counties

Lee, S. Y., Lee, S. J., Choi, D. S. and Hur, S. J. (2015). Current topics in active and intelligent food packaging for preservation of fresh foods. Journal of the Science of Food and Agriculture, 95(14), 2799-2810.https://doi.org/10.1002/jsfa.7218

Magesa, R. J., Sewando, P. and Mkenda, L. D. (2024). Fish Value Addition Practices by Women Fish Vendors in Dar Es Salaam: A Case of Mackerel Fish East African Journal of Business and Economics, 7(1), 63-71. https://doi.org/10.37284/eajbe.7.1.1793

Mohamad, R. (2011). Consumers acceptance and purchase intent of freshwater fish products developed by MARDI, Economic, and Technology Management Review, 6, 77-82. http://etmr.mardi.gov.my/Content/ETMR%20Vol.%206%20(2011)/text%20Rashilah-consumer.pdf

Munguti, J., Obiero, K., Orina, P., Mirera, D., Kyule, D. andMwaluma, J. (2021). State of aquaculture report in Kenya 2021: towards nutrition sensitive fish food production systems. Nairobi: Techplus Media House. https://kmfri.go.ke/ALL/images/pdf/reports/State_of_Aquaculture_in_KE_2021_Report_final_report_Published.pdf

Nnorom, C. E., Osuji, L. O. and Okigbo, M. N. (2018). Shelf-life extension of hot-smoked mackerel (Scombers combrus) using modified atmosphere packaging technique. Journal of Food Processing and Preservation, 42(1), 1-8.

Olusola, E. (2017). Fish Value Addition and Value Chain in Nigeria. A Working Paper.

Ojo, O. O., Afolabi, T. D. and Adebayo, A. O. (2014). Effect of salt concentration and drying method on the nutritional composition and sensory quality of dried African catfish (Clarias gariepinus). International Journal of Food Science and Technology, 49(11), 2460-2466.

Panagiotis, K., Elena, C. B. and Martin, H. (2016). Innovative postharvest technologies for sustainable value chain Nowadays, the distance that food travels from producer to consumer has incrpg 264 – 278https://www.researchgate.net/publication/331207145_INNOVATIVE_POSTHARVEST_TECHNOLOGIES_FOR_SUSTAINABLE_VALUE_CHAIN

Raquel, P. (2020). Dehydration of tilapia: Effects on drying time and texture. Journal of Food Engineering, 253, 109936.

Rincon, L., Ward, A., Vaskalis, I., Milani, M., Gallego, J. and Morese, M. (2024). Solar Energy and the Cold Chain: A Guide for Small-Scale Fisheries Interventions. FAO, Rome

Sampels S. (2015). The effects of storage and preservation technologies on the quality of fish products: a review. J Food Process Preserv.; 39:1206-15.http://dx.doi.org/10.1111/jfpp.12337

Sanches-Silva, A. (2014). Dehydration of cod: Effects on microbial quality. Journal of Food Protection, 77(10), 1736-1743.

Santhakumar. R., Sujathkumar, N. V., Ahilan, B., Shahaji, P. and Sushrirekha, D. (2023). Fishpreneurship Development [E-book]. Hyderabad: TNJFU - Fisheries College and Research Institute, Thoothukudi and National Institute of Agricultural Extension Management, Hyderabad, India. https://www.manage. gov.in/publications/eBooks/Fishpreneurship%20Development.pdf

World Bank. (2019). Fish to feed the world: Increasing efficiency and reducing waste in the seafood value chain. World Bank, Washington, DC

Yildirim, S., Röcker, B., Pettersen, M. K., Nilsen–Nygaard, J., Ayhan, Z., Rutkaite, R. and Coma, V. (2018). Active packaging applications for food. Comprehensive Reviews in Food Science and Food Safety, 17(1), 165-199.https://doi.org/10.1111/1541-4337.12322.

COMPARATIVE STUDY ON ORGANOLEPTIC QUALITY OF BRINE PRE-TREATED TILAPIA AND BONYTONGUE SMOKED WITH SELECTED HERBS

*,[1]MSHELIA, J. P, [1] A.N., OLANREWAJU AND [2] O. O, AGBELEGE
[1]Department of Fisheries Technology, Federal College of Freshwater Fisheries Technology, Baga, P.M.B 1060, Maiduguri, Nigeria
[2]Department of Aquaculture and Fisheries Management, University of Ibadan, P.M.B. 200132, Ibadan, Oyo, Nigeria
*Corresponding author:
joseph.paul.mshelia@gmail.com +2348080858146,

ABSTRACT
The effect of different aromatic herbs on sensory quality of smoked Nile tilapia, Oreochromis niloticus and African Bonytongue, Heterotis niloticus was investigated. A total of Twenty live samples each of Nile tilapia (450.66±174.70 g) and African Bonytongue (1250.80±430.35 g) were procured, processed and smoked separately with eucalyptus leaf, guava leaf, mango leaf and neem leaf in NIOMR smoking kiln. Ten freshly smoked fish samples were used for organoleptic assessment using 5-point hedonic scale and data obtained was subjected to Student's t-test. The results revealed that Nile tilapia smoked with Guava leaf had significantly high scores in taste (4.31±1.19) and overall acceptability (4.14±0.64). Also, taste (4.53±0.74) and odour (4.00±0.76) for tilapia smoked with Mango leaf was notably better ($p<0.05$) than African Bonytongue. The high scores for texture (3.86±0.83) and odour (3.67±0.82) in African Bonytongue smoked with Guava were not significantly different ($p>0.05$) from Nile tilapia. This study suggest that Guava and Mango leaves perform better on taste, odour and texture of smoked Nile tilapia and African bonytongue. Hence, these leaves can be used in smoking these fish species for more appeal to consumers.

Keywords:
Organoleptic, Smoking, Herbs, Tilapia, Nile, Consumer

INTRODUCTION

Fish is considered as a significant source of nutrition on which Nigerians depend for making assorted and healthy diets. It accounts for around 40 percent of the country's protein intake, with fish consumption at 13.3 kg/person/per year (Bradley *et al.*, 2020). Fish is predominantly sourced from artisanal fisheries found in rivers and lakes, and there are over 300 fish species inventoried in Nigeria (Olaosebikan and Raji, 2013). Many of these are not known to consumers, except those in riverine areas. However, the progress made in fish value addition have made some of these species available for consumption in various homes across the nation. Thus, value addition in fish processing has become notable, popular and all-embracing by fish consumers. It allows fish to be distributed in various forms such as smoked, fried, dried, salted, boiled, freeze-dried, fermented or as a combination of two or more of these forms (FAO, 2010). Each form followed certain procedures in their processes, and this make them unique from each other. Also, individuals were able to select their choice based on taste and/or price.

Smoked fish is the commonest and most popular, which sells both in open market and supermarkets across Nigeria and indeed Europe where it has become a delicacy. Its wide acceptance is primarily based upon the sensory quality it gets after processed and smoked with different spices. Spices and herbs (e.g., eucalyptus leaf, mango leaf, guava leaf, neem leaf etc.) are usually incorporated in smoking process of fish to add value and enhance fish sensory quality. Phenolic compounds in spices and herbs are strongly associated with their antioxidant, which impart characteristic flavour, aroma, taste, and colour to foods (Senay, 2020).

Sensory effects of spices and herbs on smoked fish have been noted by many researchers (Olusola, 2021; Adeyeye, 2019; Jega *et al.*, 2018; Ariel *et al.*, 2017; Ayeloja *et al.*, 2015), but scanty work exists on freshwater fish species in Lake Chad Basin. This study, therefore, investigate the organoleptic quality of brine pre-treated tilapia and bonytongue smoked with selected herbs.

MATERIALS AND METHODS

The study was conducted at Federal College of Freshwater Fisheries Technology (FCFFT) Baga, Borno State from November 2022 to December 2022. Twenty live samples each of Nile tilapia (450.66±174.70 g) and African Bonytongue (1250.80±430.35 g) from Lake Chad Basin were procured from artisanal fishers in Baga road, Maiduguri. The fish was moved to the Fish Processing Unit, FCFFT Baga where they were prepared following the method of Roth and Oines (2010) before gutted, eviscerated, washed clean and immersed in 15% brine solution. Samples from both species were rounded and put inside the NIOMR (Nigeria Institute of Oceanography and Marine Research) smoking kiln. Four selected herbs including eucalyptus leaf (Eucalyptus camaldulensis), guava leaf (Psidium guajava), mango leaf (Mangifera indica) and neem leaf (Azadirachta indica) were obtained around Maiduguri and used separately along with charcoal for smoking. Thereafter, samples of the smoked fish were allowed to cool and used for the sensory analysis. Ten trained panellists were used for sensory analysis of the fish following 5-point hedonic scale (5 - excellent, 4 - very good, 3 - good, 2 - fair, 1 - poor). Differences in sensory parameters between the two fish species were statistically analysed by paired t-test. All results are expressed as mean±standard deviation. Statistical significance was tested at 5% significance level. Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) (version 20.0, SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

The Organoleptic attributes of brine pre-treated Nile tilapia and African bonytongue smoked with Eucalyptus leaf is shown in Table 1. Results showed that the smoked Nile tilapia fish have highest scores in appearance (3.67±1.05), odour (3.80±1.01), taste (3.67±1.23) and overall acceptability (3.57±0.52), while texture (3.93±0.88) had the best value in smoked African bonytongue. However, the values obtained for all investigated attributes were not statistically significant ($p>0.05$) between the two species. The result indicates that smoked tilapia received very good scores in all the sensory quality parameters, while smoked bonytongue were allotted similar scores in texture and taste. It is however appeared that eucalyptus leaf adds values to texture and taste in smoked bonytongue, which could make it more acceptable to consumers (Adu-Adjei et al., 2014). Ariel et al., (2017) reported similar results on overall acceptability of pre-brined Surgeon fish Acanthurus sp. smoked with eucalyptus leaf.

Table 1. Organoleptic attributes of brine pre-treated Nile tilapia and African bonytongue smoked with Eucalyptus leaf

Sensory attributes	Tilapia		Bonytongue		*p-value*
	Range	Mean±SD	Range	Mean±SD	
Appearance	2.00 – 5.00	3.67±1.05	1.00 – 5.00	3.07±1.10	0.14
Odour	2.00 – 5.00	3.80±1.01	2.00 – 5.00	3.33±1.05	0.23
Texture	2.00 – 5.00	3.67±1.05	3.00 – 5.00	3.93±0.88	0.46
Taste	2.00 – 5.00	3.67±1.23	1.00 – 5.00	3.53±1.25	0.77
OA	3.00 – 4.00	3.57±0.52	3.00 – 4.00	3.33±0.49	0.47

OA Overall acceptability, $^{*}p<0.05$

The data presented in Table 2 showed significantly highest ($p<0.05$) score for taste (4.31±1.19) and overall acceptability (4.14±0.64) in Nile tilapia Oreochromis niloticus smoked with Guava leaf. Also, the appearance scores (3.80±0.94) were marginally higher in smoked tilapia, whereas the odour

(3.80±0.94) and texture (1.24±0.05) scores were slightly higher in the smoked bonytongue smoked with Guava leaf. This result demonstrates better taste and very high acceptance for tilapia compare to bonytongue, which indicate minimal impact of guava leaf on the organoleptic parameters measured in the study. This is because tilapia flesh is more tasteful and acceptable among consumers with or without spices (FAO, 1997). These results however differ from the findings of Ariel et al., (2017), who found significant impart of guava leaf on the organoleptic quality of pre-brined smoked Surgeon fish Acanthurus sp. The authors report excellent and highly acceptable scores for all the sensory parameters in Surgeon fish Acanthurus sp. smoked with guava leaf.

Table 2. Organoleptic attributes of brine pre-treated Nile tilapia and African bonytongue smoked with Guava leaf

Sensory attributes	Tilapia		Bonytongue		*p-value*
	Range	Mean±SD	Range	Mean±SD	
Appearance	3.00 – 5.00	3.80±0.94	2.00 – 5.00	3.43±1.05	0.21
Odour	2.00 – 4.00	3.47±0.80	2.00 – 5.00	3.67±0.82	0.19
Texture	2.00 – 5.00	3.50±0.78	2.00 – 5.00	3.86±0.83	0.18
Taste	3.00 – 5.00	4.31±1.19	2.00 – 5.00	3.70±0.83	0.04*
OA	3.00 – 5.00	4.14±0.64	3.00 – 4.00	3.52±0.52	0.02*

OA Overall acceptability, *$p<0.05$

The result of sensory analysis of brine pre-treated Oreochromis niloticus and Heterotis niloticus smoked with Mango leaf is as shown in Table 3. Odour (4.00±0.76) and taste (4.53±0.74) were significantly higher ($p<0.05$) in the smoked O. niloticus samples while smoked H. niloticus show a marginally higher appearance value (3.87±1.13). However, Texture (3.93±0.80) and overall acceptability (3.93±0.46) were slightly higher ($p>0.05$) in the smoked O. niloticus samples. The results show a wide variation in sensory quality of both species, with tilapia having better sensory performance and total acceptance. Although, there is no documented information on the effect of freshwater fish smoked with mango leaf, but Liu et al. (2020) asserts that Mango leaves pair well with aromatics such as shallots, ginger, garlic, chile peppers, and curry leaves, coconut, spices including turmeric, mustard seeds, asafoetida powder, and cumin, tofu, grains, and legumes.

Table 3. Organoleptic attributes of brine pre-treated Nile tilapia and African bonytongue smoked with Mango leaf

Sensory attributes	Tilapia		Bonytongue		*p-value*
	Range	Mean±SD	Range	Mean±SD	
Appearance	3.00 – 5.00	3.67±0.90	2.00 – 5.00	3.87±1.13	0.60
Odour	3.00 – 5.00	4.00±0.76	2.00 – 5.00	3.33±0.98	0.04*
Texture	3.00 – 5.00	3.93±0.80	3.00 – 5.00	3.80±0.86	0.66
Taste	3.00 – 5.00	4.53±0.74	2.00 – 5.00	3.80±1.08	0.03*
OA	3.00 – 5.00	3.93±0.46	2.00 – 5.00	3.53±0.83	0.12

OA Overall acceptability, *$p<0.05$

Sensory attributes of brine pre-treated Nile tilapia and African bonytongue smoked with Neem leaf is presented in Table 4. Results showed that highest taste (3.60±1.24) and overall acceptability (3.40±0.74) values were recorded in Nile tilapia, while African bonytongue revealed higher appearance (3.53±0.99), odour (3.31±1.03) and texture (3.67±1.18) values. The results however showed that value of odour in smoked Nile tilapia and smoked African bonytongue was similar. Therefore, it means that both species have the same odour after smoking with neem leaves. Similarly, it was found that these values in sensory parameters were not significantly different between the two species. Sensory effect of neem leaf in smoked fish was noted on appearance, color, odor, taste, texture and overall acceptability when Oduor-Odote et al., (2010) studied the organoleptic effect of using different plant materials on smoking marine and freshwater catfish. Ariel et al., (2017) also reported moderate acceptable scores for aroma, texture and general acceptability in brine pre-treated Surgeon fish Acanthurus sp. smoked with Calamansi leaf.

Table 4. Organoleptic attributes of brine pre-treated Nile tilapia and African bonytongue smoked with Neem leaf

Sensory attributes	Tilapia		Bonytongue		*p-value*
	Range	Mean±SD	Range	Mean±SD	
Appearance	2.00 – 5.00	3.13±1.19	2.00 – 5.00	3.53±0.99	0.33
Odour	2.00 – 5.00	3.27±1.10	2.00 – 5.00	3.31±1.03	1.00
Texture	2.00 – 5.00	3.33±1.29	2.00 – 5.00	3.67±1.18	0.47
Taste	2.00 – 5.00	3.60±1.24	2.00 – 5.00	3.33±1.05	0.53
OA	2.00 – 4.00	3.40±0.74	2.00 – 4.00	3.33±0.62	0.79

OA Overall acceptability, $^{*}p<0.05$

CONCLUSION

The study revealed variations in the organoleptic scores of brined pre-treated Nile tilapia and African bonytongue smoked with four different aromatic plants. The scores for texture and odour for Bonytongue smoked with guava and neem leaves were slightly better than that those of tilapia. However, Odour, taste and overall acceptability scores for Nile tilapia smoked with Mango and Guava leaves was significantly better than in African bonytongue.

REFERENCES

Adeyeye, S.A.O. (2019). Smoking of fish: a critical review. Journal of Culinary Science & Technology, 17:6, 559-575, DOI: 10.1080/15428052.2018.1495590

Adu-Adjei, S., Adzitey, F. and Teye, G.A. (2014). The effect of 'prekese` (Tetrapleura tetrapluera) pod extract on the sensory and nutritional qualities of pork sausage. Global Journal of Animal Scientific Research, 2(1): 7p.

Ariel, M.O., Francis, N.B. and Jonathan, M.B. (2017). Sensory, organoleptic, and proximate composition of smoked surgeon fish Acanthurus sp. using selected herbs as flavor enhancer. International Journal of Food Science and Nutrition, 2(1): 174-181.

Ayeloja, A.A., George, F.O.A., Akinyemi, A.A., Atanda, O.O. (2015). Proximate and mineral composition of spiced smoked catfish Clarias gariepinus (Burchell, 1822). J. Agri. Sci. Environ., 15(2): 68 – 74.

Bradley, B., Byrd, K.A., Atkins, M., Isa, S. Akintola, S.L., Fakoya, K.A., Ene-Obong, H. And Thilsted, S.H. (2020). Fish in food systems in Nigeria: A review. WorldFish. https://hdl.handle.net/20.500.12348/4210.

FAO (1997). Comparative taste study on Nile tilapia (Oreochromis niloticus) and maine fish in Samoa and Naura. Antonio et al. (eds). South Pacific Aquaculture Development Project (Phase II), Food and Agricultural Organisation of the United nations (GCP/RAS/116/JPN) Suva, Fiji. 68pp.

FAO. (2010). The state of world fisheries and aquaculture (2010). Rome, Italy: Food and Agricultural Organization of the United Nations.

Jega, I.S., Michael, P. and Ribah, I.M. (2018). Effect of Onion top leaves extract on the quality of smoked Heterotis niloticus (Cuvier, 1829). Research in Agriculture, Livestock and Fisheries, 5(2): 241 – 248.

Liu, H., An, K., Su, S., Yu, Y., Wu, J., Xiao, G. and Xu. Y. (2020). Aromatic Characterization of Mangoes (Mangifera indica L.) Using Solid Phase Extraction Coupled with Gas Chromatography-Mass Spectrometry and Olfactometry and Sensory Analyses. Foods, 9(1): 75. doi: 10.3390/foods9010075.

Oduor-Odote, P.M., Obiero, M. and Odoli, C. (2010). Organoleptic effect of using different plant materials on smoking of marine and freshwater Catfish. African Journal of Food, Agriculture, Nutrition and Development, 10(6): 2658–2677.

Olaosebikan, B. D. and Raji, A. (2013). Field guide to Nigerian freshwater fishes. Federal College of Freshwater Fisheries Technology, New Bussa, Niger State, Nigeria. Revised edition. 144pp.

Olusola, S. E. 2021. Influence of smoking and natural preservatives on shelf-life and microbial quality of Clarias gariepinus during storage. Ife Journal of Science, 23(1): 145 – 151. https://dx.doi.org/10.4314/ijs.v23i1.14

Roth, B. and Oines, S. (2010). Stunning and killing of Edible Crabs (Cancer pagurus). J. Anim. Welf., 19(3): 287–294.

Senay, T.L. (2020). Systematic review on spices and herbs used in food industry. American Journal of Ethnomedicine, 7(5): 20. DOI: 10. 36648/2348-9502. 7. 1. 20

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

PROXIMATE COMPOSITION AND STORAGE QUALITY OF SMOKED-GUTTED AND DEGUTTED CATFISH *(Clarias gariepinus,* Burchell 1822) FROM TWO DIFFERENT SMOKING KILNS

[1]MSHELIA, J.P., [2] K.G., MICHEAL, [1] A.N. OLANREWAJU, AND [1] F.A.GREMA
[1]Department of Fisheries Technology, Federal College of Freshwater Fisheries Technology Baga, P.M.B. 1060 Maiduguri, Borno State, Nigeria
[2]Department of Fisheries, Modibbo Adama University Yola, Adamawa State, Nigeria

Corresponding author:
joseph.paul.mshelia@gmail.com, +2348080858146,

ABSTRACT
Consumer's preference of eating smoked- gutted and degutted C*larias gariepinus* has been based on taste, but not nutritional and storage quality. This study therefore assesses the proximate composition and storage quality of smoked- gutted and degutted C. *gariepinus* from two different smoking kilns. Seventy-two live C. *gariepinus* (0.85±74.69kg) were obtained, processed and grouped into two: gutted and degutted samples. These samples were later sorted into four treatments representing gutted sample smoked in improved smoking kilns (GSSI), degutted sample smoked in improved smoking kilns (DSSI), gutted sample smoked in FUTTY smoking kilns (GSSF), and degutted sample smoked in FUTTY smoking kiln (DSSF). Proximate composition of freshly smoked and preserved smoked fish were analyzed following standard procedure. The statistical analysis of data was conducted by descriptive statistics and ANOVA at a 0.05. The GSSF and DSSF groups had significantly high crude protein (67.15±0.29, 69.15±0.29%) and dry matter (98.10±0.08, 96.00±0.00%) in freshly smoked fish. Also, freshly smoked and preserved smoked fish revealed significantly high ash (8.05±0.12, 4.70±0.15%) and low moisture (2.60±0.48, 4.10 ± 0.08%) contents in GSSF. The study indicates similar proximate and storage quality in both gutted and degutted smoked fish. However, fish in FUTTY smoking kiln show better proximate and storage quality.

Keywords:
Consumer's-preference, smoked-dried fish, nutritional quality, African catfish

INTRODUCTION

Fish are valuable dietary source of animal protein that are highly needed for nourishing human body and maintaining a healthy life. Grema and Olanrewaju (2022) asserted that fish is an excellent source of high-quality animal protein and highly digestible energy as well as extremely rich source of Omega-3 polyunsaturated fatty-acids (PUFAs), fat-soluble vitamins (B complex), and minerals (calcium, phosphorus, iron, iodine and selenium). However, the nutritional quality of food fish differs due to many factors including processing method. Sokamte et al., (2020) noted that processing methods have been reported to have a considerable effect on the nutritional value of fish. One of the processing methods that is widely popular and accepted by people all over the world is smoking. Smoking is an earliest technique that is originally meant for preservation until recently that other benefits unfold through research in value addition. Research have thus, unveils several other benefits to include infusion of flavour and/or aroma, enhancement of texture, colour, taste and proximate quality, creation of healthy-protein snacks etc. (Abolagba and Melle, 2008; Ojutiku *et al.*, 2009; Olagbemide, 2015). Owing to these facts, smoked fish are today relished as a delicacy in various homes across the Europe, Africa and Far East.

In Nigeria, smoked catfish *(Clarias gariepinus)* is an important product in cuisines of many cultures, which make a great addition to their balanced diet. According to Olanrewaju *et al.* (2022), smoked catfish constitutes a very popular delicacy that has made its way into the stews and soups of many Nigerian homes. Meanwhile, Viji et al. (2015) perceived that pos-harvest handling practices has a prominent role in determining the quality of the final fish product. Catfish is usually processed by removing the visceral organs (i.e., gutting) before being smoked in the smoking kiln. However, in some quarters, its being smoked without removing the visceral organs (i.e., degutting). Some consumers show preference to Smoked-gutted Catfish, while others preferred Smoked-degutted Catfish, which is basically due to their self-opinion, feelings and taste. Therefore, the reasons for either of these two processes are more of individual preference to taste, rather than nutritional and storage quality. Also, the types and efficiency of smoking kiln used in fish smoking affects fish quality in term of proximate composition, sensory quality and shelf-life. Hence, this study aimed to determine the proximate composition and storage quality of smoked-gutted and degutted C. *gariepinus* from two different smoking kilns.

MATERIALS AND METHODS

The study was conducted in the Department of Fisheries, Modibbo Adama University Yola, Adamawa State, Nigeria. Seventy-two live *Clarias gariepinus* (0.85±74.69 kg) were purchased from Fish Farm in Jimeta-Yola, Adamawa state and safely transported to the Department of Fisheries, Modibbo Adama University, Yola, Adamawa State. The fish were stunned and killed following the method of Roth and Oines (2010) before sorted into groups as gutted and degutted samples. In the gutted samples, guts (i.e., the visceral organs) were removed, while visceral organs (i.e., guts) were not removed in degutted samples. Both samples were washed clean and dipped in a brine solution (5% NaCl) for 10 minutes and allow to drain (Sogbesan et al., 2012). Thereafter, these samples were rounded and smoked in two different smoking kilns based on four treatments as: gutted sample smoked in improved smoking kilns (GSSI), degutted sample smoked in improved smoking kilns (DSSI), gutted sample smoked in FUTTY smoking kilns (GSSF), and degutted sample smoked in FUTTY smoking kiln (DSSF). The smoked fish samples were then cooled to room temperature for 2 h before package into polyethylene bag for preservation (30 days), while some fresh samples were kept separately. A Proximate chemical analysis was then conducted on the fresh and preserved fish samples to determine protein content, lipid content, ash content, fibre content, dry matter, NFE and moisture content following the procedure of AOAC (2020). The data obtained from the study were subjected to descriptive statistics (mean and standard deviation) and one-way analysis of variance (ANOVA), followed by Duncan's test. Differences were considered significant when $p<0.05$. Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) (version 20.0, SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

Table 1 summarizes chemical composition of freshly smoked-gutted and degutted fish samples in two different smoking kilns. The amount of protein was significantly highest ($p<0.05$) in smoked-gutted (67.15±0.29 %) and degutted (67.15±1.18 %) fish samples from FUTTY smoking kilns, while the least was recorded in DSSI (59.01±0.16 %). Lipid ranged from 13.73±0.08 % in smoked-degutted sample smoked improved smoking kiln (DSSI) to 16.65±0.04 % in GSSF samples and there was no significant difference ($p>0.05$) in lipid content between treatment groups, except in DSSF. Ash (8.05±0.12 %) and Fibre (2.70±0.33 %) contents were markedly higher in GSSF, while GSSI sample had significantly highest moisture content (17.10±0.33 %). The proximal composition of preserved smoked-gutted and degutted fish samples in two different smoking kilns was analyzed and summarized in Table 2. Crude protein (CP) showed significant difference between the smoked-degutted fish in Improved smoking kiln (DSSI) and other treatment groups. The highest CP value (69.15±0.29 %) was observed in the DSSF sample while the lowest

Table 1. Proximate composition of freshly smoked gutted and degutted Catfish

Proximate composition	Treatments			
(%)	GSSI	DSSI	GSSF	DSSF
Crude protein	64.10 ± 0.89^{b}	59.01 ± 0.16^{a}	67.15 ± 0.29^{c}	67.15 ± 1.18^{c}
Ash content	7.35 ± 0.12^{b}	5.90 ± 0.08^{a}	8.05 ± 0.12^{c}	7.65 ± 0.04^{b}
Fibre content	2.05 ± 0.20^{c}	0.30 ± 0.00^{a}	2.70 ± 0.33^{d}	0.85 ± 0.04^{b}
Lipid content	16.00 ± 0.16^{b}	16.65 ± 0.04^{b}	16.35 ± 0.49^{b}	13.73 ± 0.08^{a}
Moisture content	17.10 ± 0.33^{c}	9.10 ± 0.00^{b}	2.60 ± 0.48^{a}	1.90 ± 0.08^{a}
Dry matter	82.90 ± 0.33^{a}	90.95 ± 0.04^{b}	97.35 ± 0.53^{c}	98.10 ± 0.08^{c}
Nitrogen Free Extract	7.10 ± 0.89^{b}	9.10 ± 0.16^{c}	3.10 ± 0.33^{a}	8.60 ± 1.14^{c}

GSSI gutted sample smoked in improved smoking kilns, DSSI degutted sample smoked in improved smoking kilns, GSSF gutted sample smoked in FUTTY smoking kilns, DSSF degutted sample smoked in FUTTY smoking kiln, % percentage. Means across the same row differently superscripted differ significantly ($p<0.05$).

Table 2. Proximate composition of preserved (stored) smoked gutted and degutted Catfish

Proximate composition	Treatments			
(%)	GSSI	DSSI	GSSF	DSSF
Crude protein	67.50 ± 0.25^{b}	57.44 ± 0.46^{a}	68.45 ± 0.29^{b}	69.15 ± 0.29^{b}
Ash content	3.95 ± 0.04^{a}	4.30 ± 0.16^{a}	4.70 ± 0.15^{b}	4.00 ± 0.00^{a}
Fibre content	1.25 ± 0.04^{a}	1.35 ± 0.04^{a}	1.50 ± 0.25^{a}	1.15 ± 0.04^{a}
Lipid content	13.55 ± 0.04^{a}	16.30 ± 0.49^{b}	13.90 ± 0.08^{a}	14.20 ± 0.00^{a}
Moisture content	4.95 ± 0.04^{b}	4.50 ± 0.00^{b}	4.10 ± 0.08^{a}	4.00 ± 0.00^{a}
Dry matter	95.05 ± 0.04^{a}	95.50 ± 0.00^{a}	95.90 ± 0.08^{a}	96.00 ± 0.00^{a}
Nitrogen Free Extract	8.80 ± 0.33^{a}	16.62 ± 0.33^{b}	9.09 ± 0.58^{ab}	7.75 ± 0.12^{a}

GSSI gutted sample smoked in improved smoking kilns, DSSI degutted sample smoked in improved smoking kilns, GSSF gutted sample smoked in FUTTY smoking kilns, DSSF degutted sample smoked in FUTTY smoking kiln, % percentage. Means across the same row differently superscripted differ significantly ($p<0.05$).

value (57.44±0.46 %) was observed in the DSSI sample. Lipid (16.30±0.49 %) and Nitrogen free extract (16.62±0.33 %) contents were markedly higher in DSSI, while GSSF sample had significantly highest ash content (4.70±0.15 %). The GSSF sample had the highest fibre content (1.50±0.25 %), while DSSF sample had a higher dry matter (96.00 ± 0.00 %). However, the values obtained for fibre content and dry matter were not statistically different ($p>0.05$) between treatment groups in the study. Moisture content (MC) showed significant difference between the fish in improved smoking kilns and those in FUTTY smoking kiln. Smoked-gutted fish from Improved smoking kiln (GSSI) had the highest significant value ($p<0.05$) of 4.95±0.04 % and the least (4.00±0.00 %) was found in DSSF.

The findings of this study are in contrast with the report by Omoruyi et al. (2018) who reported higher mean crude protein value (26.07±1.28 %) for smoked-gutted C. gariepinus. However, the present finding is comparatively similar to the findings of Sotolu and Abdullateef (2017) who studied the effect of gutting and salting on the organoleptic qualities and proximate composition of smoked-gutted and ungutted, salted and unsalted catfish. The authors found high Crude protein (37.20 %) and NFE (30.30 %) in smoked-gutted and salted catfish, while moisture content (10.50 %) and crude fibre (3.00 %) were highest in smoked-ungutted and salted catfish. Further, the significant high crude protein level in smoked-gutted and degutted fish in FUTTY smoking kilns in the present study correspond with the findings reported by Sogbesan and Ibrahim (2017) for gutted Clarias gariepinus smoked in two smoking kilns. However, the crude protein levels in this study were higher than values (57.83±0.17 – 58.47±0.459 %) obtained by Sotolu and Abdullateef (2017) but similar with values (60.03±5.65 – 61.45±6.67 %) reported by Sogbesan and Ibrahim (2017). Contrary to present study, Omoruyi et al. (2018) reported significantly high crude protein in smoked-gutted C. gariepinus stored for two months. The variations might be attributed to the length of storage which is one month in this study.

CONCLUSION

The study revealed similar results in proximate and storage quality of smoked-gutted and degutted Clarias gariepinus in FUTTY and improved smoking kilns. Though, smoked-gutted C. gariepinus had significantly high ash and fibre contents in fresh samples. However, fish in FUTTY smoking kiln show better proximate and storage quality.

REFERENCES

Abolagba O.J. and Melle O.O. (2008). Chemical composition and keeping qualities of a scaly fish tilapia, Oreochromis niloticus smoked with two energy sources. African Journal of General Agriculture, 4(2):113 – 117.

AOAC (Association of Official Analytical Chemist) (2000). Official Method of Analysis of the Association of Official Analytical Chemist. (15 edition). AOAC International, Washington DC. Methods 992.16-974. 24.

Grema F.A. and Olanrewaju A.N. (2022): Proximate Composition, Microbial Content and Sensory Evaluation of Smoked Farmed and Wild Caught African Catfish (Clarias gariepinus, Burchell 1822) in Maiduguri, Nigeria. Proc. 37th Ann. Conf. Fisheries Society of Nigeria, Modibbo Adama University, Yola, Adamawa State, Nigeria. Pp. 507 – 510.

Ojutiku R.O., Kolo R.J. and Mohammed M.L. (2009). Comparative study of sun drying and solar tent drying of Hyperopisus bebe occidentalis. Pakistan Journal of Nutrition, 8: 955-957.

Olagbemide P.T (2015). Nutritional Values of Smoked Clarias gariepinus from Major Markets in Southwest, Nigeria. Global Journal of Science Frontier Research: Agriculture and Veterinary, 15(6): 2249-4626.

Olanrewaju A.N., Agbelege O.O. and Ibrahim A.U. (2022): Effect of Onion and Garlic Oils on Proximate Composition and Organoleptic Characteristics of Smoked African catfish (Clarias gariepinus, Burchell 1822). Proc. 37th Ann. Conf. Fisheries Society of Nigeria, Modibbo Adama University, Yola, Adamawa State, Nigeria. Pp. 520 – 523.

Omoruyi K., Osamede A. and Abdullahi M.M. (2018). Effects of Bleeding and Gutting Procedures on the Nutritional Value of Smoke- Dried Clarias gariepinus under Storage at Room Temperature. Journal of Applied Life Sciences International, 19(3): 1-8.

Roth, B. and Oines, S. 2010. Stunning and killing of edible crabs (Cancer pagurus). Journal of Animal Welfare, 19(3): 287 – 294.

Sogbesan O.A. and Ibrahim P. (2017). Assessment of Smoked Fish Quality Using Two Smoking Kilns and Hybrid Solar Dryer on Some Commercial Fish Species in Yola, Nigeria. J Anim Res Nutr., 2:6.

Sogbesan O.A., Onwukike C., Onyia L.U., Jauro I.A., Maude A.F., Allison D.S., Aderolu A.Z. and Ukaonu, S.U. (2012). Comparative studies on the efficiency of some economically feasible Fish Processors in North-East Nigeria. National Monthly Referred Journal of Research in Science and Technology, 1(6): 1-7.

Sokamte T.A., Mbougueng P.D., Mohammadou B.A., Tatsadjieu N.L. and Sachindra N.M. (2020). Proximal composition and fatty acid profile of fresh and smoked fillets of Pangasius hypophthalmus. Scientific African 9: (2020) e00534. https://doi.org/10.1016/j.sciaf.2020.e00534

Sotolu A.O. and Abdullateed M.M. (2017). Effect of gutting and salting on the organoleptic qualities and proximate composition of smoked-gutted and ungutted, salted and unsalted Catfish (Clarias gariepinus).

Proc. 42nd Ann. Conf. Nigerian Society for Animal Production, 26 – 30th March 2017, Landmark University, Omu-Aran, Kwara State, Nigeria. Pp. 981 – 987.

Viji P., Tanuja S., Ninan G., Lalitha K.V., Zynudheen A.A., Binsi P.K. and Srinivasagopal T.K. (2015). Biochemical, textural, microbiological and sensory attributes of gutted and ungutted sutchi catfish (Pangasianodon hypophthalmus) stored in ice. J Food Sci Technol., 52(6): 3312–3321

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

MEAT QUALITY AND SWELLING CHARACTERISTICS OF THE FLESH OF *Callinectes amnicola* FROM THE CROSS RIVER ESTUARY, ORON, SOUTHEAST NIGERIA: IMPLICATIONS FOR PROCESSING

Udoh, J. P.1 , J. E. Ukpatu2 and A. J. Otoh2

1Department of Fisheries and Aquatic Environmental Management, Faculty of Agriculture, University of Uyo, Uyo, Nigeriair: jamesudoh@ uniuyo.edu.ng, jjamesphilip@gmail.com;
2Department of Fisheries and Aquaculture, Akwa Ibom State University, Obio Akpa Campus, Oruk Anam, Nigeria; johnukpatu@aksu.edu.ng; aniekanotoh@aksu.edu.ng

Corresponding Author:
jamesudoh@uniuyo.edu.ng, +234-802-3197962, 0000-0003-1153-0915

ABSTRACT

Crab meat has a short shelf-life and therefore requires the flesh being processed immediately. Such processing could results in swelling and toughness of the meat; thereby affecting consumers' acceptance. Adult crab samples (n = 100; 63.21±8.12, 31.78-83.32 mm carapace length) were purchased from fishers at the fish market beach at Oron in Cross River Estuary, Nigeria. Their proximate composition was determined. Chunks of crab meat were subjected to 11 different acid and salt solutions commonly applied in crab canning and processing. The crab samples were of good wellbeing and shared similar proximate composition (%moisture, 72.400 ± 3.610, %ash, 1.025± 0.006, %fibre, 0.243± 0.001, %lipid, 1.120 ± 0.014, %protein, 22.050 ± 0.003, and %carbohydrate, 3.162± 4.739) with C. *amnicola* from south-western and south-eastern Nigeria. The reagents assessed in this study that evoked the 30-40% swelling capacity considered acceptable crab meat quality, both tender and firm, are: the chloride salts of ammonium (1.2 mol NH Cl), sodium (1.6-1.8 mol NaCl), and potassium (0.4-0.6 mol KCl); including potassium iodide, 0.6 mol KI.

Keywords:
Brining, blue economy, canning, water retention.

INTRODUCTION

Crabs are rich in proteins, lipids, vitamins A, C, B6, thiamine, riboflavin, niacin, panthothenic acid with small amount of folate and vitamin B12, small quantities of calcium, iron, copper, zinc, phosphorous and potassium (Oduro *et al*, 2001; Udo and Arazu, 2012).Udofia *et al.* (2013) established the protein content of marine C*allinectes amnicola* in southeast Nigeria range from: whole crab meat: 60-48%; cheliped: 35-23%; crab legs: 39-45%; with the protein content higher in males than females, respectively. The crabs have as much as 26-32, 12-15, and 7-9 mg Vitamin A per 100 g; 53-96, 99-66 and 68-71 mg Iron per 100 g; and 21-14, 23-14 and 10-9 mg Zinc per 100 g in male and female, and in crab meat, cheliped and crab legs, respectively.

Earlier studies have described the food and feeding habits (Udoh and Jimmy, 2015), nutritional profile (Udofia et al., 2013), biology and size compositions (Nlewadim *et al.*, 2009; Udoh, 2011, 2017; Udoh and Nlewadim, 2011; Udoh *et al.*, 2011); age, growth parameters and recruitment patterns (Udoh, 2020), and reproduction and sexual maturity (Udoh et al., 2009), of C. *amnicola* from southeast Nigeria.

Crab meats are highly consumed locally in the study area; therefore, there is a need to extend the shelf-life through further processing. The processing of crab meat is aimed at preserving the meat while maintaining its texture, flavor, and safety. The muscle tissue in crab meat consists of myofibrillar proteins that can tolerate a wide range of ionic concentrations including the ability to bind water molecules, increasing moisture content (protein hydration). Crab swelling could also be through osmosis (the movement of water into the crab meat cells through semi-permeable membranes) and gelation, proteins coagulate, trapping water and increasing moisture retention (Haurowitz, 2021). Other factors contributory to the phenomena of swelling and toughness in crab meat include acid (pH) and salt concentrations, temperature or heat treatment during water-washing and blanching in steam or boiling water, water activity (aw) and processing methods, e.g., cooking, freezing (Baiano and Conte, 2020; Haurowitz, 2021; Food and Drug Agency, FDA, 2022). Hence during blanching, the crab muscle proteins interact with water resulting in swelling (corresponding to its water holding affinity). Apart from crab fattening and cultivation, canning of crab meat for export will add value to the fishery sector. This study therefore, reports on aspects of treatment of crab meat for canning, particularly its swelling characteristics in different acidic and alkaline salts.

The objective of this study was to assess the meat quality of C. *amnicola* from Cross River estuary, Oron; and to examine the various concentrations of (hydrochloric) acid and 10 different salt solutions that will elicit 30-40% swelling of crab meat considered to be both tender and firm and of acceptable quality.

MATERIALS AND METHODS

Study area

Samples of C*allinectes amnicola* used for this study were collected along Cross River estuary at Oron in Akwa Ibom State, Nigeria; latitude 04° 15.9' N and longitude 08°20' E.

Sample collection, sex determination and morphometric measurement

The crab samples (n=100) were purchased from fisherfolks who landed their catch at the beach market at Oron in Akwa Ibom State, Nigeria. Sex determination was based on morphology of abdomen (Udoh *et al.*, 2011). The carapace length (CL mm), carapace width (CW mm) were measured to 0.1 mm using a sliding jaw vernier calipers (Mitutoyo 530-312) as described in Udoh et al. (2011). The total weight (TW) was taken to the nearest 1.0 g using an electronic weighing balance (TDA6002A) to the nearest tenth of a gram. Condition factor evaluated the general wellbeing of the crabs as K = TW x CL-3 x100.

Proximate analysis

The proximate composition of the crab was determined by the methods recommended by Association of Official Analytical Chemists (AOAC, 2005). The moisture content was taken as the weight loss after oven-drying crab parts at 105°C using the Kjeldahl method. Fat content was determined by acid hydrolysis using a Soxhlet apparatus and ash was determined by dry ashing after incineration of weighed sample at 600°C for 10 hours in a muffle furnace. The carbohydrate content was estimated by subtracting the sum of the weight of protein, fiber and ash from the total dry matter (AOAC, 2005). All determinations were done in duplicates.

The influence of salt and hydrogen ion concentrations on the degree of the swelling of crab meat

Blocks of crab meat (about 2 cm) were taken from the raw leg meat of each crab, weighed (g), and immersed in 50 ml of various concentrations of various salt and acid solutions and allowed to stand in a cool dry place for 24 hours. After adsorbing the salt or acid solution, the blocks were wiped off with a filter paper, and their weight measured. The ratio of the weight of the block of meat after immersion (W) to the weight of meat before immersion (Wo) was calculated as the swelling equilibrium or degree of the swelling of the block of meat (Seq= W/Wo) (Gierszewska and Ostrowska-Czubenko, 2016).

The salt solutions assessed were: NaCl – Sodium chloride, KCl – Potassium chloride, CaCl2 – Calcium chloride, KI – Potassium iodide, KNO3 – Potassium nitrate, NaNO3 – Sodium nitrate, NH4Cl – Ammonium chloride, and Na2HPO4 – Sodium phosphate. Each salt solution was assessed at 10 concentrations of 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8 and 2.0 Mol, respectively. Distilled water was used as control.

The hydrochloric acid, HCl, concentrations assessed were pH 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, and 14. Adjustment to required pH was achieved by dilution with 0.1 N NaOH, sodium hydroxide.

STATISTICAL ANALYSIS

The Statistical Package for Social Science (SPSS version 20) was applied in length and weight calculations, condition factor; as well as in calculating regression lines and coefficients for swelling behaviour of the crab meat in hydrogen ion and salt concentrations. All the statistical analyses were considered at significant level of 5% ($p<0.05$).

RESULTS AND DISCUSSION

Morphometric parameters of crab samples

The mean sizes (± standard deviation and range) of the 100 crabs used were: 63.21±8.12 mm (31.78-83.32) carapace length, 127.35±20.29 mm, (40.41 -169.55) carapace width, 150.30±55.77g (53.77-282.03) total weight and 0.645±0.454 (0.272-3.303) condition factor. Eighty-one, 81 male and 19 female samples of C. amnicola were used for this study. The mean sizes (± standard deviation and range) of male crabs used were: 64.64±7.87 mm (31.78-83.32) carapace length, 129.50±21.48 mm (40.41-169.55) carapace width, 165.89±50.17 g (67.8 -282.03) total weight and 0.680±0.486 (0.272-3.303) condition factor. The mean sizes (± standard deviation and range) of female crabs used were: 57.12 ± 6.27 mm (43.12-67.13) carapace length, 118.19±10.19 mm (91.31-130.79) carapace width, 83.82 ±12.79 g (53.77 -95.31) total weight and 0.489±0.209 (0.275-1.12) condition factor. The nutritional and swelling characteristics of crabs used in this study were determined irrespective of sex or size.

Nutritional quality of Callinectes amnicola

The summary of the proximate composition of C. amnicola from study area is shown in Table 1. The nutritional quality of the crab obtained in this study was similar and comparable to those earlier reported for the species in southeast (Udo and Arazu, 2012) and as far as southwest Nigeria (Moronkola et al., 2011; Jolaosho et al., 2023) (Table 1). This confirms that crabs are highly nutritious and rich in proteins. However, Udofia et al. (2013), reported on the nutritional quality of marine C. amnicola species which was higher (60-48% crude protein) than their estuarine counterparts in this study (22.05%). Fagbenro et al. (2014) further support the high quality of crab meat as being low in anti-nutrients such as tannin, phytin and oxalate.

Table 1: Average proximate composition of C. amnicola from Cross River estuary (Oron, Nigeria) compared with other sites

Parameter	Cross River Estuary (Oron, Nigeria)	Cross River (Calabar, Nigeria)	Makoko settlement (Lagos, Nigeria)	Ojo River (Lagos, Nigeria)
% Moisture	72.400 ± 3.610 (70.50 - 74.3)	74.54 ± 0.03	62.57 ± 2.16	67.377 ± 0.226
% Ash	1.025 ± 0.006 (0.95-1.1)	1.84 ± 0.07	3.04 ± 0.42	1.041 ± 0.002
% Fibre	0.243 ± 0.001 (0.211-0.275)	0.10 ± 0.02	0.23 ± 0.19	1.021 ± 0.002
% Lipid	1.120 ± 0.014 (1.0-1.24)	0.45 ± 0.02	1.76 ± 0.46	0.023 ± 0.008
% Protein	22.050 ± 0.003 (22.0-22.1)	20.12 ± 0.01	26.34 ± 2.02	28.000 ± 0.071
% Carbohydrate	3.162 ± 4.739 (0.9850-5.339)	2.92 ± 0.07	5.05 ± 0.86	2.50 ± 0.22
% References	**This study**	Udo an Arazu (2012)	Jolaosho *et al.* (2023)	Moronkola *et al.* (2011)

Values are in mean ± standard deviation   Ranges are in parenthesis

Swelling behaviour of C. amnicola meat immersed in hydrogen ion concentrations

The swelling capacity and meat quality of C. amnicola flesh in acid solutions was strongly dependent on pH of swelling medium. The swelling value, Seq, was high at low pH and decreased with increasing pH (Fig. 1). The highest (0.79) and lowest (0.2) degree of swelling was at pH 14.0 (in alkaline medium) and 3.0 (in acidic medium); i.e., corresponding to levels of swelling and toughness, respectively. At pH below pH 4.0 (acidic range), the degree of swelling significantly increased (from 1.24 to 2.02) and at above pH 9.0 (alkaline range), the degree of swelling increased gradually (from 0.46 to 0.79). The acid solutions toughened crab meat in two ways; by creating an isoelectric or electrochemical gradient leading to permeability of the muscle membrane to the ions and leakage of ions out from the muscle fibres through osmosis (Haurowitz, 2021). Or by formation of cross-links between proteins (Feiner, 2006), causing water to be released and resulting in drier, more rigid and tougher meat (as observed at pH 3in this study). The constituent acids in blue crabs also contribute to these quality changes. For instance, blue crabs are a rich source of calcium, magnesium, phosphorus, potassium and sodium (Moronkola et al., 2011; Fagbenro et al., 2014) as well as acidic (asparatic acid, glutamic acid) and basic amino acids like arginine and lysine (Haurowitz, 2021).

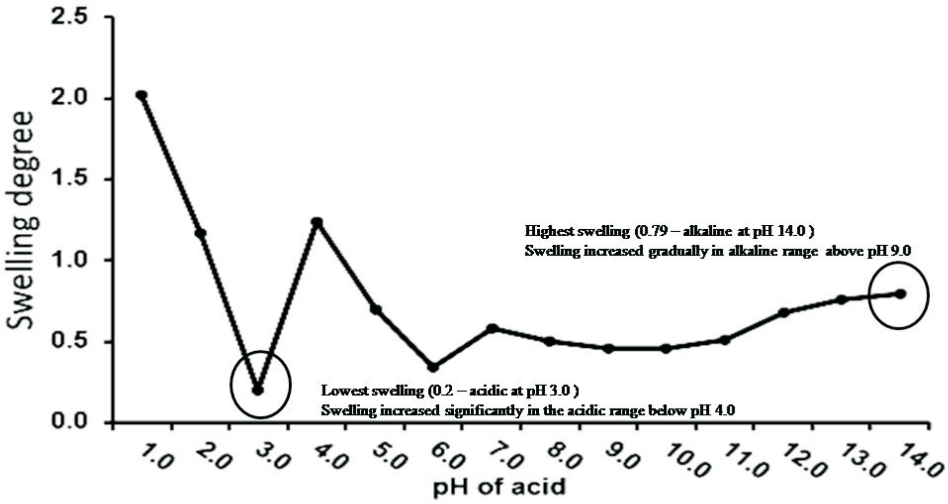

Figure 1. The influence of hydrogen ion concentration on the degree of swelling of C. amnicola meat showing acids denatured proteins causing water to be released; resulting in drier, more rigid and tougher meat (at pH 3).

Swelling behaviour of C. amnicola meat immersed in different salt concentrations

The results obtained showed that changes in meat texture or toughness increased with increase in salt concentrations depending on the ion types, whether anion or cation (Figs. 2, 3). Salt solutions (anions and cations) at different concentrations play a dual role in processing by increasing the ionic strength of the solution surrounding the crab meat; and influencing protein solubility by increasing the weight of the crab meat with or without change in meat texture (Rodriguez et al., 2020). Various changes (soft, hard, no difference) in meat texture/toughness were observed after immersion of crab meat in the different solutions till equilibrium. Immersion of crab meat in KCl, KNO3, NaCl, and distilled water solutions elicited no difference in meat texture. Crab meat dipped in CaCl2 and Na2HPO4 solutions were toughened (moisture loss) while, KI, NH4CL and MgCl2 softened crab meat (moisture retention and swelling); use of distilled water and NaNO3 recorded increase in weight with no significant difference in meat texture but imparted slight off flavour on the meat of C. amnicola ($P > 0.05$). In terms of anion concentrations, Na+ (NaNO3) elicited more swelling and increase in weight (Fig. 3A-C), followed by K+ (KCl > KI, Fig. 2B), Ca2+ (CaCl2), NH4+ ions, NH4Cl (Fig. 2C) and sodium, NaCl (Fig. 2A). Magnesium (Mg) and calcium (Ca) salts were also observed to have a toughening effect on the crab meat (Table 2). This could be because the crab membranes are impermeable to the bulk of the anion fraction, to sodium and to large ions such as calcium and magnesium, but permeable to small ions such as potassium and chloride (Ward and Courts, 2017). Furthermore, toughening of crab meat was likely caused by formation of stable protein complexes, protein aggregation and shrinkage, leading to water loss and tough crab meat (Xiong, 2015; Ward and Courts, 2017; Rodriguez et al., 2020).

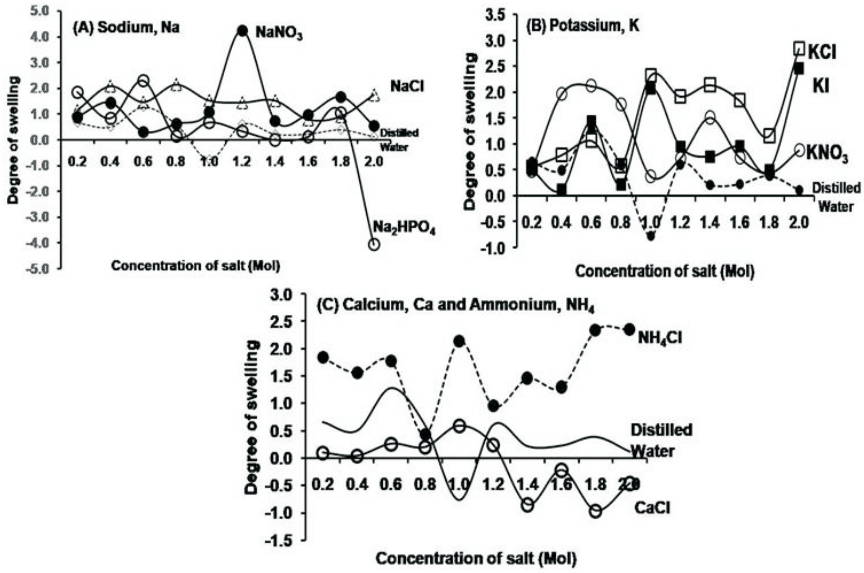

Figure 2.Swelling curves of C. amnicola flesh immersed in salt solutions of various concentrations of varying anions: a. Sodium, Na+, b. Potassium, K+ and c. Calcium, Ca and Ammonium, NH4

The cation chloride solutions (NaCl and NH4Cl, and KCl) also elicited higher swelling (Seq) values on C. amnicola meat. However, decreased swelling (Seq) (i.e., toughness) were obtained with the use of chloride (in the form of CaCl2), phosphate (Na2HPO4) and nitrate (NaNO3 and KNO3) solutions (Fig. 3B.). The order of degree of swelling at equilibrium for cation chloride and iodide solutions was KCl> KI > NH4Cl > NaCl with positive slope; negative slope (shrinking/toughened crab meat) was obtained with CaCl2 (Fig. 2A, 3C). The calculated regression lines and the regression coefficients are shown in Table 2.

C. amnicola meat immersed in salt solutions up to 2 Mol of NaCl, KNO3, NH4Cl, KCl and KI displayed swelling curves with two peaks, while NaNO3, Na2HPO4, and CaCl2 had one peak. These observations support the application of sodium chloride (NaCl) in enhancing flavor, texture, and moisture retention; potassium chloride (KCl) helps to maintain moisture retention and texture while calcium chloride (CaCl2) improves texture and moisture retention (FDA, 2022) during processing.

The practical implication of processing apart from preservation is the economic aspect of the marketability of the product in meeting consumers' preference for crab meat texture. The most desirable crab meat quality is a juicy, tender, firm crab flesh which easily breaks apart and gives a 'mouthfeel' experience during consumption; not mushy, watery or fibrous dry meat (NOAA, 2019; Baiano and Conte, 2020). Such product must have a balance between tenderness and firmness. The products in this study were not subjected to organoleptic tests but the National Oceanic and Atmospheric Administration, NOAA (2019) recommend that canned crab meat should absorb enough liquid to swell to 30-40% of its original weight to be considered both tender and firm. The reagents in this study that evoked this quality are: 0.6 mol KI, 1.2 mol NH□Cl, 1.6-1.8 mol NaCl, and 0.4-0.6 mol KCl. Reagents in this study were used one at a time. Furthermore, Rodriguez et al. (2020) recommend exploring brining with a mixture of sodium chloride and other salts to achieve a better result of enhancing flavor and maintaining juiciness during heat processing.

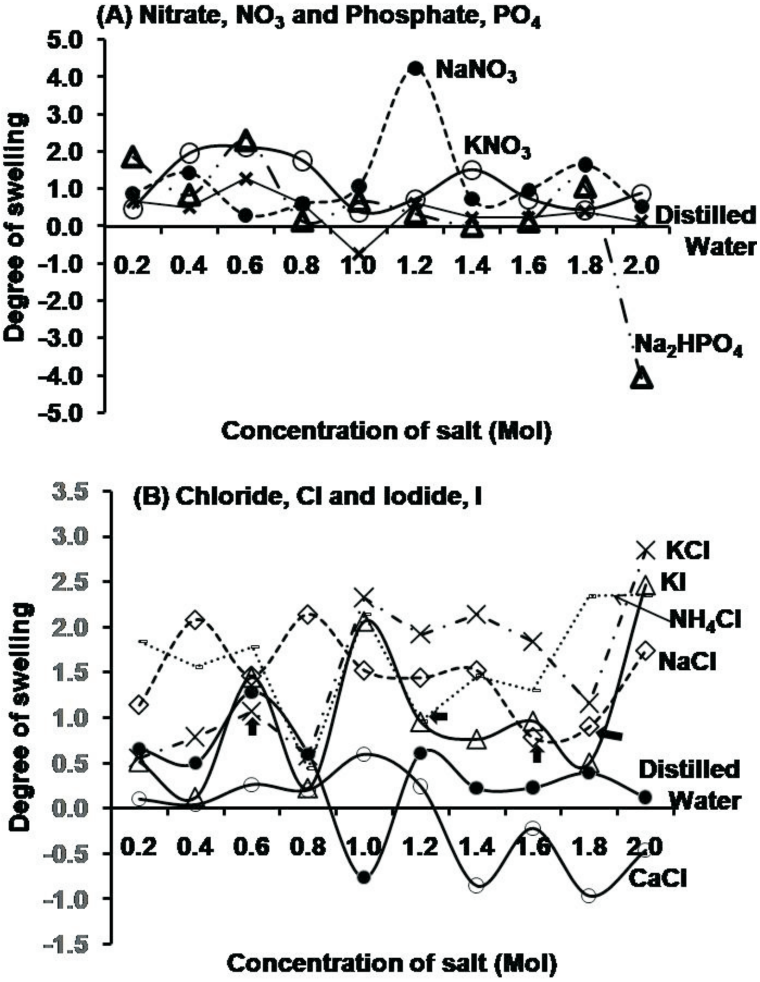

Figure 3. Swelling curves of Callinectes amnicola flesh immersed in salt solutions of various concentrations of cations : (a.) nitrate and phosphate and (b.) chloride and iodide ions

Table 2: Swelling behaviour of C. amnicola flesh in different saltx and acidy concentrations

Salt solutions	Slope, *b*	Error b	A	Error a	r	*P*	Remark
Na_3HPO_4	-1.92	0.74	2.44	0.92	-0.68	0.03*	Toughened meat
CaCl	-0.54	0.23	0.49	0.28	-0.65	0.04*	Toughened meat
Distilled Water	-0.43	0.36	1.58	0.45	-0.39	0.26^{ns}	No difference in
$NaNO_3$	-0.32	0.28	0.74	0.35	-0.38	0.28^{ns}	meat texture
KNO_3	-0.25	0.25	1.75	0.31	-0.34	0.34^{ns}	Toughened meat
NaCl	0.16	0.66	1.07	0.81	0.09	0.81^{ns}	Softened meat
NH_4Cl	0.29	0.34	1.30	0.42	0.29	0.42^{ns}	Softened meat
KI	0.56	0.41	0.39	0.50	0.43	0.21^{ns}	Softened meat
KCl	0.95	0.32	0.48	0.40	0.72	0.02*	Softened meat
Acid pH	-0.05	0.03	1.11	0.25	-0.44	0.12^{ns}	Toughened meat

ns = Non-Significant (P > 0.05)   * = Significant (P < 0.05)
xSalt concentrations = 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8 and 2.0 mols
ypH (HCl) = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14

CONCLUSION

C. amnicola meat from southeast Nigeria is protein-rich and a good candidate for further processing and added value for consumption, export and income generation. The swelling behaviour of crab meat in water, and acidic and lkaline solutions were also studied; in achieving the desired balance between tenderness and firmness of crab meat quality. The study showed that equilibrium water content, Seq, was dependent on the ionic strength of the media: high at low values of pH (below pH 4.0) and decreased with increasing pH (above pH 9.0). Crab meat swelling behaviour in the alkaline media was dependent on cation type and salt concentration. Softened, hardened, and indifferent crab meat textures were observed at equilibrium soaking. Results suggest the use of the chloride salts of ammonium (NH□Cl), sodium (NaCl), and potassium (KCl); including potassium iodide, KI. will produce crab meat that is tender and firm in line with consumers' preference.

REFERENCES

Association of Official Analytical Chemists, AOAC (2005). Official Methods of Analysis (18th ed.). Arlington, V. A., USA. 96p.

Baiano, A. and Conte, A. (2020). Food preservation: Canning, freezing, and drying. Journal of Food Science and Technology 58(6),1027-1033.

Fagbenro, O., Majolagbe, F. and Oso, J. A. (2014). Proximate composition and mineral content of the land crab Sudanonautes africanus. Journal of Scientific Research and Reports,3(2), 349-355.

Food and Drugs Administration, FDA (2022). Fish and Fisheries Products Hazards and Controls Guidance. FDA, 553 p.

Feiner, G. (2006). Meat Products Handbook: Practical Science and Technology. CRC Press, 671 p.

Gierszewska, M. and Ostrowska-Czubenko, J. (2016).Equilibrium swelling study of crosslinked Chitosan membranes in water, buffer and salt solutions. Progress on Chemistry and Application of Chitin and its Derivatives 21, 55-62. https://doi.org/10.15259.PCACD.21.05

Haurowitz, F. (2021). Protein denaturation and water retention in seafood. Annual Review of Food Science and Technology 11(2),345-367.

Jolaosho, T.L., Elegbede, I. O., Akintola, S. L., and Jimoh, A. A. (2023). Biometric and gonadosomatic indices and chemical constituents of edible tissues and exoskeletons of Callinectes amnicola and their potential for reuse in the circular economy paradigm. Scientific Reports 13,8502

Moronkola, B. A., Olowu, R. A., Tovide, O. O. and Ayejuyo, O. O. (2011). Determination of proximate and mineral contents of crab (Callinectes amnicola) living on the shore of Ojo river, Lagos, Nigeria. Scientific Reviews and Chemical Communications 1(1), 1-6

National Oceanic and Atmospheric Administration, NOAA (2019). Canned crab meat. In: Fishery Market News 57, 12

Nlewadim, A. A., Ofor, C. O. and Udoh, J. P. (2009).Size composition and population characteristics of the swimming crab Callinectes amnicola (De Rocheburne, 1883) (Crustacea, Brachyura, Portunidae) in the Imo River estuary, Nigeria. Nigerian Journal of Agriculture, Food and Environment, 9 (2-4): 47–60.

Oduro, W, Ellis, W.O., Oduro, I. and Tetteh, D (2001). Nutritional quality of selected Ghanaian crab species. Journal of Ghana Science Association 3, 37-40.

Rodriguez, A., Johnson, M., and Sanchez, E. (2020). Canning techniques in seafood processing. Advances in Food Science and Technology,22(3),478-490.

Udo, P. J. and Arazu, V. N. (2012). The proximate and mineral composition of two edible crabs Callinectes amnicola and Uca tangeri (Crustacea: Decapoda) of the Cross River, Nigeria. Pakistan Journal of Nutrition 11(1), 78 – 82.

Udofia, U.S., Udoh, J. P. and Udo, M. T. (2013). Nutritional components of male and female blue crabs (Callinectes latimanus) from marine environment. International Journal of Family and Consumer Sciences, 2, 84-90.

Udoh, J. P., Nlewadim, A. A and Ofor, C. O. (2009). Maturity estimation in male swimming brachyuran crab, Callinectes amnicola(De Rocheburne, 1883)(Decapoda, Portunidae) in the Imo River estuary, Nigeria. Nigerian Journal of Agriculture, Food and Environment 4 (1 - 4), 61 – 71

Udoh, J. P. (2011). Racial study and cheliped fluctuating asymmetry of the blue crab Callinectes amnicola De Rocheburne, 1883 (Crustacea, Portunidae) from tropical oligohaline and mesohaline estuaries of Niger Delta, Nigeria. Nigerian Journal of Fisheries 8, 176 – 183.

Udoh, J. P. (2017).Size composition and growth pattern of by-catch marine crabs Callinectes amnicola off the Atlantic Coast, Southeast Nigeria. Journal of Forestry, Environment and Sustainable Development (JOFESD) 3 (1), 71-88.

Udoh, J. P. (2020). Age, growth parameters and recruitment patterns of the blue crab Callinectes amnicola of Imo and Qua Iboe River Estuaries, Southeast Nigeria. Tropical Freshwater Biology, 29(2),95-121.

Udoh, J. P. and Jimmy, U. U. (2015). Dietary spectrum, dispersity and overlaps of Blue crab (Callinectes amnicola, de Rocheburne) fromsoutheast Nigeria. Croatian Journal of Fisheries 73,162-169.

Udoh, J. P. and Nlewadim A. A. (2011). Population characteristics of the swimming crab Callinectes amnicola De Rocheburne, 1883 (Crustacea, Brachyura, Portunidae) in the Qua Iboe River estuary, Nigeria. AACL Bioflux 4(3), 395-405

Udoh, J. P., Holzlohner, S. and Ekanem, S. B. (2011). Population Structure and Biometric Relationships of Callinectes amnicola DeRocheburne, 1883 (Crustacea, Brachyura, Portunidae) from the Cross River Estuary, Nigeria.Nigerian Journal of Fisheries 8, 145 – 153.

Ward, S., and Courts, J. (2017). The impact of calcium and magnesium salts on meat tenderness. International Journal of Food Science 5(1), 90-105.

Xiong, Y. L. (2015). Protein functionality in meat processing. Food Science Reviews 29(8), 432-440.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

BACTERIOLOGICAL STATUS OF TWO SMOKED FISH PRODUCTS FROM THREE MARKETING CENTRES IN YENAGOA, BAYELSA STATE, NIGERIA

Kosuowei, I. F., and A. O. Adeyemo

Department of Fisheries and Aquatic Studies, Niger Delta University, Wilberforce Island, Bayelsa State

Corresponding Author:
inemotimikosuowei@gmail.com; +2349156054226; 0009-0008-4123-204X

ABSTRACT

The study evaluates the bacterial and coliform load of two smoked fish species, Hake (Merluccius capensis) and Horse Mackerel (Trachurus trachurus), sold in three markets in Yenagoa Metropolis, Bayelsa State, Nigeria to help establish if the level of microbial loads exceeds the permissible levels of the ICMSF. Thirty samples were taken from the markets monthly for three months, five from each species; making a total of 90 smoked fish samples. Bacterial analysis was conducted at the microbiology laboratory of the Department of Biological Science, Niger Delta University. Result showed that Market 1 consistently had the lowest bacterial load (59.37cfu/g for Hake and 59.93cfu/g for Horse Mackerel), Markets 2 and 3 showed higher contamination levels, with the highest load in Market 2 (141.63cfu/g for Horse Mackerel). The overall mean bacterial loads from the two smoked fish products were 103.18±23.16cfu/g and 105.89±24.13cfu/g for Hake and Horse Mackerel respectively, with no significant differences between species of same market, but between the markets. The findings indicate changes in microbial contamination is dependent on market conditions, underlining the need for enhanced handling, processing and storage of smoked fish products.

Keywords:
Bacteriological status, bacterial load, coliform bacteria, smoked-fish, hake, horse mackerel

INTRODUCTION

Smoked fish are well accepted food items in our country, as well as in Bayelsa State. Smoking is the method of fish preservation resulting from a combination of drying and deposition of naturally produced chemicals resulting from the thermal breakdown of wood (Smoldering/smoke production) (Rawson, 1966). Smoking adds a desirable colour, taste and odour, a longer shelf-life to fisheries products through its anti-bacterial and oxidative effect. (Abolagba and Melle, 2008; Clucas and Ward, 1996; Eyo, 2001; Horner, 1992; Olokor *et al.*, 2007). Notwithstanding, smoked fish and shellfish products have been identified to be carriers of microbial hazards including Listeria monocytogenes, Salmonella spp., Clostridium botulinum and other pathogens (Özyurt, Polat, 2016). This could be as a result of poor fish handling at processing, marketing and storage stage or improper smoking, resulting in partial removal of water activity (Heintz and Johnson, 1998). In Southern Nigeria, fish products are the most important source of animal proteins (Kpodékon et al., 2014).

The production of safe fishery products for indigenous consumption in developing countries like Nigeria is still a major challenge (Bellmann et al., 2016; Kipkoech *et al.*, 2022). As a result, bacteriological and ecological issues have prompted the need to assess and determine microbial overloads in fishery products (Kousar *et al*, 2020; Liang *et al.*, 2021). More so, international organizations such as the Food and Agricultural Organisation (FAO) and the World Health Organisation (WHO) are working to control the infections associated with food products in various ways with the aid of some regulatory mechanisms such as the Hazard Analysis and Critical Control Point (HACCP) and Codex Alimentarius (Graham, 2014).

Considering the consequences of bacteria which includes cholera, shigellosis, typhoid fever, severe dysentery and other gastrointestinal infections to humans, it is imperative to determine some harmful bacteria associated with smoked fish. This research is intended, among other things, to help establish if the level of microbial loads exceeds the permissible levels of the International Commission on Microbiological Specifications for Foods (ICMSF). Furthermore, this study may also be useful in developing public health campaigns aimed at creating awareness of wholesomeness and safety of smoked fish, especially in Bayelsa State, as well as improve fish smoking activities along the processing chain.

MATERIALS AND METHODS

The study is a comparative cross-sectional design to explore bacteria species occurrence and abundance (loads) of smoked fish in Yenagoa, Bayelsa State. It was also directed towards determining the characteristics of the situation as it exists during the period of the study. The study area was Yenagoa, the capital of Bayelsa State. Yenagoa has an estimated population of between 600,000 and 700,000. Samples were taken from three smoked fish marketing centres (market 1-Swali, market 2-Kpansia and market 3-Etegwe) located in different geographical areas in Yenagoa using the purposive sampling technique. While simple random technique was used to select the ninety smoked samples, (five (5) of each fish species from each market for three (3) months). Bacteriological analysis was conducted at Microbiology laboratory of the Department of Biological Science, Niger Delta University, Wilberforce Island, Bayelsa State. The samples were placed in germ-free plastic bags and labelled appropriately based on the sampling area and transported to the Microbiology laboratory of the Department of Biological Science, Niger Delta University, Wilberforce Island, Bayelsa State for bacteriological analyses. The bacteriological analysis of the fish samples was done using conventional microbiological methods (WHO, 2021). Catalase test, citrate utilization test, Kliger Iron Ager Test, Indole test and oxidase test were carried out with respect to Cheeseburg (2018) guidelines.

Quality Control: Quality control measures was done during the analysis to confirm the accuracy of the results. In every analytical batch, all samples were analysed separately with a series of serial dilutions to ensure accuracy.

Statistical Analysis: The means of bacterial load among the three markets were compared using ANOVA followed by Tukey's post hoc for multiple comparisons while t test was used to compare the bacteria load of the two species. Microsoft Excel 2010 and Statistical Package for Social Sciences version 16.0 was used to analyse the data with $p<0.05$ level of significance.

RESULTS AND DISCUSSION

Mean Bacterial Load of Two Fish Species in Three Markets: The mean bacterial load of two fish species across three markets is presented in Table 1. For Hake (Merluccius capensis), Market 1 recorded the lowest bacterial load at 59.37 cfu/g, while Market 3 had the highest mean load at 138.11 cfu/g. The results indicate that the bacterial load in Market 1 is significantly different from those in Markets 2 and 3, whereas the loads in Markets 2 and 3 are not significantly different from each other.

Similarly, for Horse Mackerel (Trachurus trachurus), Market 1 had the lowest mean microbial load at 59.93 cfu/g, with Market 2 showing the highest bacterial load at 141.63 cfu/g. Again, the bacterial load in Market 1 is significantly different from those in Markets 2 and 3, while Markets 2 and 3 are not significantly different from each other. Both fish species exhibit the lowest bacterial loads in Market 1, significantly lower than those in Markets 2 and 3. In Market 2, the bacterial load significantly increases for both species. In Market 3, the bacterial load remains high but is not significantly different from that in Market 2.

The study aligns with similar studies that reported significant variations in bacterial loads in fish from different markets. For instance, a study conducted by Mensah et al. (2019) in Accra, Ghana, found that fish from open markets had significantly higher bacterial loads compared to those from supermarkets, which maintained better hygiene practices and cold chain management. Okonko et al. (2011) also opined similar findings in their study of fish markets in Lagos, Nigeria, where bacterial loads in fish varied significantly between markets with different hygiene practices. Fish from markets with poor hygiene had higher bacterial contamination levels, which is consistent with the high bacterial loads observed in Markets 2 and 3 in this present study. Adebolu et al. (2017) also found that fish from markets with inadequate sanitation facilities had significantly higher bacterial counts. This supports the current findings, where Market 1, presumably with better handling practices, shows the lowest bacterial load, having a bacterial load within the international permissible limit of microbial load in food which is 20 to < 100 cfu/gram.

The high bacterial loads observed in Markets 2 and 3 in Yenagoa are consistent with findings from Eze et al. (2020), who reported that inadequate hygiene, poor storage conditions, and high ambient temperatures contribute to higher bacterial contamination in fish sold in open markets in Nigeria (Eze et al., 2020). The current study's results reflect these conditions, emphasizing the need for improved sanitary practices. Adedeji et al. (2014) highlighted the role of environmental conditions and handling practices in determining bacterial loads in fish. Their study in Ibadan, Nigeria, showed that high ambient temperatures and poor handling practices led to increased bacterial contamination, aligning with the current study's observations in Yenagoa

Eze et al. (2020), as previously mentioned, pointed out that inadequate hygiene and storage conditions are major contributors to high bacterial loads in fish. This is consistent with the significant differences in bacterial loads observed between Market 1 and the other two markets in Yenagoa.

The current study observed that Horse Mackerel had a higher bacterial load in Market 2 compared to Hake. This observation aligns with findings by Ali et al. (2018), who noted that different fish species can exhibit varying levels of bacterial contamination depending on their physiology, habitat, and handling practices post-harvest. Olowokere et al. (2018) also elucidate that bacterial loads in fish can vary by species, influenced by factors such as their natural habitat and handling post-capture.

Table 1: Mean bacterial load of two smoked fish products in three Yenagoa markets

Fish Species	Market1 (cfu/g)	Market2 (cfu/g)	Market3 (cfu/g)
Hake (*Merculius capensis*)	59.37^{b}	112.07^{a}	138.11^{a}
Horse mackerel (*Trachurus trachurus*)	59.93^{b}	141.63^{a}	116.11^{a}

Note: Means with the same alphabet across the row are not significantly different.

Mean Coliform Bacteria Load of Two Smoked Fish products in three Markets in Yenagoa: Table 2 presents the mean coliform bacterial load of two fish species in three markets in Yenagoa. For Hake (Merluccius capensis), Market 1 recorded a coliform bacterial load of 4.14 x 105 CFU. This load is relatively lower compared to those in Markets 2 and 3, with Market 2 having the highest coliform bacterial load for Hake at 7.98 x 105 CFU/g. Market 3 recorded a bacterial load of 5.93 x 105 CFU/g, which is lower than Market 2 but higher than Market 1. Thus, the coliform bacterial load is highest in Market 2, followed by Market 3, and lowest in Market 1.

For Horse Mackerel (Trachurus trachurus), the coliform bacterial load in Market 1 was 4.16 x 105 CFU/g, which is significantly lower compared to Markets 2 and 3. Market 2 recorded the highest coliform bacterial load for Horse Mackerel at 9.15 x 105 CFU/g. In Market 3, a bacterial load of 5.90 x 105 CFU/g was observed, indicating a lower bacterial load than Market 2 but higher than Market 1. Hence, the coliform bacterial load is highest in Market 2, followed by Market 3, and significantly lower in Market 1. Comparing the fish species, Horse Mackerel has a slightly higher bacterial load compared to Hake in Market 2. In Market 3, both fish species have nearly identical bacterial loads. However, in Market 1, Hake, with 4.14 x 105 CFU/g, has a significantly higher coliform bacterial load than Horse Mackerel.

The mean coliform bacterial load from Yenagoa markets aligns with the reports of. Adebayo-Tayo et al.

(2012a) on the microbial quality of frozen fish in Ibadan, Nigeria, reported coliform loads ranging from 3.0 x 105 to 7.5 x 105 CFU/g. These values are comparable to the coliform levels in Hake across the three markets in Yenagoa, with the highest load being 7.98 x 105 CFU/g in Market 2. In a study conducted by Rahman et al. (2012) on fish sold in Dhaka, Bangladesh, coliform counts in various fish species ranged from 103 to 106 CFU/g. The bacterial load in Horse mackerel from Market 1 (4.16 x 105CFU) falls at within this range, while the loads from Market 2 (9.15 x 105 CFU/g) and Market 3 (5.90 x 105 CFU/g) are within the upper range. Coliform levels can vary significantly by region due to differences in environmental conditions, handling practices, and market infrastructure. Onyemelukwe and Ogan (2002) reported lower coliform levels in fish from markets in Enugu, Nigeria, suggesting that differences in market conditions and hygiene practices can impact bacterial loads.

Variations in coliform bacterial loads between Hake and Horse mackerel from the study can be attributed to species-specific factors such as feeding habits, habitat, and skin mucus properties. Studies by Hamed et al. (2015) who postulated that the coliform load in fish can be influenced by these factors, leading to differences even within the same market.

Table 2 Mean coliform bacteria load of two fish species in three Yenagoa market

Fish species	Market 1	Marke 2	Market 3
Hake (*Merculius capensis*)	$4.14x10^5$cfu/g	$7.98x\ 10^5$cfu/g	$5.93x10^5$cfu/g
Horse mackerel (*Trachurus trachurus*)	$4.16x10^5$cfu/g	$9.15x10^5$cfu/g	$5.90x10^5$cfu/g

Presence of Bacterial Species in Markets: Figure 1 illustrates the presence of various bacterial species in two fish species, Hake and Horse Mackerel, from Market 1. The x-axis lists the bacterial species, while the y-axis represents the count (or frequency) of each bacterial species identified. The findings show that Bacillus sp., Salmonella sp., and Providencia sp. were recorded in both Hake and Horse Mackerel, with each species having a count of 3, making them the dominant bacterial species found in Market 1. Escherichia coli was documented only in Horse Mackerel with one count, while Shigella sp. was present only in Hake with one count. Most bacteria are equally present in both Hake and Horse Mackerel, indicating similar levels of contamination in both fish species in Market 1. Micrococcus sp. was more prevalent in Hake (2 counts) than in Horse Mackerel (1 count), while Citrobacter spp. was present with counts of 1 and 2 in Hake and Horse Mackerel, respectively.

The presence of bacterial species in Market 2 is presented in Figure 2. Both fish species had the same count of Bacillus sp., Providencia sp., and Salmonella sp., each with a count of 3, indicating that these bacteria are equally prevalent in both fish species in Market 2. The equal presence of Pseudomonas sp. in both fish species suggests similar levels of fecal contamination or handling hygiene. Escherichia coli is present in both fish species, with a count of 1 in Hake and 2 in Horse Mackerel, which could indicate differences in storage conditions favoring E. coli growth in Horse Mackerel. Both Shigella sp. and Micrococcus sp. were present in Horse Mackerel but absent in Hake. Citrobacter spp. was equally present in both fish species, suggesting similar environmental exposure or handling conditions.

Figure 3 shows the presence and count of different bacterial species in two fish species, Hake and Horse Mackerel, from Market 3. It is documented that Both fish species have the same count of Bacillus sp, Providencia sp, and Salmonella sp indicating that this bacterium is equally prevalent in both fish species in Market 3. The presence of E. coli and Citrobacter spp were only found in Hake while Pseudomonas sp is present in Horse Mackerel but absent in Hake, indicating that Horse Mackerel may have been stored under conditions more favorable for Pseudomonas growth. Both fish species have an equal presence of Micrococcus sp, accounting 1 for each species of fish.

The presence of Bacillus sp in both Hake and Horse Mackerel is consistent with findings by Sivaraman et al. (2012), who reported Bacillus sp as a common bacterium in various fish species due to its ubiquitous nature in aquatic organisms. Escherichia coli presence in fish species aligns with the results from Elhadi et al. (2004), which found E. coli to be a common contaminant in fish sold in Saudi Arabian markets, indicating fecal contamination and poor hygiene practices during handling and processing. Pseudomonas sp was found only in Hake. This is supported by studies such as those by Gram and Huss (1996), which showed that Pseudomonas species are dominant spoilage bacteria in fish stored in chilled conditions, often found in higher quantities in certain species due to differences in storage and handling conditions (Gram and Huss, 1996). The presence of Micrococcus sp in Horse Mackerel is supported by research from Bhaskar et al. (2004), which identified Micrococcus sp in various marine fish, particularly those exposed to different salinity levels and handling practices. The presence of Providencia species in this present study in both Hake and Horse Mackerel can be compared with findings by Kumar et al. (2015), who found Providencia species in multiple fish species, indicating its widespread nature in dry fish (Kumar et al., 2015). Shigella sp was found only in Hake, which could be compared to findings of Hatha et al. (1998), who documented that Shigella species are often present in fish due to contamination from human sources, suggesting possible differences in contamination sources between the two fish species. The presence of Salmonella sp bacterial in both fish species so consistency with previous including Koutsoumanis and Sofos (2004), with the postulation that Salmonella is a common pathogen in fish and seafood, highlighting the need for better handling and storage practices to reduce contamination. Uddin et al. (2013), with the opinion stating that Citrobacter is a common contaminant in fish due to environmental exposure and handling practices align with the results of this present study where Citrobacter sp is found in both fish species but more in Horse Mackerel. In both Market 2 and Market 3, Bacillus sp was found in high counts (3) in both Hake and Horse Mackerel.

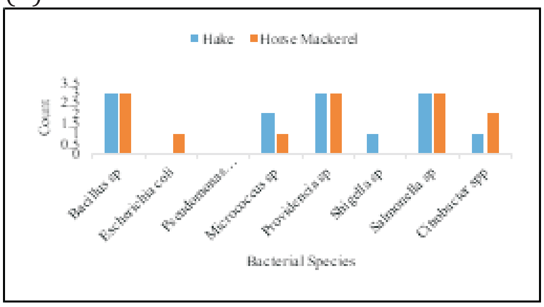

Fig. 1: Presence of Bacterial Species in Market 1

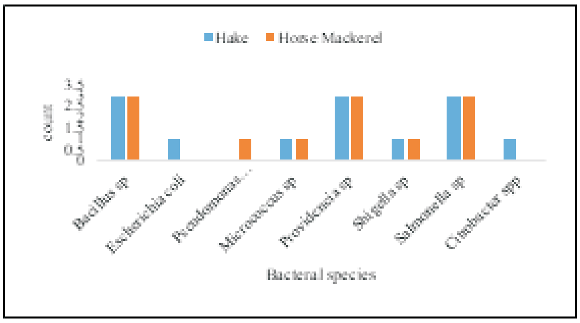

Fig. 3: Presence of Bacterial Species in Market 3

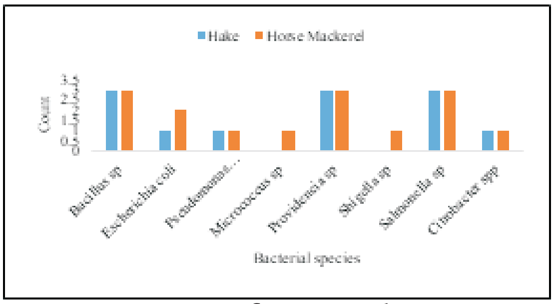

Fig. 2: Presence of Bacterial Species in Market 2

CONCLUSION

The study highlights significant bacterial contamination in fish sold in Yenagoa markets. Both Hake and Horse Mackerel showed high bacterial loads and diverse bacterial species, indicating potential health risks to consumers. The highest contamination levels in Market 2 suggest that some markets may require more immediate interventions than others. However, the microbial load in both fish species sourced from market 1 were observed to be less than 100 cfu/gram which is within the permissible limit of microbial load in food. Hence, market 1 can be said to have better hygienic practices than other markets in Yenagoa Metropolis of Bayelsa State. The consistent presence of fecal indicators like E. coli underscores the need for better handling and sanitary practices in fish markets. The similarity in bacterial profiles across different markets suggests that contamination might stem from common sources, such as water supply, handling practices, and market environments.

REFERENCES

Abolagba, O.J., and Melle, O.O. (2008). Chemical Composition and Keeping Qualities of a Scaly Fish Tilapia (Oreochromisniloticus) Smoked with Two Energy Sources. Afr J Gen Agric 4: 113-117

Adebayo-Tayo, B. C., Odu, N. N., and Esen, C. U. (2012a). Microbial Quality of Frozen Fish Sold in Uyo Metropolis. Nature and Science, 10(3), 71-77.

Adebayo-Tayo, B. C., Odu, N. N., and Esen, C. U. (2012b). Microbiological and physicochemical qualities of catfish (Clarias gariepinus) smoked with two energy sources. African Journal of Microbiology Research, 6(24), 5111-5116. https://doi.org/10.5897/AJMR11.928

Adebolu, T. T., Ifeoma, C. E., and Adeoye, O. T. (2017). Assessment of bacterial load in fish sold in some markets in Ondo State, Nigeria. Journal of Applied Sciences and Environmental Management, 21(3), 537-541.

Adedeji, O. B., Akinyemi, A. F., and Idowu, E. (2014). Microbial load of selected seafood in Ibadan, Southwest Nigeria. African Journal of Clinical and Experimental Microbiology, 15(3), 141-148.

Ali, M. A., Uddin, M. M., Habib, A., Khan, M. S., and Rahman, M. M. (2018). Bacterial contamination in fish species in retail markets of Dhaka city, Bangladesh. Journal of Food Safety, 38(1), e12419.

Bellmann, C., Tipping, A., and Sumaila, U.R. (2016). Global trade in fish and fishery products: an overview. Mar Policy, 69:1818 DOI: 10.1016/j.marpol.2015.12.019.

Bhaskar, N., Setty, T. M. R., and Hosakote, R. (2004). Incidence of enterotoxigenic and cytotoxic strains of Aeromonas species in various food and environmental samples. Indian Journal of Medical Research, 119, 225-228.

Cheesbrough, M. (2018). District laboratory practice in tropical countries (2nd ed.). Cambridge University Press.

Clucas, I.J., and Ward, A.R. (1996). Post-Harvest Fisheries Development: A guide to Handling, Preservation, processing and Quality. Natural Resource Institute Chatham Maritime. Kent, United Kingdom.

Elhadi, N., Aljindan, R., and Aljeldah, M. (2004). Prevalence of Enteropathogenic Escherichia coli in market fish in the eastern province of Saudi Arabia. Saudi Medical Journal, 25(8), 1172-1175.

Eyo, A.A. (2001). Fish Processing Technology in the Tropics. National Institute for Fresh Water Fisheries Research (FIFR), New Bussa, Nigeria.

Eze, E. I., Nweke, O. C., and Nnadozie, C. U. (2020). Bacterial load and prevalence of foodborne pathogens in retail fish in Nigeria. Nigerian Journal of Microbiology, 34(2), 2024-2034.

Graham, E.R. (2014). International organizations as collective agents: fragmentation and the limits of principal control at the World Health Organization. Eur J Int Relat.;20(2):366-90. DOI: 10.1177/1354066113476116

Gram, L., and Huss, H. H. (1996). Microbiological spoilage of fish and fish products. International Journal of Food Microbiology, 33(1), 121-137. https://doi.org/10.1016/S0168-1605(96)01144-2

Hamed, A. M., Abd El-Aziz, R. M., and Ali, H. S. (2015). Microbial Assessment of Fish Samples Collected from Different Locations in Sharkia Governorate, Egypt. Journal of Basic and Applied Zoology, 70(1), 1-8.

Hatha, A. A. M., Lakshmanaperumalsamy, P., and Mancy, K. A. (1998). Prevalence of Salmonella in fish and crustaceans from markets in Coimbatore, South India. Food Microbiology, 15(6), 579-583.

Heintz, M.L., and Johnson, J.M. (1998). The Incidence of Listeria spp., Salmonella spp., and Clostridium botulinum in smoked fish and shellfish. J Food Prot 61: 318-323.

Horner, W.F.A. (1992) Preservation of fish by curing, Drying, Salting and smoking. In: Fish Processing Technology, G.M. Hull (edn) Blackie Academic and Professional, New York.

Kipkoech, R., Takase, M., and Amankwa-Afrifa, E.K. (2022). Renewable energies in Ghana in relation to market condition, the environment, and food security. J Renew Energy, 1-8. DOI: 10.1155/2022/8243904.

Kousar, R., Shafi, N., Andleeb, S., Ali, N.M., Akhtar, T., and Khalid, S. (2020). Assessment and incidence of fish associated bacterial pathogens at hatcheries of Azad Kashmir, Pakistan. Braz J Biol, 80(3):607-14. DOI: 10.1590/1519-6984.217435.

Koutsoumanis, K. P., and Sofos, J. N. (2004). Microbial contamination of food. In Encyclopedia of Meat Sciences (pp. 727-736). Elsevier.

Kumar, R., Surendran, P. K., and Thampuran, N. (2015). Distribution and genotypic characterization of Salmonella serovars isolated from tropical seafood of Cochin, India. Journal of Applied Microbiology, 98(4), 812-820.

Liang, J., Liu, J., Zhan, Y., Zhou, S., Xue, C.X., and Sun, C. (2021). Succession of marine bacteria in response to Ulva prolifera-derived dissolved organic matter. Journal Environ Int 155:106687. DOI: 10.1016/j.envint.2021.106687

Mensah, P., Yeboah-Manu, D., Owusu-Darko, K., and Ablordey, A. (2019). Street foods in Accra, Ghana: How safe are they? Bulletin of the World Health Organization, 80(7), 546-554.

Okonko, I. O., Adejoye, O. D., Ogun, A. A., Ogunnusi, T. A., and Fajobi, E. A. (2011). Microbiological assessment of fish samples in Lagos, Nigeria. Middle-East Journal of Scientific Research, 2(5), 96-101

Olokor, J.O, Ihuahi, J.A, Omojowo, F.S, Falayi, B.A, and Adelowo, E.A. (2007) Handbook of Practical Fisheries Technology. Fisheries Technology Division, National Institute for Freshwater Fisheries Research (NIFFR), PMB 6006, New Bussa, Niger State, Nigeria.

Olowokere, F. O., Olayinka, A. M., and Olukemi, A. (2018). Comparative microbial assessment of fresh fish and smoked-dried fish from different markets in Ibadan, Nigeria. Journal of Food Quality and Hazards Control, 5(1), 27-34.

Onyemelukwe, N. F., and Ogan, M. T. (2002). Bacteriological Quality of Fish and Shellfish in Enugu, Nigeria. International Journal of Food Microbiology, 75(1-2), 105-109.

Özyurt, G., and Polat, A. (2016). Effects of processing on the quality of fish and fish products. In Seafood Processing (pp. 3-21). Springer, Cham.

Rahman, M. M., Hasan, M. M., and Sultana, R. (2012). Microbiological Quality Assessment of Raw Fish Collected from Different Markets in Dhaka City. Stamford Journal of Microbiology, 2(1), 13-18.

Rawson, G.C. (1966) A short Guide to Fish preservation. U.S Food and Agriculture Organization, Rome.

Sivaraman, G. K., Kalyani, D., and Sangeetha, M. (2012). Isolation and identification of bacteria from fish. International Journal of Current Microbiology and Applied Sciences, 1(3), 78-84

Uddin, M. N., Faruque, M. R., Rahman, M. H., and Islam, M. T. (2013). Microbial status of some fish feeds collected from different fish farms of Bangladesh. Bangladesh Journal of Microbiology, 30(1-2), 1-4

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

QUALITY OF LEATHER PRODUCED FROM FOUR SPECIES OF CAPTURED FISH FROM GALMA RESERVOIR, ZARIA, NIGERIA

[1]Folorunso, L. A., [2]N. M. Zitta and [3]J, Michael

[1]Samaru College of Agriculture, Division of Agricultural Colleges, Ahmadu Bello University, Zaria
[2]Department of fisheries and Aquaculture, Ahmadu Bello University, Zaria
[3]Nigerian Institute of Leather and Science Technology, Samaru, Zaria

Corresponding author:
f5ace2000@gmail.com; +2348037185335, 0000-0001-9256-2833

ABSTRACT
Due to its low value, fish skin is underutilized during fish processing. Thus, this research assessed some physical characters of leather produced from four notable fish species present in Galma reservoir, Zaria, Kaduna State, Nigeria. Two (2) pieces each of four (4) fish species with two (2) scaly being Lates niloticus, Heperopisus bebe and two (2) non-scaly being Auchenoglanis occidentalis, Bagrus bajad were obtained from fishermen catches at Galma Reservoir. The fresh fish was skinned, salted and the pelt was transported to Nigerian Institute of Leather and Science Technology, Zaria for soaking, descaling, liming, fleshing, deliming, drenching, tanning, piling, retanning, fatliquoring, fixing, drying and buffing using standard methods. After production, the leather was physically tested for water absorption (mg/cm3), water vapour permeability (mg/cm3), shrinkage temperature (°C) and tensile strength (N/mm2). Leather produced from the species had water absorption of 0.120±0.009 to 0.229±0.017, water vapor permeability of 0.047±0.011 to 0.078±0.024. The shrinkage temperature recorded for all the species ranged between 67±1.414 to 71±1.414 while the tensile strength for the four species ranged from 2.722±0.061 to 8.613±2.167. This study concludes that being scaly or non-scaly does not confer water absorption and water vapour permeability of fish leather. However, leather obtained from Auchenoglanis occidentalis had the lowest water absorption, comparable water vapour permeabilty, comparatively high shrinkage temperature and highest tensile strength as compared to Bagrus bajad, Lates niloticus, and Hyperopisus bebe.

Keywords:
fish skin, water absorption, water vapour permeability, scaly fish, non-scaly fish.

INTRODUCTION

An average of only 30% to 40% of fish end up as food, while the remaining 60% to 70% turns into a byproduct (Fadda *et al.*, 2024). Sarkar *et al* (2023) described 19 products obtainable from fish among which have important applications in aquaculture, agriculture, food, cosmetics and other industries to include: isinglass, pituitary gland, chitin, chitosan, pearl essence, fish skin leather, fish protein hydrolysates and concentrates, fish meal and scrap, fish oil, collagen, gelatin, glue, fish silage, pet food and wet feed from fish, fish fertilizer and compost.

Leather is a durable and flexible material created by the tanning of animal raw hide and skin, primarily cattle hide while natural grain, variation in the grains, good breathability and other natural features are all signs that the material is genuine (Duraisamy and Shamena, 2016). Tanning is the process of converting the raw skin and hides from different animals into a sustainable and manageable material called leather (Ahmed and Maraz, 2021). The production of fish skin leather is based on taking waste and turning it into a useful product and due to similarity in strength to tough cow hide, it can be used for anything from handbags, belts, clothing, small accessories and shoes, furniture, interior decoration, and so on (Duraisamy and Shamena, 2016).

Leather making is a very long process and consists of many different chemical and mechanical process steps (Ahmed and Maraz, 2021). Rawhides or skins undergo different type of mechanical and chemical technique including hair removal, trimming, soaking, liming, fat liquoring, tanning to produce finally durable and sustainable finish product of leather (Gondim et al,. 2015). After production, the quality and properties of tanned leather differ primarily because of differences in species, breed, living conditions of the animals and different areas within the same hide or skin (Ahmed and Maraz, 2021).

Apparently, the need to diversify benefits obtainable from fish and grow our economy using notable fish species abundant in Nigerian freshwaters prompted scientists to examine various ways of optimizing the usefulness of fish and its byproducts. Thus, this research assess the water absorption and water vapour permeability of leather produced from two (2) scaly fish species: Lates niloticus, Heperopisus bebe and two (2) non-scalyfish species: Auchenoglanis occidentalis, Bagrus bajad known for their abundance in Nigerian freshwaters.

MATERIALS AND METHODS

Two (2) pieces each of four (4) fish species: Lates niloticus, Heperopisus bebe, Auchenoglanis occidentalis, and Bagrus bajad were obtained from fishermen catches at Galma Reservoir, Zaria, Kaduna State, Nigeria and were identified using Suleiman (2016). The skin was removed and salted before it was taken as pelt to the laboratory at Nigerian Institute of Leather and Science Technology (NILEST), Samaru. Zaria. The pelt was soaked, descaled, limed, fleshed, delimed, drenched, tanned, piled, retanned, fatliquored, fixed, dried and buffed using standard methods. After production, the leather was physically tested for water absorption (mg/cm3) and water vapour permeability (mg/cm3) using Muver equipment. The shrinkage temperature (°C) and tensile strength were also assessed. Resulting data from the duplicate samples were pooled together, while the average and standard deviation was calculated.

Procedure:

Skin was removed with a small kitchen knife, and alt was sprinkled on the fleshy part to prevent mould. It was dried and taken to the laboratory 48hours later for tanning. It was then soaked completely in water for 3 hours to refreshen the skin; thereafter drained of the water and washed, it was then weighed for descaling. Sodium sulphite was added at 2% for descaling and removal of pigments for scaly and non-scaly respectively. It was agitated for one hour after which the scale was completely dissolved. The water was drained and the pelt was washed. Calcium hydroxide 3% was added and agitated for 2 hours and allowed to stand for 24 hours. The following day, the excess fat was removed from the fleshy part using a fleshing knife. It was then washed with water. Ammonium sulphate 2% was added to the water (based on weight) and agitated for 30minutes after which the water was drained, and the pelt was washed.

The pelt was weighed and soaked in water equivalent to 80% of the weight, 6% Sodium chloride was added and agitated for 10 minutes after which 1% formic acid was added and further agitated for 30 minutes. The pH was monitored and it was 4.5. A value of between 4.0 – 5.0 is suitable for vegetable tanning. Tanning was done inside the fluid used for drenching. The pods of dividivi plant (Caesalpinia coriaria) equivalent to 10% of the weight of the pelt was added to the mixture and agitated for 30 minutes. The pods of bagaruwa (Acacia nilotica) were ground and 15% was added and agitated for one hour. The leather was then removed, washed and piled for two days. For the piling, it was arranged flesh to flesh, grain to grain and wrapped with polythene. After the two days, the leather was soaked inside 100% weight of water and a pinch of Sodium bi carbonate was added as buffer to normalize the pH.

For retanning, 10% of dividivi was added and agitated for 30 minutes. After which 15% bagaruwa was added and agitated for 30 minutes, the water was then drained. To achieve fatliquoring, water was boiled to 50°C after which 3% of fatliquor was added and agitated for 30 minutes. Formic acid (1%) was added and agitated for 30 minutes. It was then drained washed and dried for 48 hours. The rough surface was buffed to smoothen the fleshy part. Physical testing was done to assess water absorption, water vapour permeability, shrinkage temperature, percentage elongation at maximum load, and tensile strength while the ball burst was also assessed.

RESULTS AND DISCUSSION

The results of the physical characters of leather obtained from four (4) different freshwater fish species is presented in Table 1. Previous studies have reported production of leather from fish species such as Oreochromis niloticus (Gondim et al., 2015), and Solea solea (Abid et al., 2020) amongst other species so the production of leather from Auchenoglanis occidentalis, Lates niloticus, Bagrus bajad and Hyperopisus bebe used in this study will increase the number of fish species from which leather has been produced.

Table 1: Physical characters of leather obtained from four (4) Nigerian freshwater fish species

	Non-scaly	Non-scaly	Scaly	Scaly
Parameters	*Auchenoglanis occidentalis*	*Bagrus bajad*	*Lates niloticus*	*Hyperopisus bebe*
Water Absorption mg/cm^3	0.120 ± 0.009^d	0.229 ± 0.017^a	0.154 ± 0.027^b	0.135 ± 0.000^c
Water vapour permeability mg/cm^3	0.047 ± 0.011^a	0.062 ± 0.007^a	0.078 ± 0.024^a	0.050 ± 0.029^a
Shrinkage Temperature (ºC)	70 ± 0.000^a	67 ± 1.414^b	70 ± 5.656^{ab}	71 ± 1.414^a
Percentage elongation at maximum load (%).	18.437 ± 6.352^c	33.597 ± 1.934^b	67.386 ± 16.127^a	32.398 ± 14.664^b
Tensile strength N/mm^2.	8.613 ± 2.167^a	6.679 ± 0.720^a	2.722 ± 0.061^b	6.057 ± 4.113^{ab}
Ball burst				
Force (N)	31.645 ± 5.059^a	22.615 ± 5.098^{ab}	33.030 ± 5.699^a	17.185 ± 4.122^b
Displacement (mm)	11.545 ± 2.425^a	11.58 ± 1.655^a	11.295 ± 2.722^a	11.485 ± 1.803^a

Mean values with same superscript along the same row are not significantly different

Leather produced in this study had water absorption (mg/cm3) of 0.120±0.009, 0.229±0.017, 0.154±0.027, 0.135±0.00, and water vapor permeability (mg/cm3) of 0.047±0.011, 0.062±0.007, 0.078±0.024, 0.050±0.029, for Auchenoglanis occidentalis, Bagrus bajad, Lates niloticus and Hyperopisus bebe respectively. In this study, there was no specific pattern observed in water absorption of leather produced among scaly and non-scaly fish. From the results, leather obtained from the skin of Auchenoglanis occidentalis has the lowest water absorption capacity which is significantly different from leather obtained from other species. Water absorption in leather is a measure of the maximum volume of water that the material can absorb and the lower the water absorption, the better the leather. The high-water absorption recorded for the four species is in line with Fadda et al., (2023) that reported high hydrophilicity and water absorption as a shortcoming for fish leather. The water vapour permeability determines the breathability of the leather, which is an indication of how the leather allows moisture to pass through the leather and the higher the permeability the better is the material. There is no significant difference in the vapour permeability of leather produced from the four fish species used in this study so all of them possess the same level of permeability.

Shrinkage temperature explains the temperature at which the leather will be denatured. Different tanning materials have different shrinkage temperature, vegetable tanned materials have a lower shrinkage temperature than chromium tanned materials. Alla et al., (2016) reported that chrome tanned fish skin withstood temperature up to 106°C while solefish (Solea solea) skin tanned with vegetable tannate had a shrinkage temperature of 83°C to 89°C. The shrinkage temperature observed for all the species in this study was between 67±1.414°C to 71±1.414°C and these lower values may be as a result of vegetable tannate used and due to the cold blooded nature of fish. These values are lower than Mimosa extract (standard) of 80°C reported by Teklemedhin, et al., (2023). Tanning assists the hydrothermal stability of skin protein and the shrinkage temperature is an indicator of how stable the collagen in the leather is. If leather is not stabilized, the leather will spoil when exposed to a higher temperature (eg hot water) than its shrinkage temperature.

Tensile strength with a high value is an indication that the leather was tanned properly, and it can withstand stress. The tensile strength reported for the four species in this study ranged between 2.722±0.061 to 8.613±2.167 N/mm2. These values are lower than Mimosa extract standard (14.8N/mm2) reported by Teklemedhin, et al. (2023). Percentage elongation explains how the material expands with time. Lates niloticus has the highest percentage elongation of 67.386±16.127% which was significantly different to Auchenoglanis occidentalis 18.437±6.352%. All the different characteristics reported for leather made from the different fish species confers the ability to use the leather for various purposes which can be as a main material or as a supportive material. This gives credence to Vavra (2020) who reported that the use of fish skin does not appear to be based purely on climate, subsistence strategies, or the availability of fish, but also on cultural norms and traditions. Although the size of fish used in this study and the area of leather produced may be small, but its usage cannot be limited to footwear alone, there are other areas where leather can be utilized for aesthetics and interior decoration.

CONCLUSION

Leather obtained from Auchenoglanis occidentalis has the lowest water absorption as compared to Lates niloticus, Bagrus bajad and Hyperopisus bebe. Its water vapour permeabilty is non-significantly different to other species. It can withstand a temperature up to 70°C, has the highest tensile strength of 8.613±2.167 N/mm2 and lowest percentage elongation at maximum load of 18.437±6.352 (%).

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REFERENCES

Abid, U., Mughal, T. A., Saddique, Z., and Anwar, M. (2020). Vegetable tanning of sole fish skin by using tannins extracted from plants. Asian Journal of Research in Biosciences. 2(2): 1 – 9.: Available online @ https://www.researchgate.net/publication/344776846

Ahmed, M.D. and Maraz, K.M. (2021). Benefits and problems of chrome tanning in leather processing: Approach a greener technology in leather industry. Materials Engineering Research 3(1): 156-164. https://doi.org/10.25082/MER.2021.01.004

Alla, J.P., Ramanathan, G., Fathima, N.N., Uma, T.S. and Rao, J.R. (2017). Fish Skin and Exotic Leathers. Journal of American Leather Chemists Association, 112: 36-43. Available online @ https://journals.uc.edu/index.php/JALCA/article/view/3732

Duraisamy, R. and Shamena, S. (2016). A Review of Bio-tanning Materials for Processing of Fish Skin into Leather. Chemistry and Materials Research. 8(9). Available online @ www.iiste.org. ISSN 2224- 3224 (Print) ISSN 2225- 0956 (Online)

Fadda, M., Zych, A., Carzino, R., Athanassiou, A and Perotto, G. (2024). Hydrophobic and water-resistant fish leather: a fully sustainable combination of discarded biomass and by-products of the food industry. Green Chemistry, 26: 542- 555. DOI: https://doi.org/10.1039/d3gc04048h

Gondim, R.D, Marinho, R. A. and Conceicao, R. N. (2015). Tanning handmade leather tilapia (Oreochomis sp.) from three natural tanning. Brazilian Journal of Hygiene and Animal Sanity, 9(2): 172-184. https://doi.org/10.5935/1981-2965.20150016.

Sarkar Md, S.I., Hasan, M.M., Hossain Md. S., Khan, M., Al Islam A., Paul, S. K., and Rasul Md, G. (2023). Exploring fish in a new way: A review on non-food industrial applications of fish. Heliyon 9, https://doi.org/10.1016/j.heliyon.2023.e22673.

Suleiman, B. (2016). Catalogue of fishes of River Kaduna, Nigeria. 19p. ISBN: 978-978-53916-5-7.

Teklemedhin, T. B., Gebretsadik, T.T., Gebrehiwet, T. B., Gebrekidan, G. A., Edris, M., Teklegiorgis, N. T. and Hagos, K.B. (2023). Vegetable Tannins as Chrome-Free Leather Tanning. Advances in Materials Science and Engineering. Available online @ https://doi.org/10.1155/2023/6220778.

Vavra, R. (2020). Fish and Chaps: Some Ethnoarchaeological Thoughts on Fish Skin Use in European Prehistory. Open Archaeology 6:329 – 347. Available online @ https://doi.org/10.1515/opar-2020-0115

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

QUALITY ASSESMENT OF SMOKED FISH: A REVIEW

Kaan I. U., Y. Ibrahim, R. Aliyu, M. Tukur, A. B. Ayuba, A.I. Mohammed, and N. P. Abugwu

National Institute of Freshwater Fisheries Research, New Bussa.

Corresponding authors:
kaanisaac88@gmail.com, +2347035320968

ABSTRACT
An essential protein source that promotes both economic growth and better human nutrition is fish. The inability to launch a fish business, costly processing technologies, and postharvest losses from spoiling continue to limit the number of communities and impoverished rural people that depend on fish to meet their end needs. As a result, smoking fish has emerged as the most popular preservation technique. This study examines acceptable techniques to solve potential issues endangering the safety of fish and fish products in order to address the quality and safety of smoked fish.

Keywords:
Fish, Smoked, Quality, Safety

INTRODUCTION

Fish is highly susceptible to deterioration in the absence of any processing or preservation techniques. (Okonta & Ekelemu, 2005) and needs to be handled and preserved properly to improve its nutritional value, shelf life, and quality (Ye, 1999). The fishing industry suffers enormous postharvest losses, which are estimated to be between 35 and 40 percent of landed weight (FAO, 1994) notwithstanding its significance. Around 25% of the yearly global catch is still lost after harvest (FAO, 1994). These losses have a significant negative impact on fishing communities, whose livelihood and status often depend on post-harvest activities. For the worldwide fish industry, the quality of fish and fishery products has become a significant issue (Huss *et al.*, 2003). Fish is one of the most perishable meals, even with technical developments in manufacturing. As a result of the globalization of the food trade, fish products are more likely to be rejected for poor quality, particularly if the initial raw materials are of low quality.

Concerns over the quality of processed and fresh fish products are a persistent concern for both producers and consumers. This fact will never alter because fish is one of the diets that is necessary for the best possible health outcomes for humans. For many low-income rural areas, fish is a significant source of income and protein (Béné et al., 2009). Due to its high vulnerability to microbial attack, fish is extremely perishable after harvest (Ashie *et al.*, 1996). Fish has a shelf life of a few days to around three weeks, making it a perishable food item (Amit *et al.*, 2017). Akande and Diei-Quadi (2010) define post-harvest fish losses as three types: market force loss (i.e., monetary), quality loss (i.e., unacceptability or spoiling), and physical loss (i.e., damage to body parts).

IMPROVED FISH HANDLING & SMOKING REWARDS BETTER QUALITY

In the realm of fish processing and safety, there is an increasing need for improved fish handling and smoking (IFHAS). Quality assurance is one of the areas targeted for guaranteeing the safety of fish or food. It has been defined by International Standards (Sciortino & Ravikumar, 1999) as a planned, methodical action designed to ensure confidence regarding the caliber of a certain good or service. Fish quality assurance necessitates precise yet comprehensive scientific information (FAO & WHO, 2001), which also takes into account controls and dangers related to fish and fisheries products (Food and Drug Administration [FDA], 2011). It has been advised to take steps to reduce microbial spoilage and delay lipid oxidation, including controlling the storage temperature, applying brine solution, packing

methods, and using supplemental or natural antioxidants (Medina et al., 2009).
Appropriate policies and technologies that can be applied correctly during the processing and storage stages should also serve as a reference for such efficient methods or strategies intended to prevent food spoiling (Odeyemi *et al.,* 2020). Fish must be preserved properly for a prolonged amount of time in order to maintain its nutritional value, color, texture, and flavor (Amit *et al.*, 2017)
With increasing consumers' demand for fresh food and growing efforts to keep or maintain the freshness of raw fish upon harvest, strategies such as efficient storage of fish in the forms of chilled and frozen products are examples of highly recommended practices which have also dominated the proportion of fish production and consumption in areas with developed technologies driven by rising demand for high quality products and the impact of distant markets and the need for long -term storage (Medina *et al*., 2009). Application of ice in ice -cooler boxes as the only method of fresh fish storage by fish retailers in the local markets in the developing countries (Alosias, 2019) is an example of chilled storage for fresh fish preservation commonly practiced in developing countries, albeit the use of refrigerators for storage of all types of fresh and other processed foods can be found in supermarkets. The term chilling and freezing are sometimes used interchangeably when cooling is conducted below 5°Celsius as described in the physical principles of food preservation (Amit *et al.*, 2017).

QUALITY AND SAFETY STATUS OF SMOKED FISH

Traditional smoking methods entail applying wood smoke to pre-salted, whole, or filleted fish, allowing smoke from incomplete wood burning to come into direct contact with the product. If the process is not sufficiently regulated or extremely intense smoking methods are used, it has been discovered that PAHs will contaminate the fish (Gómez-Estaca *et al.,* 2011). Smoked fish is one source of polycyclic aromatic hydrocarbons (PAHs), which are a broad class of organic molecules with two or more fused aromatic rings composed of carbon and hydrogen atoms (Guillen *et al.,* 1997). The incomplete combustion or thermal degradation of the organic components occurs when fish is smoked, roasted, barbecued, or grilled, leading to the formation of PAHs (WHO, 2006). Pyrolysis of the fats in the meat/fish generates PAHs that become deposited on the meat/fish. PAHs production by cooking over charcoal (barbecued, grilled) is a function of both the fat content of the meat/fish and the proximity of the food to the heat source (Kazerouni *et al*., 2001; Phillips, 1999).
Several analyses of charcoal roasted/grilled common fish by several researchers (Ogbadu and Ogbadu, 1989; Guill´en and Sopelana, 2005; Akpambang *et al.*, 2009; Linda *et al.*, 2011) have proven the presence of PAHs such as benzo [*a*] pyrene, anthracene, chrysene, benzo[*a*]anthracene, indeno [1,2,3-c,d] pyrene. Several researchers (Bababunmi et al., 1982; Alonge, 1988; Lijinsky, 1999; Fritz and Soos, 1980; Borokovcova et al., 2005) reported that most of these PAHs have been found to be carcinogenic while some are not. Emerole (1980) studied and screened for the presence of PAH in local foodstuffs available in Nigerian market. He discovered that appreciable amounts of benzo[a] anthracene and benzo [*a*] pyrene were found present in three varieties of smoked fish and smoked meat (suya) purchased from a popular market in Ibadan, Nigeria. High levels of PAHs have been reported to be associated with the dark colorations in intensively heated fish products. Research has also revealed the existence of aflatoxins in fish and fish feed. Aflatoxin-producing microsclerotia species of Aspergillus section Flavi, Aspergillus flavus, and Aspergillus parasiticus naturally create these extremely deadly substances. (Almeida *et al.*, 2011; Barbosa *et al.*,).
Furthermore, the detrimental impacts of aflatoxin-contaminated feeds on fish health and productivity have been well-documented (Jantrarotai et al., 1990;). Despite the wealth of information on aflatoxin contamination of different foods and livestock feeds, as well as the health consequences associated with it, little to no data are available regarding the prevalence of Aspergillus species and aflatoxin in fish in Nigeria and many other developing nations, despite the fact that fish is a common food item in these countries. A good fish smoking plan (FAO, 2005) should not only consider applying IFHAS approach but also improved smoking kiln or fish drier.

CHEMICAL COMPOSITION OF SMOKED FISH

Smoking is one of the methods of preserving fishery products. Various studies on preservation by smoking have been carried out, such as the Coban and Patir (Ficicilar *et. Al.*, 2017) study on smoking Oncorhynchus mykiss with the addition of clove oil, and Ficicilar and Genccelep (Adedeye et al., 2018) on Rainbow Trout. The quality of smoked fish products is influenced by raw materials, smoking methods, smoking concentrations and raw materials for smoking sources (Adedeye *et al.*, 2018). Indicators in assessing the durability of smoked fish products can be seen from the values of TBA, TVB and pH as well as the value of biogenic amines consisting of histamine, putrescine, cadaverine, tyramine, and tryptamine compounds. The quality of smoked fish can be seen from the value of protein, vitamins and minerals it contains. According to Adeyeye *et al.* The processing of raw materials will influence on the nutritional composition of the final product (Syam). Several nutrients in the food will be lost during the processing. Amino acids, vitamins, and minerals will usually be easily decomposed due to heat so that the quality of smoked fish can be determined also from the content of amino acids, vitamins, and minerals.

MICROBIOLOGY OF SMOKED FISH

Traditionally processed fishery products are very susceptible to microbiological damage. Microbiological damage can be caused by pathogenic bacteria or fungi. Damage to a product depends on the initial bacterial count, sanitation and hygiene during processing, and preservation methods and storage methods. Improper processing methods will cause the growth of Salmonella bacteria in the product. The smoking method using liquid smoke at a temperature of 30-60°C can extend the shelf life of smoked fish products. This can be determined by the number of bacterial colonies during storage. Some pathogenic bacteria in smoked fish will not grow because of the heat from the smoking process. The high temperature used can damage these pathogenic bacteria as well as the presence of chemical compounds from the smoke that are useful as antimicrobials.

Table 1. Chemical composition of smoked fish

Parameter	Hot Smoked	Cold Smoked
Moisturecontent	71.01-73.52 %	34.56-52.50 %
Protein	16.11-52.13 %	10.16-21.54 %
Lipid	0.90-7.60 %	30. 14-46.46 %
Ash	0.32-0.64 %	1.00-2.70 %
pH	6.54-6.5	75.00-5.01
Histamin	11-18.26 mg/kg	100-220 mg/kg
Putresin	3.26-8.90 mg/kg	4-15 mg/kg
Kadaverin	**4.19-7.95 □g/g**	**10-200 □g/g**
Tiramin	**5.31-6.65 mg/kg**	**90-130 mg/kg**
Triptamin	**14.47-32.17 mg/kg**	**< 5 mg/kg**
Lysine	**7.36-7.72 g/100 g**	**1.70-2.10 g/100 g**
Histidine	**2.46-2.92 g/100 g**	**0.50-0.65 g/100 g**
Arginine	**6.27-6,71 g/100 g**	**1.11-1.41 g/100 g**
Threonine	**4.58-4.91 g/100 g**	**0.94-1.13 g/100 g**
Valine	**4.52-4.98 g/100 g**	**1.04-1.35 g/100 g**
Glutamic acid	**14.19-14.93 g/100 g**	**2.47-2.94 g/100 g**
Tyrosine	**3.17-3.67 g/100 g**	**1.65-1.85 g/100 g**

PAH	**< 0.25 ppb**	**< 0.25 ppb**
Phenol	**0.4 -12.6 %**	**0.01-0.02 %**
Mg	**381-441 mg/kg**	**324-327 mg/kg**
Cu	**0.5 -0.7 mg/kg**	**0.4 -0.5 mg/kg**

**Asian Journal of Fisheries and Aquatic Research (2021)*

Table 2. The number of microbes in smoked fish

Parameter	Hot Smoked	Cold Smoked
TPC	4.5x101-1.1x103 Colonies/g	7.3 -7.9 Log cfu/g
Lactid acid bacteria	2.5 -4.26 Log cfu/g	2.5 -4.6 Log cfu/g
Enterobacteriaceae	0.3 -5.27 Log cfu/g	< 6.8 Log cfu/g
Gram-negative psychotropic Bacteria	< 1 Log cfu/g	< 1 Log cfu/g

*Asian Journal of Fisheries and Aquatic Research (2021)

Lactid Acid Bacterial (LAB) was reported as part of natural micro flora of fish fillets. Based on (Adeyeye et al., 2018) reported there were no significant differences were observed in LAB values of cooked and smoked samples. From the presence of LAB in the finished products, it can be concluded that these species were capable of surviving cooking and smoking. LAB seem to form the main micro flora of the vacuum-packed smoked fish at the end of the storage period generally, since they are well adapted to the conditions prevalent in these products: low pH, vacuum packaging, higher salt content, refrigerated storage. Enterobacteriaceae were also found to be part of Lactid Acid Bacterial (LAB) was reported as part of natural micro flora of fish fillets. Based on (Adeyeye *et al.*, 2018) reported there were no significant differences were observed in LAB values of cooked and smoked samples. From the presence of LAB in the finished products, it can be concluded that these species were capable of surviving cooking and smoking. LAB seem to form the main micro flora of the vacuum-packed smoked fish at the end of the storage period generally, since they are well adapted to the conditions prevalent in these products: low pH, vacuum packaging, higher salt content, refrigerated storage. Enterobacteriaceae were also found to be part of the spoilage micro flora of vacuum packaged smoked fish. In hot smoked rainbow fillets, the initial Enterobacteriaceae count was low as 0.3 log cfu/g and reached to 5.27 log cfu/g at the end of storage time. The initial total number of Enterobacteriaceae on the hot smoked rainbow trout and cooked rainbow trout was lower than 1 log cfu/g. Smoking reduced the Enterobacteriaceae count throughout the storage duration (Adeyeye *et al.*, 2018)

CONCLUSION.

The study addressed significant topics that demonstrate the range of IFHAS strategies to guarantee high-quality, safe food products. An endeavor of this kind can be effectively accomplished if fishermen, fish processors, traders, and everyone else involved in handling fish until it is consumed in developing nations where customary hot fish smoking has been documented as a widespread practice, are better prepared for any obstacles they may face and are aware of the acceptable or recommended practices, the necessary skills, and the potential rewards in terms of quality and profits.

REFERENCES

Adeyeye S.A.O, Fayemi O.E, and Oyetoro A.O.A. (2018). Amino acid, vitamin and mineral profiles of smoked fish as affected by smoking methods and fish types. Journal of Cullinary Science and Technology. p.1-14

Akande, G., and Diei-Quadi, Y. (2015). Post-harvest losses in small- scale fisheries: case studies in five sub-Saharan countries. FAO isheries and Aquaculture Technical Paper, Rome. ISSN 50:I, III, IV, V, IX, X, XI, XII, XIII, 1-13,15-39, 41-59,61-65,67-69,712 https:// search.proquest.com/ openview/ 74897eldadc 44c7c3577cdd930604/1? pqorigsite=gscholar&cbl=237320.

Akpambang, V. O. E., Purcao, G., Lajide, L., Amoo, I. A., Conte, L. S., and Moret, S. (2015). Determination of polyaromatic hydrocarbons in commonly consumed Nigerian smoked/grilled fish and meat. Food Additives and Contaminants, 26(07), p.1090–1103.

Almeida, I. F. M., Martins, H. M. L., Santos, S. M. O., Freitas, M. S., Da Costa, J. M. G. N., and Bernardo, F. M. A. (2017). Mycobiota and aflatoxin B1 in feed for farmed Sea Bass (Dicentrarchus labrax). Toxins, Food Additives and Contaminants 3, p.163–171. doi:10.3390/toxins3030163

Alosias, J. K. B. (2019). A pilot survey on retail fish marketing in Juba, South Sudan: perceptions on motivation and challenges. African Journal of Tropical Agriculture, 7(12), p.001-011.

Amit, S. K., Uddin, M. M., Rahman, R., Islam, S. R., and Khan, M. S. (2017). A review on mechanisms and commercial aspects of food preservation and processing. Agriculture & Food Security, 6(1), p.51.

Ashie, I. N. A., Smith, J. P., Simpson, B. K., and Haard, N. F. (2019). Spoilage and shelf-life extension of fresh fish and shellfish. Critical Reviews in Food Science & Nutrition, 36(1-2), p.87-121

Bababunmi, E. A., Emerole, G. O., Uwaifo, A. O., and Thabrew, M. I. (2016). The role of aflatoxins and other aromatic hydrocarbons in human carcinogenesis. In H. Bartsch and N.Armstrong (Eds.), Host factors in carcinogenesis (Vol. 39), p. 395–403. IARC Scientific Publications

Barbosa, T. S., Pereyra, C. M., Soleiro, C. A., Dias, E. O., Oliveira, A. A., Keller, K. M., and Rosa, C. A. R. (2018). Mycobiota and mycotoxins present in finished fish feeds from farms in the Rio de Janeiro State, Brazil. International Aquatic Research, 5, 3. doi:10.1186/2008-6970-5-3.

Béné, C., Steel, E., Luadia, B. K., and Gordon, A. (2015). Fish as the “bank in the water”– Evidence from chronic-poor communities in Congo. Food policy,34(1), p.108-118.

Borokovcova, I., Dofkova, M., Rehurkova, I., and Ruprich, J. (2015). Polycyclic aromatic hydrocarbons in the Czech Foods stuffs. Chemical Listings, 99, p.268–270.

Emborg J, and Dalgaard P. (2016) Formation of histamine and biogenic amines in cold-smoked tuna: an investigation of psychrotolerant bacteria from samples implicated in cases of histamine fish poisoning. Journal of Food Protection.69(4) p.897-906

Emerole, G. O. (2015). Carcinogenic PAHs in some Nigerian Foods. Bulletin of Environmental Contaminants and Toxicology, 24, p.641–646. doi:10.1007/BF01608167

FAO and WHO. (2014). Hazard analysis and critical control point (HACCP) system and guidelines for its application. Annex to CAC/RCP 1-1969, Rev. 3 (1997)

FAO. (2014). Utilization of Bonga (Ethmalosa fimbriata) in West Africa. A. Jallow. Rome. Food and Drug Administration (FDA). (2011). Fish and fishery products hazards and controls guidance. Fourth Edition. U.S. Department of Health and Human Services, Food and Drug Administration, Center for Food Safety and Applied Nutrition.

Ficicilar B.B. and Genccelep H.A. (2017). Characterization study of hot smoked Rainbow Trout for Each Production Stages. International Journal of Agriculture Innovations and Research. 6(2): p.2319-1473.

Fritz, W., and Soos, K. (2015). Smoked Food and Cancer. Journal of Bibliographic Nutrition and Dietetics, 29, p57–64.

Gómez-Estaca, J, Gómez-Guillén, M.C, Montero, P, Sopelana, P, and Guillén, M.D. (2011). Oxidative stability, volatile components and polycyclic aromatic hydrocarbons of cold smoked sardine (sardina pilchardus) and dolphin fish (coryphaena hippurus). Lwt – Food Sci. Technol., 44, p.1517-1524.

Guillén, M. D, and Sopelana, P. (2015). Headspace solid-phase microextraction as a tool to estimate the contamination of smoked cheeses by polycyclic aromatic hydrocarbons. Journal Of Dairy Science, 88, p.13–20.

Huss H, Ababouch L, Gram L. (2016) Assessment and Management of Seafood Safety and Quality, FAO Fisheries Technical Paper 444, Rome, 230.

Jantrarotai, W., and Lovell, R. T. (2017). Subchronic toxicity of dietary aflatoxin B1 to channel catfish. Journal of Aquatic Animal Health, 2, 248–254. doi:10.1577/1548-8667(1990) 002<0248:STODAB>2.3.

Kazerouni, N., Sinha, R., Hsu, C. H., Greenberg, A., and Rothman, N. (2019). Analysis of 200 food items for benzo[a]pyrene and estimation of its intake in an epidemiologic study. Food Chemical Toxicology, 39, 423436. doi:10.1016/S0278-6915(00)00158-7

Lijinsky, W. (2019). The formation and occurrence of polynuclear aromatic hydrocarbons associated with foods. Journal of Muttagenic Research, 259(3–4), p.251–261.

Medina, I., Gallardo, J. M., and Aubourg, S. P. (2018). Quality preservation in chilled and frozen fish products by employment of slurry ice and natural antioxidants. International Journal of Food Science & Technology, 44 p.1467-1479.

Ogbadu, G. H., and Ogbadu, L. J. (2018). Levels of benzo (a) pyrene in some smoked ready-to eat Nigerian foods. Lebensmittel- Wissenschaft Und Technologie, 22(5), p.313–314.

Okonta, A. A., and Ekelemu, J. K. (2015). A preliminary study of micro-organisms associated with fish spoilage in Asaba, Southern Nigeria. Proceedings of the 20th Annual conference of fisheries society of Nigeria (FISON), Port- Harcourt 14th-18th November, p.557-560.

Phillips, D. H. (2017). Polycyclic aromatic hydrocarbons in the diet. Mutagen Research, 443, p.139–147.

Ye, Y. (2015). Historical consumption and future demand for fish and fishery products, exploration calculations for the years 2030. FAO Fisheries Circular No 949 Rome.

FISH TRADE MARKETING AND VALUE CHAIN DEVELOPMENT(FTMV)

DETERMINANTS OF FISH CONSUMPTION PATTERN IN AKINYELE LOCAL GOVERNMENT, IBADAN, OYO STATE

[1]Ayanboye, A. O., [2]Z. O. Oluwafemi, [1]A. O. Busari and [3]H. E Dienye

[1]College of Agriculture, Ejigbo Campus, Osun State University, Osogbo, Nigeria
[2]Oyo State College of Agriculture, Igboora, Oyo State, Nigeria
[3]University of Port Harcourt, Port Harcourt, River State, Nigeria

Corresponding mail:
oluyemi.ayanboye@uniosun.edu.ng, +2348062075491, 0000-0003-3834-1209

ABSTRACT
Fish is a proteinous food and is therefore capable of reducing the inadequacy of protein in the diet of many Nigerians. The estimated annual average per capita fish consumption for Nigeria is 13 Kg, a lower estimate of 8.33kg has recently being reported. Adequate fish consumption would go a long way in combating the shortfall. This paper therefore examined the consumption pattern of fish among households in Akinyele Local Government Area, Ibadan, Oyo State. The source of data for this study was of primary origin and the data was collected with the aid of structure questionnaire. Simple random sampling method was employed to select 120 households in the study area. Descriptive statistics were employed in the analysis of the socio-economic characteristics of fish consumers and determinants of fish consumption was done with the aid of regression analysis. The study showed that both male (15%) and female (85%) consumed fish. The mean household size of the respondents was 4±1 and about 44.2% of the respondents are traders. The majority (79.2%) of the respondents had mean monthly income of N62,555±N15,425 in the study area. The inferential analysis revealed that income, age, education and occupation of the respondents were positively determined fish consumption. It is therefore recommended that the government should consider putting more efforts to increase fish supply from aquaculture in the area to provide fresh fish at an affordable price that will encourage more fish consumption in the State.

Keyword:
Animal Protein,
Consumer,
Household, Nigeria

INTRODUCTION

Fish is an important source of animal protein in all stages of human development. It contributes more than 60% of the world supply of protein, especially in the developing countries. A complete protein is said to have a high biological value when it contains all the essential amino acids that is adequate in amounts and proportions to maintain life and support growth. Fish provides high quality protein, fats, vitamins and minerals like magnesium and phosphorus (Ali *et al.*, (2020) The protein value of fish is much greater than that of other foods containing protein due to the high amount of amino acids in it (Kizilaslan, 2019).

Besides, fish is easy to digest because of the absence of conjunctive tissue (Kizilaslan and Nalinci, 2013). Several research scholars have explored the fish's dietary value and its paramount significance in human food from different aspects. Many recent studies reported that fish consumption aids in stopping various health diseases, including bacterial infections, Alzheimer's disease, metabolic disorder, protein-calorie malnutrition, high blood pressure, cardiovascular and coronary heart diseases

(Hansen and Grung, 2016; Bogard etal., 2017; Samoggia and Castellini, 2017; Balami etal., 2020).
The consumption pattern of a household is the combination of qualities, quantities, acts and tendencies characterizing a community or a human group's use of resources for survival, comfort and enjoyment. Consumption patterns normally contribute greatly to the social and economic policy of the country. In a developing country like Nigeria, the consumption pattern is skewed towards food i.e., food accounts for a higher proportion of the total expenditure while in developed countries the opposite is the case (NBS, 2010).Consumer behaviour is a means of studying why consumers behaves the way they do when it comes to making a choice in purchasing goods. It attempts to explain the buyer decision-making process both individually and in groups. The theory of consumer behaviour assumes that a consumer is rational and aims at attaining the highest possible satisfaction given his income and the prevailing market prices. He attempts spending his income in a way that gives him maximum satisfaction (Agbaje, 2003).
The craving for fish is on the increase in Nigeria, given its important in individual and national health. Against this background, there is need to know the level of fish consumption which has been adjudged as common and relatively cheapest source of protein. Therefore, this paper is set out to investigate the determinants of fish consumption among the respondents in the Akinyele Local Government Area, Ibadan, Oyo State, Nigeria.

MATERIALS AND METHOD

This study was conducted in Akinyele Local Government Ibadan, Oyo State, Nigeria. Akinyele Local Government Area (LGA) is one of the eleven local governments that make up Ibadan metropolis. It is bounded in the East by Lagelu LGA, Afijio LGA in the North, Ibadan North LGA in the South, and Ido LGA in the West.
A multistage sampling technique was employed in the selection of respondents to collect primary data. In the first stage, Ibadan town was purposefully chosen in the State. This is because the town is the capital of the state, the most populated and has abundant fish markets. The second stage involved the chosen of Akinyele local government from the eleven Local Government Areas in Ibadan Metropolis because of financial constraint. Akinyele local government area is subdivided into 12 wards, out of which Ojoo/Ajibode/Laniba ward was chosen due to the educational level of the households. The third stage involves a probability proportional to the size selection of 120 respondents from the ward, using population data from 2006. A semi-structured questionnaire that was validated before actual administration was designed to elicit relevant information.

The households' demographic characteristics and consumption patterns were analysed using illustrative statistics like mean, frequencies, and percentages. The multiple regression model was used to analyse factors determining household fish consumption.
The regression model is stated as follows

$Y = f(X_1, X_2, X_3, X_4, D_1, D_2)$

Where Y = Consumption Expenditure on fish

x_1 = Household monthly income in Naira

x_2 = Household size

x_3 = Age of household head

x_4 = Educational level of household heads

D_1 = Occupation of household head = Salary earner =1; otherwise =0

D_2 = Taste preference of respondents (fresh fish =1, others = 0)

Four functional forms were fitted to the data, and these are the Linear, Semi Log, Double Log and Exponential functions. The criteria for choosing the most appropriate functional forms for the study is based on computational simplicity and statistical accuracy of the fitting, others include R2, standard error of regression estimate, co-efficient with respect to sign of magnitude.

RESULTS AND DISCUSSION

Table 1 presented the results on socio-economic characteristics of respondents in the study area. The analysis revealed that 85% were female while 15% of the respondents were male. This showed that majority of the respondents are female. This is because they are those involved in cooking activities as either wife or mother at home. This result is in agreement with Oyibo et al., (2020). Also, majority (63.34%) of the respondents were between 21-40 years, followed by the respondents with 35.00% which falls between 41-60 years of age while 0.83% respondents fall between the age 1-20 and 61-80 years respectively. The mean age was 39years ±9years. This implied that majority of the respondents were young and in their active age, which by implication requires more nutrients to sustain their productive activities, especially protein and carbohydrate sources that could boost their energy and rebuild their worn-out tissues. Majority (77.50%) of the respondents were married, 10% were widow, 5.83% were divorced while 4.17% were single and 2.50% were widower. The result indicated that the married people consumed more fish. This may be because the respondents in the study area perceived fish as means to provide nutritious meal enriched with balance protein source that is relatively cheap, of different types and forms, and affordable to their family members. The results also revealed that 35.00% of the respondents had secondary school education, 29.17% had B.Sc./HND education, 20.83% had NCE/OND education while 9.17% had primary school education and 5.83% had M.Sc. education. This result shows that the education status in the study area was relatively low and is a typical attribute of peri-urban household in which this study area belong. The people with household size between 1 – 5 were 84.20% while that of 6 – 10 were 12.50% and >10 household were 3.30%. The mean household size of the respondents was 4±1. These indicated that majority of the respondents have moderate family size. The table also showed that few of the respondents interviewed were likely to have extended family members living with them. The occupational distribution of the respondents shows that about 44% were into trading, 35% were civil servant while 5.80% were artisan and 5.00% were farmers. This could infer that fish consumption will be high due to the level of occupation of the respondents. The results showed that only 2.5% of the respondents had income above N100,000, followed by about 8% that earned income between N71,000-100,000 while 79.17% earned income ranging between N40,000 to N70,000. The least monthly income earned by about 10.00% of the respondents was between N11,000 and N40,000. The mean income of the respondents was N62,555± N15,423. This implied that majority of the respondents in the study area are within the low-income group and those with higher income class are relatively few.

Table 1. Socioeconomic Characteristics of the Respondents

Gender	Frequency	Percentage (%)
Male	18	15.00
Female	102	85.00
Age		
<20	1	0.83
20-40	76	63.34
41-60	42	35.00
>60	1	0.83
Mean 39±9		
Marital Status		
Single	5	4.17
Married	93	77.50
Divorced	7	5.58
Widow	12	10.00
Widower	3	2.50

Education Status		
Primary school	11	9.17
Secondary school	42	35.00
NCE/OND	25	20.83
B.Sc./HND	35	29.17
MSc	7	5.83
Household size		
<5	101	84.20
6-10	15	12.50
>10	4	3.30
Mean 4±1		
Occupation		
Civil servant	53	44.20
Trading	42	35.00
Farming	06	5.00
Artisan	07	5.80
Monthly Income		
11,000- 40,000	12	10.00
41,000 – 70,000	95	79.17
71,000- 100,000	10	8.33
101,000 – 130,000	3	2.50
Mean ≤ N62,555±N15,425		

Result of determinants of fish consumption

From the four functional forms fitted, the double log function gives the best fit, hence, it is selected as the lead equation. This is based on the r^2, t-ratio and F- ratio obtained from the number of statistically significant variables and the economic theory of consumption expenditure. The regression equation of the double log function is given by

Log Y= -0.169+ 0.595logx1*** + -0.088logx2** + 0.237logx3* + 0.042logx4 + 0.1528D1*** – 0.5084D2***

(1.753) (0.189) (0.188) (0.408) (0.209) (0.156) (0.185)

*** = t-value significant at 1% ** = t-value significant at 5% * = t-value significant at 10%

Figures in Parenthesis are standard errors

The value of the coefficient of determination R2 of the result is 0.6603 and this implies that the explanatory variable explains 66.03 percent of the variation in the value of fish consumption expenditure. The F-test indicates that the overall equation is significant at 1 percent level.

From the regression result, income with a coefficient of 0.595 has a positive significance on the consumption of fish at 1% implying that every unit increase in the income level of respondents in the study area will result to a higher consumption level of 0.595 units. This is consistent with the economic theory of demand that shows a positive relationship existing between the income level of respondents and consumption. This is also in consonance with Oyibo et al. (2020) and Onyeneke et al. (2020) who reported that there is a relationship between income level and fish eating. The coefficient of household size is negative and statistically significant at 5 percent level suggesting that household size is indirectly related to fish consumption in the area. This could imply that as household size increases, the respondents switched over to a more relatively cheaper protein source such as the local cheese. This is much cheaper fish. Genschick et al., (2018) reported a positive relationship between fish consumption and household size, however, the researchers opined that this may not translate to actual higher consumption by household members, as it may cost more to provide enough fish for all members of the family all the time. The age of respondents' variable had a positive coefficient of 0.237 at a 10% level of significance. Thus, with a unit increase in the age of the household head, there would be about a 0.23 % increase in the probability of fish consumption by a household which implies that it has a direct relationship on the fish consumption; this is possible because of constant warning against the consumption of red meat for health issues. As one is advancing in age, fish consumption also increases because of different health issues that comes with old age with the consumption of red meat. Fish is most ideal for the aged and the growing youth because of the ease of digestibility of its soft tissue (Eyo, 2002). Occupation and Taste of the respondents have a positive relationship with fish consumption in the study area and both are significant at 1%.

CONCLUSION

The factors influencing fish consumption discovered were income, age, education and occupation of the respondents. The households of Akinyele local government consumed fish without gender restriction. In this light, the households are advised to go into homestead fish production to increase the supply of fresh fish in the area. Government should also assist the households by considering putting more efforts to increase fish supply from of aquaculture in the area, this will go a long way to provide fresh fish at an affordable price that will encourage fish consumption the more in the State.

REFERENCES

Agbaje, F.I. (2003). Consumption preference and acceptability of some fresh water fishes in Abeokuta, Ogun State" Unpublished B. Sc. Project. Department of Fisheries and Aquaculture. University of Agriculture, Abeokuta, Ogun State.

Ali, S.S.R, Abdhakir, E.S., Muthukkaruppan R., Sheriff, M.A. and Ambasankar, K. (2020). Nutrient Composition of Some Marine Edible Fish Species from Kasimedu Fish Landing Centre, Chennai (TN), India. International Journal of Biological Innovations. 2(2):165-173. https://doi.org/10.46505/IJBI.2020.2213

Balami, A.D., Md. Said, S., Mohd. and Zulkefli, N.A. (2020). Determinants of uptake of first dose of intermittent preventive treatment among pregnant women in a secondary health Centre in Maiduguri, Nigeria. BMC Pregnancy Childbirth 20, 726 https://doi.org/10.1186/s12884-020-03388-8

Bogard, J.R., Farook, S., Marks, G.C., Waid, J., Belton, B. and Ali, M. (2017). Higher fish but lower micronutrient intakes: Temporal changes in fish consumption from capture fisheries and aquaculture in Bangladesh. PLoS ONE 12(4): e0175098. https://doi.org/10.1371/journal. pone.0175098

Eyo, A.A. (2002): Fish processing in the tropics. Published by National Institute for Fresh Water Fisheries Research (NIFER). Pg, 1-4.

Genschick, S., Marinda, P., Tembo, G., Kaminski, A.M. and Thilsted, S.H. (2018). Fish consumption in urban Lusaka: The need for aquaculture to improve targeting of the poor. Aquac., 492, 280-289. https://doi.org/10.1016/j.aquaculture.2018.03.052 G

Hansen, A.L. and Grung, B. (2016). Fish Consumption and Heart Rate Variability, Fish and Fish Oil in Health and Disease Prevention, Pages 231-238, Academic Press.

Kizilaslan, H. and Nalinci, S. (2013). Red Meat Consumption Habits of Households in the Central District of Amasya Province and Factors Affecting Red Consumption. Gaziosmanpasa Scientific Research Journal (3), 76-99.

Kizilaslan, N. (2019): An analysis of factors affecting fish consumption in a healthy and balanced nutrition. Asian J. Clin. Nutr., 11: 9-16.

National Bureau of Statistic (2010). Consumption Pattern in Nigeria 2009/10 Consumption Report 1-3:23-25.

Onyeneke, R.U., Amadi, M.U., Iheanacho, S.C., Uwazie, U.I. and Enyoghasim, M.O. (2020). Consumption of different forms of fish in Abakaliki metropolis of Ebonyi State, Nigeria. Afr. J. Food Agric. Nutr. Dev., 20 (2), 15523-15537. https://doi.org/10.18697/ajfand.90.19175.

Oyibo, F.O., Ajibade, Y.E., Haruna, O.E. and Samuel, S.D. (2020). Analysis of fish consumption pattern among Kogi State University students, Anyigba, Kogi State, Nigeria. Asia. J. Adv. Agric. Res., 14 (1), 43-55. https://doi.org/10.9734/ajaar/2020/v14i130124

Roos, E.M., and Lohmander, L.S. (2003). The Knee injury and Osteoarthritis Outcome Score (KOOS): from joint injury to osteoarthritis. Health and quality of life outcomes, 1, 1-8.

Samoggia, A and Castellini, A. (2017). Health-Orientation and Socio-Demographic Characteristics as Determinants of Fish Consumption, Journal of International Food & Agribusiness Marketing, DOI: 10.1080/08974438.2017.1403986

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

ECONOMIC ANALYSIS OF CATFISH PRODUCTION IN ASA LOCAL GOVERNMENT OF KWARA STATE, NIGERIA

Folorunsho, B., E. K. Ajani and J. Halimat

Department of Fisheries and Aquaculture, Kwara State University, Malete, Kwara State, Nigeria

Corresponding author's:
folorunshobamidele7@gmail.com

ABSTRACT

The study examined catfish production in three villages (Afon, Egbejila and Ago-oja) in Asa Local Government Area of Kwara state, Nigeria. 150 catfish respondents were evaluated using multistage sampling procedure and descriptive statistical tools to evaluate frequency, means and percentages, while gross margin, net farm income were used as inferential tools in making inference about the data collected. Results shows that 22.67% of the respondents were above 51 years of age with 63.33% being married and 66.67%, having tertiary education. Both male (63.33%) and female folks (36.67%) were involved in catfish production with mean age of 42 years and 5 years of experience. The mean total fixed and variable cost is N1,923,400 and mean total revenue earned by the respondents is N2,369,933.33. The gross margin (GM), net returns on investment ((NRI)) and cost benefit ratio (CBR) are N1,756,133.34, N1,672,500.01 and 1.23 respectively. The study therefore recommends that catfish farming is a profitable agricultural venture which can increase farmers likelihood in Nigeria.

Keywords:
catfish production, respondents, socio-economic characteristics, variable and fixed cost

INTRODUCTION

Fish is a vital source of income for many developing countries in which Nigeria is one (Williams *et al.*, 2010). Apart from being animal protein source, other benefits of fish as a resource include employment generation, poverty reduction and saving foreign exchange by stimulating local production at various rural areas (Yunusa and Maidala, 2008). Fish farming is a profitable enterprise and it is rapidly expanding and it will continue to be viable if its management and planning are well implemented (Runfu *et al.*, 2009). Adewunmi (2006) reported that Nigeria is a protein deficient nation and as such there is an urgent need to increase protein intake through fish farming.

MATERIALS AND METHOD

This study was conducted in Asa Local Government Area (LGA) of Kwara State, Nigeria, which is one of the sixteen LGAs in the State. The area covered 1,286 km2 and lies between Latitudes 8.80o and 8.40o North of the equator and Longitude 4.12o and 4.40o E (Kwara Agricultural Development Projects, 2006).

Method of Data Collection and Sampling Technique

Primary sources of data were used for the study with the use of structured questionnaire to explore the minds of the practitioners' fish farmers in the study area. The primary data was collected with the aid of structured questionnaires administered to the respondents. Data were collected based on the socio-economic variables such as gender, age, farming experiences, educational status, household size and income level of the respondent, as well as profitability variables with a total sample size of 150. The tools used for the of analysis of data collected are descriptive Statistics and farm budgeting technique.

Problems associated with fish production by the respondents, were requested to indicate the severity of each constraint with the aid of a 3-point Like t-type scale and the mean score used to rank the constraints in order of severity.

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents.

Results in Table 1, shows that majority of the respondents were aged between 51 and above (22.67%), while 63.33% were males, 66.7% had tertiary education, 66.33% were married, household size that were involved in production ranges between 1-5, while 70% were part time fish farmers and only between 1- 5 years of experience were 56.66%. These observations in the study agreed with Runfu et al., (2009), William et al., (2010) and Adewumi *et al.*, (2006. Most of respondents (48.67%) used their personal fund to produce their fish, while 52% employed between 1- 3 people to support them as labourers. About 56.66% were pond owners with 3-4 pond unit constituting 37.33%. These are evident with work done by Adebayo (2012) and Olagunju et al., (2007). Most of the respondents used intensive feeding system (53.34%), while pumping machines were mainly used as a means of water supply to their ponds (80%). Most respondents adopted use of medication (80%) to prevent and to cure their fish in case of infection, while majority (66.67%) of the respondents stocked their ponds at juvenile stage.

Table 1. Socio-economic characteristics of the catfish farmers (n = 150)

Age	Frequency	Percentage (%)
20 – 25	10	6.67
26 – 30	28	18.66
31 – 35	21	14.00
36 – 40	26	17.34
41 – 45	16	10.66
46 – 50	15	10.00
51 – above	34	22.67
Male	95	63.33
Female	55	36.67
Education		
No formal education	8	5.33
Primary	12	8.00
Secondary	30	20.00
Tertiary	100	66.67
Marital status		
Single	42	28.00
Married	95	63.33
Divorced	6	4.00
Widow	7	4.67
Household size		
1 – 5	81	54.00
6 – 10	46	30.66
11 – 15	1	0.67
16 – above	22	14.67
Part time farming		
Yes	105	70.00
No	45	30.00
Years of experience		
1 – 5	85	56.66
6 10	37	24.67

–		
11 – 15	11	7.34
15 – 20	8	5.33
21 – above	9	6.00
Sources of fund		
Bank	18	12.00
Cooperative society	37	24.66
Personal saving	73	48.67
Government loan	22	14.67
No of people employed		
1 -3	78	52.00
4 – 6	40	26.67
7 -10	30	20.00
Pond ownership		
Yes	85	56.66
No	65	43.34
No of pond units		
1 – 2	50	33.33
3 – 4	56	37.33
5 – 6	16	10.66
7 – 8	11	7.34
9 – 10	6	4.00
11 – above	11	7.34
Feeding practices system		
Intensive	80	53.34

Problems associated with catfish production by the respondents

The problems associated with catfish production in the study area in Table 2 is ranked according to their severity, which are as follows; lack of fund as 1st (66.67%), high cost of feed was 2nd (53.33%), both high cost of labour, theft and pouching were 3rd (53.33%) and lack of information about the market price ranked 4th (44.44%) respectively. Others are diseases and predation being 4th (13.33%), lack of good roads as 5th (10%), water pollution as 6th (6.67%), Flooding as 7th (3.33%) and attitude of middle men as 8th (2.66%). According to the report of Anthonio and Akinwumi (2002), FAO (2007) and WFC (2009), similar problems were observed.

Table 2: Problems associated with catfish production by the respondent.

S/N	Problems/Constraints	Not a problem F (%)	Little problem F (%)	Serious problem F (%)	Rank
1.	Lack of fund	10(6.67)	40(44.44)	100(66.67)	1
2.	High cost of feed	20(13.33)	50(33.33)	80(53.33)	2
3.	Theft/Pouching	60(40.0)	50(33.33)	40(44.44)	3
4.	Lack of information about market price	70(66.66)	60(40.00)	30(20)	4
5.	High cost of labor	60(40)	50(33.33)	40(44.44)	3
6.	Diseases/Predation	80(53.33)	50(33.33)	20(13.33)	5
7.	Lack of good road	90(60)	45(30)	15(10)	6
8.	Water pollution	95(63.33)	45(30)	10(6.67)	7
9.	Flood	100(66.67)	45(30)	5(3.33)	8
10.	Attitude of middle men	110(73.33)	46(30.67)	4(2.66)	9

Cost Analysis of catfish production by the respondents.

Results in Table 3 show cost analysis for the production of catfish in the three locations including Afon, Egbejila and Ago Oja towns, respectively. The total variable cost for the three locations is N5,519, 300, with Afon (N1,822,000), Egbejila (N1,847,400) and Ago Oja (N1,849,900) respectively. The analysis shows the cost of feed as the highest of N4,545,00, while others cost is juvenile (N153,000), pond preparation (N93,000), liming and fertilization (N44,850), fueling (N53,000), medication (N36,900), labour and security (N267,950), netting and logistics (N105,000) and transportation (N120,700). The total fixed cost is N250,900, with a breakdown of land rentage (N151,500), depreciation cost on security house (N43,900), water bill, (N30,000) and depreciation on tools and machine (N25,500). The means for both the total variable and fixed cost is N1,923,400. The results in this study is similar to other field survey conducted by Emokaro et al., (2010) Ugwumba and Nnabuife (2008).

Table 3. Cost analysis of the catfish production respondents

Items of variable cost	Afon	Egbejila	Ago oja	Total cost (N)
Feed	1,500,000	1,520,000	1,525,000	4,545,000
Juvenile	50000	51000	52000	153,000
Pond preparation	30000	32000	31000	93,000
Liming/fertilization	15000	14900	14850	44,750
Fueling for pumping water	50000	52000	51000	153,000
Medication	12000	13000	11900	36,900
Labor/security	90000	89000	88950	267,950
Netting/logistics	35000	34500	35500	105,000
Transportation	40000	41000	39700	120,700
Total	**1,822,000**	**1,847,400**	**1,849,900**	**5,519,300**
Mean of TVC				**1,839,766.67**
Fixed cost				
Land rentage	50000	51500	50000	151500
Depreciation cost on security house	14000	15000	14900	43900
Water bill	10000	10000	10000	30000
Depreciation on tools and machine	8000	9000	8500	25500
Total	**82,000**	**85,500**	**83,400**	**250,900**
Mean of TFC				**83,633.33**
Total cost = TVC+TFC # (5,519,300 +250,900)				**5,895,700.00**

Analysis for catfish production by the respondents.

The results in Table 4 are the revenue analysis from the three locations of the respondents for one round of production within the year. Total revenue of N7,109,800 was realized representing the locations, out of which Afon, Egbejila and Ago Oja contributed N2,340,000, N2,438,000 and N2,331,800, respectively. The mean total revenue stand at N2369,933.33. According to William et al., (2010) and Yunuba and Maidala (2008), the cost of feed and inability to buy fish at higher price reduces the total revenue in fish production.

Table 4. Revenue analysis by the catfish production respondents

Quantity (Kg)	Afon	Egbejila	Ago Oja	Total
Harvested (Kg)	900	920	890	2710
Rate /Kg (₦)	2600	2650	2620	7870
Total revenue	2340000	2438000	2331800	**7,109,800**
Mean total revenue				**2,369,933.33**

Profitability analysis on catfish production by the respondents

Table 5, is a summary of the profitability analysis of catfish production of the respondents in the study area. The results shows that the total revenue, gross margin and net return on investment are N1,672,500.01, N2,369,933.33, N1,756,133.34, while cost benefit ratio (CBR) is 1.23 respectively. This shows that catfish production by the respondents in the three-location evaluated is profitable since the CBR value is higher than one.

Table 5. Profitability analysis of catfish production by the respondents in Asa LGA

Cost Analysis	Value (#)
Total revenue (TR)	2,369,933.33
Total variable cost (TVC)	1,806,466.67
Total fixed cost (TFC)	83,633.33
Gross Margin (GM) = TR – TVC N (2,369,933.33 – 1,839,766.67)	**1,756,133.34**
Net Return (NR) = GM – TFC N (1,756133.34 – 83,633.33)	**1, 672,500.01**
Cost Benefit Ratio (CBR) = TR/TC 2,369,933,33/1,923,400	**1.23**

CONCLUSION

Catfish farming is a productive venture that can support livelihood in Nigerian when proper cultural methods are used. It is also imperative that the cost of feed, which account for almost 80% of the total production can be cut down through the removal of tariffs on imported feeds and its raw materials. Also, loans with low interest should be provided to fish farmers by government to boost production.

REFERENCES

Adebayo, O.O. (2012). Determinants of Extension Service Needs of Catfish Farmers in Oyo State, Nigeria (A case Study of Ido Local Government Area)". J. Humanities and Soc. Sci., 1(4): 54-58.

Anthonio, O.R. and Akinwumi, J.A. (2002). Supply and distribution of fish in Nigeria. Geographical Journal, 14: 16-16.

BA., Lal S., (2009). Common Moorhen Gallinula chloropus in the diet of the African catfish Clarias gariepinus in Keoladeo Ghana National Park, India. Indian Birds, 5(2):22-23.

Emokaro, C.O., Ekunwe, P.A. and Achille, A. (2010). Profitability and viability of catfish farming in Kogi State, Nigeria". J. Agric. Biol. Sci., 6 (3):215-219.

FAO Fisheries Department, Fishery Information, Data and Statistics Unit. Food and Agriculture Organization (2007). State of World Fisheries & Aquaculture http://www.fao.org/fi/statist/fisoft/fishplu.asp.

Okwu, O.J. and Acheje, S. (2011). Socio-Economic Analysis of Fish Farming in Makurdi Local Government Area, Benue State, Nigeria. Eur. J. Social Sc., 23(4).

Olagunju, F.I., Adesiyan, I.O. and Ezekiel, A.A. (2007). Economic Viability of Catfish Production in Oyo State, Niger. J. Human Ecol., 21(2): 121-124.

Runfu, M.O., Adepuju, M.O., Salau, A.S., and Adebiyi, O.A. (2009). Determinant of yield performance of small-scale fish farming in Alimosho Local Government Area of Lagos State. International Journal of Agric. Econs. and Rural Devpt., 2(1): 9-14.

Ugwumba, C.O.A. and Nnabuife, E.L.C. (2008). Comparative Study on the Utilization of Commercial Feed and Home-made Feed in Catfish Production for Sustainable Aquaculture. Multidiscipl. J. Res. Dev., 10: 164–169.

Vanguard (2009): "Nigeria: Catfish Farming – a Reliable Investment". Lagos, Nigeria.

Williams, B.S., Kareem, R.O. and Eneh N.M. (2010). Profitability Analysis of Fish farming: An attitude to Economic meltdown. Journal of Sustainable Development, 7(1): 15-18

Williams, S.B., Kareem, R.O. and Ojolowo, O.A. (2012). Economic Analysis of Catfish Production in Ile-Ife, Osun State, Nigeria". J. Human Ecol., 40(1): 1-7.

World Fish Center (2009). World Fish Medium – Term plan 2010 – 2012, Reducing Poverty and Hunger by improving Fisheries and Aquaculture. 18p.

Yunuba, M. and Maidala, A. (2008). The Need to include fisheries in the Nation's Secondary Schools. Paper presented at the First National Conference of School vocational and Technical Education College of Education Azare.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

A REVIEW OF FISH MARKET AND MARKETING IN KAINJI LAKE BASIN NIGERIA

[1]Bello, A, [1]P.I Ifejika,[1]M Yisa, [1]B.H Okojie, [1]G. O Nwabeze, [1]T Olowosegun, J. E Omeje, [1]S.A Faleke, [2]D.E Abuh, [3]C.E Eze, [1]M Najaka, [1]N Hussaini, and [1]T.I Ibitoye,

[1]National Institute for Freshwater Fisheries ResearchNew-Bussa, Niger State,P.M.B 6006.
[2]Eco-Climate Foundation, Social Centre Complex, ABU Zaria, Kaduna State.
[3]Fisheries and Aquaculture DepartmentFederal College of Animal Health and Production, Vom, Plateau State, Nigeria.

Corresponding Author:
babdullahi463@gmail.com +2348064745374

ABSTRACT
This paper reviews the markets and marketing of fishing Kanji Lake basin, Nigeria, by examine the types of fish market, ascertain fish marketing channels and challenges of fish marketing in the area. A secondary data source from published journal, conference proceeding, books among others were used. The findings revealed existence of different types of fish markets to be physical and online which are classified into primary, secondary and tertiary markets. Also there exist five fish marketing channels for fish distribution from producers The price of fish is cheaper at the farm gate and river shore than in the open markets due to inference of middle men and commission agents. It was revealed that kilogram of Lates now sold for N3,500.00, Clarias pond fish N2,400.00, and Tilapia N1,000.00. Major constraints to fish marketing are high cost of transportation, inadequate capital, lack of proper handling and processing technique and lack of storage facilities, which hinder efficient preservation of fish and access to international markets. The recommendations include the use of online platform to connect directly to consumers, infrastructure provisions, cooperative formation and standardization in processing, packaging and transportation.

Keywords:
Fish, Aquaculture, Kainji Lake, marketing, Channels

INTRODUCTION

Kainji lake basin is a vital economic zone, which characterized by rich aquatic biodiversity and significant reliance on fisheries. As the communities within the lake basin increasingly turn to fish production as a sustainable livelihood, understanding the dynamic of fish market become crucial. Market is an area/medium in which commercial dealing are conducted. (Omotunde and Adetunji, 2008) defined Marketing involves the process of planning and executing the conception, pricing, promotion and distribution of ideas, goods and services to create exchanges that satisfies individual and organizational objectives. Fish marketing may be broadly defined as overall activities from point of catching of fish, to the point consumption. It is the series of efforts that are carried out inmoving fish and fish products from the point of initial cultured or catch to the final consumers. Making fish available to consumer at the right place and time require effective marketing system. Marketing efficiency is defined as the maximization of ratio of output to input in marketing (Ojo, 2010). The marketing inputs are the costs of providing marketing services while outputs are the benefits or satisfaction created or value added to the commodity as it passes through the marketing system. Fish marketing does not usually involve the fishermen and consumers only but other actors in the fish distribution channels especially the middlemen (Daryanto and Wibowo (2023). Olukosi et al. (2005) categorized marketing channels into centralized and decentralized channels. A centralized channel has agents who serve as middleman between producers and consumers while the decentralized marketing channel is typical to fish marketing in most developing countries including Nigeria and these methods were used in marketing of fish within kainji Lake environments. The women dominate the trading aspect while men involve in catch and culture of fish. However, the marketing of fish is family business, has the women introduced their children to the business, they catch and assemble fish in market where several buyers come from other state to buy. Also, wholesalers and commission agent may go to farm to buy at the farm price. The common spices of fish found in the market are:Clarias, Lates , Synodontis, Tilapias, Alestes lates, Tilapia Alestes Ciprates Citharinus, Bagrus, Mormyrus and Clupeids (Yekinni, O.A and Ipinloju, O.S 2014)

Study revealed that the major players in the marketing of fish are women because they lack productive resource to engage in the other nodes of the value chain (Ike- Obasi and Ogubunka 2019) thus contradicting Nwabeze, et al (2019) who opined that smoke fish marketer are dominated by males. Irrespective of the findings of these scholars, the fact remains that men and women are key players in marketing of fish in the area. Therefore, the study sought to examine types of fish market, ascertain fish marketing channels and identify challenges of fish marketing in the area.

METHODOLOGY:

Secondary data were sourced from published works in institutional based journals, conference proceedings, among others. Journals were sourced through academic search engines such as Google scholar and other academic platforms like Research gate. Academic journals that fit into the topic were selected and scrutinized based on the reliability of the information therein.

RESULTS AND DISCUSSION

Presented below are the findings in the subheadings;

Types of Fish Markets in Kainji Lake Basin.

The domestic freshwater fish market in Kainji Lake basin is complex and comprises of many types of markets with large number of actors. The identified fish markets within the lake is classified as primary and secondary markets found at Kokoli, New-Bussa, Malale, Toro, Yauri, Shagunu, Wara, Yelwa, as well as Moni due to farm gate market available for the sales of cultured fish. Other types are distant markets in urban cities classified as tertiary market like Onitsha, Minna, Bida, Ilorin, Abuja, Lagos, Kano, Kaduna, and Kebbi with large numbers of consumers. The stakeholder in the market are fishers and fish farmers (producers) followed by wholesalers and retailers (fish traders or buyers) who came from nearby and far cities to buy fish whereas the third actors are consumers who buy fish for household use while middle men interface in the whole process as commission agents between producers, traders and consumers. Past studies had confirmed that women dominate fish marketing in the Lake basin but men were found to be major bulk fish buyers in fish market enterprise (Omeje et al 2022; Nwabeze et al 2019; Ike-Obasi and Ogubunka 2019). In the markets, fish are either sold fresh or smoked or frozen but mostly smoked for preservation and easy transportation to long distances. Meanwhile, about 40% of cultured fish are sold live and transported in jerry can and plastics to cities like Abuja, kebbi, Kaduna, and Kano. Types of fish species found in the markets are Clarias, Synodontis ,Tilapias, Alestes, Lates, Ciprates Citharinus, Bagrus, Mormyrus and Clupeids (Yekini, O.A et al 2014). Price of fish is a function of the value, size and quality. High priced fish like: Lates, Mormyrus, and Catfish attract higher price due to value attached to them unlike Tilapias, Synodontis and Citharinus considered as low-quality fish with low price. For instance, a kilogram of Lates now sold for N3,500.00, Clarias pond fish N2,400.00, and Tilapia N1,000.00. However, it is important to note that cultured fish is more costly than capture fish in the lake basin due to high cost of inputs and selling with scale to cover cost and make profit unlike fishers that sell catch fish at their own discretion. The price of fish is cheaper at the farm gate and river shore than in the open markets (primary, secondary and tertiary) due to inference of middle men and commission agents. Also, smoke fish attracts higher price by almost two or three – fold as a result of value addition and packaging compare to fresh fish. Some of the markets operate weekly except farm gate and New-Bussa partially daily. Transporters play important role in logistic movement of the fish to different locations by bus, cars, trucks (pick-ups) and Lorries. The market operates uniformly with limited infrastructure and regulatory policy, hence the need to upgrade market infrastructure with warehouse, modern packaging, preservation methods and food safety measure. In recent time, the advent of online marketing with social media and mobile phone had sprout rapidly in Kainji lake Basin as a trend among fish producers and marketers. Some fish traders and producers use online platforms like Facebook, WhatsApp, TikTok to advertise and sell their fish to both local and distant buyers as costumers opting for contactless delivery. Fish are marketed with video and pictures with mobile phones which has been on among fish traders and producers as found by Ifejika et al (2009).

Fish Marketing Channel in Kainji Lake Communities:

A marketing channel is a collection of procedures or actions required to move the ownership of products from the producing location to the consumer location (Danmaigoro and Gona, 2023).

Figure 1 depicts the fish marketing channels in Kainji Lake basin which involves five channels. The first major channel of fish market distribution is from the producers (fishers/fish farmers) to wholesalers, retailers and final consumers. The second channel of fish distribution is from producers to middlemen known as commission agents to wholesalers and retailers. Third is from retailers to consumers which are found in primary, secondary and tertiary markets. The fourth channel is from wholesaler to consumers with limited flow of supply. The fifth channel is producers selling directly to consumers. Wholesalers buy in bulk and need more capital than retailers and middlemen; hence men are found to be dominating in fish wholesale enterprise (Omeje et al 2022). Also, some of fresh fish wholesalers and retailers buy to add value before selling to consumers.

Possible distribution channels for fish marketers

- Fish Farmer-Middleman/collectors-contractors-commission Agents-Wholesaler's retailers-consumers
- Fish farmer-middle/collector/contractor/-Wholesaler-Retailer-consumer.
- Fish farmer-fish cooperative / fish entrepreneur committee-consumer.
- Fish farmer-middleman/ collector/contractor-retailer-consumers.
- Fish farmer-retailer-consumers

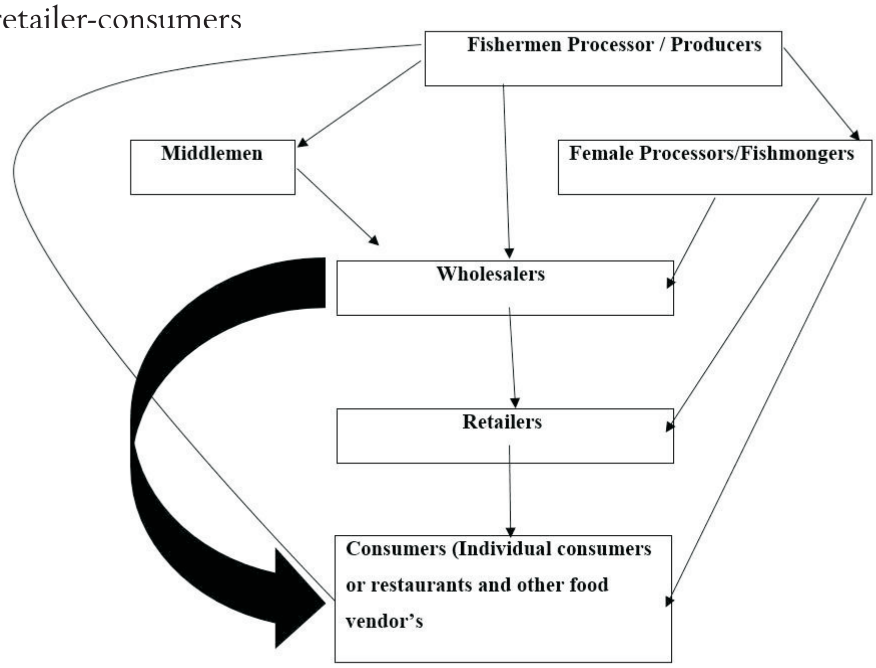

Figure 1: Flow chart of fish marketing channel (Nwabeze 2019)

Challenges of Fish Marketing in Kainji Lake Communities:

Fish marketing in the lake basin has multiple challenges towards its modernization and standardization. Presently, it is operated as a local enterprise with little or no improvement in terms of fish packaging, smoking quality, and hygiene practices. Another challenge found among fish marketers in the communities was poor pricing in wholesale fish marketing due to the presence of middlemen usually negotiated at a rate below the expectations of the producers (Omeje et al, 2022). This will enable market unions set an acceptable price for the product that will be quite rewarding to producers, wholesale marketers, middlemen and retailers. Furthermore, high cost of transportation is another serious challenge which increases the marketing cost of fish and production cost as reported by Kabwe and Zulu(2017). However, the actors in the fish market chain pointed out that rising cost of fuel used for transport was the major factor behind the rise in goods. Access to capital by wholesaler which requires large amount of capital due to high cost of purchasing large volume of fish and transport to other market centers. This result is consistent with Agbebi and Adetuwo (2018) that inadequate capital as well as access to credit is a major constraint faced by fish marketers. According to Hamid (2020), in order to finance smoked fish marketing, timely access to low interest rate credit facilities is required to facilitate and sustain efficient and effective marketing processes. Furthermore, lack of proper handling and processing technique can lead to quality degradation as well as lack of storage facilities hinder efficient preservation of fish and access to international markets.

CONCLUSION:

In conclusion, the study finds that market within the Kainji lake are primary and secondary market where the major actor are producers, wholesaler and retailer who buy to resell in tertiary markets in the cities for more profit. The marketing channel is a perfect competition with free entry and exits. The limitation to marketing activities involves inadequate capital, high cost of transportation, poor pricing and lack of proper handling

RECOMMENDATION:

The review, recommends

- Farmer should make use of online platform to connect directly to consumers
- Fish marketers should be encouraged to form cooperative marketing group to device a means of providing transportation.
- Fish marketers should have a proper storage facility within the market.
- Government should provide basic infrastructure in the market for easy accessibility
- Government should provide low interest rate credit to marketer to buy in large quantity.

REFERENCES:

Agbebi, F.O. and Adetuwo, K. I. (2018). Analysis of Socio-Economic Factors Affecting Fish Marketing in Igbokoda Fish Market, Ondo State, Nigeria. International Journal of Environment, Agriculture and Biotechnology (IJEAB), 3(2), 512–521.

Danmaigoro A and Gona A (2023). Analysis of smoked Fish marketing in some selected Local Government area of Kebbi State. Journal of food and agricultural research 101-111

Daryanto A.M and Wibowo, F.E (2023). The role of middlemen in Fishing Marketing, Journal of Economics and management (24) 213-228

Hamid, M. Y. (2020). Analysis of Smoked Fish Marketing in Mubi North Local Government Area, Adamawa State. International Journal of Forest, Animal and Fisheries Research (IJFAF), 4(4), 52–63.

Ifejika and Godfrey O.N (2009) Utilization of mobile phone as a communication channel in fish marketing Enterprise among Fishmongers in Western Nigeria's Kainji Lake basin. Journal of information Technology impact (9),107-114

Ike-Obasi, J. and Ogubunka, S. O. (2019).The Roles of Women in Fish Processing Activities in Some Local Government Areas of Rivers State, Nigeria. Agricultural Extension Journal, 3(2) 73–77.

Kabwe,S. and Zulu,C. (2017).Agricultural Trade: A qualitative analysis of effects of crop levies grain trade in Zambia. Indaba Agricultural Policy Research Institute (IAPRI,) No. 127.

Nwabeze G.O and Faleke, S.(2019) Strategies used by smoked fish marketers in kainji lake basin Nigeria. Journal of Agricultural Extension (23) 54-56Olukosi, J.O., Isitor, S.U and Ode, M.O.(2005).Introduction to Agricultural Marketing and Prices: Principles and Application. Longman Books Series G.U publications, Abuja.166p.

Ojo, O. (2010). The role of marketing in Economics Development in Nigeria. Africa journal of marketing management, 2(3), 42- 49

Omotunde, L.O. and Adetunji, O.L (200).Agricultural Marketing in Perspective.Pp3.roysab ventures, Lagos.

Omeje, J.E., Achike, A.I. and Ifejika.,P.I(2022).Marketing margins and efficiencies of smoked fish in kainji lake basin, Nigeria Agricultural Policy Research Journal (NAPReJ) Agricultural Policy Research Network (APRNet) Vol. 10, Special Issue. Website: http:// www.aprnetworkng.org ©2022

Yekini, O.A and Ipinloju, O.S (2014) Environmental influences on Fish Species richness in Kainji Lake Basin. Nigerian Journal of Agricultural and Environmental Science 9(1), 85-92

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

SURVEY OF CONSUMER PREFERENCE OF FISH SPECIES IN MAIDUGURI METROPOLITAN COUNCIL, BORNO STATE, NIGERIA

[1]Oforishe P. O., [1] M. O. Adadu And [2] M. F. Tarbee

[1]Department of Fisheries Technology, Federal College of Freshwater Fisheries Technology, Baga, P.M.B. 1060, Maiduguri, Borno State, Nigeria
[2]Joseph Sarwuan Tarka University, Markurdi, Benue State, Nigeria

Corresponding email: princeovie05@gmail.com; +2348169094443

ABSTRACT
The study was conducted to assess consumer's preference of fish species in Maiduguri metropolitan council, Borno state. The survey was conducted in two markets namely Gamboru and Baga road fish markets, using structured questionnaires. A total of 30 questionnaires were administered in each of the markets, making a total of 60. The data were analyzed using frequency and percentage. The result revealed that majority of the respondents are male (70.0%) while female ware (30.0%). It was also observed that people between the age brackets of 32-40 (40.0%) are the highest consumer, while those belonged to the age of 41year and above (10.0%) are ranked least. However, the consumer's preference and reason for fish consumption. (35%) of the respondents purchased fish for protein content, (30%) purchase fish for taste, (25%) purchased fish for cheap and affordability while (10%) purchased fish for other reason such as easy digestibility, price, availability etc. In this study majority of the consumers about (50.0%) buy fresh fish for home consumption, it is an indication that fresh fish are mostly consumed at home, Apart from high quality. cheap and affordability, price, the respondents also indicated that protein content (35.0%), taste (30.0%) while texture (45%) and availability (20.0%) are the main reasons why they buy and consumed fresh fish in Maiduguri.

Keyword:
Clarias gariepinus, Consumers, Preference, Fish Species

INTRODUCTION

Fish is a nutritious animal protein and is believed to be a comparatively cheaper and available source of animal protein in most countries around the world Martins (2015), providing essential fatty acids and micronutrients. The interventions of food-based strategies which promote production and consumption of locally available nutritious foods have utilized fish instead of supplement distribution as a sustainable way of tackling micronutrient deficiencies (Gibson and Hotz, 2001; Tontisirin *et al.*, 2002; Global fish consumption has increased from an average of 10.1 kg per capita per year in 1965 to 16.4 kg in 2005 reflecting the general increase in fish consumption in most of the world's regions except in Latin America and the Caribbean, and sub-Sahara Africa where fish consumption had stagnated over the last four decades (FAO, 2009ab). Fish consumption in sub-Sahara Africa is currently the lowest in the world. Nevertheless, fish is still nutritionally important in many African countries as well as in Asia and Oceania Countries where fish contributes more than 1/3 of the total animal protein supply, calculated from the FAO food balance sheets (FAO, 2009a). There are 30 countries who meet this criterion, including 22 countries which were officially referred to as low-income food deficit countries (LIFDC) in 2009 (FAO, 2009 b). In other words, a large majority (73%) of the countries where fish is an important source of animal protein are poor and food deficient countries. In the LIFDC, in particular, the majority of protein in fact comes from plant-source foods and the amount of fish contributed to protein intake is very little, although fish is a major source of animal protein (Kawarazuka, 2010). A study in Nigeria found that male heads of households consumed 59% more fish by weight than the wife and children. The consumption gap calculated per unit body weight shows that the average fish consumption is 0.27 kg/kg body weight/year for the male head of households and 0.17 kg/kg body weight/year for the wife and children. When a single fish was shared within the household, there was a tendency to distribute the body of fish to the man, the tail to his wife, and the head to the children on 7-8 out of 10 occasions (Gomna and Rana, 2007). Therefore, the present work aims at assess the consumers preference of fish species in Maiduguri metropolitan council Borno state.

MATERIALS AND METHOD

The study was conducted in Gambaro and Baga road Fish Markets, Maiduguri Metropolitan Council area of Borno State. The metropolitan area was occupied with a total Land mass of about 50,778 square Kilometers. It has between Latitude 11o and 14o east and Longitude 10o and 40o North (Bureau of Land and Survey, 2012) it is located within the semi-arid zone of west Africa and Suda Office of statistic Annual report, 2009).

Data collection

The data were collected using structure questionnaires, which were administered to 30 respondents from each Market (Gamboru kasua and Baga Fish Markets) making a total of 60 respondents. The respondents were purposively sampled due to Consumers preference on fresh fish species. The data obtained were analyzed using percentage and frequency.

RESULTS AND DISCUSSION

The socio-economic characteristics of fresh fish consumers in the study area is as presented in Table 1. The result revealed that majority of the respondents are male (70.0%) while female ware (30.0%). It was also observed that people between the age brackets of 32-40 (40.0%) are the highest consumer, while those belonged to the age of 41year and above (10.0%) are ranked least. This ranking does not mean that the older people consumed less fish than the younger once, it implies that younger people (26-35) prefer consuming a type of fish species to the others as posited by Ajana et al. (2018).

Table 1: Socio-economic Characteristics of Respondents

Item	Variable	Frequency	Percentages
Sex	Male	42	70.0
	Female	18	30.0
	Total	**60**	**100**
Age	20-25	15	25.0
	26-32	15	25.0
	32-40	24	40.0
	41Yrs and above	6	10.0
Educational status			
	Total	60	100
	Non formal edu	9	15.0
	Quran	3	5.0
	Primary	6	10.0
	Secondary	18	40.0
Marital Status			
	Tertiary	24	30.0
	Total	60	100
	Single	15	25.0
	Married	36	60.0
Occupation			
	Widowed	9	15.0
	Divorced	-	-
	Total	**60**	**100**
	Civil Servant	24	40.0
	Trader	15	25.0
	Farming	9	15.0
	Others	20	20.0
	Total	60	100
Household size	<3	12	20.0
	4-6	15	25.0
	7-9	24	40.0
	>10	9	15.0
Religion		**60**	**100**
	Total		
	Christianity	18	30.0
	Muslim	42	70.0
	Traditional	-	-
	Others	-	-
	Total	**60**	**100**

Source: Field Survey, 2023

Most preferred fish species by Consumers in study area

The survey in table 2 revealed that, the consumer's preference and reason for fish consumption. (35%) of the respondents purchased fish for protein content, (30%) purchase fish for taste, (25%) purchased fish for cheap and affordability while (10%) purchased fish for other reason such as easy digestibility, price, availability etc. (50%) buy fish for home consumption (25%)while some buy fish for commercial reason, and (15) % buy for social event. this conforms to the observations of FAO (1996) that with awareness of fish nutritional values, peoples' consumption may switch to fish or fishery products if they can economically afford them.

Table 2: Fish species most preferred by consumers in MMC

Item	Variable	Frequency	Percentages
Sex	Male	42	70.0
	Female	18	30.0
	Total	**60**	**100**
Age	20-25	15	25.0
	26 32	15	25.0
	32-40	24	40.0
	41Yrs and above	6	10.0
Educational status			
	Total	60	100
	Non formal edu	9	15.0
	Quran	3	5.0
	Primary	6	10.0
	Secondary	18	40.0
Marital Status			
	Tertiary	24	30.0
	Total	60	100
	Single	15	25.0
	Married	36	60.0
Occupation			
	Widowed	9	15.0
	Divorced	-	-
	Total	**60**	**100**
	Civil Servant	24	40.0
	Trader	15	25.0
	Farming	9	15.0
	Others	20	20.0
	Total	60	100
Household size	<3	12	20.0
	4-6	15	25.0
	7-9	24	40.0
	>10	9	15.0
Religion		**60**	**100**
	Total		
	Christianity	18	30.0
	Muslim	42	70.0
	Traditional	-	-
	Others	-	-
	Total	**60**	**100**

Source: Field Survey, 2023

During this study, it was observed that 45.0% of the respondents buy fish on weekly basis, indicated that fish are mostly consumed weekend because of the busy schedule of most consumers, this agrees with (Leek et al., 2000) who state that Frequent buyers of fresh fish are important to sellers because of their repeated purchased. In this study majority of the consumers about (50.0%) buy fresh fish for home consumption, it is an indication that fresh fish are mostly consumed at home, Apart from high quality. cheap and affordability, price, the respondents also indicated that protein content (35.0%), taste (30.0%) while texture (45%) and availability (20.0%) are the main reasons why they buy and consumed fresh fish in Maiduguri.

Table 3: Purchasing power of consumers in Maiduguri metropolitan council.

Frequency of fresh fish purchased	Every day	27	45.0
	Once A week	21	35.0
	Once A Month	12	20.0
	Others		-
	Total	60	100
Size of Fish Fresh fish purchased	<1kg	6	10.0
	1-2kg	27	45.0
	3-4kg	15	25.0
	>5kg	12	20.0
	Total	60	100
Price of Fish paid By Consumers	<N700	12	20.0
	N800-N900	27	45.0
	>N1000	21	35.0
	Total	60	100
Did You Get the Size You Prefer	Most often	21	35.0
	Often	24	40.0
	No	9	15.0
	Others	6	10.0
	Total	60	100
Does the Price You Pay Varies with The Following	Species	21	35.0
	Size	30	50.0
	Season	6	10.0
	Others	3	5.0
	Total	60	100
Mode of Buying Fish	Auction	3	5.0
	Bargaining	30	50.0
	Fixed Price	18	30.0
	Others	9	15.0
	Total	60	100

Source: Field Survey 2023

CONCLUSION

Based on the findings Clarias gariepinus was found to be the most preferred freshwater fish species in Maiduguri metropolitan council because of its fleshy, tasty, and availability of the species in the markets. The study also showed that price of fish; monthly income, household size and level of education were major determinants of consumer's demand for fresh fish in the study area, while factors such as price of fresh fish, size of fish and frequency of fish purchases were secondary determinants.

REFERENCES

Ajana A. M (2018): Overview of highlight and problems of fisheries extension in Nigeria. Paper presented at NIOMER during a workshop on "Improvement of Fisheries Extension in Nigeria. pp.22.

FAO. (2009 a). Calculated from food balance sheets. [Online] FAOSTAT (Updated: 18 December 2009) Available at: http://faostat.fao.org/site/368/DesktopDefault.aspx?PageID=368#ancor. [Accessed 22 January 2010].

FAO. (2009 b). Low - income food - deficit countries 2009. [Online] FAO country profiles. Available at: http://www.fao.org/countryprofiles/lifdc.asp [Accessed 21 November 2015].

Gibson, R. S., Hotz, C. (2001). Dietary diversification/modification strategies to enhance micronutrient content and bioavailability of diets in developing countries, British Journal of Nutrition, 85(2), 159 – 166

Gomna, A., Rana, K. (2007). Inter-household and intra-household patterns of fish and meat consumption in fishing communities in two states in Nigeria. British Journal of Nutrition, 97(1), 145 - 152.

Kawarazuka N. (2010). The contribution of fish intake, aquaculture, and small-scale fisheries to improving nutrition: A literature review. The World Fish Center Working Paper No.2106. The World Fish Center, Penang, Malaysia. 51 p.

Leek, Sh., S. Maddock and G. Foxall, (2000). Situational determinants of fish consumption. Br. Food J.,102(1): 18-39.

Martins Library (2015). Fish Consumption in Nigeria: Implications for Fishery Development Policies, www.http://martinslibrary.blogspot.com.ng. Retrieved on 26th, November, 2015

Tontisirin, K., Nantel, G., Bhattacharjee, L. (2002). Food-based strategies to meet the challenges of micronutrient malnutrition in the developing world. Proceedings of the Nutrition Society, 61(2), 243 - 250.

GENDER IN FISHERIES AND AQUACULTURE (IMCA)

CHILDREN'S INVOLEMENT IN THE FISHERIES: A REVIEW

Sunday, J. E. and Seikorowei, B. L.

Niger Delta University, Wilberforce Island, Bayelsa state, Nigeria

Corresponding Author:
ebisunday6@gnail.com, +2347010796589

ABSTRACT
Fisheries sector encompasses all activities related to the management of fish and aquatic resources, from the production of gear to the sale of harvested products, which sustains the livelihoods of those engaged directly/indirectly in it. Fisheries can be categorized into two main aspects: industrial/large-scale fisheries and artisanal/small-scale fisheries. Artisanal fisheries primarily cater to the needs of families on a smaller scale. Fishing communities consist of family's dependent on fisheries, with fishers defined as individuals over 18 years old engaged in fisheries activities. While the involvement of children in fisheries is not officially recognized, it is evident in tasks such as fishing, gear repair, and product marketing. Children's roles in fisheries are often gender-specific, with boys assigned more strenuous tasks like fishing and gear maintenance, while girls are typically tasked with fish processing and product selling. The impact of fisheries on children can vary from physical risks to emotional and psychological stress, which can hinder their education. Despite the lack of recognition, the involvement of children in fisheries cannot be disregarded. This study therefore reviewed the involvement of children in fisheries activities. While children's participation in fishing activities may be seen as a way of supporting their family's livelihoods, it can also expose them to various forms of harm and hinder their educational and developmental opportunities. In addressing this challenge, a multifaceted approach is needed that involves collaboration among various stakeholders, including governments, international organizations, NGOs, local communities, and the private sector.

Keywords:
Income, Waterbody, Household, Labor, Awareness

INTRODUCTION

The fisheries sector plays a vital role in providing livelihoods and food security for millions globally. It comprises artisanal (small-scale) and industrial (large-scale) fishing activities. In Nigeria, the captured fisheries practice involving harvesting from natural habitats is mainly carried out by artisanal fishers using small-scale equipment (Oyetade *et al.*, 2023). The fisheries sector provides means of livelihood for millions of people through job opportunities, high valued protein source, source of income, and rural development. Globally, around 90% rely on small-scale fisheries compared to just 3% on agriculture (Allison, 2006). In Africa, about 5% of over 35 million people depend partially or entirely on fisheries (Fakayode *et al.*, 2016).

Fishing communities often located near shorelines engage in fishing activities for sustenance and income (Nismawati et al., 2023). Every family member contributes, with men in physical tasks, women in processing/trading, and children in various roles like gear preparation and selling produce

(Nismawati et al., 2023; Jariegoa et al., 2023). Over 70% of children worldwide are involved in the fisheries sector (Nyonje and Kachieng, 2014). The objectives are as follows: 1. To understand the involvement of children in the fisheries sector. 2. To identify the gender distribution of children in the fisheries sector. 3. To determine the impact of fisheries on the children. 4. To discuss already existing efforts to address the problems associated with the involvement of children in the fisheries sector.

Children's Involvement in Fisheries Activities

Children's involvement in the fisheries sector encompasses a wide range of activities, including fishing, diving, cleaning of fish, making and mending of fishing nets, smoking and drying of fish, selling fresh or dried fish, and other fishing-related tasks (FAO/ILO, 2013; Viviane, 2018). These activities can expose children to various forms of harm, both physical and emotional/psychological, during their work in the fisheries (Bellwood-Howard and Abubakari, 2023). The duration of a child's involvement in the fisheries sector is a determining factor in whether their work is considered child labor or child work (Viviane, 2018). Child labor refers to any hazardous activities carried out by children that can be detrimental to their health and obstruct their education (Viviane, 2018). On the other hand, child work may refer to lighter activities that do not interfere with a child's education, health, and overall well-being (Bellwood-Howard and Abubakari, 2023).

In rural areas, children are often viewed as a source of labor and a blessing to the household (Adeokun et al., 2006). Their involvement in fishing activities can be seen as a means to assist their parents in improving their livelihoods through the fisheries (Jariegoa et al., 2023). Children's interactions with the natural environment from an early age help them develop an understanding of their surroundings and build a sense of livelihood connected to their environment (Jariegoa et al., 2023). Children's involvement in the fisheries sector often begins by observing their parents' activities, such as catching of fish, transporting, processing, and marketing the processed fish (Ashimolowo et al., 2015). They may then imitate these activities by gradually getting involved in various tasks. This early exposure and involvement can expose children to dangerous health issues (Ashimolowo et al., 2015).

The involvement of children in the fisheries sector can be categorized into three broad areas: fishing activities, fish processing activities, and fish marketing activities (Ashimolowo et al., 2015). Fishing Activities includes: Canoe paddling, fish catching, repair and making of nets, loading and off-loading of fish and maintaining gears and boats. Fish processing and preservation activities include: Smoking of fish, sorting of fish and collecting of firewood. Fish marketing activities include: Selling fish on shore, transporting catch. Other on-shore activities performed by children include pulling up boats to the shore, emptying fishing boats, sorting the catch, cleaning gear, boats, and catch, as well as boat and net repair (FAO/ILO, 2013). Children may also be involved in collecting fish or shellfish near the shoreline on foot, diving, or using hook and line (FAO/ILO, 2013).

Gender Distribution of Children's Involvement in Fisheries

There is a distinct gender distribution in the involvement of children in fisheries activities (Sule and Raji, 2001; Bellwood-Howard and Abubakari, 2023). Boys are typically involved in activities related to the maintenance of equipment and gears, such as boats, traps, and nets (Bellwood-Howard and Abubakari, 2023). They are often tasked with paddling canoes, retrieving fishing nets, and diving into the water to free entangled nets, which can be highly dangerous (Bellwood-Howard and Abubakari, 2023; FAO/ILO, 2013). On the other hand, girls are more commonly involved in post-harvest fisheries activities, such as sorting fish, transporting, packing, smoking, roasting, and selling (FAO/ILO, 2013). The division of labor is often based on the perception that boys are physically stronger and can handle more strenuous tasks, while girls are considered weaker and better suited for less strenuous tasks like processing and marketing (Sule and Raji, 2001). The hawking of smoked fish pieces in markets is often observed to be carried out by children, particularly girls (Sule and Raji, 2001).

Impacts of Children's Involvement in Fisheries

The involvement of children in the fisheries sector can have significant impacts on their well-being, health, and education. Bellwood-Howard and Abubakari (2023) suggest that the harm children face in the fisheries can be reversible or irreversible, ranging from minor physical injuries to psychological and emotional stress, as well as the possibility of drowning or death in adverse situations.

- **Physical Harm and Health Risks:**

Children's lack of experience in fishing activities can expose them to injuries caused by fish or other aquatic animals in the waterbody (Ashimolowo et al., 2015). They may also face risks of drowning, cuts, and other physical harm while working on boats, handling fishing gear, or diving to untangle nets (Bellwood-Howard and Abubakari, 2023). Prolonged exposure to water and sun can also lead to skin problems and other health issues (FAO/ILO, 2013).

- **Emotional and Psychological Stress:**

In some cases, children may be forced by adults to engage in strenuous and dangerous fishing activities against their will (Bellwood-Howard and Abubakari, 2023). Failure to comply or resistance can result in punishments such as scolding, food deprivation, or severe beatings (Ashimolowo et al., 2015). This can create emotional and psychological stress for the children involved.

- **Impact on Education:**

The involvement of children in the fisheries sector can negatively impact their education (Nyonje and Kachieng, 2014; Bellwood-Howard & Abubakari, 2023). Children may be absent from school activities during early hours of the day due to their engagement in fishing or related tasks (Bellwood-Howard and Abubakari, 2023). This can lead to gaps in their learning and hinder their overall educational development. Bellwood-Howard and Abubakari (2023) emphasize that any work that interferes with a child's education, physical health, mental, spiritual, or social well-being is considered child labor, as opposed to lighter child work that does not pose such risks. In some cases, parents may send only one or two of their children to school while involving the others, especially boys, in fishing activities to supplement the family's income and support the education of the other children (Fakayode et al., 2016). This practice further perpetuates the cycle of limited educational opportunities for some children within the same family. Despite the involvement of children in the fisheries sector to support their families' livelihoods, they are often also responsible for carrying out various household chores and other duties within their communities, such as cooking, farm work, and running errands (FAO/ILO, 2013). This additional workload can further exacerbate the challenges faced by children in balancing their educational and domestic responsibilities.

Efforts to Address Children's Involvement in Fisheries

Recognizing the potential negative impacts of children's involvement in the fisheries sector, various efforts have been made to address this issue at local, national, and international levels.

- **Policy and Regulatory Frameworks:**

Governments and international organizations have established policies and regulatory frameworks aimed at protecting children's rights and preventing exploitative child labor practices. For example, the International Labour Organization (ILO) has set standards and conventions to eliminate the worst forms of child labor, including hazardous work in the fisheries sector.

National laws and regulations have also been put in place in many countries to address child labor issues, including restrictions on the involvement of children in specific types of work and minimum age requirements for employment (FAO/ILO, 2013). However, the effectiveness of these policies and regulations can vary depending on the level of enforcement and implementation at the local level.

- **Education and Awareness Campaigns:**

Efforts have been made to raise awareness about the importance of children's education and the potential risks associated with their involvement in hazardous work, including in the fisheries sector. These campaigns often target parents, communities, and local authorities, emphasizing the long-term benefits of investing in children's education and development (FAO/ILO, 2013).

- **Community-based Interventions:**

Some initiatives have focused on community-based interventions to address the root causes of child labor in fishing communities. These may include providing alternative livelihood opportunities for families, improving access to education and social services, and promoting sustainable fishing practices that do not rely on child labor (FAO/ILO, 2013).

- **Collaboration and Partnerships:**

Addressing the issue of children's involvement in the fisheries sector requires collaboration and partnerships among various stakeholders, including governments, non-governmental organizations (NGOs), international organizations, local communities, and the private sector. These partnerships can enable the sharing of resources, knowledge, and best practices, as well as the development of comprehensive and sustainable solutions (FAO/ILO, 2013). In spite of these efforts, the involvement of children in the fisheries sector remains a persistent challenge in many parts of the world, particularly in rural and coastal communities where poverty and limited access to education and alternative livelihoods are prevalent (FAO/ILO, 2013). Continued efforts and a holistic approach that addresses the underlying socioeconomic factors are necessary to protect the rights and well-being of children while supporting sustainable livelihoods in fishing communities.

CONCLUSION

The involvement of children in the fisheries sector is a complex issue with far-reaching implications for their health, education, and overall well-being. While children's participation in fishing activities may be seen as a way to support their families' livelihoods, it can also expose them to various forms of harm and hinder their educational and developmental opportunities. To address this challenge, a multi-faceted approach is needed that involves collaboration among various stakeholders, including governments, international organizations, NGOs, local communities, and the private sector.

RECOMMENDATIONS

- Governments should review and strengthen existing policies and regulations related to child labor, with a specific focus on hazardous work in the fisheries sector. These policies should aim to protect children's rights, ensure their access to education, and provide alternative livelihood opportunities for families.
- Efforts should be made to improve monitoring and compliance mechanisms, with appropriate penalties for violations involving child labor in the fisheries sector.
- Campaigns should be conducted to raise awareness about the importance of children's education and the potential risks associated with their involvement in hazardous work. These campaigns should involve community leaders, parents, and local authorities to promote a shift in attitudes and practices.
- To address the root causes of child labor in fishing communities, initiatives should focus on providing alternative livelihood opportunities for families. This could include skills training, microfinance programs, and support for sustainable and responsible fishing practices that do not rely on child labor.
- Enhancing access to basic social services, such as healthcare, education, and child protection services, can help address the vulnerabilities that contribute to child labor in fishing communities.

- Local communities should be engaged and empowered to identify and address the challenges they face. Community-based interventions that involve all stakeholders can lead to more sustainable and culturally appropriate solutions.

REFERENCES

Adeokun, O. A., Adereti, F. O., and Akanni, K. A. (2006). Children's Involvement in Fish Production: A Strategy for Poverty Alleviation in Waterside Local Government Area, Ogun State, Nigeria. Research Journal of Fisheries and Hydrobiology, 1(1): 10-13.

Allison, E. H. (2006). The Importance of Fisheries Development. School of Development Studies, University of East Anglia, Norwich NR4 7TJ, UK e.allison@uea.ac.u

Ashimolowo, O. R., Awotunde, E. D., Ojebiyi, W. G., and Oose, M. O. (2015). Assessment of Rural Children's Involvement in Fishery Activities in Ogun Waterside Local Government Area of Ogun State, Nigeria. J. Agric. Sci. and Env., 15(2): 37 – 46.

Bellwood-Howard, I., and Abubakari, A. (2023). Children's Harmful Work in Ghana's Lake Volta Fishery: Beyond Discourses of Child Trafficking https://doi.org/10.51952/9781529226072.ch011

Fakayode, O. S., Adeogun, O. A., Unah, L. R., and Bolaji, D. A. (2015). Children Involvement in Artisanal Fishing: A Case Study of Lagos Lagoon, Nigeria ISSN(P): 2304-1455/ISSN(E):2224-4433 Asian Journal of Agriculture and Rural Development Volume 6(2), 36-40

FAO/ILO (2013). Guidance on Addressing Child Labour in Fisheries and Aquaculture http://www.fao.org/3/i3318e/i3318e.pdf

Jariegoa, I. M., Holgadoa, D., Castillob, A. C., Corrala, D. F. and Mestresc, S. G. (2023). Children's Interaction with Ecosystem Services in a Mangrove Forest: Perceptions of Fisherfolks on the Involvement of Minors in Fishing Activities in The Gulf of Fonseca in Honduras https://doi.org/10.1016/j.ocecoaman.2023.106502

Nismawati, Oruh S., Kamaruddin S., Agustang, A. and Wirda, M. A. (2023). Awareness of the Importance of Children's Education in the Small Island Fisherman Community (Case Study of LiukangLoe Island Journal Geografi https://doi.org/10.24114/jg.v15i1.34027 - Vol 15, No 1 – 2023

Nyonje, R. O., and Kachieng, J. A. (2014). Fishing Related Activities and their Impact on Pupils Participation in Education. The Cradle of Knowledge. African Journal of Educational and Social Science Research, Volume 2 No 1, 2014 ISSN 2304- 2885

Oyetade, O. P., Olaoye, O. J., Ojebiyi, W. G., And Idowu, I. F., (2023) Assessment of Women Involvement In Artisanal Fishery Enterprises In Lagos State, Nigeria Ghana Journal of Agricultural Science Volume 58 (2), 115-127 https://dx.doi.org/10.4314/gjas.v58i2.10

Sule, O. D and Raji, A. (2001). Involvement of fishermen children in fishing activities in Lake Chad region Journal of Arid Zone Fish Volume (1) 74-88, Pp 74-88 http://hdl.handle.net/1834/21347

Vivian, D. (2018). Child Labour in Small-scale Fisheries in the Coastal Areas of Cameroon, A Case Study of Kribi. A Master Thesis in Development Geography Department of Sociology and Human Geography, Faculty of Social Sciences, University of Oslo Pp 9-10, 15-17

GENDER IN AQUACULTURE FISH PRODUCTION AND MARKETING IN IBENO METROPOLIS OF AKWA IBOM STATE, NIGERIA

[1]Jimmy, S. P., [2]Omeje, J. E., [2]Ifejika, P. I. and [2]Aganagana, D. O.

[1]Department of Agricultural Economics, Extension and Rural Development, Niger Delta University, Bayelsa State, Nigeria;
[2]National Institute for Freshwater Fisheries Research, Niger State, Nigeria

Correspondence:
juliusomeje@gmail.com, +2348036792983, 0000-0002-8374-8887

ABSTRACT
The study examined gender in aquaculture fish production and marketing in Ibeno Metropolis of Akwa Ibom State, Nigeria. Specifically, the study described the socio-economic characteristics of the respondents, identified gender roles and the perceptions of producers and marketers on the value chain. A survey design was adopted to collect primary data from 105 respondents using a multistage sampling procedure. Data were presented using percentages and mean. Results showed that more females (79.2 %) than males were aged between 36-45 years. Majority (64.2%) of the females had 5-10 years of experience while 42.8% of the males had 11-15 years of experience. Most of the roles in aquaculture were mostly performed by the male youths while the women predominate in roles associated with Catfish marketing. The major perceptions of producers and marketers on the value chain were that the skills involved are exclusively designed to the interest of men/youths (x=3.23), institutions favour men/youths in interventions (x=2.98), and aquaculture is capital intensive which women don't have access to (x=2.87), Therefore, it is recommended that training programs have to be strengthened to improve technical skills and knowledge among fish farmers and marketers, with a focus on gender-responsive approaches and inclusive training modules.

Keywords:
Gender, Aquaculture, Marketing, Catfish

INTRODUCTION

Aquaculture, the systematic cultivation of aquatic organisms (Omeje *et al.*, 2021), stands as a transformative force in the economic and nutritional tapestry of Ibeno Metropolis, nestled within the State of Akwa Ibom, Nigeria. This locale, endowed with abundant aquatic resources, has experienced a pronounced upswing in aquaculture endeavors, emerging as a cornerstone for both local sustenance and broader regional food security initiatives.

The roles shouldered by men, women and youths within the aquaculture value chain are nuanced and multifaceted, mirroring the complexity of the industry itself. Traditionally, fishing might be perceived as a male-dominated domain (Essien *et al.*, 2018), yet the reality in Ibeno Metropolis extends far beyond this stereotype. Concerns about the weaker claims of women to resources and benefits as well as the extent to which women are involved in management decisions in both domestic and other spheres are as significant in reports on the aquaculture and capture fisheries sector as in other natural resource sectors. However, these claims vary considerably by location and production system (Essien *et al.*, 2018).

Nevertheless, women invariably play key roles in processing and possibly marketing and it is widely agreed that their earnings make a significant contribution to household livelihoods (FAO, 2023). At the same time, women often remain invisible in the sector and frequently lose out in information and skill training, especially in new techniques and products in aquaculture. Women are also excluded from new institutions set up to address problems of resource-based deterioration because they are not viewed as being directly concerned; their interests are assumed to be represented by men; or they are just too busy at the time when meetings are held. Overall, this situation has led to women being more constrained than men in their ability to protect their interests in the sector and influence its development, all of which has significant implications for household survival as women find themselves unable to fulfill their responsibilities (FAO, 2023).

Despite the growing importance of aquaculture in Ibeno Metropolis, there exists a gap in our understanding of how gender roles influences and as well perceived within the aquaculture production and marketing.

The aim of this study is to examine gender in aquaculture fish production and marketing in Ibeno metropolis of Akwa Ibom State, Nigeria. Specifically, the study; described the socioeconomic characteristics of the respondents, identified gender roles in aquaculture activities and marketing and identified the perception of the respondents on the value chain.

MATERIALS AND METHODS

Study area

The study was conducted in Ibeno Local Government Area of Akwa Ibom State, Nigeria. The Local Government Area comprises of Sixty villages/fishing ports. Multi-stage sampling procedure was used in selecting the respondents for this study. The first stage involved a purposive selection of three communities; Mkpanak, Upenekang and Iwuoachang communities out of the six communities in Ibeno Local Government Area. The purposive selection was due to the preponderance of fish farming activities in those communities. Stage two involved the random selection of 40 respondents from each of the three previously selected communities to make up 120 respondents for the study. The sampling frame for the study was obtained from Akwa Ibom State Agricultural Development (AKADEP). Data for this study were collected from primary sources using questionnaire. From the 120 questionnaires administered, only 105 questionnaires were successfully retrieved and used for analysis. Frequency, percentage and mean were used for data presentation.

RESULTS AND DISCUSSION

Socioeconomic characteristics of the respondents

The socioeconomic characteristics of the respondents is presented in Table 1. The majority (79.2%) of the females and 48% of the males were aged between 36-45 years. This age distribution indicates that younger individuals are actively involved in aquaculture fish production and marketing in the study area. Education-wise, most females (81.1%) had attained post-secondary education, while males had a more varied educational background, with 40.4% having post-secondary education and 25% having secondary education. The educational attainment of females exceeding that of males underscores the potential for gender empowerment through education within the aquaculture value chain sector, as observed in studies by Adam and Njogu (2023). Also, the farming experience varied, with females having a higher percentage (64.2%) in the 5-10-year range, while males were more evenly distributed across different experience levels. This suggests that a significant portion of the respondents in the study area might be relatively new to the sector. Farmers with more years of experience are better in management of farm enterprise (Enimu and Edet, 2019) as well adopting innovations for the improvement of productivity.

Table 1. Socioeconomic characteristics of respondents

	Female(n=53)		Male(n=52)		
Variables	**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Pooled Mean**
Age					47 years
25-35	2	3.8	1	1.9	
36-45	42	79.2	25	48.0	
46-55	7	13.2	8	15.4	
≤ 56	2	3.8	18	34.6	
Education qualification					
Primary Education	8	15.1	18	34.6	
Secondary Education	2	3.8	13	25.0	
Post-Secondary Education	43	81.1	21	40.4	
Pond size					5 Ponds
1-3	18	34.0	7	13.5	
4-6	25	47.2	30	57.7	
≤ 7	10	18.9	15	28.8	
Farming experience					8 years
5-10	34	64.2	18	34.6	
11-15	16	30.2	22	42.3	
16-20	3	5.6	12	23.1	

Source: Field Survey, 2024

Gender roles in aquaculture fish production and marketing

The result on gender roles in aquaculture fish production and marketing in presented in Table 2. The men primarily engage in activities such as cleaning of ponds (39%), pumping of water and draining (34.3%), and fingerlings stocking (33.3%). On the other hand, women are predominantly involved in marketing (69.5%), fish sampling (59%), fish medication (54.3%) and fish feeding (53.3%). Meanwhile, youths are more engaged in activities like weighing (62.9%), washing fish ponds (53.3%), and cleaning ponds (45.7%). The gender roles identified in aquaculture activities reflect broader socio-cultural dynamics and economic opportunities. The predominance of men, women and youths in various tasks underscores traditional gender divisions in labor within the aquaculture sector. Such gendered divisions may have implications for resource allocation, access to extension services, and decision-making processes, affecting overall productivity and sustainability in aquaculture (Adam and Njogu, 2023).

Table 2. Gender roles in aquaculture fish production and marketing

	Gender		
Activity	**Men**	**Women**	**Youths (male)**
Pumping of water and draining	34.3	27.6	38.1
Fingerlings stocking	33.3	29.5	37.1
Liming	26.7	34.3	39.0
Feeding of fish	21.9	53.3	24.8
Cleaning of pond	39.0	15.2	45.7
Fish medication	31.5	54.3	14.3
Washing of fish pond	24.8	21.9	53.3
Marketing	17.1	69.5	13.3
Fish Sampling	25.7	59.0	15.2
Harvesting/dragging	37.1	27.6	35.2
Weighing	23.8	13.3	62.9
Environmental cleaning	12.4	44.8	42.9

Source: Field Survey, 2024

Perceptions of Catfish producers and marketers on the value chain

The perceptions of catfish producers and marketers on the value chain is presented in Table 3. The actors in the value chain under consideration perceived that the skills involved in fish production are exclusively designed to the interest of men (x=3.23), most institutions favour men than women in their interventions in aquaculture (x=2.98), fish production is capital intensive which women don't have access to (x=2.87) etc. . These perceptions ranked 1st, 2nd and 3rd, respectively. Historically, control over resources in aquaculture, such as land and capital, has been vested in men. In more traditional settings, women's access to resources has been limited (Njuki *et al.*, 2022). This control has direct implications for the perceptions of the actors in respect to the value chain. Hence, prompting the active involvement of women in other segments of the value chain such as marketing.

Table 3. Perceptions of Catfish producers and marketers on the value chain

Items	Mean	Rank
The skills involved in fish production are exclusively designed to the interest of men	3.23	1st
Most of the value chain activities requires one with masculine disposition	2.86	4th
The technologies used are not gender sensitive hence women are demotivated in its use	2.73	6th
Fish production is capital intensive which women don't have access to	2.87	3rd
women don't have access to land required for participation in fish production	2.82	5th
Decisions on resource allocation are done by men/youths who don't consider the needs of men/women	2.71	7th
Most institutions/Organizations favour men/youths in their interventions in this value chain	2.98	2nd
Mean	**2.88**	

Source: Field Survey, 2024

CONCLUSION AND RECOMMENDATION

The study established that most of the roles in aquaculture Catfish production were mostly performed by male youths while women dominate in roles associated with marketing. Also, major factor which demotivates women participation in aquaculture catfish production is that the skills involved in fish production are exclusively designed to the interest of men. Therefore, it is recommended that extension services and training programs have to be strengthened to improve technical skills and knowledge among fish farmers and marketers, with a focus on gender-responsive approaches and inclusive training modules.

REFERENCES

Adam, R. and Njogu, L. (2023). A review of gender inequality and women's empowerment in aquaculture using the reach-benefit-empower-transform framework approach: A case study of Nigeria. Front. Aquac., 1(1052097), 1-16.

Enimu, S. and Edet, O. G. (2019). A Stochastic Frontier Approach for Measuring Technical Efficiency of Catfish Production in Delta State; Nigeria. South Asian Res J Agri Fish, 1(3), 91-98.

Essien, E. N., Eminue, U. O. and Ekpo, E. J. (2018). Artisanal fish marketing in Akwa Ibom State, Nigeria: Problems and Prospects. European Journal of Management and Marketing Studies, 3(3), 170-181

FAO. (2023). Gender Analysis of Aquaculture Value Chain in Northeast Vietnam and Nigeria. http://www.fao.org/3/at243e/at243e.pdf

Njuki, J., Eissler, S., Malapi, H., Meinzen-Dick, R., Bryan, E., Quisumbing, A. (2022). A review of evidence on gender equality, women's empowerment, and food systems. Global Food Security, 33 (2022), 1-12.

Omeje, J. E., Achike, A. I., Arene, C. J., Faleke, S.A., Manuike, Q. C. and Usman, G. A. (2021). Socio-economic determinants of net-income in fish farming in Kainji Lake Basin, Nigeria. Global Journal of Agricultural Sciences, 20(1), 53-61.

GENDER ROLES OF COASTAL FISHING HOUSEHOLDS IN FISH PRODUCTION IN SOUTHWEST, NIGERIA

[1]Oyetade. O. P., [2] S. A. Omitoyin and [3]O. B. Oyesola

[1]Department of Aquaculture and Fisheries Management, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria
[2]Department of Aquaculture and Fisheries Management, University of Ibadan, Ibadan, Nigeria
[3]Department of Agricultural Extension and Rural Development, University of Ibadan, Ibadan, Nigeria

Corresponding Author:
oyetadeop@funaab.edu.ng, +2347031849361, 0000000189874916

ABSTRACT
The study assessed the roles of coastal fishing households' members in fish production in Southwest, Nigeria. Total number of 366 coastal artisanal fishers were selected using multistage sampling techniques. Data on socio-economic characteristics and various fisheries activities were collected with the aid of structured questionnaire. The socio-economic analysis revealed that 92.6% were male and 7.4 % were female, with a mean age of 37.36±9.88 and46.12% had secondary education. Number of income earning members revealed that 39.9% had three or more household earning members. Results on various fisheries activities indicated that majority 95. 6 and 35.2% of men and boys are involved in fishing while 70.5 and 26.2% of women and girls are involved in fish processing. Furthermore, both men and women are involved in fish sales and marketing with 66.6 and 48.1% respectively. Construction and repair of fishing gears with fabrication of crafts results shows that 43.4, 66.9 and 34.2%. relationship between selected socioeconomics and fisheries activities revealed no significant relationship (R2=0.11, p= 0.001) between number of income earning members, household size and other fisheries activities but a significant relationship exists between age, income from fishing and gender. The study concluded that both male and female are important in fish production.

Keywords:
Gender, food security, livelihood, coastal communities and coastal artisanal fishers.

INTRODUCTION

The Nigeria fisheries sector comprises of captured, industrial and aquaculture. According to Garlock et al. (2020) the fisheries sector is a means of growing the economy by creating employment, enhancing food security and poverty reduction. The sector is of great relevance to coastal communities as it serves as source of livelihood and food. The sector contributes bulk of the domestic fish produced in the country, although faced decline in production thereby increasing the gap between fish production and supply in the country. In achieving sustainable fish production, gender participation of fishing household members is important. According to Olusola et al., (2017) gender can be described as the roles and responsibility of males and females in the society as a social classification of sex. It is a socioeconomic variable tool used by researcher to analyse the roles and responsibility of both men and women. Fishing in Nigeria is traditionally regarded as masculine while the female gender is considered complementary. Therefore, this study identifies the roles of men and women in fish production in southwest, Nigeria.

RESEARCH METHODOLOGY

The study was carried out in Southwestern geo-political zone of Nigeria. The Southwestern zone lies between longitude 20 48' – 60 0' E and latitudes 505' – 90 12'N, with an area of 114,271 square kilometers representing 12% of the country's total land mass. The 2006 Census put the population of the zone at 21,974,678 (National Population Commission, NPC, 2006).

Figure 1: Map of the study area
Source: Geography Department, University of Ibadan, Nigeria

Data collection and Sampling techniques

This study used a validated structured questionnaire to gather data on socio-economic characteristics of artisanal fishers and gender involvement in fisheries activities. The targeted populations were coastal fishers in Southwest, Nigeria. A multistage sampling techniques was used to ensure representation across various fishing operations scales, with a sample size of 366 artisanal fishers.
Analytical technique
The data was analysed using descriptive and inferential statistics (multiple regression)

RESULTS AND DISCUSSION

Socioeconomics characteristics of respondents

Table 1 summarizes the socioeconomic characteristics of coastal artisanal fishers in the study. Results indicated that 92.6% are males with mean age of 37.37±9.88. Most (46.2%) of the fishers had secondary education and are identified as Christian (70.8%). Households are relatively large, with an average of 9.0±4.57 members. Three or more income household earning members had the highest 39.9%, with an average income of 160224.04±109088.45 from fishing.

Table 1. Respondents' socio-economic characteristics

Variables	Mean	Std.Dev	Majority
Age	37.36	9.88	31-40 (39.1%)
Gender	-	-	Male (92.6%)
Marital status	-	-	Married (78.7%)
Highest level of Education	-	-	Secondary (46.2%)
Religion	-	-	Christianity (70.8%)
Household size	9.0	4.57	6-10 (45.9%)
Number of income earning members	2.70	1.79	≤3 (39.9%)
Estimated monthly income	160224.04	109088.45	≤100000 (46.7%)

Gender roles of fishing household in various fisheries activities

Table 2 presents the roles of both male and female in fisheries activities in the study area. Results revealed that majority (95.6 and 35.2%) of the male (men and boys) gender are involved in fishing activities while the majority of the female gender (women and girls) are involved in fish processing with 70.5 and 26.2% respectively. Further, data on fish sales and marketing indicated that both male and female are involved in sales either live or processed fish with 66.6 and 48.1%, respectively. Results on construction of fishing gears, fabrication of fishing crafts and repair shows that majority of the male gender are involved with only few females.

Table 2. Gender roles in fisheries activities of coastal artisanal fishers in Southwest, Nigeria (n = 366)

Fisheries activities	Gender	Frequency (%)
Fishing	Men	95.6
	Boys	35.2
	Women	4.4
	Girls	1.4
Fish processing	Men	11.2
	Boys	8.1
	Women	70.5
	Girls	26.2
Fish sales and marketing	Men	66.6
	Boys	1.6
	Women	48.1
	Girls	12.6
Construction of fishing gears	Men	43.4
	Boys	1.9
	Women	7.4
	Girls	3.5
Fabrication of crafts	Men	34.2
	Boys	24.9
	Women	1.0
	Girls	1.0
Repair of fishing gears and crafts	Men	66.9
	Boys	21.9
	Women	1.6
	Girls	1.0

Relationship between selected socioeconomics characteristics and fisheries activities

Results on relationship between selected socioeconomics and fisheries activities is presented in table 3. The results revealed that there is no significant relationship ($R2=0.11$, $p= 0.001$) between number of incomes earning members, household size and other fisheries activities but there exist significant relationship between age, income from fishing and gender.

Table 3. Relationship between selected socioeconomics characteristics and fisheries activities

Variables	ß	T	Sig.
Constant	0.65	2.560	0.013
Age	-0.143	4.228	0.001
Number of income earning members	-0.086	1.768	0.754
Household size	0.034	-0.993	0.610
Income from fishing	0.324	5.035	0.001

Findings from the study on respondents mean age indicated that they are within the economical and productive age which is inversely related to fisheries activities, this implies that as the age of the respondents is increasing there is tendency for decrease in their involvement in fisheries activities as they grow older thereby affecting fish production. This finding is similar to the work of Olusola et al. (2017) and Oyetade et al. (2023) who in their various research discovered that majority of the fishers are still within the active age category. Furthermore, results on educational status indicated that majority of the respondents had secondary education, this implies a high level of literacy among the fishing households, which could influence decision making positively (Mukaila et al., 2021). Gender results on fishing activities revealed that high percentage of male gender are involved in fishing, which may be attributed to the risky nature of fishing, traditional belief and uncertain weather conditions. The results is in line with the work of Omitoyin and Tosan (2012) who reported high dominance of male fishers in fishing and that the female role is mostly complementary. Majority of the fishers are married indicating high level of responsibility which will help to boost family labour and reduce dependency on hired labour. Gender participation results on fish processing affirmed the work of oyetade et al. (2023) who reported high number of women involvements in fish processing but in contrary with Ologbon et al. (2014) who stated that fishing and resources collection is the responsibility of both male and female. The low level of women involvement in other fisheries activities may be influenced by family responsibility and submission to their husband's decision.

CONCLUSION AND RECOMMENDATIONS

The contribution and role of both male and female gender in Nigeria fisheries sector is essential for fisheries development and growth. The study revealed that the male gender is majorly involved in most fisheries activities while the female gender is mostly involved in fish processing and sales. The study however, recommends equal resources distribution between male and female in fisheries sector since both genders are key actors in in the industry. Also, there is need for eradication of traditional beliefs that limits the strength and capacity of women in fisheries.

REFERENCES

Garlock, T., Asche, F., Anderson, J., Bjørndal, T., Kumar, G., Lorenzen, K., Ropicki, A., Smith, M.D., and Tveterås, R. (2020). A global blue revolution: Aquaculture growth across regions, species, and countries. Rev. Fish. Sci. Aqua., 28(1): 107-116.

Mukaila, R., Falola, A., and Egwue, L.O. (2021). Income diversification and drivers of rural smallholder farmers' income in Enugu state Nigeria. Sci. Papers Series Manag. Econ. Eng. Agri. Rural Dev. 21(3): 585-592.

N.P.C. 2006. Population and housing census 2006: Data for National Development, National population commission at http://www.population.gov.ng. Federal Republic of Nigeria Abuja vol. 2 pp. 124-155

Ologbon, O.A.C., Idowu, A.O., Salmonu, K.K., and Oluwatayo, I.B. (2014). Incidence of multidimensional poverty among riverine households in Southwestern Nigeria. Journal of Agricultural Science, 6(5), 167–179.

Olusola, B., Samuel, A, Abimbola, A., Ajibade, A and Victor, A. (2017). Gender Participation in Fish Harvesting Activities in Catch-Locations in Lagos State Nigeria: A Tool for Food Security and

Sustainability. Agriculture and Healthcare, 7(16): 223-235.
Omitoyin, S.A. and Tosan, F.B. (2012). Potential impacts of climate change on livelihood and food security of artisanal fisher folks in Lagos State, Nigeria. Journal of Agricultural Science, 4(9): 20 – 30.
Oyetade. O.P., Olaoye, O.J., Ojebiyi, W.G. and Idowu, I.F. (2023). Assessment of women involvement in artisanal fishery enterprises in Lagos State. Ghana Journal of agricultural science, 58(2): 2023

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

INLAND COASTAL AND MARINE AQUACULTURE(IMCA)

GROWTH PERFORMANCE, CONDITION FACTOR AND SURVIVAL OF NILE TILAPIA *(Oreochromis niloticus,* LINNAEUS 1758) FINGERLINGS RAISED UNDER DIFFERENT PHOTOPERIOD

Olanrewaju A. N., A. Umar and Ali Muhammad Hajjatu

[1]Department of Fisheries Technology, Federal College of Freshwater Fisheries Technology Baga, P.M.B. 1060 Maiduguri, Borno State, Nigeria

Corresponding author's e-mail:
audamaturu@gmail.com; +234 803 625 1378

ABSTRACT

A six-week feeding trial was carried out to determine the growth performance and survival of Oreochromis niloticus fingerlings raised under different photoperiods. Triplicate groups of 40 fingerlings (2.23±0.43 g) were assigned into nine plastic tank aquaria (2.9 m3) representing different photoperiods as 24-hour photoperiod, 12-hour photoperiod and 6-hour photoperiod. Feeding was done at 3% body weight per day, and fish were weighed every week. Growth performance parameters such as mean weight gain (MWG), specific growth rate (SGR), feed conversion ratio (FCR) and survival rate were determined. Water quality parameters were also monitored every three days following the standard procedures. Data were analysed using descriptive statistics and ANOVA at □0.05. In all parameters measured, fish raised under a 6-hour photoperiod had superior growth (1.17±0.19 g) and best feed conversion ratio (0.51±4.46), while 24-hour photoperiod statistically favoured the survival rate (95.00±0.00). Therefore, it can be concluded that O. niloticus can be raised under a 6-hour photoperiod for good growth and survival rate. The study, however, suggests similar research in an extended duration to determine if the results obtained in this study could be different.

Keywords:
Light regime,
aquaria, growth,
Nile tilapia,

INTRODUCTION

In aquaculture, tilapia species have become the mainstay of many small-scale aquaculture projects through the expansion of semi-intensive pond aquaculture and the development of techniques for hatchery production of seed. The culture of tilapia in freshwater ponds and cages has been a commercial success in Nigeria. Among tilapia species, Nile tilapia Oreochromis niloticus is the most popular culture species because of its rapid growth, large size and high yield potential. Like other tilapias, this species is resistant to parasites, diseases, and overcrowding and can survive under low oxygen levels (Loan et al., 2021). They also grow in both natural and artificial fish foods and utilise manure well. Out of the 82.1 million metric tons of aquaculture food-fish production in 2018, 5.5 million metric tons came from tilapia, 81 per cent of which was Nile tilapia (FAO, 2018). It is considered an excellent table food fish with firm white flesh and no intramuscular bones; thus, the demand for this fish is very high due to its great flavour and high nutritional value. This tropical freshwater fish is an omnivore and prefers to inhabit lakes, ponds, and rivers. Nile tilapia can live longer than 10 years and reach a weight exceeding 5 kg. Currently, the Nigeria fish industry is poised for rapid expansion in tilapia aquaculture with a breakthrough of an improved strain, "Sex reversed O. niloticus" or "All male tilapia" (Fontainhas-Fernandes et al., 2002). The major snag remains the appropriate techniques, especially the suitable photoperiods for best growth and survival in intensive O. niloticus culture.

The photoperiod corresponds to one of several environmental stimuli and is related to the duration of light time over a day (Bizarro et al., 2019). Light is a key environmental factor that synchronises all life stages of fish, from embryo development to sexual maturation. According to Wang et al. (2020), light is an essential natural factor of fish growth and development, and its regime in indoor aquaculture is critical for sustainable fish production. Consequently, Hernández (2020) reported that the photoperiod and intensity of light can condition feed intake, energy use, and even the social behaviour of farmed fish. The author found that lighting on fish production influences the growth and survival of the farmed species. As well, several aquaculture scientists have reported a relationship between photoperiod and growth rate in different species of fish with a conclusion that the application of optimum photoperiod can raise the yield of fish in aquaculture (Mustapha et al., 2012; Elsbaay, 2013; Awasthi et al., 2017; Wang et al., 2020). However, in Nigeria, previous studies have been performed on Clarias gariepinus, but very scanty information exists on Oreochromis niloticus, especially in arid zones in Nigeria. Hence, the current investigation was designed to explore the photoperiodic regulation of growth performance and survival in Oreochromis niloticus to explain better how the environment regulates this critical physiological process. The direct benefit of such knowledge would be the subsequent adoption of refined management practices based on artificial photoperiod manipulation, allowing mass production of Oreochromis niloticus fingerlings for pond stocking.

MATERIALS AND METHODS

The research was conducted at the indoor fish hatchery complex of the Federal College of Freshwater Fisheries Technology, Baga (Latitudes 11051'43" N and Longitudes 13013'36" E), for six weeks from 2nd July to 13th August 2022. Three hundred and sixty (360) fingerlings of Nile tilapia (Oreochromis niloticus L.) with a mean weight of 2.23±0.43 g were used. The experiment was conducted in 9 plastic tanks (2.9 m3) with volume of 30L. Three photoperiods were chosen and designated as Treatments: LPP (24-hour photoperiod), NDL (12-hour photoperiod), and LDP (6-hour photoperiod). The experimental design is 3 × 3 Completely Randomised Design, and the experimental fish and treatments were randomly assigned in triplicate. The tanks were stocked with 40 fish per tank at the same density.

The experimental units were supplied with dechlorinated borehole water and changed twice weekly to maintain water quality and prevent ammonia build-up. Five water quality parameters (Dissolved oxygen, nitrite, nitrate, temperature, and pH) in each tank were measured twice weekly. Temperature was measured using a mercury-in-glass thermometer, while pH and dissolved oxygen were measured with a probe (BICASA model B.E.104). Nitrite and nitrate were determined in the laboratory following the APHA (1995) procedure. Body weight and assessments were performed with ten randomly selected fish in each tank at the beginning and every week using a digital weighing scale (Scout Pro SPU202 Model) and 30 cm wooden meter rule, respectively. The mortality rate of each of the tanks was recorded daily, and dead fish were removed. The fish were fed with commercial dry pellet food of 1.2 – 1.5mm containing 35% crude protein. Following the procedure by Wang et al., (2020) fish were fed based on an established ratio of 3% body weight. Feed was administered twice daily (0800 and 1700 hours), and feeding was generally completed in 5 – 10 minutes.

The growth performance of the fish in the three experimental groups was compared in terms of absolute weight gain (WG), specific growth rate (SGR), daily growth rate (DGR), feed conversion ratio (FCR), and survival rate (SR) using the following formulas (Akinwole and Faturoti, 2006):

Absolute weight gain (WG, g): WG = Wt2-Wt1

Specific growth rate (SGR, %/day): $SGR = \frac{inWt2 - inWt1}{P} x\ 100$

Daily weight gain (DWG, g/day): $DGR = \frac{Wt2 - Wt1}{P}$

Where,
Wt1 = initial weight
Wt2 = final weight
P = duration of the experiment (days).

Food conversion ratio (FCR): FCR= $\frac{total\ feed\ intake}{total\ weight\ gain}$

Where Total weight gain = *mean individual weight gain x number of survival fish*

Condition factor (K) = SR $\frac{100(body\ weight)}{(total\ lenght)\ 3}$

Survival rate (SR, %): SR= $\frac{final\ number\ of\ fish}{initial\ number\ of\ fish}\ x\ 100$

The results are presented as mean±SD and analysed through one-way variance analysis (ANOVA). Fisher's LSD post-hoc test was used to compare variations in the mean values at a significant level of $p<0.05$. The statistical analysis was performed using the SPSS statistical package program (SPSS, version 20) and Microsoft Office Excel software (Windows 10).

RESULTS

The growth performance of Oreochromis niloticus fingerlings reared under different photoperiods is presented in Table 1. The initial body weight of the fish in the 24-hour photoperiod (LPP) and 12-hour photoperiod (NDP) tanks is higher than the initial body weight of the fish placed in the 6-hour photoperiod (LDP) tanks. Still, no significant difference ($p>0.05$) exists. The mean body weight gain of the fish reared in the LDP tank is higher compared to the weight of the fish in the LPP and NDP tanks, with an established statistically significant difference ($p<0.05$). The final mean body weight was marginally higher ($p>0.05$) in the 24-hour photoperiod than in the 6-hour photoperiod, while the 12-hour photoperiod had the least. The daily weight growth in NDP tanks was significantly lower than those under LPP and LDP tanks. A similar trend was followed in the specific growth rate of the experimental fishes. However, the FCR was best in the 6-hour photoperiod, followed by the 24-hour and 12-hour photoperiod, respectively. The Condition Factor (K) during the experiment ranged from 0.62±0.54 to 1.04±0.63. The minimum K was reported in the 6-hour photoperiod, while the maximum K was in the 24-hour photoperiod. Meanwhile, there was no significant difference in condition factor between experimental groups.

Table 1. Growth performance parameters of Oreochromis niloticus fingerlings raised under different photoperiod

	Treatments		
Variable	**LPP**	**NDL**	**LDP**
Initial mean Body Weight (g)	2.35 ± 0.52^a	2.35 ± 0.49^a	2.32 ± 0.30^a
Final mean Body weight (g)	3.21 ± 0.25^a	3.09 ± 0.39^a	3.15 ± 0.41^a
Mean Body Weight gain (g)	0.85 ± 0.27^b	0.74 ± 0.28^b	1.17 ± 0.19^a
Daily weight gain (g)	0.66 ± 0.27^a	0.26 ± 0.89^b	0.64 ± 0.45^a
Specific growth rate (% d^{-1})	0.28 ± 0.19^a	0.09 ± 0.28^b	0.36 ± 0.22^a
Feed conversion ratio	0.83 ± 0.37^b	1.12 ± 8.37^b	0.51 ± 4.46^a
Condition factor (K)	1.04 ± 0.63^a	0.62 ± 0.54^a	0.85 ± 0.49^a

LPP 24-hour photoperiod; NDP 12-hour photoperiod; LDP 6-hour photoperiod; Means across the same row differently superscripted differ significantly ($P < 0.05$). Values are means ± SD.

The survivability parameters of Oreochromis niloticus fingerlings under this experiment are presented in Table 2. Each treatment tank was stocked with 40 fingerlings each, but there were significant variations in the final number of fish at the end of the experiment. The LPP tank (38.00±0.00) had the highest number of fish, followed by the LDP tank (32.67±4.62), while the NDL tank had the least (28.00±5.29). Similarly, significantly ($p<0.05$), the highest survival rate (95.00±0.00 %) was observed in 24-hour photoperiod as compared to 81.66±11.54 % in 6-hour photoperiod and 70.00±13.23 % in 12-hour photoperiod. Results for water quality analyses of experimental treatments, as shown in Table 3, indicate no significant variations. The 24-hour photoperiod tanks had higher dissolved oxygen (4.51±0.47 mg l-1) and nitrate levels (4.12±0.01 mg l-1), while the same nitrite value (0.02±0.01 mg l-1) was recorded in all the experimental groups. The highest pH (7.33±0.41) and temperature (27.60±0.53 oC) were observed in 12-hour and 6-hour photoperiods, respectively.

DISCUSSION

In the present study, the mean weight gain of Oreochromis niloticus fingerlings is affected by photoperiod treatments, with the fish under a 6-hour photoperiod having significantly the highest weight gain (1.17±0.19 g). This result contradicts the earlier findings of Elsbaay (2013), who reported significantly higher weight gain in Nile tilapia raised under long photoperiod in tanks. The difference could be attributed to variations in climate because the latter study was conducted in Egypt. The present result also disagrees with the findings of Mustapha et al. (2014), who studied the effect of photoperiod on the mortality and welfare of cultured O. niloticus. These authors reported the highest growth rate in O. niloticus fingerlings under a long photoperiod. The slight variations in the specific growth rate (SGR) of O. niloticus in the present study is consistent with the findings of Awasthi et al. (2017), who recorded statistically the same SGR for Trichogaster lalius under three photoperiods. However, Elsbaay (2013) and Ali and El-Feky (2013) reported notably high SGR in 24-hour light exposure Oreochromis niloticus fingerlings compared to other photoperiodic treatments.

Table 2. Survivability parameters of Oreochromis niloticus fingerlings raised under different photoperiod

	Treatments		
Variable	**LPP**	**NDL**	**LDP**
Initial number of fish	40.00 ± 0.00^{a}	40.00 ± 0.00^{a}	40.00 ± 0.00^{a}
Final number of fish	38.00 ± 0.00^{a}	28.00 ± 5.29^{b}	32.67 ± 4.62^{ab}
Mortality	2.00 ± 0.00^{b}	12.00 ± 5.29^{a}	7.33 ± 4.62^{ab}
Survival rate (%)	95.00 ± 0.00^{a}	70.00 ± 13.23^{b}	81.66 ± 11.54^{ab}

LPP 24-hour photoperiod; NDP 12-hour photoperiod; LDP 6-hour photoperiod; Means across the same row differently superscripted differ significantly ($P < 0.05$). Values are means ± SD.

Table 3. Physico-chemical parameters of the culture media for Oreochromis niloticus fingerlings reared under different photoperiod

	Treatments		
Parameters	**LPP**	**NDL**	**LDP**
Dissolved Oxygen (mg l^{-1})	4.51 ± 0.47^{a}	4.39 ± 0.26^{a}	4.05 ± 0.10^{a}
pH	7.10 ± 0.17^{a}	7.33 ± 0.41^{a}	7.23 ± 0.51^{a}
Temperature (^{0}C)	26.70 ± 0.92^{a}	26.20 ± 0.75^{a}	27.60 ± 0.53^{a}
Nitrite (mg l^{-1})	0.02 ± 0.01^{a}	0.02 ± 0.01^{a}	0.02 ± 0.00^{a}
Nitrate (mg l^{-1})	4.12 ± 0.01^{a}	4.08 ± 1.13^{a}	3.55 ± 1.91^{a}

LPP 24-hour photoperiod; NDP 12-hour photoperiod; LDP 6-hour photoperiod; Means across the same row differently superscripted differ significantly ($P < 0.05$). Values are means ± SD.

The Feed conversion ratio (FCR) in this study was best in a 6-hour photoperiod and is in contrast with the findings of Elsbaay (2013) and Ali and El-Feky (2013), who reported the best FCR for O. niloticus fingerlings in 24-hour photoperiod. Statistically, a similar condition factor was obtained between experimental groups, indicating that 24-hour, 12-hour, and 6-hour photoperiods were safe for O. niloticus well-being.

There was a significant difference in survival rate across the treatments. The fish exposed to 24-hour photoperiod showed the highest survival rate, which conforms with Mustapha et al. (2014), who worked on the effect of photoperiod on the mortality and welfare of cultured O. niloticus. Similar results were also reported by El-Sayed and Kawanna (2004) and Veras et al. (2013) for O. niloticus fingerlings raised in different photoperiods. The physicochemical parameters in the experimental tanks were not influenced by photoperiod treatment, and the values recorded show a suitable environmental condition for rearing Nile tilapia fingerlings. Also, the ranges of dissolved oxygen, pH, temperature, nitrite, and values obtained are within the range obtained by El-Sayed and Kawanna (2004), El-Sherif and El-Feky (2009), and Tran-Duy et al. (2012). The observed water quality parameters may be due to constant water change in the culture system.

CONCLUSION

The findings from this study reveal that manipulating the photoperiod does influence growth and survival rates in Oreochromis niloticus fingerlings. Nile tilapia, Oreochromis niloticus fingerlings under a 6-hour photoperiod had superior growth and best feed conversion ratio. However, the survival rate was favoured by 24-hour and 6-hour photoperiods. The study suggests similar research in an extended duration to determine if the results obtained in this study could be different.

REFERENCES

Akinwole, A. O. and Faturoti, E. O. (2006). Biological performance of African catfish (Clarias gariepinus) culture in recirculating system in Ibadan. Aquacultural Engineering, 36: 18-23. https://doi.org/10.1016/j.aquaeng.2006.05.001

Ali, M.A.M. and El-Feky, A.M.I. (2013). Effect of different photoperiods on growth performance, survival rate and skin colour of Nile tilapia fingerlings. Egyptian J. Anim. Prod., 50(3):186 -192.

APHA (1995). American Public Health Association. Standard Methods for the Examination of Water and Wastewater. 18th ed. Washington. D.C. 200pp.

Awasthi, M., Gupta, P., Bano, F. and Serajuddin, M. (2017). Effects of Photoperiods on the Growth Performance of Juvenile Trichogaster lalius (Hamilton, 1822). International Letters of Natural Sciences, 65: 16-21. DOI: 10.18052/www.scipress.com/ILNS.65.16

Bizarro, Y.W.S., Navarro, F.K.S.P., Ribeiro Filho, O.P. and Rodrigo Diana Navarro, R.D. (2019). Photoperiod effects in blood glucose, cortisol, haematological parameters and reproductive indexes of GIFT lineage reversed male tilapia. Bioscience Journal, 35(6): 1915-1922. DOI: https://doi.org/10.14393/BJ-v35n6a2019-41844

Tran-Duy, A.T., Dam, A.A. and Schrama, J.W. (2012). Feed intake, growth and metabolism Nile tilapia (Oreochromis niloticus) in relation to dissolved oxygen Concentration. Aquaculture Research, 43: 730–744. DOI: 10.1111/j.1365-2109.2011.02882.x

El-Sayed, A. F. M. and Kawanna, M. (2004). Effects of photoperiod on the performance of farmed nile tilapia Oreochromis niloticus: I. Growth, feed utilisation efficiency and survival of fry and fingerlings. Aquaculture, 231: 393–402. https://doi.org/10.1016/j.aquaculture.2003.11.012

Elsbaay, A.M. (2013). Effects of Photoperiod and Different Artificial Light Colors on Nile Tilapia Growth Rate. Journal of Agriculture and Veterinary Science, 3(3): 05-12. DOI: 10.9790/2380-0330512

El-Sherif, M.S. and El-Feky, A.M.I. (2009). Performance of Nile tilapia Oreochromis niloticus fingerlings. II. Influence of different water temperatures. International Journal of Agriculture and Biology, 11: 301-305.

FAO. (2018). The State of World Fisheries and Aquaculture 2018-Meeting the sustainable development goals. Rome. Licence: CC BY-NC-SA 3.0 IGO

Fontainhas-Fernandes, A., E. Gomes, M.A. Reis-Henriques and J. Coimbra, 2002. Plasma thyroid hormones and hepatic nucleic acids in relation to sex of tilapia Oreochromis niloticus. J. Appl. Ichthyol., 18: 185-191.DOI: 10.1046/j.1439-0426.2002.00329.x

Hernández, M. A. (2020). The influence of lighting on fish production: Effect of lighting on different life stages of cultured fishes. Veterinarian Digital Magazine. November 2020 Edition.

Loan, P.P., Hang, N.T.T. and Tuyen, N.L. (2021). Impacts of different methods on water quality management on growth performance and quality of tilapia intensively cultured in earthen ponds. Livestock Research for Rural Development, 33(10): 1 – 5. http://www.lrrd.org/lrrd33/10/33127pploh.html

Mustapha, M. K., Okafor, B. U., Olaoti, K. S. and Oyelakin, O. K. (2012). Effects of three different photoperiods on the growth and body coloration of juvenile African catfish, Clarias gariepinus (Burchell). Arch. Pol. Fish., 20: 55-59. DOI 10.2478/v10086-012-0007-1

Mustapha, M.K., Oladokun, O.T., Salman, M.M., Adeniyi, I.A. and Dele Ojo, D. (2014). Does light duration (photoperiod) have an effect on the mortality and welfare of cultured Oreochromis niloticus and Clarias gariepinus? Turkish Journal of Zoology, 38: 466-470. doi:10.3906/zoo-1309-23

Veras, G. C., Murgas, L. D. S., Rosa, P. V., Zangeronimo, M. G., Ferreira, M. S. S. and SolisDe Leon, J. A. (2013). Effect of photoperiod on locomotor activity, growth, feed efficiency, and gonadal development of Nile tilapia. Revista Brasileira de Zootecnia, 42: 844-849. https://doi.org/10.1590/S1516-35982013001200002

Wang, K., Li, K., Liu, L., Tanase, C., Mols, R. and van der Meer, M. (2020). Effects of light intensity and photoperiod on the growth and stress response of juvenile Nile tilapia (Oreochromis niloticus) in a recirculating aquaculture system. Aquaculture and Fisheries, 64: 1-6. https://doi.org/10.1016/j.aaf.2020.03.001

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

THE IMPACT OF REARING SYSTEMS ON THE SURVIVABILITY OF TILAPIA SPECIES

[1]Eze, J. O., O. I. Binyotubo., I.Y. Yem., E. A. Robert., D. C. Nwangwu., K. E. Ogbuebunu., E. A. Gabriel., I.U. Ibrahim., 9U.B. Mohammed., H. Ahmed and A. A. Ibrahim

[1]National Institute for Freshwater Fisheries Research, P.M.B 6006, New Bussa, Niger State, Nigeria.

Corresponding author:
ezejoseph840@gmail.com, +234 8039367240

ABSTRACT
Two hundred and seventy (270) Thai tilapia, Hybrid tilapia and Nile tilapia were observed for forty-three (43) days in nine (9) tanks. There were three treatments and triplicates: Thai tilapia stocked in three (3) 2x2x1m2 stagnant concrete tanks (TTS), with stocking density of thirty fish per tank; Hybrid tilapia also stocked in three (3) concrete tanks fitted with three (3) PVC pipes to serve as the flow-through systems (HTF), with stocking density of thirty fish per tank; and Nile tilapia stocked in three (3) hapas (LTH) fitted to three rearing concrete tanks, with stocking density of thirty fish per tank. The tilapia stocked were fed to satiation using Coppens feed. Mean initial weight (MIW) was 4.11±0.00g for TTS, 4.10±0.00g for HTF and 4.05±0.00g for NTH. Mean final weight (MFW) recorded values of 6.30±0.00g for TTS, 7.05±0.10g for HTF and 6.47±0.01g for NTH. Percentage survival was reported to be 97.78% for TTS , 97.41% for HTF and 98.15% for NTH. The highest weight gain observed was 20.81±0.00g for fishes in the HTF tanks, and the lowest weight gain was 16.05±0.00g for fishes in the TTS tanks. There were significant differences ($p<0.05$) throughout the treatments. Condition factor reported values of more than 1, depicting good rearing conditions and fishes being in a state of wellness. The growth of fish in this study revealed positive allometry for each treatment. Water quality parameters were at recommended ranges. This study aimed to document best survivability and growth of Tilapia species reared under different rearing systems.

Keywords:
Thai tilapia, Hybrid tilapia, Nile tilapia, stagnant, flow-through, hapas

INTRODUCTION

The Nile Tilapia, popularly known as the local or indigenous tilapia; and scientifically called Oreochromis niloticus, is successfully farmed in Nigeria and across the globe because of its growth and reproduction under a wide range of environmental conditions and because it exhibits low trophic level for feeding; while tolerating stress caused by handling and poor water quality conditions (Oluwalola et al., 2020). The first strain of Thai tilapia (resembling an oceanic redfish) emerged in Taiwan in 1960. It was a fusion of mutant red-orange Mozambican tilapia and the Nile tilapia (Oreochromis mossambicus x Oreochromis niloticus). The second strain was created in Florida in the 1970s using a Zanzibar female tilapia and the red-gold Mozambican male tilapia (Oreochromis urolepsis hornorum x mutant strain of Oreochromis mossambicus). The third strain of Thai tilapia was created in Palestine, Israel using a combination of mutant pink Nile tilapia and a wild blue tilapia (a strain of Oreochromis niloticus x Oreochromis aureus (Vajargah, 2021). A red tilapia (Thai tilapia) was created the strain and their crossings. The hybrid tilapia strain is the progeny from a cross between Oreochromis aureus x

Oreochromis niloticus (Samaddar et al., 2024). Tilapia reared in hapas have been reported to yield better weight gain and higher growth rates (Zidana et al., 2015); while providing a basis for easy handling and sampling. They also show high production per unit area and lowest mortality (Towers, 2015). Flow-through systems are most effective when a good supply of quality water is available as this system significantly impacts fish productivity (Robert et al., 2019). Therefore, this study will inform aquaculture stakeholders on the most productive system for growing tilapia species for the best results in survivability and increased chances for more income to stakeholders and the nation at large.

MATERIALS AND METHODS

The study area was the National Institute for Freshwater Fisheries Research (NIFFR), Borgu Local Government Area in Niger state. Borgu Local Government Area is located at 9°53'N 4°31'E coordinates (Robert, 2021). Tilapia species (Thai, Hybrid and Nile) were obtained from the Tilapia unit of NIFFR. The Kigera dam, a reservoir in the Borgu Kingdom, provided water for this study. The experimental design for this study was a factorial design. There were three treatments and ninety fishes per treatment. There was a bi-weekly sampling of the fish to take recordings of the growth and survivability in the respective rearing systems. Total lengths and standard lengths were calculated to the nearest 0.1cm following measuring using a ruler. Weights were measured bi-weekly using a CAMRY 50kg electronic scale for which the weight values were converted to grams. Using the mechanism requiring PVC (polyvinyl chloride) pipe for the flow-through tanks, water was constantly flowing into the culture tanks by an inlet and flowing out through an outlet, day and night. The PVC pipe was cut to 1.5inch diameter, equal to the water depth in tanks while being a precise fit to each of the three tanks slated for the flow-through rearing system to enable excess water drain out. Therefore, water was left at a ¾ depth throughout all the flow-through tanks. The same flow rate into the tanks via the inlet was the same flow rate out of the tanks (Robert et al., 2019; Robert et al., 2020). The three tanks fitted with hapas measured 2m X 1.0m X 1.2m and helped assess tilapia species' growth. Feeding was done twice daily using Coppens, a commercial fish feed with 56% crude protein. 0.5mm of Coppens was fed to fish from stocking to week three. 0.8mm Coppens feed was given the experimental fishes from week four to week six. Fishes were fed to satiation every twelve hours.

Growth, mortality and survival parameters were assessed using the following formulae:

Mean Initial Weight (MIW) = $\frac{TW}{TN}$
TN=Total number of fish *(Dauda et al, 2022)*

Mean Weight Gain (MWG)= *MFW-MIW*
Where: MFW= Mean Final Weight
MIW= Mean Initial Weight *(Dauda et al, 2022)*

Percentage Mortality (% mortality) $\frac{CM}{TnS} x\ 100$
Where: CM= Cumulative Mortality
TnS= Total Number Stocked (Abdulraheem *et al.*, 2018).

Percentage Survival (% survival)
Wehere: CS = Cumulative Survival
TnS= Totak Number Stocked (Dauda *et al*, 2023)

Survival Rate (SR) = NS-NM
Where: NS=number of fish stocked
NM= number of mortalities (Sultana *et al.*, 2018)

$$\text{Specific Growth Rate \% day (SGR)} = \frac{\log_n FW - \log_n IW}{D} \times 100$$

Where: $\log_n FW = \log_n$ final weight
$\log_n IW = \log_n$ initial weight
D= Feeding Period in days (Yunusa *et al.*, 2020).

$$\text{Feed Conversion efficiency (FCE)} = \frac{FW}{WF} \times 100$$

Where: FW = Final weight of experimental fish
WF= Weight of feed given during experimental duration (Abaho *et al.*, 2020)

$$\text{Performance Index(PI)} = \frac{SR \times FMW - IMW}{D}$$

Where; SR= Survival Rate
FMW= Final mean weight
IMW= Initial mean weight
D=Rearing duration in days (Abdulraheem *et al.*, 2018)

$$\text{Condition factor} = \frac{FW \times 100}{SL}$$

Where:
FW= Weight of fish
SL= Standard length of fish (L3) (Dauda *et al.*, 2023)

Data was analysed using Microsoft Excel (23 version). Data were subjected to a one-way analysis of variance (ANOVA) to assess the difference among means (Ojuwoni et al., 2019). Significant results from ANOVA were examined using the Duncan Multiple range test; which was used to compare means (Yakubu et al., 2014). Analysis for regression was also computed (Nwachi et al., 2020). Water quality parameters and their measurements were carried out as follows: temperature, was measured in degree Celsius using a mercury-in-glass thermometer; □H was measured using a ? H meter as documented by APHA (1990); and Dissolved oxygen of the treatments was measured using Winkler's method (APHA, 1985).

RESULTS

Table 1: Growth and survival of Thai tilapia, Hybrid tilapia and Nile tilapia cultured under different rearing systems.

Species/ Treatments	MIW (g)	MFW(g)	MWG (g)	% SGR	FCR	FCE	PI	CF
Thai tilapia/stagnant tanks (TTS)	4.11±0.00^{c}	6.30±0.00^{a}	16.05±0.00^{a}	0.84±0.01^{a}	0.03±0.00^{b}	0.94±0.00^{b}	98.5±0.00^{a}	1.32±0.00^{a}
Hybrid tilapia/flow-through tanks (HTF)	4.10±0.00^{b}	7.05±0.10^{c}	20.81±0.00^{c}	1.02±0.00^{b}	0.02±0.00^{a}	0.84±0.00^{a}	127.3±0.00^{c}	1.34±0.00^{a}
Nile tilapia/hapas tanks (NTH)	4.05±0.00^{a}	6.47±0.01^{b}	18.54±0.00^{b}	1.00±0.00^{b}	0.03±0.00^{b}	0.91±0.00^{b}	114.3±0.04^{b}	1.49±0.00^{b}

Means in the same columns (for each section) with different superscript are statistically significant ($p<0.05$). MIW=Mean initial weight (g), MFW= mean final weight (g), WG =weight gain (g), SR= survival rate, %SR =%survival rate, %SGR = %specific growth rate, FCR=feed conversion ratio, FCE=feed conversion efficiency, PI= performance index and CF=condition factor

Table 2: Length-weight relationship regression of Thai tilapia, Hybrid tilapia and Nile tilapia reared under different rearing systems.

Species/ Treatments	Intercept (a)	Growth pattern (b)	Coefficient of determination (R^2)
Thai tilapia/stagnant tanks (TTS)	0.38	4.72	0.42
Hybrid tilapia/flow-through tanks (HTF)	0.75	5.97	0.67
Nile tilapia/hapas tanks (NTH)	0.58	5.94	0.50

Table 3: Water quality parameters of the rearing systems in the study.

Species/Treatments	Temperature °C	DO mg/L	ρH
Thai tilapia/stagnant tanks (TTS)	27.00 ± 0.10^a	5.18 ± 0.00^a	6.0 ± 0.24^a
Hybrid tilapia/flowthrough tanks (HTF)	27.10 ± 0.01^a	5.20 ± 0.01^a	6.5 ± 0.10^a
Nile tilapia/hapas tanks (NTH)	27.00 ± 0.00^a	5.15 ± 0.02^a	6.0 ± 0.05^a

Means in the same columns (for each section) with different superscript are statistically significant ($p<0.05$).

DISCUSSION

There was a significant difference ($p<0.05$) between the treatments for growth and survival. Growth throughout the systems was positively allometric. The condition factor showed values of more than 1 throughout the study; indicating good rearing conditions and healthy fishes. Water quality values showed normal ranges throughout the study (Robert, 2021). However, there was no significant difference ($p>0.05$) in the water quality of the rearing systems. Nile tilapia (Oreochromis niloticus) that were reared in hapas, recorded the lowest mortality. The mortality result was in agreement with Samaddar et al. (2024). Bhosle et al. (2022) also agreed with the findings of this study as their earlier study documented higher growth and survival of GIFT in hapas placed in concrete tanks. Romana-Eguia et al. (2010) further reported higher survival and growth of Nile Tilapia and Red Tilapia strains in cage-based systems than tank-based systems. The greatest weight gain was achieved by the Hybrid tilapia (Oreochromis aureus x Oreochromis niloticus) that were raised in the flow-through systems however, reported the highest weight gain in this study. This result could be attributed to the optimization of the cultured environment (i.e. flow-through system simulating a natural environment), optimal maximization of feed which played a crucial role in the weight gain of fishes, resulting in a low FCR as they fed every twelve hours. Abd El-Hack et al. (2022) agrees with this result, stating in an earlier study that optimizing of the culture environment is important in achieving higher growth rates and survival as this helps fish feed more efficiently. Abanikannda et al. (2019) however disagrees, citing a six-hour interval feeding regimen as the best, encouraging fish weight gain. Robert et al. (2019) however reported in an earlier report, which agrees with the results of this study, that flow-through systems were the best rearing systems significantly impacting on fish productivity.

CONCLUSION AND RECOMMENDATIONS

It is concluded that, while the highest survivability was observed in the hapa rearing systems for Nile tilapia (Oreochromis niloticus), Hybrid tilapia (Oreochromis aureus x Oreochromis niloticus) performed optimally, growth-wise; in the flow-through rearing systems, closely followed by good growth performance of Nile tilapia (Oreochromis niloticus) in the hapa rearing systems. It is now recommended that the culture of tilapia species be carried out in the flow-through systems to aid faster growth and provide income to all aquaculture stakeholders. More research on the rearing of tilapia species in different rearing systems should also be carried out to compare results and observations.

REFERENCES

Abaho, I., Thaddeus, Z., Arinaitwe, I.Z.A., Howard, K., Norman, M., Gilbert, S.B., Mujibu, N., Sylvester, D.B., David, H. and Jackson, E. (2020). Effect of stocking density on growth and survival of Nile Tilapia (Oreochromis niloticus, Linnaeus 1758) under cage culture in Lake Albert, Uganda. International Journal of Fisheries and Aquaculture, 12, 26-35. doi: 10.5897/IJFA2018.0671

Abanikannda, O.T.F., Jimoh, A.A., Bakare, K.O., Shitta, S.A. and Shopeyin, Z.F. (2019). Influence of feeding regimen on growth parameters of African Catfish (Clarias gariepinus, Burchell 1822). Nigerian Journal of Animal Production, 46(3), 192-204.

Abdulraheem, I., Bamidele, N.A., Adeosun, F.I., Odebiyi, O.C. and Alade, W.S. (2018). Growth performance and survival of Clarias gariepinus under varying stocking density. Ife Journal of Science, 20(2), 451-459.

Abd El-Hack, M.E., El-Saadony, M.T., Nader, M.M., Salem, H.M., El-Tahan, A.M., Soliman, S.M. and Khafaga, A.F. (2022). Effect of environmental factors on growth performance of Nile Tilapia (Oreochromis niloticus), International Journal of Biometeorology, 6 (11), 2183-2194.

Bhosle, R.V., Sampathkumar, J.S., Antony, C., Aanand, S., Senthilkumar, V., Betsy, C.J. and Lingam, R.S.S. (2022).Comparative study on growth and survival of genetically improved farmed Tilapia (Oreochromis niloticus)fry reared under two different culture systems. Journal of Environmental Biology, 43, 385-389.

Dauda, A.B., Ajadi, A., Bashir, Z. and Ikpe, J. (2022). Frequency of water change on growth performance, nutrient utilization and liver histology of Nile Tilapia (Oreochromis niloticus, Linnaeus, 1758) Asian Journal of Fisheries and Aquatic Research, 16(2), 42-50.

Dauda, A.B., Adamu, H.M. and Abubakar, S.H. (2023). Inference of culture tank colours on the water quality, growth performance and feed utilization of Oreochromis niloticus (Linnaeus, 1758) juveniles. UMYU Scientifica, 2(2), 016-22.

Kunda, M., Harun-Al-Rashid, A., Morshed, F., Islam, A. and Mazumder, S.K. (2014). Production of Tilapia (Oreochromis niloticus)fingerling in hapa using swim-up fry involving women in the Haor Region of Bangladesh. Journal of Agriculture and Veterinary Science, 7, 2319-2380.

Nwachi, O.F., Zelibe, S.A.A. and Kelly-Igumbor, S. (2020). Culture of catfish (Clarias gariepinus) fed with diet containing 17-*a*-methyltestosterone. Nigerian Journal of Fisheries, 17(2), 2017-2021.

Oluwalola, O.I., Fagbenro, O.A. and Adebayo, O.T. (2020). Comparative study on growth and economic performances of Nile Tilapia, Oreochromis niloticus reared under different culture enclosures in Akure, Nigeria. Aquaculture studies, 20(2), 91-98.

Ojuwoni,A.A., Akinwole, A.O. and Faturoti, E.O. (2019). Growth performance and Nutrients Utilization of Oreochromis niloticus fed maggot meal-based diets. Proceedings of the 34th Annual Conference of Fisheries Society of Nigeria (FISON), held on the 28th October-1st November at the Law Auditorium, Ebonyi State University, Abakiliki. pp.130-133.

Robert, E.A., Yisa, A.T. and Tsadu, S.M. (2019).Growth performance and survival of monosex cultured Heterobranchus longifilis juveniles in concrete flow-through and stagnant water systems. Scientific Research Journal (SCIRJ). 7(2), 43-65. doi:10.31364/SCIRJ/v7.i2.2019.P0219615

Robert, E.A., Yisa, A.T. and Tsadu, S.M. (2020). Growth performance of monosex cultured Clarias gariepinus Juveniles in concrete flow-through and stagnant water tanks. Proceedings of the 35th Annual Conference of Fisheries Society of Nigeria (FISON) MINNA 2020, held on the 15th November-19th November at Raw Materials Research and Development, Abuja, FCT. pp.53-56.

Robert, E.A. (2021). Effects of Testosterone Propionate on the Sex-Ratio Determination in Clarias gariepinus fry reared in Concrete Water Tanks. Proceedings of the 36th Annual Conference of Fisheries Society of Nigeria (FISON), held on the 24th October-29th October at Ebitimi Banigo Auditorium, University Of Port Harcourt, Choba, Rivers State. pp.851-854.

Romana-Eguia, M.R., Ikeda, R.M., Basiao, Z.U. and Taniguchi, N. (2010). Growth comparison of Asian Nile and Red tilapia strains in controlled and uncontrolled farm conditions. Aquaculture International,6, 1205-1221.

Samaddar, A., Ghosh, T. and Verma, D.K. (2024). Global Diversification of Tilapia Production Techniques: Recent Overview-Part 1. Journal of Advanced Biology and Biotechnology, 27(7), 745-760.

Sultana, S., Alam, S. and Hossain, S. (2018). Growth and survival rate of two indigenous fish species with three different feeds under tank condition. International Journal of Fisheries and Aquatic Studies, 6 (3), 340-343.

Towers, L. (2015). Hatchery management and tilapia fingerling production. Fish Site, pp: 1-6.

Vajargah, M.F. (2021). A review of the physiology and biology of Nile tilapia (Oreochromis niloticus). Journal of Aquaculture and Marine Biology, 10(6), 244-246.

Yakubu, A.F., Nwogu, N.A., Olaji, E.D., Ajiboye, O.O., Apochi, J.O., Adams, T.E., Obule, E.E. and Eke, M. (2014). A comparative study on growth performance and survival rate of Clarias gariepinus Burchell 1822 and Heterobranchus longifilis Valenciesnnes, 1840 under water recirculation system Agriculture, Forestry and Fisheries, 3(1), 30-33.

Yunusa, A., Yusuf, A., Buba, W., Muhammed, F.O. and Salaudeen, M.M. (2020). Growth performance of African catfish (Clarias gariepinus) juveniles fed without diet of different protein levels. Journal of Animal Production Research, 34(2),105-118.

Zidana, H., Phiri, F., Kapute, F., Ajiboye, O. and Singini, W. (2015). Effect of stocking density and rearing facility on growth and profitability of Tilapia rendalli fry. International Journal of Aquaculture, 24, 1-5.

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WATER QUALITY DYNAMICS IN CULTURE TANKS OF AFRICAN CATFISH FED DIETS CONTAINING VARYING INCLUSION LEVELS OF FERMENTED *Ampelocissus africana* (WILD GRAPE)

Dauda, A. B., I. Abubakar, I.A. Masari, H.Y. Shuaibu, Y.M. Isah, A. Lawal, and Y. Bello

Department of Fisheries and Aquaculture, Federal University Dutsin-ma, Katsina State, Nigeria

Corresponding author:
iabubakar21@fudutsinma.edu.ng: +234-9074628336

ABSTRACT

A fifty-six-day experiment was conducted to investigate the water quality dynamics in culture tanks of the African catfish fed diets containing different inclusion levels of fermented leaves of *Ampelocissus africana* (Wild grape) as a replacement for maize. *Clarias gariepinus* juveniles with an average body weight of 10g were stocked and hand-fed at 5% body weight with a 35% crude protein diet twice daily. The experiment had five treatments, T1-100% maize and 0% *A.africana*, T2-75% maize and 25% *A. africana*, T3-50% maize and 50% *A.africana*, T4-25% maize and 75% *A.africana*, T5-0% maize and 100% *A.africana*. All the water quality parameters examined (temperature, dissolved oxygen, pH, alkalinity, and ammonia-nitrogen) during the experiment were not significantly different among the treatments. The highest DO concentration was observed in T5 (4.13±0.39mg/L), the highest temperature value in T3 (28.9±0.10oC), the highest pH in T3 (7.53±0.15), T4 had the highest alkalinity (20.7±0.5 mg/L) while highest ammonia-nitrogen (0.69±0.09mg/L) was recorded in T2. Temperature and DO had a significant inverse relationship, while DO and pH, and ammonia-nitrogen and pH had significant positive correlations. All the selected water quality parameters were within the acceptable range for tropical fish culture. The results revealed that African catfish juveniles can be reared with a diet containing *A.africana* up to 100% replacement with no negative consequences on the water quality parameters.

Keywords:
Ampelocissus africana,
Clarias gariepinus,
diet formulation,
water quality.

INTRODUCTION

Nigeria is one Africa's of top aquaculture producers, and there are still numerous opportunities to increase large-scale production (Dauda *et al.*, 2018). Several researchers have reported constraints to aquaculture development, including water quality, water quantity, high feed cost, disease infestation, and inadequate technical capacity (Dauda *et al.*, 2015). Nonetheless, the prospects can be achieved by expanding aquaculture production zones, improving management practices of the production system, and enhancing product quality (Amosu *et al.*, 2017). Ampelocissus africana belongs to the genus Ampelocissus and the family Vitaceae. This plant's leaves, roots, and fruits are useful as food and medicine. It is distributed throughout Western and Eastern African countries. It has garnered attention as a potential substitute for energy-based ingredients in the African catfish diet (Dauda *et al.*, 2023a). Increasing aquaculture production is highly desired to meet the increased demand for fish and fish products. However, the high cost of fish feed has been identified as a major constraint to sustainable aquaculture development (Dauda *et al.*, 2015). A poorly acceptable and digestible fish feed ingredient may lead to fast deterioration of water quality due to increased waste generation, which may stress the fish and lead to poor production despite the cheap cost of fish feed. It is uncertain how acceptable fermented A. africana at different inclusion levels will be to fish and the consequences on the water quality dynamics. Water is a basic element in rearing fish, and water quality is a critical factor in determining the success of the operation. Poor water quality can lead to disease outbreaks, reduced growth rates, and even death of the fish (Boyd, 2017). This research was carried out to examine the feasibility of using Ampelocissus africana in the fish diet by providing information on the water quality dynamics in culture tanks of African catfish fed with different inclusion levels as a replacement for maize, as well as the interdependence among the water quality parameters.

MATERIALS AND METHOD

The experiment was carried out at the mini research laboratory of the Department of Fisheries and Aquaculture, Federal University Dutsin-ma Katsina State, Nigeria. The leaves of Ampelocissus africana were collected from the surroundings of Dutsin-Ma town in Katsina state, Nigeria. The leaves were washed, air-dried, and fermented with yeast for 48 hours and then dried again following the description of Dauda et al. (2023a). The fermented leaves were ground into powdery form and were used to substitute maize as a source of energy (carbohydrate) in formulating fish feed.

One hundred and fifty (150) juveniles of *Clarias gariepinus* were bought from a private fish farm in Katsina. The fish was transported from the farm down to the fish market, Dutsin-Ma, in a 50-litre 'jerry can' by road. After the arrival of the fish it was randomly distributed into fifteen tanks for the experiment and each tank of 44cm × 29cm × 25cm, with a water capacity of 30L (each tank was filled with 25L of water) and stocked with ten (10) fish of 7.94g average weight. The fish were not fed on the first day of arrival because of stress till after 20-24 hrs.

The design used was a complete randomized design (CRD) comprising five (5) treatments with three replicates each. The first treatment, which is the control (T1), was fed formulated feed containing 0% *A.africana* and 100% maize; the second treatment (T2) was fed 25% *A.africana* and 75% maize; the third one (T3) was fed 50% *A.africana* and 50% maize; the fourth one was (T4) fed 75% *A.africana* and 25% maize and the last one which is the fifth one was fed 100% *A.africana* only. The experiment lasted for eight 8 weeks (56 days), and all five (5) treatments were fed the diet twice a day (morning and evening) at 5% body weight. Water quality parameters were measured twice every week during the experiment.

Five diets (T1-T5) were formulated containing 35% crude protein, using Pearson square method. All the feed ingredients were integrated to compute the required quantities to make up 100% of the feed (Table 1).

Table 1: Composition (%) of experimental diets

INGREDIENTS (%)	T1	T2	T3	T4	T5
Fish meal	17.61	17.50	17.39	17.24	17.15
Soybean Meal	52.84	52.52	52.17	51.72	51.46
Maize	22.55	17.23	11.72	6.01	0.00
Wild grape	0	5.75	11.72	18.03	24.39
Palm Oil	2.00	2.00	2.00	2.00	2.00
Cassava	2.00	2.00	2.00	2.00	2.00
Salt	0.75	0.75	0.75	0.75	0.75
Vitamins	0.75	0.75	0.75	0.75	0.75
Methionine	0.25	0.25	0.25	0.25	0.25
Bone meal	1.00	1.00	1.00	1.00	1.00
Lysine	0.25	0.25	0.25	0.25	0.2
Total	**100**	**100**	**100**	**100**	**100**

Water quality in the tanks was maintained by siphoning out the bottom debris (faecal matter, uneaten food) and changing 70% of the water twice a week (water level re-adjusted by refilling with clean water). Physicochemical parameters like water temperature (oC) were measured using a mercury-in-glass thermometer, pH, dissolved oxygen, DO (mgL-1), alkalinity (mgL-1) and total ammonia-nitrogen (mgL-1) were measured using Fresh Innovative Multitec kits.
All data obtained from the experiment were expressed in mean ± SE. Before subjecting the data to one-way analysis of variance (ANOVA), a variance homogeneity test was carried out. Duncan's multiple range test was used to separate the significant means at $p<0.05$. Person correlation analysis was used to test the interdependence among the water quality parameters.

RESULT AND DISCUSSION

According to Dauda et al. (2023b), the successful culture of fish is hinged on three basic things: the quality of fish seeds, satisfactory fish feed, and adequate water quality. So, any ingredient to be introduced to improve fish production must not be the one that can lead to fast deterioration of water quality. In this study, the inclusion of A. africana up to 100% as a replacement for maize did not harm the water quality. As shown in Table 2, all the water quality parameters were not different significantly among the treatments ($P>0.05$), except alkalinity, which was higher significantly ($p<0.05$) in treatment 4 with 20.7±0.51mg/L compared to 20.0±0.00mg/L in all other treatments. Nonetheless, all the water quality parameters are within the recommended range for the culture of tropical fish species (Dauda and Akinwole, 2014; Sulem-Yong et al., 2023).

Table 2: Water quality (Mean±SE) parameters in the rearing tanks of African catfish fed diet containing different inclusion levels of Ampelocissus africana

Parameters	T1	T2	T3	T4	T5
Temperature (^{o}c)	28.74±0.12	28.56±0.14	28.91±0.10	28.46±0.16	28.37±0.32
Dissolved oxygen(mg/l)	3.81±0.41	3.58±0.48	4.04±0.47	4.04±0.47	4.13±0.39
pH	7.06±0.19	7.24±0.75	7.53±0.15	7.39±0.16	7.43±0.19
Alkalinity (mg/l)	20.0±0.00^{a}	20.0±0.00^{a}	20.0±0.00^{a}	20.7±0.51^{b}	20.0±0.00^{a}
Ammonia-Nitrogen(mg/l)	0.66±0.09	0.69±0.09	0.62±0.10	0.63±0.10	0.67±0.10

Different letters as superscripts across the row indicate significant differences ($p<0.05$)

Table 3 shows a significant negative correlation between DO and temperature, while pH had a significant positive correlation with DO and ammonia-nitrogen. The results imply that an increase in DO corresponds with a decrease in temperature and vice-versa, while the increase in pH corresponds with increased DO and ammonia-nitrogen. An inverse relationship between DO and temperature was reported by Dauda and Akinwole (2014) in water quality parameters from recirculating aquaculture systems. Dauda et al. (2021) also reported a negative correlation between temperature and DO, as well as ammonia and pH, though not significant.

Table 3: Interdependence among the water quality parameters in rearing tanks of African catfish fed diet containing different inclusion levels of Ampelocissus africana

	Temperature	DO	pH	Alkalinity	Ammonia
Temperature	1				
DO	-0.195*	1			
pH	-0.126	0.281**	1		
Alkalinity	0.075	-0.090	0.090	1	
Ammonia	0.090	0.159	0.522**	-0.121	1

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

CONCLUSION

The study revealed that regardless of the inclusion level of fermented Ampelocissus africana in the fish feed, the water quality parameters were not significantly different. Therefore, it can be concluded that Clarias gariepinus juveniles can be fed a diet containing 100% without any adverse effect on water quality parameters. Further study on the impact of varying inclusion levels on the growth performance and well-being of the cultured fish is recommended, as the success of this might lead to a reduction in the cost of fish feed and overall production.

REFERENCES

Amosu A.O., Hammed A.M., Togunde K.A., Joseph O.O. and Adekoya (2017). Possible Aquaculture Development in Nigeria. Journal of Agricultural Science and Technology 7:194-205

Boyd, C. E. (2017). General relationship between water quality and aquaculture performance in ponds. In Fish diseases (pp. 147-166). Academic Press.

Dauda, A. B., and Akinwole, A. O. (2014). Interrelationships among water quality parameters in recirculating aquaculture system. The Nigerian Journal of Rural Extension and Development, 8(1): 20-25.

Dauda A.B., Dasuki A. and Bichi A.H. (2015). Analysis of constraint to aquaculture development in Sudano-Sahelian region of Nigeria. Trop Subtrop Agroecosystem, 18:189-193.

Dauda A.B., Natrah F.M.I., Murni K., Mohd S.K. and Bichi A.H. (2018). African Catfish Aquaculture in Malaysia: Status, Trends and Prospects. Journal Fisheries and Aquaculture.9:1.

Dauda A.B., Bichi, A.H. Salim A. M. and Saidu, A.K. (2021) Interdependence and interrelationship among water quality parameters in biofloc systems. In: L.A. Saulawa, H.B.Usman, A. Aruwayo, M.G. Garba, E.A. Rotimi, A.B. Dauda, S.S. Adeola and M.N. Sabo (eds). Animal agriculture: A panacea for Nigeria's economic growth in the post-pandemic era. Proceedings of the 46th annual conference of the Nigerian Society for Animal Production, held between 14 and 18 March 2021 at Federal University Dutsin-Ma, Katsina State, pp 1346 -1350.

Dauda, A.B., Isah, M.M., Nasir, B., Abdulrahman, K., Echuo-Odu, C. A., Ismail, Q. O. Abdurrasheed, N., Salele, H.A. and Abdulkareem H. O. (2023a). Fermentation enhances the quality of wild grape (ampelocissus africana) leaf meal: a potential ingredient in fish diet formulation. In: Book of proceeding of 38th Annual Conference of the Fisheries Society of Nigeria, Bayelsa 2023, held between 27th November and 1st December 2023.

Dauda, A.B., Ajadi, A., Salele, H.A., Ikpe, J., Basir, Z., Oladapo, O. and Pelebe, R.O.E. (2023b). Water renewal frequency affects water quality, growth performance and physiological status of African catfish, Clarias gariepinus juveniles. Journal of Aquaculture, 31: 13-24. https://doi.org/10.61885/joa.v31.2023.278

Sulem-Yong, N. N., Tchiedjo-Marie, L. D., Boudem-Tsane, C. R., Essoh-Etouke, A. M., Noudjio,C., K. Yong-Sulem S., Etchu, A. K., Nola, M., Zebaze-Togouet, .S.H (2023). Water Quality Effects on Survival and Weight of Tank-Raised African Catfish (Clarias gariepinus, Burchell, 1822) Fed Commercial and Farm-made Feeds. J. Exp. Agric. Int., 45 (12): 140-154.

GROWTH PERFORMANCE AND SURVIVAL OF *Clarias gariepinus* (BURCHELL, 1822) FINGERLINGS RAISED IN VARYING-COLOURED RECEPTACLES AND THE ASSOCIATED WATER QUALITY

Olanrewaju A.N., *B. A. Isa and Y. M. Umar

Department of Fisheries Technology, Federal College of Freshwater Fisheries Technology, Baga, P.M.B 1060, Maiduguri, Nigeria

Corresponding author:
bashtrust029@gmail.com, +234 7067388378, 0009-0009-7775-6176

ABSTRACT

The aim of this study was to assess the influence of tank colour on the growth, survival, and water quality of *Clarias gariepinus* fingerlings. A total of 180 fingerlings (1.48±0.49 g) were distributed into 9 aquariums (2.9 m3) and divided into three treatments (aquariums with green, purple, and black colour) in three replicates (20 fish per aquarium). The fingerlings were fed at 5% of their body weight twice daily for 84 days. Results showed that C. *gariepinus* cultured in the purple aquarium had slightly higher final weight (17.43±0.24 g), weight gain (15.91±0.84 g) and higher feed conversion ratio (1.30±0.01). In the water quality parameters, nitrate (0.58±0.12 – 2.67±2.27 mg/l) and nitrite (0.01±0.00 – 0.61±0.60 mg/l) were significantly higher but not detrimental. It was concluded that C. *gariepinus* fingerlings can be suitably raised in all the tanks, but purple tank exhibited better prospect towards improved growth performance and survival rate.

Keywords:
Tank colour,
growth performance,
Clarias gariepinus,
fingerlings

INTRODUCTION

African catfish, *Clarias gariepinus* is an economically important fish species that constitutes a larger part of Nigeria's aquaculture production, reaching 261,700 tonnes in 2020 (FAO, 2022). This species is mostly appreciated by fish farmers in Nigeria due to its biological attributes, including stress tolerance, disease resistance, fast growth, robustness, and high survival rate (Manyise *et al.,* 2024). Recently, in Northeast Nigeria, the prominence of *Catfish aquaculture* as a food fish source is growing because of insurgency that has deprived its supply from the natural waterbodies. Most youth is embracing Catfish farming in Maiduguri as a source of livelihood. Meanwhile, the availability and affordability of healthy fast-growing fingerlings and juveniles in the required quantities has been a major bottleneck in the area. Kareem et al. (2013) noted that despite the spectacular growth recorded in Catfish fingerlings production through artificial propagation, the demand for the fingerlings still outstrips the supply. The shortfall in fingerling supply could be linked to the inappropriate selection of the best tank colour for the fry-fingerling growth phase, which has remained intractable over the years. According to Sykes *et al.* (2011), tank background colour can be a stressor that affect the behaviour, habitat preference, and metabolic rates of fish. Recently, different tank colours have been observed as the best for nurseries in various species (McLean, 2021).

Fish culture tanks offer significant flexibility for aquaculture production, and many studies indicate that certain species perform better in terms of growth, survival, and feed conversion when maintained in alternative-coloured tanks (McLean, 2021). Similarly, many studies have revealed that culture tank background colors significantly affected cultured fish's growth and survival (McLean, 2021; Okomoda *et al.*, 2017; Opiyo, 2010). Hence, there is a need to know the effects of varying-coloured receptacles on Catfish fry/fingerling survival and growth in Maiduguri, Nigeria.

MATERIALS AND METHODS

The Clarias gariepinus were obtained from the fish hatchery unit, Federal College of Freshwater Fisheries Technology Baga, Maiduguri where the study was also conducted. The initial mean weight of the fingerlings is 1.48±0.49 g. The fish were acclimatized in two experimental plastic tanks (22.06 m2) under laboratory conditions for 24 hours prior to the start of the experiment. After that, nine experimental plastic tanks (2.9 m3) of three different colours were stocked with twenty fish each. The treatments were represented by three replicates each and labelled as: Green (GRN), Purple (PUP) and Black (BLK). The fish were fed with commercial feed of 45% crude protein twice daily (8:00 h and 18:00 h). The daily ration was 5% of the stock biomass, as recommended by Adewolu and Olakunle (2009). Fish were reweighed weekly, and the feeding rate was adjusted with digital analytical balance (Scout Pro SPU202 Model). The feeding trial lasted 12 weeks (84 days) between June 6 and August 28, 2022.
Water quality parameters were analyzed weekly using standard methods by Boyd and Tucker (1998), and in-situ measurements were done for pH, temperature, and dissolved oxygen using a multi-parameter water quality meter (BICASA model B.E.104). Nitrite and nitrate were determined in the laboratory following the APHA (1998) procedure. The weight gain, specific growth rate, feed intake, feed conversion ratio, and survival rate were calculated for each treatment according to Akinwole and Faturoti (2006).
Mean weight gain (MWG, g): MWG = final mean weight - initial mean weight

Specific growth rate (SGR, %/day): $SGR= \frac{lnWt2\text{-}lnWt1}{P}\ x\ 100$

Food conversion ratio (FCR): $FCR= \frac{total\ feed\ intake}{total\ weight\ gain}$

Survival rate (SE, %): $SR= \frac{final\ number\ of\ fish}{initial\ number\ of\ fish}\ x\ 100$

Data obtained from the experiment were subjected to analysis of variance using SPSS (20.0 version) and presented as Mean±Standard deviation (S.D). Fisher's LSD post-hoc test was used to evaluate the differences at 5% level of significance.

RESULTS

The physicochemical parameters of water in the fish culture environment in different coloured receptacles were observed for three months of the experiment (Table 1). There was no significant difference ($p>0.05$) in mean dissolved oxygen, pH, and temperature values at different receptacle colours. The mean nitrate and nitrite levels in the black culture medium were significantly higher ($p<0.05$) than in purple and green tank treatments. The obtained values for growth performance such as body weight gain (BWG), specific growth rate (SGR), feed intake (FI) and feed conversion ratio (FCR) are shown in Table 2. Initial average fish weight in all groups was not significantly different ($p>0.05$), and the performance during 84 days of growth were evaluated. No significant variations were observed in the BWG and SGR, while the lowest value was recorded for fish raised in black and green tanks. Fish raised in purple tank had a higher mean feed intake value ($p<0.05$) than those raised in green and black receptacles. However, treatment groups had no significant differences in the feed conversion ratio. Percentage survival was very high (>70%) across all colour treatment groups and no significant difference ($p>0.05$) was recorded in the percentage survival of all the fish in treatment groups (Figure 1). However, purple tank had the highest survival rate (92.00±2.10 %), while black gave the least (77.33±3.25 %).

DISCUSSION

The water quality results presented in this study showed no significant differences in temperature, pH and dissolved oxygen between treatment groups, indicating that these parameters remained constant throughout the experimental period. Also, their values were within the recommended levels for catfish culture (Boyd and Tucker, 1998). However, Nitrate and nitrite levels were significantly high in black receptacles but within the optimum levels recommended for catfish (Boyd and Tucker, 1998). The significant variations in nitrate and nitrite imply that black culture receptacles have no detrimental effects on the surrounding water quality of the fish. Purple culture receptacles in the current study had the highest mean body weight gain and specific growth rate (SGR), which were not statistically different from the fish raised in green and black receptacles. This data corroborates the findings of Krasteva et al. (2020) who obtained slight variations in weight gain and SGR of European catfish (Silurus glanis L.) fingerlings reared in light blue, white, green, and black tanks. This observation also agrees with the work of Alabi and Ocholi (2018) where differences in body weight gain and specific growth rate in African catfish raised in white and black culture receptacles showed an

Table 1: Physicochemical water parameters in different coloured receptacles for raising C. *gariepinus* **fingerlings**

	Receptacle colours		
Water parameters	**GRN**	**PUP**	**BLK**
Dissolved Oxygen (mg/l)	5.27 ± 0.21^{a}	5.64 ± 0.25^{a}	5.60 ± 0.12^{a}
pH	7.83 ± 0.08^{a}	7.82 ± 0.10^{a}	7.78 ± 0.07^{a}
Temperature (°C)	27.92 ± 0.52^{a}	28.17 ± 0.39^{a}	28.25 ± 0.62^{a}
Nitrate (mg/l)	0.58 ± 0.12^{b}	1.05 ± 0.83^{ab}	2.67 ± 2.27^{a}
Nitrite (mg/l)	0.01 ± 0.00^{b}	0.10 ± 0.12^{b}	0.61 ± 0.60^{a}

GRN Green; PUP Purple; BLK Black; Means across the same row differently superscripted differ significantly ($P < 0.05$). Values are means ± SD.

Table 2: Growth performance and nutrient utilization efficiency of C. *gariepinus* **fingerlings**

	Treatments		
Variable	**GRN**	**PUP**	**BLK**
Initial mean Weight (g)	1.75 ± 0.31^{a}	1.52 ± 0.69^{a}	1.47 ± 0.35^{a}
Final mean weight (g)	17.21 ± 2.17^{a}	17.43 ± 0.24^{a}	15.28 ± 0.95^{a}
Mean Weight gain (g)	15.46 ± 2.26^{a}	15.91 ± 0.84^{a}	14.11 ± 1.29^{a}
Specific growth rate (%)	1.06 ± 0.13^{a}	1.26 ± 0.27^{a}	1.24 ± 0.27^{a}
Feed intake (g feed/fish)	210.59 ± 24.54^{ab}	235.56 ± 11.04^{a}	181.74 ± 8.85^{b}
Feed conversion ratio (%)	1.71 ± 0.07^{a}	1.30 ± 0.01^{a}	1.43 ± 0.08^{a}

GRN Green; PUP Purple; BLK Black; Means across the same row differently superscripted differ significantly ($P < 0.05$). Values are means ± SD.

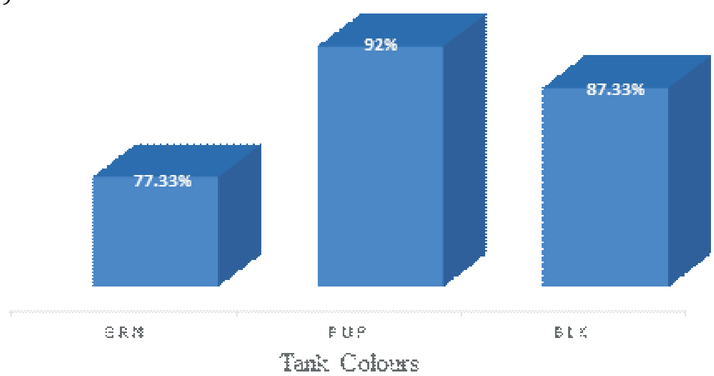

Figure 1: Survival rate of C. gariepinus fingerlings reared in different receptacle colours.

insignificant variation. Okomoda et al., (2017) reported a significantly higher growth rate in C. gariepinus fingerlings raised in black culture tanks than those in white, blue, green, and red.

Background colour did not significantly affect the FCR of C. gariepinus fingerlings in this study, but fish in purple receptacles showed slightly better FCR. In congruence to this data, Okomoda et al. (2017) did not record the marked difference in FCR of African catfish fingerlings raised in different tank colours. Also, a study conducted by Krasteva et al. (2020) revealed that tanks with light blue, white, green and black colours did not reflect any effect on FCR of European catfish fingerlings, which agrees with those found in this study. The survival rate in this study was not significantly affected by the different colours of tanks. Okomoda et al. (2017) indicated slight differences in the survival rate of C. gariepinus fingerlings when reared in different coloured tanks. Furthermore, some research have shown that tank colour does not distinctly impact the survival rate of several fish species, for instance, Oscar fish (Astronotus ocellatus) juveniles (Dopeikar et al., 2024), European catfish (Silurus glanis L.) fingerlings (Krasteva et al., 2020), and Rainbow trout (Oncorhynchus mykiss) juveniles (Üstündag and Rad, 2015).

CONCLUSION

From this study, it can be concluded that the colour of the receptacle has no significant effect on growth performance and survival rate of Clarias gariepinus fingerlings raised for 84 days. Although the surrounding water quality of the fish is impacted, it is not detrimental.

REFERENCES

Adewolu, M.A. and Olakunle, A.O. (2009). Growth, feed utilization and haematology of Clarias gariepinus (Burchell, 1822) fingerlings fed diets containing different levels of Vitamin C. American Journal of Applied Sciences, 6(9), 1675–1681. DOI: 10.3844/ajassp.2009.1675.1681

Akinwole, A. O. and Faturoti, E. O. (2006). Biological performance of African catfish (Clarias gariepinus) culture in recirculating system in Ibadan. Aquacultural Engineering, 36, 18–23. https://doi.org/10.1016/j.aquaeng.2006.05.001

Alabi, K. and Ocholi, O.S. (2018). Effects of Background Colour on Incubation and Larval Rearing of African Catfish Clarias gariepinus (Burchell, 1822) in Water Recirculating System. International Journal of Modern Science and Technology, 3(12), 262-268.

Antonio, V.S., Pedro, D., Lorenzo, M. and Jose Pedro, A. (2010). The effects of tank colours on the growth and survival of cuttlefish (Sepia officinalis, Linnaeus 1758) hatchlings and juveniles. Aquaculture Research, 42(3), 441 – 449. https://doi.org/10.1111/j.1365-2109.2010.02639.x

APHA (1998). Standard Methods for the Examination of Water and Wastewater. American Water Works Association, Water Environment Federation, L.S. Clesceri, A.E. Greenberg and A.D. Eaton (Eds.), 20th ed., Washington, D.C.

Boyd, C.E. and Tucker, C.S. (1998). Pond Aquaculture Water Quality Management, Springer US, Boston, MA, doi:10.1007/978-1-4615-5407-3.

Dopeikar, H., Khoshkhholgh, M., Ghasemi, S.A. and Morshedi, V. (2024). Effects of Background Color on Growth, Stress, Biochemical, Hematological, and Immunological Responses, and Expression of Growth-Related Genes in Oscar Fish (Astronotus ocellatus). Aquaculture Research, 2024, 1–10. https://doi.org/10.1155/2024/6957201

FAO (2022). The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome, FAO. https://doi.org/10.4060/cc0461en

Kareem, O.K., Olanrewaju, A.N. and Agbelege O.O. (2013): Optimum stocking density of Clarias gariepinus fingerlings in outdoor tanks. Journal of Field Aquatic Studies, 9, 14–24.

Krasteva, V., Zaikov, A. and Yankova, M. (2020). Effect of different tank colours on some productive parameters of European catfish (Silurus glanis L.) fingerlings. Agricultural Science and Technology, 12(1), 19–23. DOI: 10.15547/ast.2020.01.004

Manyise, T., Rose, K.B., Catherine, M.M., Olutokunbo, O., Sunil, S., Fregene, B., Steven, M.C., Eric, B.D., Rodolfo, D.L., Denise, L.L., Cristiano, M.R. and John, A.H.B. (2024). Farmer perspectives on desired catfish attributes in aquaculture systems in Nigeria. An exploratory focus group study. Aquaculture, 588, 740911, https://doi.org/10.1016/j.aquaculture.2024.740911.

McLean, E. (2021). Fish tank color: An overview. Aquaculture, 530, 2021, 735750, ISSN 0044-8486, https://doi.org/10.1016/j.aquaculture.2020.735750

Okomoda, V.T., Tiamiyu, L. and Vase, G. (2017). Effects of tank background colour on growth performance and feed utilization of African catfish Clarias gariepinus (Burchell, 1822) fingerlings. Croatian Journal of Fisheries, 75, 5–11. DOI: https://doi.org/10.1515/cjf-2017-0002

Opiyo, A.P. (2010). Influence of stocking density and background color on the growth performance and survival of Nile tilapia fry (Oreochromis niloticus), unpublished Msc. Thesis submitted to department of fisheries and aquatic sciences (aquaculture), MOI. University, Nigeria, 67pp.

Sykes, A.V., Domingues, P., Marquez, L. and Andrade, J. P. (2011). The effects of tank colours on the growth and survival of cuttlefish (Sepia officinalis, Linnaeus 1758) hatchlings and juveniles. Aquaculture Research, 42(3), 441– 449. DOI: 10.1111/j.1365-2109.2010.02639.x

Üstündag, M. and Rad, F. (2015). Effect of different tank colours on growth performance of Rainbow trout juvenile (Oncorhynchus mykiss Walbaum, 1792). Journal of Agricultural Sciences, 21, 144–151. DOI: 10.15832/tbd.15181

PHYSICOCHEMICAL AND BACTERIOLOGICAL ANALYSIS OF GROUNDWATER BOREHOLES FOR FISH FARMING IN MAIDUGURI, BORNO STATE, NIGERIA

[1]Olanrewaju A. N., [1]Shehu A. and [2]Tubbo M. T.

[1]Department of Fisheries Technology, Federal College of Freshwater Fisheries Technology, Baga, P.M.B. 1060, Maiduguri, Nigeria
[2]Department of Basic Sciences, Federal College of Freshwater Fisheries Technology, Baga, P.M.B. 1060, Maiduguri, Nigeria

Corresponding author:
ahmadshehu56@gmail.com

ABSTRACT
The study analysed physicochemical and microbiological qualities of groundwater boreholes for fish farming in Maiduguri. Eleven water parameters were analyzed at four different locations (Angua Doki, Damboa road, Jidari Polo and Kofa Biu) in Maiduguri for 3 months and data generated were analysed using descriptive statistics and ANOVA at *a*0.05. The result revealed desirable quality in all the physic-chemical parameters investigated, except dissolved oxygen (2.58±0.22 – 3.35±0.17 mgL-1), temperature (23.60±0.54 – 24.50±0.20 oC), alkalinity (30.46±9.55 – 33.61±11.34 mgL-1), cadmium (0.00±0.00 – 0.04±0.05 mgL-1) and iron (0.14±0.02 – 0.17±0.02 mgL-1) levels. Also, the result shows high coliform density (2.06±1.09 – 6.00±5.29 cfu mL-1) and bacteria contaminant (51.66±16.50 – 92.00±12.53 cfu mL-1) in all the water samples, which indicate pollution and imminent danger of communicable disease. Despite most of the physicochemical parameters analyzed support aquaculture production, caution is needed since the water has high coliform density and bacteria contaminant. The study, thus recommended proper coliform and bacteria treatment in these water before considering it for sustainable aquaculture.

Keywords:
Aquaculture, groundwater borehole, water quality, heavy metal, pollution, Maiduguri

INTRODUCTION

Groundwater boreholes are valuable resources for drinking, domestic, aquaculture, agricultural or industrial purposes. However, in Maiduguri, groundwater is majorly abstracted for household use. According to Isa *et al.*, (2013) over 70 percent of people in Maiduguri rely on groundwater as their main source of drinking water. Also, the surge in human population in Maiduguri due to Boko Haram insurgency have imposed significant stress on water supply in the area. Thus, there is a growing demand for adequate quality water resources for domestic and agricultural use. Similarly, the Government of Nigeria and various Non-Governmental Organisations in their effort to assist the State in restoring economic productivity and livelihoods choose to train and empower people in fish farming. This is undoubtedly creating an urgent need to link research with improved water management, better monitoring and assessment. Usman *et al.*, (2016) however emphasized that the usefulness of groundwater to humans essentially depends on its chemical status, thus, assessment of groundwater quality is important for any chosen purpose.

Water quality for aquaculturists refers to the quality of water that enables successful propagation of the desired organisms, especially fish. According to Olanrewaju and Kareem, (2018) water quality determines to a great extent the success or failure of a fish culture operation. Quality of water is, therefore, an essential factor to be considered when planning for commercial aquaculture production. Water quality includes all physical and chemical factors that influence the beneficial use of water. In assessing the quality of borehole water for fish farming, physico-chemical parameters and heavy metal contamination is a primary concern of investigation (Sabrina et al., 2013).
A number of studies have been conducted on suitability of groundwater borehole quality for fish farming in Maiduguri metropolis (Olanrewaju et al., 2023; Olanrewaju and Shobowale, 2023), but there is dearth of such documented information in Maiduguri Metropolitan Council. Thus, the physico-chemical and microbiological quality of groundwater boreholes for fish culture in Maiduguri, Borno State, Nigeria was investigated.

MATERIALS AND METHODS

The study area is Maiduguri and environs; Maiduguri is the capital city of Borno state and it is the largest city in the North eastern Nigeria, with land size covering an area of 543 km2. The city is located on geographic grid reference Longitude 13°03'23" E – 13°14'19" E, Latitude 11°46'18" N – 11°53'21" N (Daura, 2002). Groundwater boreholes from four selected areas including Angua Doki (11048'48"N, 13010'51"E), Damboa road (11047'54" N, 13007'47" E), Jidari (11047'47" N, 13008'56" E) and Kofa Biu (11051'17" N, 13009'54" E) were used for the study. Water samples were collected weekly from two randomly selected boreholes in each of the sampling area between October and November, 2019. Water parameters such as dissolved oxygen, nitrate, nitrite, total hardness, sulphate, magnesium and potassium were analyzed in the laboratory, while water temperature, pH, conductivity, and alkalinity were measured directly in the location where the samples are taken. Heavy metal concentrations (cadmium, lead, zinc, iron and manganese) were measured using ? ame atomic absorption spectrometer (Perkin Elmer model 306). Total bacteria, total coliform and faecal coliform were also determined by Membrane Filtration Method using M-Endo-Agar Les (Difco) at 37°C and on MFC Agar at 44°C, respectively in the laboratory. The laboratory analyses are conducted at the Water and Biological Laboratory, NAFDAC Office, Maiduguri following APHA (2012) procedure. Data obtained were analysed using descriptive statistics and one-way analysis of variance a 0.05. Fisher's LSD was employed for mean separation to asses any significant difference at the probability level of $p<0.05$ among the studied locations. Statistical analysis was performed using SPSS software statistical program version 20.0 (SPSS Inc., Chicago, IL, United States of America).

RESULTS AND DISCUSSION

The result of physico-chemical analysis of borehole water samples from selected areas in Maiduguri is as shown in Table 1. Water samples from Kofa Biu had significantly ($p<0.05$) low dissolved oxygen (2.40±0.08 mgL-1), hardness (130.25±2.73 mgL-1) and magnesium (0.14±0.03 mgL-1), but higher sulphate (11.93±0.11 mgL-1) and potassium (7.33±1.52 mgL-1) levels ($p<0.05$). Nitrite level (0.03±0.02 mgL-1) was slightly higher in samples from Damboa Road, but had the least pH (8.00±0.10) and temperature (23.60±0.54 oC) values ($p>0.05$). Also, water samples from Jidari Polo gave the least alkalinity (30.46±9.55 mgL-1) and conductivity (0.05±0.02 dSm-1) levels, but highest nitrate (2.44±1.85 mgL-1) level ($p>0.05$). Same values were obtained for nitrite (0.02±0.01 mgL-1) in water samples from Angua Doki, Jidari Polo and Kofa Biu. Similar trend was followed in conductivity having the same value (0.08±0.03 dSm-1) in Angu Doki and Kofa Biu water samples. The present results indicate that all the physico-chemical parameters explored were in consonance with the optimum range for growth, reproduction and survival of fish (Omitoyin, 2007; Boyd, 1998) except few parameters including dissolved oxygen, temperature and alkalinity. This finding differs from the previous report by Olanrewaju et al. (2023) and Olanrewaju and Shobowale (2023), who studied the suitability of groundwater boreholes for fish farming in Maiduguri metropolis. These authors, however found some of the parameters investigated within the standard recommended limits for aquaculture.

Table 1. Physico-chemical properties of borehole water samples from selected areas in Maiduguri

Parameters	Locations			
	ADK	DRD	JPO	KBU
DO (mgL^{-1})	2.77 ± 0.43^{a}	3.35 ± 0.17^{b}	2.58 ± 0.22^{a}	2.40 ± 0.08^{a}
pH	8.37 ± 0.15^{a}	8.00 ± 0.10^{a}	8.03 ± 0.06^{a}	8.33 ± 0.12^{a}
Temperature (°C)	23.80 ± 0.70^{a}	23.60 ± 0.54^{a}	24.20 ± 0.28^{a}	24.50 ± 0.20^{a}
Nitrate (mgL^{-1})	1.94 ± 2.02^{a}	2.37 ± 0.88^{a}	2.44 ± 1.85^{a}	2.06 ± 1.73^{a}
Nitrite (mgL^{-1})	0.02 ± 0.01^{a}	0.03 ± 0.02^{a}	0.02 ± 0.01^{a}	0.02 ± 0.01^{a}
Alkalinity (mgL^{-1})	30.53 ± 11.62^{a}	32.77 ± 12.14^{a}	30.46 ± 9.55^{a}	33.61 ± 11.34^{a}
Conductivity (dSm^{-1})	0.08 ± 0.03^{a}	0.06 ± 0.01^{a}	0.05 ± 0.02^{a}	0.08 ± 0.02^{a}
Hardness (mgL^{-1})	135.46 ± 3.05^{a}	138.34 ± 3.17^{ab}	140.31 ± 2.06^{b}	130.25 ± 2.73^{a}
Sulphate (mgL^{-1})	8.37 ± 0.13^{a}	8.00 ± 0.12^{a}	8.07 ± 0.15^{a}	11.93 ± 0.11^{b}
Magnesium (mgL^{-1})	0.21 ± 0.07^{b}	0.18 ± 0.06^{a}	0.17 ± 0.02^{a}	0.14 ± 0.03^{a}
Potassium (mgL^{-1})	3.60 ± 0.56^{a}	3.03 ± 0.31^{a}	3.60 ± 0.40^{a}	7.33 ± 1.52^{b}

DO – Dissolved Oxygen, ADK – Angua Doki, DRD – Damboa Road, JPO – Jidari Polo, KBU – Kofa Biu

The results of heavy metal analysis from borehole water samples in the study area is as presented in Table 2. Cadmium varied from 0.00±0.00 mgL-1 (Angua Doki) and 0.04±0.05 mgL^{-1} (Kofa Biu) with slight differences among the sample locations ($p>0.05$). The sample from Jidari Polo had the highest recorded concentrations of lead (-0.16±0.05 mgL^{-1}), while samples from Damboa Road (0.17±0.02 mgL^{-1}) and Jidari Polo (0.17±0.01 mgL^{-1}) had higher iron level. However, the values obtained for lead and iron were not statistically significant ($p>0.05$) between locations. The zinc content in samples from Damboa Road (0.34±0.03 mgL^{-1}) were significantly higher compared to other locations. Manganese levels varied between 0.13±0.03 mgL^{-1} (Kofa Biu) and 0.19±0.08 mgL^{-1} (Angua Doki) with significant differences between the sample locations ($p<0.05$). The heavy metals value obtained in this study were in consonance with recommended limits by Saah et al. (2021), except cadmium and iron. Olanrewaju et al. (2023) and Olanrewaju and Shobowale (2023) also found similar trends in heavy metal levels in boreholes from Maiduguri metropolis.

Table 2. Heavy metal concentrations of borehole water samples from selected areas in Maiduguri

Parameters	Locations			
	ADK	DRD	JPO	KBU
Cadmium (mgL^{-1})	0.00 ± 0.00^{a}	0.02 ± 0.01^{a}	0.01 ± 0.01^{a}	0.04 ± 0.05^{a}
Lead (mgL^{-1})	-0.13 ± 0.08^{a}	-0.14 ± 0.03^{a}	-0.16 ± 0.05^{a}	-0.12 ± 0.01^{a}
Iron (mgL^{-1})	0.15 ± 0.01^{a}	0.17 ± 0.02^{a}	0.17 ± 0.01^{a}	0.14 ± 0.02^{a}
Zinc (mgL^{-1})	0.21 ± 0.07^{a}	0.34 ± 0.03^{b}	0.18 ± 0.05^{a}	0.17 ± 0.02^{a}
Manganese (mgL^{-1})	0.19 ± 0.08^{b}	0.15 ± 0.01^{ab}	0.15 ± 0.03^{ab}	0.13 ± 0.03^{a}

ADK – Angua Doki, DRD – Damboa Road, JPO – Jidari Polo, KBU – Kofa Biu

The data presented in Table 3 indicated significant difference ($p>0.05$) in bacteriological parameters of water samples in the study locations. The samples from Jidari Polo had the highest feacal coliform count (22.00±19.69 cfu mL-1) while the least was found in Angua Doki (1.24±0.54 cfu mL-1). The total coliform count in samples from Kofa Biu was highest (23.00±5.00 cfu mL-1), followed by Jidari Polo (6.00±5.29 cfu mL-1), while the least value (2.06±1.09 cfu mL-1) was recorded in Angua Doki. Mean the total bacteria count of the water samples ranged between 51.66±16.50 and 92.00±12.53 cfu mL-1 with the minimum in Angua Doki and highest in Damboa Road, respectively. The values in this study were far above the World Health Organization and Nigeria Standard for Drinking Water Quality acceptable standard of 0 CFU mL-1. The reasons to this poor water quality can impugned on proximity to toilet facilities, sewage, refuse dump site and various anthropogenic activities as seen in the study areas. This result corroborates the findings of a previous study conducted by Olanrewaju and Agbelege, (2023) and Biu et al. (2020) in borehole water samples in Maiduguri, Nigeria.

Table 3. Bacteriological quality of water samples from boreholes in selected areas in Maiduguri

Parameters	Locations			
	ADK	DRD	JPO	KBU
FCC cfu mL^{-1}	1.24 ± 0.54^{a}	6.33 ± 5.69^{a}	22.00 ± 19.69^{b}	18.67 ± 6.03^{ab}
TCC cfu mL^{-1}	2.06 ± 1.09^{a}	5.33 ± 4.73^{a}	6.00 ± 5.29^{a}	23.00 ± 5.00^{b}
TBC cfu mL^{-1}	51.66 ± 16.50^{b}	92.00 ± 12.53^{c}	68.00 ± 42.00^{ab}	75.67 ± 27.01^{bc}

ADK – Angua Doki, DRD – Damboa Road, JPO – Jidari Polo, KBU – Kofa Biu

CONCLUSION

This study demonstrated that the water from selected boreholes in Maiduguri had good physic-chemical quality for aquaculture, except low dissolved oxygen, temperature and alkalinity levels. Also, cadmium and iron levels are slightly above the desirable ranges for aquaculture. The high coliform density and bacteria contaminant in all the borehole water samples in the study area, however, make the water deplorable for fish culture unless after proper treatment.

REFERENCES

APHA (2012). Standard methods for the examination of water, 22nd edn. American Public Health Association, Washington.

Biu, A.A., Mohammed, G.A., Na'isa, M.A.K., Musa, A., Aliyu, A. and Marte, M.L. (2020). Physico-microbiological examinations of domestic water used by the community of college of agriculture and its environs, Maiduguri, North-Eastern Nigeria. Int. J. Res. GRANTHAALAYAH, 8: 362-373. https://doi.org/10.29121/granthaalayah.v8.i7.2020.226

Boyd, C.E. (1998). Water Quality for Pond Aquaculture. Research and Development Series No. 43. International Center for Aquaculture and Aquatic Environments, Alabama. Agricultural Experiment Station, Auburn University Publisher, Alabama. Pp.183. http://hdl.handle.net/11200/49690

Isa, M.A., I.A. Allamin, H.Y. Ismail and A. Shettima, 2013. Physicochemical and bacteriological analyses of drinking water from wash boreholes in Maiduguri Metropolis, Borno State, Nigeria. Afr. J. Food Sci., 7: 9-13. DOI: 10.5897/AJFS12.073

Olanrewaju, A.N. and Agbelege, O.O. (2023). Bacteriological and physico-chemical assessment of groundwater boreholes for aquaculture in Internally Displaced People's (IDPs) camps in Arid Zone, Nigeria. Asian Journal of Biological Sciences, 16(2): 137–144. https://doi.org/10.17311/ajbs.2023.137.144.

Olanrewaju, A.N. and Kareem, O.K. (2018). Fish Pond Management. In: A Training Manual for Fish Farming Entrepreneurship for Youths in the North East Nigeria. A Comprehensive Guide to Small-scale Fish Farming Business. Olanrewaju et al. (Eds.). 2018 Edition. Pp. 44 – 57. ISBN: 978-978-56375-9-5

Olanrewaju, A.N. and Shobowale, J.O. (2023). Suitability of selected groundwater for fish culture in Maiduguri Metropolis, Nigeria. Trends in Applied Sciences Research, 18(1): 63–70. https://doi.org/10.17311/tasr.2023.63.70.

Olanrewaju, A.N., Ikagu, I.I. and Tubo, M.T. (2023). Suitability of surface and groundwater for pisciculture in Maiduguri Metropolis, North-East, Nigeria. Trends in Agricultural Sciences, 2(2): 139–145. https://doi.org/10.17311/tas.2023.139.145.

Omitoyin, B.O. (2007). Introduction to fish farming in Nigeria. Ibadan University Press, University of Ibadan, Nigeria. IBSN 9789781214271. 90pp.

Saah, S.A., Adu-Poku, D. and Boadi, N.O. 2021. Heavy metal contamination and water quality of selected fish ponds at Sunyani, Ghana: A comparison with WHO standards. Chem. Int., 7: 181-187. https://ssrn.com/abstract=3865906

Sabrina, S., Daniela, P., Joseph, M., Sieliechi, M. and Ngassoum, B. (2013). Assessment of physical-chemical drinking water quality in the Logone Valley (Chad-Cameroon). Sustainability, 5: 3060–3076. DOI: 10.3390/su5073060

Usman, Y.M., Mohammed, A., Ibrahim, B. and Saleh, B.A. (2016). Assessment of Groundwater Quality status along River Ngadda in Maiduguri, Nigeria. The International Journal of Engineering and Science, 5(1): 2319 – 1805.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

DETERMINATION OF GROWTH PERFORMANCE, HAEMATOLOGY AND WATER QUALITY OF JUVENILE AFRICAN CATFISH *(Clarias gariepinus*, BURCHELL 1822) REARED IN STATIC RENEWAL AND FLOW-THROUGH SYSTEMS

[1]Olanrewaju A.N., *,[1] Y.M. Umar and[2] O.K. Kareem

[1]Department of Fisheries Technology, Federal College of Freshwater Fisheries Technology Baga, P.M.B. 1060 Maiduguri, Borno State, Nigeria
[2]Department of Aquaculture and Fisheries Management, University of Ibadan, P.M.B. 200132, Ibadan, Nigeria

Corresponding author's e-mail: yarimamohammad@gmail.com

ABSTRACT
This study was conducted to determine growth performance, haematological response and water quality of Clarias gariepinus juveniles reared in static renewal (SRS) and flow-through system (FTS). Two hundred C. gariepinus juveniles (4.74±1.63 g) in duplicate of 50 fish were randomly stocked in SRS and FTS tanks. The fish were fed twice daily with commercial feed at 3% total body weight for 12 weeks. Data was analyzed using T-test and ANOVA at p<0.05. Results showed that the fish in FTS tanks had slightly higher weight gain (52.52±8.68 g), specific growth rate (1.31±0.15 g day-1) and feed conversion ratio (1.39±0.33). However, higher (p>0.0) survival rate (82.60±1.42 %) was noted in fish raised in SRS. Elevated white blood cell count (9.70±2.01 x 109 l-1), haemoglobin (11.60±1.84 g dl-1), packed cell volume (35.00±6.00 %), and total protein (121.00±11.07 mg dl-1) levels were observed in fish from FTS tanks (p<0.05). Also, marginal differences (p>0.05) were observed in water parameters measured in SRS and FTS tanks. The study recommended further research on the influence of increase duration of flow-through system on growth performance and physiological response of African catfish juveniles in indoor tanks.

Keywords:
Clarias gariepinus, growth parameters, physiological response, water parameters, survival.

INTRODUCTION

Aquaculture continues to grow more rapidly than all other animal food-producing sectors in the world (FAO, 2006). One of the important aspects of aquaculture is fish farming, which provides about 40% of the dietary intake of animal protein and constitutes a third of the world's supply of fish products. Fish is lower in total fat and calories than meat or poultry, hence a healthy protein choice (Gramma *et al.*, 2011). Fish farmers in Nigeria developed special interest in *Clarias gariepinus* due its biological attributes that include resistance to diseases, faster growth rate, and possibility of high stocking density (Ekasari *et al.*, 2019). The cultivation of C. *gariepinus* can be achieved using different culture systems, but semi-intensive system is more popular among Nigeria fish farmers. In this system, fish are culture in ponds either with mechanical aeration and/or flow-through system to enhance water quality for good growth and survival.

One of the common water-use management techniques in catfish farming is flow-through system that can be used to obtain faster growth in less time during the intense production in indoor ponds. This system allows organic materials to be removed from the tank at constant rate and give rise to good water quality, which promotes good growth and yield at harvest. Chainark and Boyd, (2010) noted that the quality of water used in aquaculture influences feeding, growth, disease burden, and survival. Previous studies on different water-use management techniques have only looked at the impact on survival and growth results (Alabi and Ocholi, 2018; Olanrewaju *et al.*, 2016; Omitoyin, 2003), little is however reckoned on the impact of these techniques on the physiological response of the fish. Esmaeili (2021) attests that fish growth is closely related to its health status. This study therefore, investigates the growth performance, haematology and water quality of C. *gariepinus* juveniles raised in static renewal and flow-through systems.

MATERIALS AND METHODS

The experiment was conducted in indoor fish hatchery complex of Federal College of Freshwater Fisheries Technology, Baga, Borno State. Two hundred *Clarias gariepinus* juveniles (average weight; 4.74±1.63 g) was obtained from a reputable fish farm for the experiment. The fish was acclimatized and fed ad-libitum for two days prior the experiment. Thereafter, fifty fish were randomly distributed in four concrete rearing tanks (5.28 m3) and reared for 12 weeks. The tanks were supplied with dechlorinated borehole water and managed based on individual treatment of the study. Prior to starting the experiment, the fish were measured to obtain the initial length (cm) and weight (g). The two experimental treatments in the study were Static Renewal System (SRS) and Flow-Through System (FTS). Water in SRT tanks was changed twice weekly, while FTT have 6 hours flow-through water daily during the night (00.00 – 06.00 h). The fish were fed with the same commercial feed at (40 – 52% CP) based on 3% of the fish biomass in all treatments. Fish were reweighed weekly and feeding rate was adjusted accordingly.

Growth parameters were assessed in terms of mean weight gain (MWG), specific growth rate (SGR), feed conversion ratio (FCR), and survival rate (SR) using the formulae of Akinwole and Faturoti, (2006). Blood samples (2 mL) were extracted and dispensed into a sample bottle containing Ethylene Diamine Tetra-acetic Acid (EDTA) anticoagulant for haematological studies while 3 mL was transferred into non-heparinized tubes to obtain plasma for biochemical analysis. Haematological assay was carried out at the NAFDAC Office, Maiduguri, Borno State, Nigeria. Red blood cell (RBC), white blood cell (WBC), packed cell volume (PCV), haemoglobin concentration (Hb), lymphocytes, monocytes, eosinophils and platelets. The serum was analyzed for Total protein (TP), Aspartate Aminotransferase (AST), Urea, Creatinine, Alkaline phosphate (ALP), Cholesterol, Albumin, glucose and, Alanine Aminotransferase (ALT). Water quality parameters were analyzed weekly using standard methods by Boyd and Tucker (1998) and in situ measurements were done for dissolved oxygen, pH and temperature using a multi-parameter water quality meter (BICASA model B.E.104) and mercury thermometer. Nitrate was determined in the laboratory as described by APHA (1995).

Growth performance data were analyzed using T-test, while data resulted from haematological and water quality parameters were subjected to one-way ANOVA at $P<0.05$ for significance differences among groups. Differences between means were further analyzed using Fisher's LSD at $P<0.05$. Analyses were carried out using SPSS software statistical program version 20.0 (SPSS Inc., Chicago, IL, United States of America).

RESULTS

Growth performance and survival rate of juvenile *Clarias gariepinus* raised in different water-use management are presented in Table 1. After 84 days of feeding, the mean final weight (54.86±7.94 g fish-1) and weight gain of fish (50.11±8.65 g fish-1) raised in static renewal (SRS) tanks was slightly lower than fish raised in flow-through (FTS) tanks. However, the specific growth rate (1.31±0.15 g day-1), feed intake (38.08±24.75 g fish-1) and feed conversion ratio (1.81±0.54) of fish in SRS tanks were higher ($p>0.05$) than the ones in FTS tanks. No significant differences in survival rate were revealed between fish in SRS and FTS tanks (p>0.05). Table 2 show the effects of different water-use management on haematological and serum biochemical parameters of juvenile C. *gariepinus* reared for 84 days. Notably, higher white blood cells (9.70±1.00 x106 l-1), haemoglobin (11.60±1.84 g dl-1) packed cell volume (35.00±6.00 %) and monocytes (57.00±2.00 %) were seen in the group raised in FTS tanks compared to those in the

Table 1. Growth performance parameters of juvenile *Clarias gariepinus* **reared in static renewal and flow-through system for 12 weeks**

Parameters	Treatments		
	SRS	FTS	P-value
Initial mean weight (g fish^{-1})	4.75±1.40	4.75±1.54	0.99
Final mean weight (g fish^{-1})	54.86±7.94	57.27±9.13	0.38
Mean weight gain (g fish^{-1})	50.11±8.65	52.52±8.68	0.36
Specific growth rate (g day^{-1})	1.31±0.15	1.28±0.16	0.66
Feed intake (g fish^{-1})	38.08±24.75	35.39±22.91	0.69
Feed conversion ratio	1.81±0.54	1.39±0.33	0.31
Survival rate (%)	82.60±1.42	80.50±2.13	0.40

SRS Static renewal system, FTS Flow-through system

Table 2. Haematology of juvenile *Clarias gariepinus* **reared in static renewal and flow-through system for 12 weeks**

	Treatments		
Parameters	Initial	SRS	FTS
Red blood cell (x 10^6 l^{-1})	85.50±3.60$_a$	86.00±10.10$_a$	96.67±17.60$_a$
White blood cell (x 10^9 l^{-1})	4.80±1.00$_b$	4.90±0.70$_b$	9.70±1.00$_a$
Packed cell volume (%)	24.00±3.00$_b$	30.00±4.36$_{ab}$	35.00±6.00$_a$
Hemoglobin (g dl^{-1})	7.95±1.31$_b$	10.00±2.00$_{ab}$	11.60±1.84$_a$
Neutrophils (%)	58.00±4.51$_a$	53.00±3.72$_a$	39.67±2.55$_b$
Lymphocyte (%)	0.50±0.05$_a$	0.35±0.05$_b$	0.33±0.04$_b$
Monocytes (%)	38.50±1.77$_c$	46.00±1.61$_b$	57.00±2.00$_a$
Platelets (x 10^9 l^{-1})	3.00±0.61$_a$	1.03±0.08$_b$	0.30±0.07$_c$

SRS Static renewal system, FTS Flow-through system

initial and SRS tanks. The initial lymphocytes (0.50±0.05 %) and platelets (3.00±0.61 %) were markedly higher than the ones in fish from experimental groups. The neutrophil level (39.67±2.55 %) of fish in FTS tank was significantly lower (p<0.05) than the ones in initial and SRS tanks. No significant difference in red blood cell count between initial and experimental groups. Fish in FTS tanks had significantly higher total protein, while glucose in SRS tanks rose (p<0.05) above the initial and FTS groups (Table 3). There was no significant difference between the albumin, cholesterol and creatinine contents of fish in the experimental groups and initial, respectively. Fish raised in FTS tanks had significantly lower AST (77.00±5.00 IU l-1) and ALT (18.00±3.00 IU l-1) contents compared to those in initial and SRS group. Urea level was significantly lower in experimental groups than the initial value. Whereas, glucose level in fish from treatment groups were significantly surpass (p<0.05) the initial value.

Table 3. Serum biochemistry of juvenile *Clarias gariepinus* reared in static renewal and flow-through system for 12 weeks

Parameters	Treatments		
	Initial	SRS	FTS
Total protein (mg dl^{-1})	$58.50\pm1.08_b$	$66.00\pm2.23_b$	$121.00\pm11.07_a$
Albumin (g l^{-1})	$18.83\pm6.44_a$	12.00±1.00a	18.67±4.02a
Creatinine (mmol l^{-1})	$32.00\pm0.50_a$	30.00±1.93a	$30.00\pm1.28_a$
Cholesterol (mmol l^{-1})	$307.00\pm6.18_a$	$307.00\pm12.00_a$	$292.00\pm26.00_a$
Glucose (mmol l^{-1})	$2.10\pm0.17_c$	$6.50\pm0.44_a$	$4.70\pm0.18_b$
Urea (mmol l^{-1})	$1.60\pm0.08_a$	$1.40\pm0.08_b$	$1.20\pm0.0.10_c$
AST (IU l^{-1})	$97.50\pm2.50_a$	$99.00\pm4.00_a$	$77.00\pm5.00_b$
ALT (IU l^{-1})	$26.50\pm1.50_a$	$24.00\pm1.00_a$	$18.00\pm3.00_b$

ALT alanine aminotransferase, AST aspartate aminotransferase, SRT Static renewal system, FTT: Flow-through system.

The physicochemical parameter analysis in both treatment groups indicated no significant difference ($p>0.05$) in all the parameters investigated in the study (Table 4). However, the values of dissolved oxygen (4.39±0.46 mg l^{-1}), pH (7.12±0.30), nitrate (9.38±0.18 mg l^{-1}), and temperature (26.69±0.85 °C) were marginally higher in FTS tanks than those in SRS tanks.

Table 4. Water quality parameters measured in static renewal and flow-through systems during the study.

Parameters	Treatments		P-value
	SRS	FTS	
Dissolved oxygen (mg l^{-1})	3.46±0.49	4.39±0.46	0.84
pH	6.97±0.44	7.12±0.30	0.27
Temperature (°C)	26.62±0.87	26.69±0.85	0.78
Nitrate (mg l^{-1})	8.51±2.05	9.38±0.18	0.59

SRS Static renewal system, FTS Flow-through system

DISCUSSION

The fish growth performance in present study revealed marginally higher weight gain in FTS tank, which differs from the findings of Omitoyin (2003) where fish raise in flow-through system had significant higher weight gain (3.73±0.27g) compared to static renewal system (2.35±0.32g). in the same vein, Ogle and Solangi (1982) also found that Fundulus grandis grown in an outdoor flow-through system have higher weight gain (1009±0.93 mg) compare to those reared in an outdoor static system that had 899±0.83 mg. The specific growth in the current study is however slightly lower in fish reared in FTS tanks. This finding contrast with the previous study by Omitoyin (2003) who reported significant high Specific growth rate in fish raised in flow through system (4.57±0.35%) compare to those raised in aerated and static renewal system with 3.44±0.40% and 3.20±0.36% respectively. This disparity could be attributed to variability in the number of hours of flow-through used in both studies. The best feed conversion ratio found in FTS in this study are in consonance with the findings of Omitoyin (2003) who found significant higher Feed conversion ratio in fish grown in flow-through system as compared to those reared in static renewal system. The mean survival rates in the current study concurs with the results of Omitoyin (2003) who recorded high survival rates with no significant variations between treatment groups. Ogle and Solangi (1982) however reported significantly higher survival rate in static renewal system compared to other treatment groups.

Among all the haematological parameters tested in the present study, white blood cells, packed cell volume, haemoglobin and monocytes were comparatively higher in fish reared FTS. According to

Olanrewaju et al. (2023), WBC counts has implication for immune responses and the ability of the animal to fight infection. Hence, the increase in WBCs count in fish from flow-through system indicate stress condition in that culture treatment, and this is supported by Roberts (1978). The fluctuations in the hours of flow-through daily might be stressful to the fish and resulted in high WBCs count. The red blood cells show no significant difference between experimental groups and initial value. This probably mean there is no infections related to viral, bacterial and/or parasitic in the culture environment due to water conditions (Olanrewaju et al., 2023). In the present study, the fish in FTS show elevated total protein compared to those in SRS and initial. The high total protein value in FTS group could be associated with a stronger innate response due to stress in those fish (Wiegertjes et al., 1996). Further, the results of the current investigation revealed no significant difference in creatinine, cholesterol and albumin levels between treatment groups and initial. This implies that there is no factor affecting the liver and kidney of the fish due to water conditions in the study. The current findings showed an increased level of dissolved oxygen, temperature, pH and nitrate in the water from the flow-through system as compared to the water in the static renewal tank, though not significant. The mean values of water parameters observed in this study fell within the acceptable range for good growth performance and survival of African catfish under culture (Omitoyin, 2007; Boyd and Tucker, 1998).

CONCLUSION

In conclusion, the water-use systems in the study influenced some haematological and serum analytes of juveniles Clarias gariepinus, but growth was not affected. These results suggest that fish can grow well in both systems, but with different physiological responses.

REFERENCES

Akinwole, A.O. and Faturoti, E.O. (2006). Biological performance of African Catfish (Clarias gariepinus) culture Recirculating System in Ibadan. Aquaculture engineering, 36: 18-23. https://doi.org/10.1016/j.aquaeng.2006.05.001

Alabi, K. and O.S. Ocholi, 2018. Effects of background colour on incubation and larval rearing of African Catfish Clarias gariepinus (Burchell, 1822) in Water Recirculating System. International Journal of Modern Science and Technology, 3(12): 262-268.

APHA (1995). American Public Health Association. Standard Methods for the Examination of Water and Wastewater. 18th ed. Washington. D.C. 200pp.

Boyd, C.E. and Tucker, C.S. (1998). Pond Aquaculture Water Quality Management, Springer US, Boston, MA, doi:10.1007/978-1-4615-5407-3.

Chainark, S. and Boyd, C.E. (2010): Water and sediment quality, phytoplankton communities and channel catfish production in sodium nitrate-treated ponds. J Appl Aquacult., 22(10): 171–185. DOI: 10.1080/10454431003736524

Ekasari, J., Setiawati, R., Rahmadani, F., Setiawati, M. and Suprayudi, M. (2019). Growth and health performance of African catfish Clarias gariepinus (Burchell 1822) juvenile fed graded levels of biofloc meal. Aquaculture Research, 50(7). https://doi.org/10.1111/are.14059

Esmaeili, M. (2021). Blood Performance: A New Formula for Fish Growth and Health. Biology, 10, 1236. https://doi.org/10.3390/ biology10121236

FAO (2006): State of world fisheries and Aquaculture. FAO report 2006, available online at ftp://ftp.fao.org/docrep/ fao/011/i0250e/i0250e.pdf

Gramma, G., Ajana, A. and Pichavant, K. (2011). Nutritional and feeding of fish. Kluwer Academic Publishers. Second edition.

Ogle, J. T. and Solangi, M. A. (1982): Evaluation of Flow-Through, Static, and Recirculating Systems for the Intensive Culture of the Gulf Killifish Fundulus grandis with Observations on a Solar-Heated Recirculating System for the Bait Industry. Gulf Research Reports 7 (2): 151-156. DOI: https://doi.org/10.18785/grr.0702.06

Olanrewaju, A.N., Kareem, O.K. and Ajani, E.K. (2016): Comparative growth performance and survival of African Catfish (Clarias gariepinus, Burchell 1822) fry in indoor and outdoor concrete and hapa culture system. Journal of Fisheries Sciences.com, 10(1): 027–030

Olanrewaju, A.N., Kareem, O.K. and Emikpe, B.O. (2023). Haematological and biochemical status of cultured and wild Blue Tilapia, Oreochromis aureus from Alau Lake, Northeast, Nigeria. Comparative Clinical Pathology, 32: 139–146. https://doi.org/10.1007/s00580-022-03423-4

Omitoyin, B.O. (2003): Growth performance and nutrient utilization of Clarias gariepinus fingerlings raised under different water quality conditions. African Journal of livestock Extension 2: 86–90. https://www.ajol.info/index.php/ajlex/article/view/135

Omitoyin, B.O. (2007). Introduction to fish farming in Nigeria. Ibadan University Press, University of Ibadan, Nigeria. IBSN 9789781214271. 90pp.

Roberts, R.J. (1978). The pathophysiology and systemic pathology of teleosts. Pages 55-91 in R. J. Roberts, editor. Fish pathology. Bailliere Tindal, London, UK.

Wiegertjes, G.F., Stet, R.J.M., Parmentier, H.K. and Van Muiswinkel, W.B. (1996): Immunogenetics of Disease Resistance in Fish: A Comparative Approach. Develop. Comp. Immunol., 20: 365-381. DOI: 10.1016/s0145-305x(96)00032-8

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

EFFECT OF VARYING STOCKING DENSITIES ON GROWTH PERFORMANCE OF WIDEHEAD CATFISH FRY IN INDOOR RECIRCULATORY AQUACULTURE SYSTEM (RAS)

[1]Alabi, K. I., [2]S. G. Solomon, [2]R. A. Obande, [2]S. O Olufeagba, [3]A. S Oladimeji., [4]O. O. Alabi-Shauntel[1], and [5]I. N. Noah

[1] Department of Agricultural Extension and Management, Federal College of Forestry,P.M.B 2019, Jos. Nigeria
[2] Department of Fisheries and Aquaculture, Joseph Sarwuan Tarka University, Makurdi, Nigeria
[3]Agricultural Department, National Biotechnology Development Agency (NABDA), Abuja, Nigeria
[4]Department of Fisheries Technology, Federal College of Land Resources Technology, P.M.B 2025,Kuru. Jos. Nigeria 5Department of General Studies, Federal College of Land Resources Technology, P.M.B 2025, Kuru-Jos. Nigeria

Corresponding author:
talk2fish85@gmail.com, +2348036977644,0000-0002-7203-0861

ABSTRACT

This study investigated the management of Widehead Catfish (Clarotes laticeps, RÜPPEL, 1829) fry at different stocking densities in indoor Recirculatory Aquaculture System (RAS) for a period of eight weeks. The culture of Widehead catfish is gradually gaining popularity nationwide, therefore there is need to investigate its appropriate stocking density. A simple 4000 Litres RAS technology was developed, built and evaluated for this study. Clarotes laticeps fry of 0.16g mean weight were reared in indoor recirculating tanks (1m3) at stocking rates of 500, 1000 and 1500 fry/m3 designated as treatment LD, MD and HD. The experiment was replicated and fish were fed at 4% body weight with 42% crude protein diet in four installments daily. The results indicated increased mean body weight gain and SGR with increasing stocking density. However, high growth performance in weight gain (45.42±9.00), SGR (3.00±0.00) and FCR (0.81±1.10) were obtained in treatment HD. The lowest FCR (0.81±1.10) value was obtained in HD but show no significant difference (p>0.05) to other treatments. The percentage of Shooters (%) were also observed to be low (20.5±0.67) in HD as compared to values obtained for LD and MD. Stocking densities did not significantly affect (p>0.05) the percentage survival of the fish in all treatments. Results of Water quality parameters indicated an optimum water quality for growth and survival of Widehead catfish throughout the experimental period. This study revealed that, the stocking density of 1500 fry m3 is recommended for efficient feed utilization, optimum growth performance and survival in RAS.

Keywords:
Recirculatory Aquaculture System (RAS), Widehead catfish, growth performance, stocking density

INTRODUCTION

Stocking density affects fish growth and productivity in the aquaculture industry; therefore it is important to check its effects to ascertain the appropriate stocking density that enhances adequate nutrient utilization, growth and survival for fish species. According to Ellis et. al., (2002) "… the term 'stocking density' refers to the concentration at which fish are initially stocked into a system" (sensu strictu). However, most often, the term is used to describe the density of fish at any time. It may thus be understood as a dynamic factor, since the actual density increases or decreases as the fish grow or are removed from the rearing volume. Fish species in aquaculture are stocked at very different densities, typically ranging from < 10 to 100 kg m- 3 (Baldwin, 2011). This widely varies due to the different needs and/or tolerances of the respective species. Similarly, the impact of a specific stocking density on the species' welfare may differ as well (Baldwin, 2011). Increasing stocking density ensures the optimization of fish production with the recent development of intensive aquaculture. However, high stocking density has been considered as stressor in the aquaculture (Li et. al., 2021). Increase in stocking density intensifies competition for space and food among individuals within populations. These affects fish feeding, physiology, growth, behavior, metabolism, and immune function (Dai et. al., 2011). Metabolic rate and feeding behavior of fish are affected by high stocking densities especially if the metabolic products and wasted feed are left within the culture system, they deteriorate the culture water leaving negative impact fish health (Li et. al., 2021). Aquaculture development and productivity in Africa is severely constrained by rearing single fish species, water, adequate land, and environmental concern. Recently, the inadequate water supply in required quantity and quality for aquaculture threatens the future development of aquaculture in Africa. Water conservation and reuse has become a major issue that need to be addressed for continuous and stable aquaculture. Water reuse systems have been developed for fish culture since the 1960s (Martins et. al., 2010a). Recirculatory Aquaculture System (RAS) are systems used for rearing aquatic organisms; this culture system functions on continuous cleaning of water for reuse after undergoing treatment. They are system that employs intensive mechanical, biological, chemical filtration and other treatment steps to achieve high rates of water reuse, (Martins et. al., 2010a). To sustain fish production from aquaculture, particularly for food protein, introduction and studies on the breeding and rearing conditions of new fish species into aquaculture should be strongly encouraged (Alabi et al., 2022). The widehead catfish Clarotes laticeps (Rüppel, 1829) was selected for this study. There is paucity of information on the stocking density and growth performance of widehead catfish in captivity. This fish species is one of the highly sought after freshwater fish species in Africa. It is an anadromous fish which usually stay in the tropics (20oC – 26oC) and mostly found in African water bodies such as Rivers Niger, Benue, Nile and Lakes Volta and Chad (Alabi et al., 2022). It is a seasonal fish but found in abundance in the rainy season, feeding on crustaceans, insects, mollusks and small fish (Alabi et al., 2022). A specimen of Widehead Catfish (Clarotes laticeps, Rüppel, 1829) weighing up to 10kg and having up to 80cm standard length has been reported by Lewis and Wehr (1976). This study therefore aimed to determine the appropriate stocking density for efficient nutrient utilization, optimum growth performance and survival of widehead catfish in captivity. The outcome of this study can supply the necessary information required on the stocking density that enhances efficient nutrient utilization, optimum growth performance and survival of widehead catfish in Recirculatory Aquaculture System (RAS).

MATERIALS AND METHODS

Six (6) live samples (3 male and 3 female) of Widehead catfish (Clarotes laticeps) brood stock (700grams average weight) were obtained from Fishermen in Wadata, Benue State. Nigeria. Samples were identified and transported with an open head 50litre gerican to Joseph Sarwuan Tarka University Fish Farm, North Bank, Makurdi. Benue, State. Nigeria. Fish samples were stocked in earthen pond (5m3) and fed Altech Coppens (42%c.p) GmbH Deller Weg14, 41334, Germany) diet for 12 weeks (December 2022 - February, 2023). Fish samples were transported in aerated water to Korex Aquatics Farms, North Bank, Makurdi. Benue State Nigeria, were they are further stocked and fed 42%c.p diet for additional 16 weeks (April – July, 2023) in an earthen pond (15m3). During the peak of the season (July), The Widehead catfish broodstocks were sampled, selected and isolated for induced breeding using Ovaprim® at 0.5 ml/kg body weight of fish. The eggs were artificially stripped, inseminated and incubated in aerated Recirculatory plastic tanks (400L) at 2.0 ft water depth and managed as described by Viveen et al. (1985). After 48 hours of incubation, the hatchlings were observed and fed to satiation with 0.2-0.3mm (45%c.p) dry commercial feed at intervals of 4hrs for 7 days and later fed with 0.3mm-0.5mm) for 7 days. 9000, fourteen-days-old hatchery-raised fry were randomly distributed into a Solar powered recirculatory system indoor plastic rearing tanks (400L) connected to a common biofilter, sedimentation unit and settling tank. Water was recirculated between the filter and the tanks using 25W pump powered by 330w solar panel, 1.5kva inverter and 200amp dry cell battery as backup. For oxygen concentration supply, the recirculation system was provided with a by-pass connection for continuous return of water within the pump tank for aeration at a flow rate of 15L/min. Oxygen concentration, pH and water temperature were monitored in each tank using JBL Testlab freshwater aquaculture test kit (Made in Germany). Three treatments with replicates were established: (1) Low density (LD: 500 fry/tank), (2) Medium density (MD: 1000 fry/tank) and (3) High density (HD: 1500 fry/tank). The fry were fed 45% crude protein diet four times daily (morning: 08:00 and 12:00 h and evening: 16:00 and 20:00 h) in split-rations at 5% body weight for eight (8) weeks. The water volume in the entire rearing unit were kept and maintained at ¾ to prevent fish from jumping out. Feeding began a day after stocking the fry. The experimental fish were fed 0.3-0.5mm (2 weeks), 0.5-0.8mm (2weeks) and 0.8-1.2mm (4weeks) commercial pellet feeds (Coppens™). During the eight (8) week experiment, random samples of 20 fish were measured and weighed weekly from each tank. Fish were weighed using electronic digital balance (METLER TOLEDO AB54, CAPACITY Max. 5000 g; Min. 10 mg) and total length taken in centimeters using meter rule, after being scooped out with a hand net and drained. Food Conversion Ratio (FCR), Mean Growth Rate (MGR), Specific Growth Rate (SGR) and Mean Live-Weight Gain (MWG) were calculated as follows: MGR=W2-W1/ 0.5 (W1 W2) X 100-day/1 Where, W1 = Initial weight, W2 = Final weight, d = stock density, 0.5 = Constant. SGR %/day= (loge W2 - loge W1)/ T2 - T1 100; Where, W2 and W1 represent final and initial weight of fish, T1 and T2 represent final and initial time (days), Loge represent Natural log to base. FCR= Weight of dry feed fed (g)/ Live weight gained (g), MWG= Mean final weight - Mean initial weight; PWG= Mean weight gain/initial weight gain x 100, SR (%) = Total number of fish harvested/ Total number of fish stocked X 100.

The data collected was subjected to statistical analysis using IBM SPSS 23. Statistical differences between variable was tested using one-way ANOVA and Duncan's Multiple Range Test, DMRT and significance levels set at $p<0.05$

RESULTS AND DISCUSSION

The result of growth performance and survival of Widehead catfish Clarotes laticep fry reared in indoor solar powered recirculatory system at different stocking densities is presented in Table 1. The results revealed that the stocking density at which fish were cultured significantly (p0.05) affected the final body weight, Mean Growth Rate (MGR), Specific Growth Rate (SGR) and final Weight Gain (MWG), except Food Conversion Ratio (FCR). Fish kept at high stocking density (HD) had a greater absolute growth (45.58±3.46) in comparison to others. The mean final weight gain for fish was also found to be highest (45.42±9.00) in treatment HD followed by fish in treatment MD (37.43±6.10) and treatment LD (33.19±4.15), respectively. Among the treatments, food conversion ratio was observed to be relatively higher in MD (0.94±0.65). Several authors have reported on the survival of African catfish which has again been differently described. In the present study, the LD stocked fish showed the weakest growth performance, significantly lower to the growth performance of HD stocked fish For instance, Toko et. al., (2007) reported increased growth performance with increasing extensive stocking densities (4–8 fish m- 3) of juvenile African in ponds. Consequently, this study contradicts conclusions regarding the influence of stocking density on growth of catfishes as reported by several previous studies (Wang et. al., 2017); in this case, widehead catfish fry tend to grow slightly higher under high stocking densities than under Low density conditions in indoor RAS culture. However, other studies have reported lower growth with increasing densities in juveniles of approx. 30–100g in tanks at 35–125 kg m- 3 (Wang et. al., 2013; Wang et. al., 2017) . According to Toko et. al., (2007) stocking density can impact growth in early developmental stages (larvae) of African catfish. Li et. al., (2021) pointed out the heterogeneity of studies regarding the effect of stocking densities on growth. This was also visible when comparing the FCR (Table 1). The mean number of fast growers (Shooters) was found to be highest in treatment LD while, treatment HD recorded the least. At the end of the study, significant high survival was recorded in HD (95±0.095±0.06), Akinwole and Faturoti (2007) described a survival rate of 75–93% (conversely, 7–25% mortality) for different developmental stages in commercial RASs which is within the range obtained in this study. Results of the weekly Water-quality parameters as presented in Figure 1 indicated that the tested parameters were relatively stable throughout the experimental period. Water temperature ranged between 26.0oC and 28.5oC. The minimum Dissolved oxygen was recorded at week 8 (4.2 mg/L) and the highest at week 4 (6mg/L). The recorded highest pH value of the culture water was at week 7 (8mg/L). However, values obtained for Conductivity, Ammonium, Nitrate and Nitrite water parameters were observed to be within the tolerable limits for catfish growth and health which was in agreement with Alabi et. al., (2022) on Widehead catfish pond culture, they reported that detrimental fluxes in oxygen levels were largely eliminated which agrees with those found in this study. Indeed, dissolved oxygen remained above the tolerable limit throughout the study and never dropped to a critical level.

Table 1: Growth performance and nutrient utilization of Widehead catfish (Clarotes laticeps) cultured at different stocking densities in RAS for eight (8) weeks

Parameters	LD(500)	Stocking Density MD(1000)	HD(1500)	p-value
Mean Initial weight (g)	0.16±0.04	0.17±0.05	0.16±0.05	0.94
Mean Final weight (g)	33.35±2.65	37.60±2.77	45.58±3.46	0.78
Mean weight gain(g)	33.19±4.15	37.43±6.10	45.42±9.00	3.55
Mean weight gain (%)	20743.75±39.50	22017.64±40.00	28387.50±47.10	39.60
Feed Intake(g)	129.00±12.48	130.50±18.48	155.50±11.00	5.20
Protein Intake	55.47±0.50	56.12±1.10	65.31±0.48	0.70
Specific Growth Rate	2.79±0.00	2.90±0.01	3.00±0.00	0.55
Feed Conversion ratio	0.93±0.70	0.94±0.65	0.81±1.10	1.25
Protein Efficiency ratio	0.52±1.90	0.54±1.68	0.53±1.68	1.15
Shooters(%)	38.0±0.55	43.5±0.18	20.5±0.67	0.58
Survival(%)	90±0.17	90±0.22	89.5±0.06	0.62

Values are mean of 3 replicates ±SD, Means across the same row differently superscripted differ significantly ($p<0.05$), LD: Low density, MD: Medium density, HD: High density

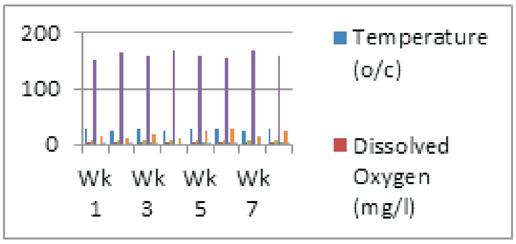

Figure 1: Weekly water quality parameters of culture water used in rearing Widehead catfish (C. laticeps) for eight weeks

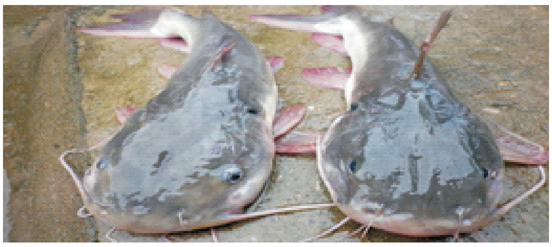

Plate 1: Sample of Widehead Catfish (C. laticeps) broodstocks obtained from Lower River Benue for the study

CONCLUSION AND RECOMMENDATION

The growth rate and survival of Widehead catfish were high at all stocking densities. However, at the end of this study, HD (1500fry/m3) had significantly higher weights than the LD and MD fish. This study demonstrated that particularly for early fry life stages of Widehead catfish, increasing stocking density influences growth performance. In addition, further investigation revealed evidence of the influence of high stocking density on survival rate without adversely affecting the optimum water quality parameters for growth and health of the studied fish species. We therefore suggest an adoption of (1500fry/m3) stocking density during the growth phases of Widehead catfish after size-grading in aquaculture to enhance production efficiency and fish welfare.

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REFERENCE

Akinwole, A.O. and Faturoti, E.O. (2007). Biological performance of African Catfish (Clarias gariepinus) cultured in recirculating system in Ibadan. Aquaculture Engineering. , 36, 18–23.

Alabi K. I.,Solomon. S.G, Obande, R.A, Cheikyula, J.O., Vihi, S.K., Alamanjo, C.C and Ocholi. O.O. (2022). Rearing water quality parameters for widehead catfish Clarotes laticeps (Ruppel, 1829) in pond aquaculture. Nigerian journal of Animal production. 1762-1765

Baldwin, L. (2011). The effects of stocking density on fish welfare. Plymouth Student Science., 4, 372–383.

Dai, W., Wang, X., Guo, Y., Wang, Q. and Ma, J. (2011). Growth performance, hematological and biochemical responses of African catfish (Clarias gariepinus) reared at different stocking densities. African Journal Agriculture Research. 6, 6177–6182.

Ellis, T. North, B. Scott, A.P. Bromage, N.R. Porter, M. and Gadd, D. (2002). The relationships between density and welfare in farmed rainbow trout. Journal Fish Biology, 61, 493–531.

Lewis W.M, and Wehr L.W. (1976). A fish-rearing system incorporating cages, water circulation, and sewage removal. Progressive Fish Culture 38(2):78–81. https://doi.org/10.1577/1548-8659(1976)38[78: AFSICW] 2.0.CO;2

Li, L. Shen, Y. Yang, W. Xu, X. and Li, J. (2021). Effect of different stocking densities on fish growth performance: A meta-analysis. Aquaculture, 544, 737152.

Martins C.I.M, Ochola D, Ende S.S.W., Eding E.H., and Verreth J.A.J (2010a). Is growth retardation present in Nile tilapia Oreochromis niloticus cultured in low water exchange recirculating aquaculture systems. Aquaculture 298:43–50. https://doi.org/10.1016/j.aquaculture.2009.09.030

Rüppel, (1829). World checklist of Freshwater Fish species. In: Tedesco, P., Leveque, C., Oberdorff, T., Paugy, P. and M.L.J stiassny (2010). Worldwide electronic publication. Available online athttp://fada.biodiversity.be/group/show/52

Toko, I. Fiogbe, E.D. Koukpode, B. and Kestemont, P. (2007). Rearing of African catfish (Clarias gariepinus) and vundu catfish (Heterobranchus longifilis) in traditional fish ponds (whedos): Effect of stocking density on growth, production and body composition. Aquaculture 262, 65–72.

Viveen, W.J.A.R., C.J.J. Ritcher, P.G.W.J. Van Oordti, J.A.L. Janssen and E.A. Huisman, (1985). Practical Manual for Culture of African Catfish Clarias gariepinus. The Netherlands Ministry for Development Cooperation, The Hugue, Netherlands, Pages: 121

Wang, X. Dai, W. Xu, M. Pan, B. Li, X. and Chen, Y. (2013). Effects of stocking density on growth, nonspecific immune response, and antioxidant status in African catfish (Clarias gariepinus). Isreal Journal of Aquaculture. Bamidgeh , 65, 1–6.

Wang, X.M., Gao, J.W., Xu, M., Mo, B.L., Dai, W. and Chen, C.H. (2017). Responses of growth rates and growth hormone levels of African catfish (Clarias gariepinus) to stocking density. Iran Journal Fisheries Science (16), 698–710.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

EFFECTS OF WATER AERATION ON GROWTH PERFORMANCE, CONDITION FACTOR AND HAEMATOLOGY OF *Clarias gariepinus* FINGERLINGS RAISED IN INDOOR CONCRETE TANKS

Olanrewaju A. N., S. Ebenezer, and A. G. Asheik

[1]Department of Fisheries Technology, Federal College of Freshwater Fisheries Technology Baga, P.M.B. 1060 Maiduguri, Borno State, Nigeria

Corresponding author:
arogidigbaonline@yahoo.com

ABSTRACT
The aim of this study was to determine the effect of water aeration on the growth performance, condition factor and haematology of fingerlings of African catfish. Clarias gariepinus fingerlings with initial mean weights of 4.74±1.63 g was stocked (50 fish each) in four indoor concrete tanks (5.28 m3) and were conditioned under two different treatments; aerated static renewal (ASR) and aerated flow-through (AFT) systems. After 84 days of feeding, results showed significantly higher dissolved oxygen (5.75±1.02 mg l-1) but low pH (6.84±0.42) was recorded in AFT tank, while elevated specific growth rate (1.35±0.16 g day-1) was however observed in ASR tank. The mean weight gain (51.24±9.86 g fish-1), mean length gain (11.68±1.83 cm fish-1), and condition factor (0.66±0.07) were slightly higher in fish from ASR tank. Fish from ASR tank showed best feed conversion ratio (1.59±0.33) but low survival rate (84.00±2.13 %) ($p>0.05$). The packed cell volume, haemoglobin, total protein and glucose in fish from experimental groups were significantly above the initial values. In conclusion, the treatment had significant effect on water quality and haematology but marginal effect on growth performance.

Keywords:
Aeration, static renewal, flow-through, growth, haematology, African catfish

INTRODUCTION

Good culture environment is highly significant to optimum production in terms of growth performance, survival and meat quality. It constitutes a stress-free environment that prevent fish from any infraction that shortchange production. An optimum culture environment allow fish to feed optimally with best feed conversion ratio, which transform into higher productivity and better efficiency in the use of resources (FAO, 2022). In relation to this, Chainark and Boyd (2010) stated that the quality of water used in aquaculture influences feeding, growth, disease burden, and survival. In fish production, the cumulation of good growth performance, best feed conversion ratio and disease-free environment leads to high economic gain, which is the ultimate goal of every farmer. For these reasons, aquaculturists strive to attain such an optimum condition through different manipulations in water-use management.

African catfish, an important economic freshwater fish species is reared in ponds (earthen, concrete, fibre and/or plastic) under intensive or semi-intensive culture system. Most farmers use semi-intensive ponds where static renewal and flow-through systems become an option for water-use management. The use of either static or flow in pond system is expected to produce optimal growth and survival of fish, because there is enhanced dissolved oxygen. Mohanty (2001) however, noted that aeration is required in semi-intensive ponds for higher dissolved oxygen in the pond system. Aeration provides an oxygen-rich environment in the pond, which promote healthy habitat for good growth, wellbeing, and survival of fish. Further, the environmental condition of the fish is closely related to its growth and health status (Esmaeili, 2021). The author maintained that a fish with a higher growth rate is more likely to be a healthy one, while any change in the physiological status of the fish, from pollution to nutritional stress, can cause changes in the blood parameters.

Few studies regarding the effect of water aeration for catfish growth are available (Ojeikere and Okonji, 2020; Mark et al., 2019; Omitoyin, 2003). This current investigation attempt to evaluate the effect of aeration in static renewal and flow-through systems on growth, condition factor and haematology of African catfish juveniles. The need to encourage and sustain fish farming in arid-zone, Nigeria to make aquaculture more reliable and resilient prompted this study with a view of recommending strategies to fish farmers, particularly in Maiduguri, Borno State.

MATERIALS AND METHODS

The research was conducted at the indoor fish hatchery complex of Federal College of Freshwater Fisheries Technology, Baga, Borno State, Nigeria over the duration of 84 days. Four indoor concrete tanks (5.28 m3) were used for the study to constitute two treatments and two replications in a complete randomized design. Fifty juveniles Clarias gariepinus (average weight; 4.74±1.63 g) each were stocked in the experimental tanks. The treatments include static renewal with aeration (ASR) and flow-through with aeration (AFT). Water in ASR tanks was changed twice weekly and aerate 6 hours daily, while AFT have 6 hours flow-through with 6 hours mechanical aeration daily. The fish were fed with commercial feed at 3% bodyweight of biomass, administered twice daily (0800 and 1700 h). The biological parameters including absolute length of fish, weight gain, specific growth rate, feed conversion ratio survival rate, water quality and analysis of blood profile were observed. The calculation of the variables- growth performance according to (Akinwole and Faturoti, 2006), condition factor according to (Pauly, 1984), blood profile according to (Svobodova et al., 1991), and water quality (dissolved oxygen, pH, temperature and nitrate) according (APHA, 1995). The weight gain, specific growth rate, feed conversion ratio and survival rate were calculated for each treatment as follow:

Mean weight (MWG, g): MWG = final mean weight - initial mean weight

Specific growth rate (SGR, %/day): SGR= $\frac{lnWt2\text{-}lnWt1}{Culture\ period}\ x\ 100$

Food conversion ratio (FCR): FCR = $\frac{total\ feed\ intake}{total\ weight\ gain}$

Survival rate (SR , %): SR= $\frac{final\ number\ of\ fish}{initial\ number\ of\ fish}\ x\ 100$

Blood samples (2 mL) were extracted and dispensed into a sample bottle containing Ethylene Diamine Tetra-acetic Acid (EDTA) anticoagulant for haematological studies while 3 mL was transferred into non-heparinized tubes to obtain plasma for biochemical analysis. Haematological assay was carried out at the NAFDAC Office, Maiduguri, Borno State, Nigeria. Red blood cell (RBC), white blood cell (WBC), packed cell volume (PCV), haemoglobin concentration (Hb), lymphocytes, monocytes, eosinophils and platelets. The serum was analyzed for Total protein (TP), Aspartate Aminotransferase (AST), Urea, Creatinine, Alkaline phosphate (ALP), Cholesterol, Albumin, glucose and, Alanine Aminotransferase (ALT). The obtained data were tabulated and analyzed using T-test and one-way ANOVA at a 95% confidence level. Differences between means were further analyzed using Turkey's-b at $P<0.05$. Analyses were carried out using SPSS software statistical program version 20.0 (SPSS Inc., Chicago, IL, United States of America)

.

RESULTS

The result in Table 1 indicated significant increase in dissolved oxygen level (5.75±1.02 mg l-1) of AFT tanks, while ASR tanks showed elevated pH level (7.31±0.33) ($p<0.05$). The values obtained for temperature (26.70±0.80 °C) and nitrate (10.04±0.88 mg l-1) were marginally higher in AFT tanks than those of ASR tanks. The growth performance indices of juvenile C. gariepinus reared in static renewal and flow-through with aerations is given in Table 2. The mean weight gain (51.24±9.86 g fish-1), and mean length gain (11.68±1.83 cm fish-1) of fish in ASR tanks were marginally higher ($p>0.05$), but specific growth rate (1.35±0.16 g day-1) was statistically ascended ($p>0.05$). The best feed conversion ratio (1.59±0.33) was noted in fish from ASR tanks, though not markedly different those of AFT tanks. The fish in ASR tanks showed marginally higher condition factor (0.66±0.07), while survival rate of fish (88.20±1.57 %) was slightly higher in AFT tanks.

Table 1. Water quality parameters measured in aerated static renewal and flow-through tanks during the study

Parameters	Treatments		P-value
	ASR	AFT	
Dissolved oxygen (mg l^{-1})	4.94±0.64	5.75±1.02	0.02*
pH	7.31±0.33	6.84±0.42	0.00*
Temperature (°C)	26.58±0.83	26.70±0.80	0.39
Nitrate (mg l^{-1})	8.93±1.73	10.04±0.88	0.13

ASR Aerated static renewal, AFT Aerated flow-through, *$p<0.05$.

Table 2. Growth performance indices of juvenile C. gariepinus reared in static renewal and flow-through with aerations for 84 days

Parameters	Treatments		P-value
	ASR	AFT	
Mean weight gain (g $fish^{-1}$)	51.24±9.86	48.62±11.88	0.45
Mean body length gain (cm $fish^{-1}$)	11.68±1.83	11.37±1.38	0.88
Specific growth rate (g day^{-1})	1.35±0.16	1.22±0.23	0.05*
Condition factor	0.66±0.07	0.63±0.15	0.41
Feed intake (g $fish^{-1}$)	33.09±20.04	33.06±20.67	0.99
Feed conversion ratio	1.59±0.33	1.81±0.54	0.92
Survival rate (%)	84.00±2.13	88.20±1.57	0.12

ASR Aerated static renewal, AFT Aerated flow-through, *$p<0.05$.

Data on haematological parameters shown in Table 3 revealed no significant difference in differential leukocyte count (neutrophils, lymphocytes and monocytes) between experimental groups and initial values. Packed cell volume and haemoglobin were considerably high in experimental groups compared to the initial value. Significant high red blood cells and platelets were observed in initial and AFT group, while comparatively high white blood cell was spotted in initial value and ASR group. The ANOVA test showed that the treatment had a significant effect ($p<0.05$) on serum biochemical profile analyzed in the study (Table 4). Total protein and glucose level showed considerable increase in experimental groups when compared to initial values. Further, alanine aminotransferase and aspartate aminotransferase in aerated flow-through fish significantly rose above those in aerated static renewal and initial. However, albumin, creatinine, cholesterol and urea markedly progressed in aerated static renewal tanks as compared to AFT group and initial.

Table 3. Haematology of Juvenile C. gariepinus reared in static renewal and flow-through with aerations for 84 days

	Treatments		
Parameters	Initial	ASR	AFT
Red blood cell (x 10^6 l^{-1})	8.20±0.36^a	5.70±0.60^b	7.50±0.70^a
White blood cell (x 10^9 l^{-1})	5.50±0.50^a	6.20±0.40^a	4.00±0.30^b
Packed cell volume (%)	24.50±1.70^b	32.00±4.00^a	27.00±3.00^{ab}
Hemoglobin (g dl^{-1})	8.15±0.15^b	10.60±0.60^a	9.00±1.50^{ab}
Neutrophils (%)	46.33±3.25^a	49.00±4.00^a	50.00±9.00^a
Lymphocyte (%)	51.50±1.50^a	48.00±4.00^a	46.00±5.00^a
Monocytes (%)	2.00±0.50^a	2.00±0.35^a	3.00±1.00^a
Platelets (x 10^9 l^{-1})	93.00±3.00^a	76.00±6.00^b	94.00±4.00^a

ASR Aerated static renewal, AFT Aerated flow-through, Means across the same row differently superscripted differ significantly (P<0.05). Values are means ± SD.

Table 4. Serum biochemistry of juvenile Clarias gariepinus reared in static renewal and flow-through systems with aerations for 84 days

	Treatments		
Parameters	Initial	ASR	AFT
Total protein (mg dl^{-1})	39.00±6.00^b	92.00±6.00^a	89.00±7.00^a
Albumin (g l^{-1})	15.00±4.00^b	54.00±12.00^a	16.33±0.77^b
Creatinine (mmol l^{-1})	20.00±3.00^b	38.00±7.00^a	15.00±4.00^b
Cholesterol (mmol l^{-1})	207.00±19.00^b	246.00±15.88^a	200.00±10.15^b
Glucose (mmol l^{-1})	1.70±0.30^b	5.00±0.90^a	6.50±2.00^a
Urea (mmol l^{-1})	0.90±0.13^b	4.10±0.46^a	1.00±0.23^b
AST (IU l^{-1})	77.00±8.66^b	67.00±6.08^b	98.00±7.94^a
ALT (IU l^{-1})	20.50±1.32^{ab}	17.00±1.10^b	22.00±3.00^a

ALT alanine aminotransferase, AST aspartate aminotransferase, ASR Aerated static renewal, AFT Aerated flow-through, Means across the same row differently superscripted differ significantly (P<0.05). Values are means ± SD.

DISCUSSION

In the current study, growth expressed by mean weight gain was slightly higher in fish grown in ASR tanks than those from AFT system. This finding was comparable with the report of El-Sayed et al. (2023) that weight gain of Oreochromis niloticus fry reared in flow-through system did not significantly differs from those in blower aerated system. The result also agrees with the work of Okunsebor et al. (2015) on Clarias gariepinus hatchlings cultured in different enclosures. The authors found no significant difference in percentage weight gain of C. gariepinus fry reared in the aerated and non-aerated hapa and aquaria. Similarly, fish reared in ASR had significantly high (P<0.05) specific growth rate (SGR) compared to those grown in AFT. The SGR in this study was in contrast with earlier findings of Ojeikere and Okonji (2020) who studied the effects of varied hours of aeration on the spawning success of African catfish (Clarias gariepinus). These authors report significant high SGR (0.17 g day-1) in fish reared in 12 hours aeration compared to those reared in lesser aeration hours in their study. Similar contravening result of significant high SGR (19.19 % day-1) in Heterobranchus bidorsalis fry raised in 12 hours aeration was reported by Dada et al. (2003). The feed conversion ratio (FCR) of fish reared in AST tanks was numerically better (P>0.05) than those in AFT tanks in this study. The results imply that fish in flow-through with mechanical aeration influenced the culture system with negative impact on their feeding efficiency. The present observation gives credence to the work of Okomoda et. al. (2016) who studied the effect water renewal on growth of Clarias gariepinus. These authors found the best FCR in fish reared under daily water change (1.21±0.185) and water change every four days (1.26±0.035).

In this work, no significant differences in survival rate were observed between fish grown in aerated static renewal and aerated flow-through system, but Ojeikere and Okonji (2020) observed a significant effect of varied hours of aeration on the survival of C. gariepinus fry. The current result was however concurred with the observations of Dada et al. (2003) who reported no significant differences in survival rate of Heterobranchus bidorsalis fry that received varying aeration hours. For haematology, the packed cell volume (PCV) and haemaglobin were markedly increased in fish reared in both experimental treatments compared to initial values. This slight increase in the PCV and haemoglobin of experimental fish could be attributed to the optimum oxygen concentrations found in both environments (Olanrewaju et al., 2023). The increase in white blood cell count (WBC) from fish from ASR tanks indicate some degree of stress condition in the culture treatment, and this is supported by Roberts (1978). Serum total protein and glucose levels in fish in experimental groups were significantly ascended above the initial values in the current study. This high total protein and glucose values in treatment groups could be associated with a stronger innate response due to stress in those fish (Wiegertjes et al., 1996). The current study also revealed a considerably elevated levels of albumin, cholesterol, creatinine and urea in fish from ASR group, and this could only be a signal to some physiological instability due to stressors (Bojarski et al. 2020). Further, the results of the current investigation showed significant increase in alanine aminotransferase and aspartate aminotransferase levels in fish grown in AFT group. This could be a signal to some factor affecting the liver and kidney of the fish due to water conditions in the tank. The dissolved oxygen and pH levels obtained in this study were significantly higher in AFT tanks than the levels observed in AST tank. However, all the investigated water parameters (DO, pH, temperature and nitrate) were within the required levels recommended for a successful fish growth, welfare and survival (Omitoyin, 2007; Boyd and Tucker, 2008).

CONCLUSION

The application of mechanical aeration in static renewal and flow-through systems had no significant effect on the weight gain, length gain, condition factor, feed utilization and survival rate of African catfish (Clarias gariepinus). Significantly higher specific growth rate was however observed in ASR tank, while elevate dissolved oxygen and pH was recorded in AFT tank. The study has further shown that aeration in both static renewal and flow-through systems constitute stress to the fish and cause some haematological imbalance. In conclusion, the treatment had significant effect on water quality and haematology but marginal effect on growth performance.

REFERENCES

Akinwole, A.O. and Faturoti, E.O. (2006). Biological performance of African catfish (Clarias gariepinus) culture in recirculating system in Ibadan. Aquacultural Engineering, 36: 18-23. https://doi.org/10.1016/j.aquaeng.2006.05.001

APHA (1995). American Public Health Association. Standard Methods for the Examination of Water and Wastewater. 18th ed. Washington. D.C. 200pp.

Boyd, C.E. and Tucker, C.S. (1998). Pond Aquaculture Water Quality Management, Springer US, Boston, MA, doi:10.1007/978-1-4615-5407-3.

Chainark, S. and Boyd, C.E. (2010). Water and sediment quality, phytoplankton communities and channel catfish production in sodium nitrate treated ponds. J Appl Aquacult., 22(10):171–185. DOI: 10.1080/10454431003736524

Dada, A.A., Okoye, F.C. and Okwundu, E.C. (2003). Effects of duration of aeration on the production of fry in indoor hatchery. Bioscience Research Communications, 15(2): 121-124.

Esmaeili, M. (2021). Blood Performance: A New Formula for Fish Growth and Health. Biology, 10, 1236. https://doi.org/10.3390/ biology10121236

FAO. 2022. The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome, FAO. https://doi.org/10.4060/cc0461en

Mark, Y., Amoah, P., Agbo, N.W., Sey, S.E. and Ashley, M. (2019). Effect of pond aeration on growth performance of African Catfish (Clarias gariepinus) cultured in treated wastewater in Kumasi, Ghana. J Mar Biol Oceanogr., 8. DOI: 10.4172/2324-8661-C1-017

Mohanty, R.K. (2001). Effect of pond aeration on growth and survival of Penaeus monodon Fab. Bangladesh J. Fish. Res., 5(I): 59-65. http://hdl.handle.net/1834/33176

Ojeikere, B.A. and Okonji, V.A. (2020). Effects of varied hours of aeration on the spawning success of African catfish (Clarias gariepinus). International Journal of Fisheries and Aquatic Studies, 8(2): 126-131.

Okunsebor, S.A., Shima, K.G. and Sunnuvu, T.F. (2015). Effect of water volume on growth, survival rate and condition factor of Clarias gariepinus hatchlings cultured in different enclosures. American Journal of Experimental Agriculture, 7(3): 150-154. DOI: 10.9734/AJEA/2015/8353

Olanrewaju, A.N., Kareem, O.K. and Emikpe, B.O. (2023): Haematological and biochemical status of cultured and wild Blue Tilapia, Oreochromis aureus from Alau Lake, Northeast, Nigeria. Comparative Clinical Pathology, 32: 139–146. https://doi.org/10.1007/s00580-022-03423-4

Omitoyin, B.O. (2003): Growth performance and nutrient utilization of Clarias gariepinus fingerlings raised under different water quality conditions. African Journal of livestock Extension 2: 86–90

Omitoyin, B.O. (2007). Introduction to fish farming in Nigeria. Ibadan University Press, University of Ibadan, Nigeria. IBSN 9789781214271. 90pp.

Pauly, D. (1984). Fish population dynamics in tropical waters: a manual for use with programmable calculators. ICLARM Studies and Revision, 8, 1–325. https://hdl.handle.net/20.500.12348/3445

Roberts, R.J. (1978). The pathophysiology and systemic pathology of teleosts. Pages 55-91 in R. J. Roberts, editor. Fish pathology. Bailliere Tindal, London, UK.

Svobodova, Z., Pravola, D. and Palackova, J. (1991). Unified methods of haematological examination of fish. Research Inst. of fish culture and Hydrobiology. Vodnany, Czechoslovakia., 31Pp

Wiegerties, G.F., Stet, R.G.M., Parmentier, H.K. and van Muiswinkel, W.B. (1996). Immunogenetics of disease resistance in fish: a comparative approach. Dev Comp Immun., 20: 365–381. DOI: 10.1016/s0145-305x(96)00032-8

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

DESIGN, CONSTRUCTION, AND PERFORMANCE EVALUATION OF SOLAR-POWERED AQUAPONICS SYSTEM PROTOTYPES FOR *Amaranthus hybridus* AND *Clarias gariepinus* PRODUCTION.

[1]Oladimeji A. S., [2]S.G Solomon, [2]S.O. Olufeagba, [2]R.A Obande, [2,3]V. T. Okomoda, [4]K. I Alabi, and [5]J.A Tutuwa

[1]Agricultural Department, National Biotechnology Development Agency (NABDA), Abuja, Nigeria
[2]Department of Fisheries and Aquaculture, Joseph Sarwuan Tarka University (JOSTUM), Makurdi, Nigeria.
[3]World Fish Country Office, International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria.
[4]Department of Agricultural Extension and Management, Federal College of Forestry, Jos. Plateau, Nigeria.
[5]Federal Institute of Industrial Research Oshodi (FIIRO), Lagos Nigeria.

Corresponding Author:
sunnybleek2013@gmail.com, +234 803 070 7123, 0009-0007-2602-654X

ABSTRACT
Aquaponics integrates aquaculture and hydroponics, where fish waste fertilizes plants, and nitrifying bacteria convert ammonia to nitrate for plant absorption. The study investigated the performance of Catfish *(Clarias gariepinus)* and Green Spinach *(Amaranthus hybridus)* in three aquaponics system prototypes: Media-Based Growing Bed (MBGB), Deep Water Culture (DWC), and Nutrient Film Technique (NFT). The experiment was conducted in a solar-powered 48m² greenhouse using locally sourced materials. Fish and plant growth metrics were assessed, with data analysed using One-way ANOVA and Student's T-tests. Results indicated that the MBGB prototype had better performance than NFT and DWC systems. Catfish in MBGB achieved the highest weight gain of 169g, while Green Spinach in MBGB showed superior growth, including the tallest plant height (90.7 cm), highest stem diameter (0.99 cm), and largest fresh plant yield (26,010 g). the experiment lasted for two months. These findings are consistent with previous research, suggesting that MBGB is more effective in bioremediation and nitrogen utilization due to its volume-to-surface area ratio for microbes efficient. The study concludes that MBGB is the most efficient system for integrating Catfish and Green Spinach in aquaponics compared to NFT and DWC, supporting its potential for sustainable food production.

Keywords:
Aquaculture, Hydroponics, Soilless, Catfish, Farming.

INTRODUCTION

Aquaponics integrates aquaculture and hydroponic cultivation, where water circulates between the fish tank, biofilter, and hydroponic system. Fish waste becomes fertilizer for plants, while nitrifying bacteria convert ammonia to nitrate, which plants absorb (Rakocy, 1994; Nichols and Savidov, 2012; Wongkiew *et al.*, 2017). This system enhances water use efficiency, reuses aquaculture wastewater, and avoids environmental pollution (Love, 2015; Endut *et al.*, 2011). Aquaponics, adaptable to various scales and conditions, holds potential for urban agriculture (Palma, 2016). The main types include Media-Based Growing Bed (MBGB), Deep Water Culture (DWC), and Nutrient Film Technique

(NFT), each with distinct characteristics. MBGB is space-efficient but challenging to maintain, DWC offers easier cleaning and higher nitrate removal but requires additional components, and NFT is water-efficient but yields less (Goddek et al., 2015). Systems are either coupled, where water cycles back into the aquaculture system, or decoupled, allowing for better control over water quality at the cost of higher water use (Gibbons, 2020). MBGB is more efficient in nitrogen utilization and popular among small-scale operations but costly to maintain (Lennard & Leonard, 2006; Maucieri et al., 2018; Pattillo, 2017; Palm, 2018). NFT systems are less effective for larger crops due to potential root blockages and limited microbe support, making them suitable for smaller vegetable species (Cherif, 1997; Engle, 2015). Green amaranth (Amaranthus hybridus L.), also known as slim amaranth or Smooth pigweed, is an annual plant from the Amaranthaceae family, characterized by erect growth, ovate to lance-shaped leaves, and a stout, grooved stem (Oluwole et al., 2019). Vegetables, including amaranth, are vital sources of macro and micro elements, essential for health and disease prevention (Asaolu et al., 2010; Robinson, 1990; Nnamani et al., 2007). This study aims to Design, Construct and test NFT, DWS and MBGB hydroponics system on the performance of African Catfish (Clarias gariepinus) and Green Spinach (Amaranthus hybridus).

MATERIALS AND METHODS

The experiment was conducted at Aso-aqua Integrated Bioresources Farm Ltd located in Kubwa, Abuja, Nigeria (9°1'6" N, 7°19'58" E). The aquaponics systems were constructed within a $48m^2$ greenhouse powered by 1000-watt solar panels using locally sourced materials like IBC tanks, blue barrel drums, and PVC pipes. Nine IBCs were arranged in three replicates for rearing African catfish (Clarias gariepinus) in aquaponics systems. Each IBC tank (1000L) was divided into two (800L and 200L) sections, with the larger section maintained at 750L for fish rearing. A total of 450 juvenile African catfish (12.00±2.21g, 15.32±0.12cm) were stocked at 50 per tank and fish indices were measured according to the method adopted by Okomoda, (2017). A 120W Resun air blower provided oxygen, and water loss was replenished via a pre-aeration tank. Tank openings were covered with a 20 mm net to prevent fish escape, and tanks were painted black and covered to block sunlight and inhibit photosynthesis.

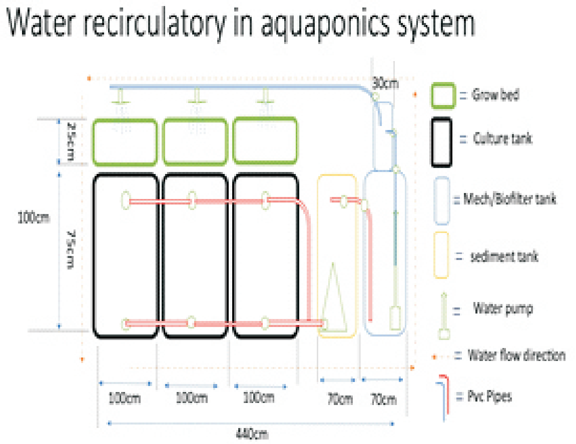

Fig 1: Prototype layout as used for the study.

Plate 1: Side view of prototype unit

The system included a 200L sump/mechanical filter tank and a 50L biofilter, with a 2400 L/hour submersible pump adjusted to distributing fish effluent at hydraulic loading rate of 7.5L/hour. The Nutrient Film Technique (NFT) used 12 drainage pipes (4-inch, 10 feet long) with 16 holes each, fortified with Palm Kernel Shell (PKS) and husk to hold 6 plants per hole and 96plants per square meter. The Deep-Water Culture (DWC) setup used -modified IBC tanks (200L) with perforated Styrofoam, while the Media Base Growing Bed (MBGB) used PKS prepared as described by Oladimeji et al. (2020b) the schematic diagram is depicted in (Plate 1, Fig 1). The water quality test was conducted I the laboratory, while Percentage removal of ammonia, nitrite, nitrate, Phosphorous and Potassium was calculated using the formula adopted by Effendi et al., (2015): Percentage (%) Reduction = (a-b)/b × 100, where 'a' is inlet concentration, and 'b' is outlet concentration. At the end of the experimental period, data were collected on the average length and weight of the fish. Additionally, Data collection for the yield parameters of the plants were initiated four weeks after seed germination and subsequently every two weeks according to the method specified by Cornelissen, et al. (2003). This includes the vine length, leave number, number of branches and plant yield. Data collected across different aquaponics prototypes was subjected to One-way analysis of variance (ANOVA), tested using the SPSS statistical package (SPSS Inc. v3.0 Chicago, Illinois) and where significant different were indicated, means where tested using Fisher Least Significant Different (LSD) and 95% confidence test at P= 0.05 significant.

RESULT AND DISCUSSION

The results, as shown in Fig. 2, indicated that Catfish (Clarias gariepinus) reared in the Media-Based Growing Bed (MBGB) achieved the highest accumulative weight gain of 169g compared to the NFT (157g) and DWC (152g) systems at the end of 60 days of the experiment. The outstanding performances of MBGB could be attributed to system design efficiency in handling waste. These findings are consistent with previous studies by Mamat et al. (2016) and Schmautz et al. (2016), which reported better performance of Fish and vegetables in MBGB compared to NFT and DWC systems. Similarly, highest value was also recorded in MBGB for plant height (90.7 cm), number of leaves (86 cm^2), stem diameter (0.99 cm) and fresh plant yield (26,010 g), while the numbers of leave show no significant difference (P>0.05), (Table 1).

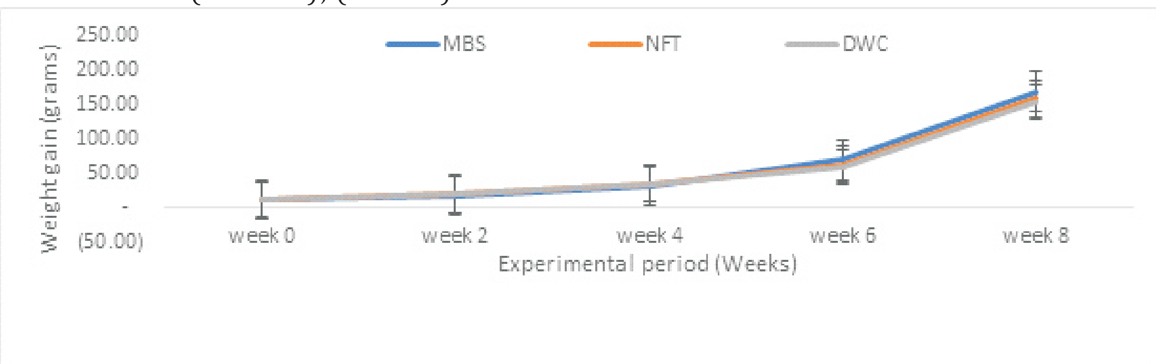

Fig 2: Cumulative Weight gain of Catfish in different Aquaponics system.

Table 1: Growth Indices of Amaranthus in three Aquaponics

Parameters	Systems Design		
	MBGB	NFT	DWC
Plant height (cm)	90.70±36.90^a	87.33±1.44^b	85.53±17.84^c
Leave area (cm^2)	86.22±0.38^{ab}	79.89±1.65^a	62.35±4.77^b
Number of leaves	24.80±0.52^a	24.66±0.63^a	24±1.00^a
Stem diameter (cm)	0.99±0.08^b	0.83±0.00^a	0.74±0.14^b
Fresh plant yield(gm^{-2})	26,010.00±32.10^a	25,070.00±111.00^b	24,170.00±132.00^c

Means on the same row with different superscript are significantly different (p<0.05)

The water quality fluctuates throughout the study (Table 2), but are within the tolerant range for aquaculture system according to Ajani et al. (2011). Though the highest percentage of nutrient reduction was recorded in MBGB (Fig 4) compared to DWC and NFT, indicating more nutrient absorption or utilization by Amaranthus hybridus in MBGB aquaponics system compared to others. The best performance of Clarias gariepinus and Amaranthus hybridus in MBGB may be attributed to volume-to-surface area ratio for microbes (Lennard & Leonard, 2006) provided by substrate media used. This result is consistent with previous findings by Oladimeji et al., (2020) which highlighted the successful production of pumpkin (Telfairia occidentalis) using various media substrate as grow beds in conjunction with African Catfish (Clarias gariepinus).

Table 2: Water quality parameters recorded in the three Aquaponics systems.

System	Point	DO	pH	Temp	NH_3-N	NO_3	NO_2	P	K
DWC	Inlet	4.96±0.00[a]	6.42±0.00[a]	25.83±0.03[a]	0.28±0.00[a]	125.40±0.00[a]	0.44±0.00[a]	0.94±0.00[a]	10.80±0.00[a]
	Outlet	4.72±0.00[a]	6.32±0.00[b]	25.90±0.00[a]	0.26±0.02[a]	108.87±0.59[b]	0.42±0.00[b]	0.61±0.25[b]	09.52±2.38[b]
MBGB	Inlet	5.14±0.10[a]	7.46±0.00[a]	25.81±0.00[a]	0.22±0.00[b]	129.06±0.00[a]	0.51±0.00[a]	1.42±0.05[a]	10.86±0.34[a]
	Outlet	4.08±0.01[b]	6.14±0.02[b]	25.74±0.02[b]	0.14±0.02[a]	100.12±0.35[b]	0.42±0.00[b]	1.06±0.27[b]	08.46±0.71[b]
NFT	Inlet	5.12±0.00[a]	6.46±0.00[b]	25.76±0.03[b]	0.29±0.00[a]	122.80±0.00[a]	0.44±0.00[a]	09.67±0.00[a]	1.06±0.00[a]
	Outlet	4.94±0.00[b]	6.34±0.00[b]	25.53±0.00[a]	0.20±0.02[a]	119.33±2.05[b]	0.40±0.03[a]	08.91±0.10[b]	1.00±0.15[b]

Means on the same column with different superscript for each point, are significantly different ($p<0.05$).

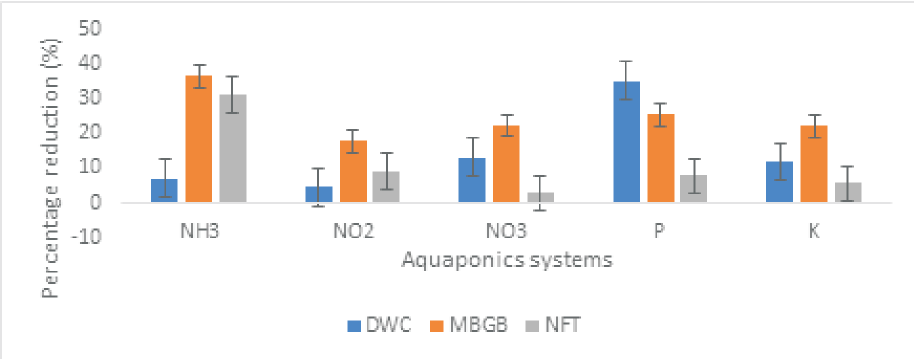

Fig 4: Reduction percentages of Micro nutrient in the three Aquaponics systems.

While the Media-Based Growing Bed (MBGB) proof to be more efficient than the NFT and DWC systems in the production of Clarias gariepinus and Amaranthus hybridus, MBGB was also cost effective compared to NFT and DWC, in contrary to Lennard & Leonard, 2006; Maucieri et al., 2018; Pattillo, 2017; Palm., 2018, who alleged that MBGB to be more costly than NFT and DWC due to the cost of maintenance. Separate biofilter was provided for all the systems which prevented the systems from clogging and easy to maintained. Though similar materials cost were employed for the purchased and assembled of all the three systems (N580,000 each), except for the hydroponic support system. As a matter of fact, the Palm Kernel Shell (PKS) used as substrate media for MBGB was procured at no cost, it was source from the dumping site of palm oil milling industry, as a means of converting waste to wealth, while Polyvinyl Chloride (PVC) pipes (N62,000) and Styrofoam's (N25,000) used in NFT and DWC respectively increase the cost of construction.

CONCLUSION

MBGB system performed favourable compared to NFT and DWC, achieving the highest weight gain and exhibiting superior plant growth. These findings are consistent with previous studies as alighted, which emphasize the effectiveness of MBGB in aquaponics systems bioremediation. However, Further studies should include variety of indigenous vegetables and cultured fish as well as the economic cost analysis of various aquaponics systems.

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REFERENCES

Asaolu, S.S., and Asaolu, M.F. (2010). Trace Metal Distribution in Nigerian Leafy Vegetables. Pakistan Journal of Nutrition 9 (1): 91-92.

Endut, A., Jusoh, A., Ali, N., and Nik, W.B.W. (2011). Nutrient removal from aquaculture waste water by vegetable production in aquaponics recirculation system. Desalination Water Treatment 32, 422–430.

Gibbons, G.M. (2020). An Economic Comparison of Two Leading Aquaponic Technologies Using Cost Benefit Analysis: The Coupled and Decoupled Systems. Master's Thesis, Utah State University, Logan, UT, USA.

Goddek, S., Delaide, B., Mankasingh, U., Ragnarsdottir, K.V., Jijakli, M.H., and Thorarinsdottir, R. (2015). Challenges of sustainable and commercial aquaponics. Sustainabilty, 7, 4199–4224.

Ikhwanuddin M., Martins C. O., Umaru J. A. and Hassan A. (2020b). Aquaponics production of Catfish and Pumpkin: Comparison with Conventional Production Systems. Food Science and Nutrition. 8: 2307 – 2315

Lennard, W.A., and Leonard, B.V. (2006). A comparison of three different hydroponic subsystems (gravel bed, floating and nutrient film technique) in an aquaponic test. Syst. Aquac. Int. 14, 539–550. https://doi.org/10.1007/s10499-006-9053 2

Love, D.C., Uhl, M.S., and Genello, L. (2015). Energy and water use of a small-scale raft aquaponics system in Baltimore, Maryland, United States. Aquaculture Engineering, 68, 19–27. publisher, New York. USA.

Mamat, N.Z., Shaari, M.I. and Abdul Wahab, N.A.A. (2016). The production of catfish and vegetables in an aquaponic system. Fisheries and Aquaculture Journal, 7(4), pp.5-7.

Nichols, M.A., and Savidov, N.A. (2012). Aquaponics: A Nutrient and Water Efficient Production System; International Society for Horticultural Science (ISHS): Leuven, Belgium.

Nnamani, C. V., Oselebe, H. O. and Okporie, E. O. (2007). Ethnobotany of Indigenous leafy Vegetables of Izzi Clan in Ebonyi State, Nigeria. In: Proceedings of 20th Annual National Conference of Biotechnology Society of Nigeria. Abakaliki, November 14th 17th, p. 111-114

Okomoda, V.T., Tiamiyu, L.O., and Akpan, I.S. (2017). Nutritional evaluation of toasted Mucuna utilis seed meal and its utilization in the diet of Clarias gariepinus (Burchell, 1822). Journal of Applied Aquacultue. 29 (2), 167–182.

Oladimeji, A.S., Olufeagba, S.O., Ayuba, V.O., Solomon, S.G., and Okomoda, V.T. (2020a). Effects of different hydroponics growth media on water quality and plant yield in a Catfish-pumpkin Aquaponics system. Journal of King Saud University - Science, 32, 60–66.

Oluwole, S.O., Fajana, O.O., Ogun, M.L., Ogbe, A.A., and Ademola, O.A. (2019). Proximate and mineral composition analysis of the leaves of amaranthus cruentus and ocimum gratissimum in some selected areas of Lagos State, Nigeria. International Journal of Ecosystem, 9 (1), pp.6-11.

Palma, L., and Dos Santos, M.J. (2016). Smart cities and urban areas-Aquaponics as innovative urban agriculture. Urban For. Urban Green, 20, 402–406.

Rakocy, J.E. (1994). Aquaponics: The Integration of Fish and Vegetable Culture in Recirculating Systems. In Proceedings of the Caribbean Food Crops Society, 30th Annual Meeting, Virgin Islands, USA, 31 July–5 August.

Robinson, D.S. (1990). Food biochemistry and nutritional value. Longman scientific and technical Sustainability 2020, 12, 7783 12 of 14

Wongkiew, S., Hu, Z., Chandran, K., Lee, J.W., and Khanal, S.K. (2017). Nitrogen transformations in aquaponic systems: A review. Aquaculture Engineering. 76, 9–19.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

EVALUATION OF PAWPAW *(Carica papaya)* SEEDS EXTRACT EFFICIENCY IN THE PRODUCTION OF ALL MALE NILE TILAPIA *(Oreochromis niloticus)*

[1]Abdulazeez, H. R. and [2]B. Abdulkarim

[1]Department of Biological Sciences, Federal University Dutsin-Ma, PMB 5001, Dutsin-Ma, Katsina State, Nigeria
[2]Department of Biology, Umaru Musa Yaradua University, Katsina State Nigeria.

Correspondence author:
halimatuarafindadi@gmail.com

ABSTRACT
This study was conducted to evaluate the efficiency of C*arica papaya* seeds extract in the production of all male Nile tilapia *(Oreochromis niloticus)* for a period of six months (March to September, 2023) using standard methods and procedures. A total of four hundred and eighty (480) newly hatched tilapia were collected. Carica papaya seeds were collected and extracted with methanol and hexane using a soxhlet apparatus. 17a -Methyltestosterone hormone was also purchased. The experiment consisted of a control and 7 treatments in triplicates labeled as; Control, 17a -MT, 20mlCPM (20ml Carica papaya extracted with methanol per kg diet), 40mlCPM (40ml C*arica papaya* extracted with methanol per kg diet) , 60mlCPM (60ml C*arica papaya* extracted with methanol per kg diet), 20mlCPH (20ml C*arica papaya* extracted with Hexane per kg diet), 40mlCPH 40ml C*arica papaya* extracted with Hexane per kg diet), 60mlCPH (60ml C*arica papaya* extracted with Hexane per kg diet), making a total of 24 aquaria, each consisting of 20 hatchlings. The treatments involved mixing the hormone and various concentrations of Carica papaya seed extracts per kilogram of the fish diet. The result of sex ratios in the various treatments shows that the negative control group (Control) which was fed with the basal diet only, had the lowest male to female sex ratio (M:F) of 2:1. There was significantly higher ($p<0.05$) males to female ratio of 7:1 in the positive control group fed with feed mixed with 17a -MT hormone. 40mlCPM was able to skew the ratio in favour of males at 6:1. It is concluded that the 40mlCPM yielded the best result following the standard for the production of all male Nile tilapia and therefore recommended for usage by the fish farmers.

Keywords:
Nile tilapia,
17*a*-Methyltestosterone,
methanol, hexane,
Carica papaya, all male,
seed extract

INTRODUCTION

Aquaculture, the cultivation of aquatic species, is a crucial industry for providing protein to human diets (FAO, 2020). Nile tilapia *(Oreochromis niloticus)* is a popular species in aquaculture due to its rapid growth, adaptability, and high market demand (El-Sayed, 2006). However, the expansion of tilapia farming faces challenges, particularly related to sex ratios and growth rates. Female tilapia, which reproduce prolifically and grow slower in high densities, can hinder production, while male tilapia exhibits faster growth and are preferred for monosex aquaculture (Guerrero, 2007).

Synthetic hormones are commonly used to induce sex reversal in tilapia, but their use raises environmental and health concerns due to potential contamination and adverse effects on consumers. Consequently, there is growing interest in finding environmentally friendly alternatives (Kristesen, 2017). Phytochemicals, such as those from Carica papaya seeds, offer a promising solution. Carica papaya seeds contain carpaine, an androgenic compound that may induce sex reversal in fish. The seeds are inexpensive, readily available, and non-toxic, making them an attractive alternative to synthetic hormones (Raji, 2018).

As regulations on chemical use in aquaculture increase, exploring safe, natural alternatives becomes essential. This study was aimed at assessing the effectiveness of Carica papaya seed extracts in producing all-male Nile tilapia *(Oreochromis niloticus)*.

MATERIALS AND METHOD

Study Area, Sources of Seeds, Feeds, Hormone and Fishes

This study was conducted at the Fisheries Department of the National Biotechnology Development Agency (NABDA) in Katsina, Nigeria, from March to September 2023.Carica papaya seeds were collected from local markets and plantations in Katsina, while 17*a*-Methyltestosterone hormone was obtained from the Federal University, Dutsin-ma (FUDMA) Katsina State. Commercial fish feed was purchased in Katsina town. A total of four hundred and eighty (480) newly hatched Oreochromis niloticus were collected from the fish hatchery of National Biotechnology Development Agency, Katsina.

Seeds and Feeds Processing

The Carica papaya seeds were washed, dried, and ground into powder, and then extracted with Methanol and Hexane using a soxhlet apparatus according to the procedure of Hussain et al. (2009). The 17*a*-Methyltestosterone was prepared by dissolving it in 95% ethyl alcohol to create a stock solution according to procedure described by Vinarukwong *et al.* (2018). The treatments involved mixing the various concentrations of Carica papaya seed extracts with the fish feed as follows: 20ml Carica papaya extracted with methanol per kg diet, 40ml Carica papaya extracted with methanol per kg diet, 60ml Carica papaya extracted with methanol per kg diet, 20ml Carica papaya extracted with Hexane per kg diet, 40ml Carica papaya extracted with Hexane per kg diet, and 60ml Carica papaya extracted with Hexane per kg diet.

Experimental Design

The experiment was conducted in two phases. The first phase lasted for 60 days and involved treating the fish with the hormone and plant extracts. The second phase extended for 130 days and focused on rearing the fish on untreated feed to assess the long-term effects of the treatments. The fish were distributed into 24 ponds, with 20 fish per pond and three replicates for each treatment.

Feeding and Water Change

During the rearing period, the fish were fed twice daily at 5% of their body weight, and the ponds were filled with de-chlorinated water, which was changed daily to ensure optimal conditions.

Gonads Examination

Gonads were analysed by using the standard acetocarmine squash technique as described by Suman, (2016).

DATA ANALYSIS

The data was presented using a bar chart. One way Analysis of Variance (ANOVA) was used to compare the means at 5% significance level. The analysis was performed using Graphpad instant (Version 3.0).

RESULTS AND DISCUSSION

The identification of gender by means of acetocarmine squash method was performed with ease at the end of the 180 days trial period. At the end of the 180 days trial, in the negative control group (Control) which was fed with the basal diet only, the male to female (M:F) sex ratio of 2.3:1 had the lowest sex ratio

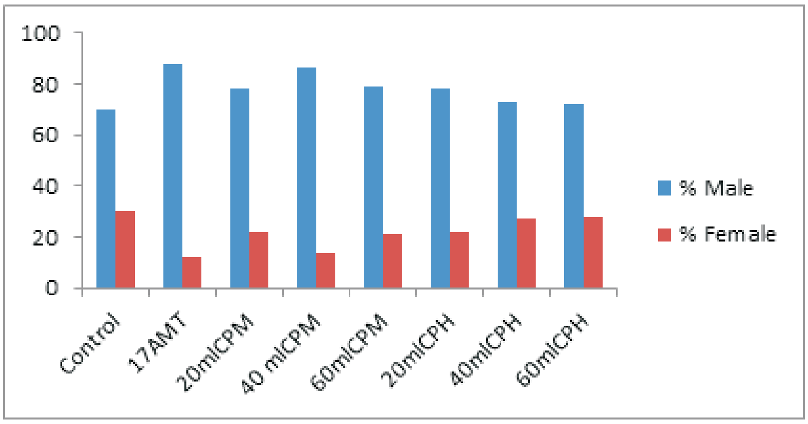

Figure 1. shows sex ratios of Oreochromis niloticus treated with 17*a*-MT hormone, Carica papaya seeds extract after a 180 days trial.

(CPM: Carica papaya extracted with methanol; CPH: Carica papaya extracted with hexane)

The result of sex ratios in the various treatments shows that, the negative control group (Control) which was fed with the basal diet only, had the lowest male to female sex ratio (M:F) of 2:1. There was significantly ($p<0.05$) higher males to female ratio of 7:1 in the positive control group (17a -MT) which were fed with feed mixed with 17*a*-MT hormone. 40mlCPM was able to skew the ratio in favour of males at 6:1. This is in accordance with the result of Onyia et al., 2022 who reported high male to female ratio.

Gonad histology

The male gonads were differentiated by fine granular-like structure of spermatogonia and the female gonads were characterized by having a structure with pre-vitellogenic oocytes (Fig. 2 and 3).

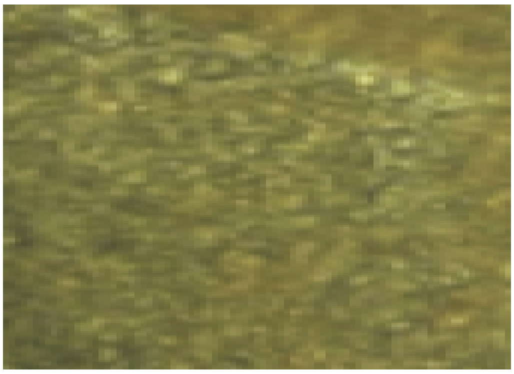

Figure. 2. Male gonads differentiated by fine granular-like structure of spermatogonia. Mg x 100

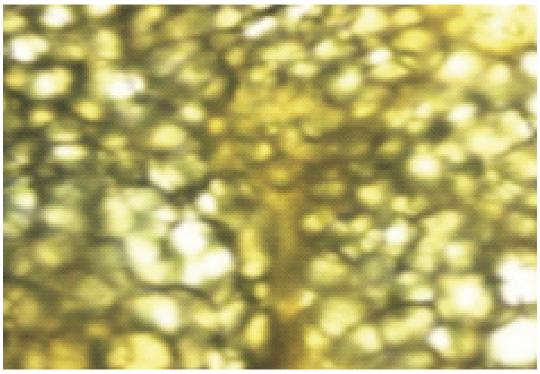

Figure: 3 Female gonads differentiated by previtellogenicoocytes. Mg x 100

DISCUSSION

The use of phytochemicals as viable alternative to 17-a -methyl testosterone in the production of monosex tilapia an economically important food fish holds a great prospect. From this study, it shows that Carica papaya seeds extract has the potential to induce sex reversal in tilapia. The study highlights the potential of using Carica papaya seed extracts as an alternative to 17a -Methyltestosterone for producing monosex tilapia, a key food fish. This method offers an environmentally friendly approach that could enhance profitability and reduce environmental degradation. It also minimizes health risks associated with synthetic steroids. In developing countries like Nigeria, where natural water systems are abundant, this phytochemical-based approach can provide a cost-effective and sustainable solution for aquaculture. The research suggests that using plant extracts for sex reversal in tilapia can benefit fish farmers, aquaculture scientists, and consumers by offering a safer, more affordable alternative to synthetic hormones.

ACKNOWLEDGEMENT

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REFERENCES

El-Sayed, A. F. M. (2006). Tilapia culture. CABI Publishing. CABI International Wallingford Oxfordshire UK. pp215.

FAO (2020).The State of the World's Fisheries and Aquaculture.Food and Agriculture Organization of the United Nations.

Guerrero, R. D. (2007). Sex reversal in Tilapia: A review. Asian Fisheries Science, 20(2), 131-144.

Hussain, S., Shah, S.T., Farooq, M. A. and Iqbal, M.Z. (2009). Phytochemical analysis and antimicrobial activity of extracts from Trachyspermumammi (L.) Sprague. African Journal of Biotechnology, 8 (22), 6226-6233.

Kristensen, T. (2017). Hormone use in Aquaculture: A review. Journal of Aquaculture Research & Development, 8(2), 1-9.

Raji, A. R. (2018). Sex reversal in Nile tilapia using Carica papaya seeds extract. Journal of Fisheries and Aquatic Science, 13(2), 123-128.

Suman, S., Raghavan, R. and Gupta, S. (2016). Effects of 17a -methyltestosterone on sex reversal and growth in Nile tilapia (Oreochromisniloticus).Journal of Applied aquaculture, 28(2), 147-155.

Vinarukwong N, Lukkana M., and Wongtavatchai J. Decreasing duration of androgenic hormone feeding supplement for production of male monosex in Tilapia (Oreochromis spp.) fry. Thai Journal of Veterinary Medicine, 48 (3) (2018), pp. 375-383

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

EVALUATION OF THE PRODUCTION PERFORMANCE OF LOCAL Oreochromis niloticus, THAI AND THEIR HYBRIDS.

Binyotubo, O. I., Maradun, H. F., Eze, J. O., E. A. Robert., K. E. Ogbuebunu., U. B. Abdullahi., Z. J. Ibrahim., I. Abdulkadri., U. B. Mohammed and C. C. Offor

National Institute for Freshwater Fisheries Research (NIFFR), PMB 6006, New Bussa, Niger state.

Corresponding author:
wumibintotubo@yahoo.com, +2348076150751

ABSTRACT

Two hundred and twenty-five (225) progeny samples of the local Nile, Thai and the hybrid tilapia were purchased from NIFFR Fish breeding and culture program. They were distributed into nine (9) hapa measuring 2m x 1m x 1.5m in a 10m x 10m concrete tank. Stocking density was 25 fishes per tank and 75 fishes per treatment. There were three treatments. Fish were fed to satiation using NIFFR feed which is 25% rich in crude protein. The experimental duration was 90 days. Body weight measurements were taken bi-weekly. Results from this study documented that treatment H, the hybrid (cross) between local O. niloticus, and Thai Tilapia reported the highest final total weight of 2468.10g among the treatments. This was closely followed by treatment T (for the Thai species) whose final total weight showed 2245.60g. Treatment L (the local species) reported the lowest results of 2240.30g in the study. There was no significant difference ($p>0.05$) throughout the study treatments. Physico-chemical parameters of the water during the study were within optimal range for Tilapia culture. This report sought to assess comparatively, the growth performance of the local Oreochromis niloticus, Thai and their hybrids. This document will also serve as a source of information for tilapia studies worldwide.

Keywords:
culture, pond, growth, local Oreochromis niloticus, Thai, hybrids

INTRODUCTION

Tilapia species Oreochromis niloticus, are in abundance in Nigeria water bodies, amongst other species of fishes (Omeje et al., 2020). Tilapia production enhances development in countries of the world. Nile tilapia has gained popularity in many parts of the world and has contributed to the growth of the economy in countries such as Asia (Arumugam et al., 2023). Concern over declining harvest in Nigeria and the obvious reduction in abundance and biodiversity of fish species from the wild has led to a more holistic approach in fisheries management and research in fish genetics so as to enhance food security, sustainable development and to understand the sustainability performance of the aquaculture sector (Adeleke et al., 2021).

The knowledge of the comparative growth performance of Oreochromis niloticus, Thai tilapia, and their hybrids is vital for optimizing aquaculture practices, improving productivity, and ensuring sustainable fish production. This research focused on addressing this challenging knowledge gap through a detailed analysis of the growth performance of Oreochromis niloticus, Thai tilapia, and their hybrids under controlled aquaculture conditions.

MATERIALS AND METHODS

Samples of the local Nile and Thai tilapia were obtained from NIFFR Fish Breeding and Culture Program, in New Bussa, Niger state Nigeria. Broodstocks of Nile tilapia and Thai Tilapia were allowed to mate at random. The broodstocks of Nile and Thai tilapia were crossed to produce hybrids used for this experiment. At age 45 days (±2.15g), progeny groups of the hybrids were randomly distributed into concrete culture tanks, numbering 25 per tank, per treatment and in triplicates. The local Nile Oreochromis niloticus and the Thai tilapias were also distributed into the concrete tanks, 25 per tanks per treatment and triplicated. Culture tanks measured 2 x 2 x1m2. Fishes were fed high energy commercial diet (25% crude protein NIFFR feed). The duration of the experiment was for 120 days. Body weight measurements were taken bi-weekly. Physico-chemical parameters of water such as: water temperature, dissolved oxygen, pH, were monitored and measured during the experiment. Data collected were subjected to statistical analysis using SPSS Version 25. Mean separation was also tested using Duncan Multiple Range Test (DMRT). The levels of significance ($p < 0.05$) (Duncan, 1955) were determined by the differences observed in the study. Regression analysis was also determined (Robert, 2021).

RESULTS

Results for growth, water quality and length-weight regression are documented in Table 1 and table 2 of this study.

Table 1: Growth studies of Oreochromis niloticus (local tilapia), Thai tilapia, and their hybrids

	Treatments		
Parameters	**L (Local O. *niloticus*)**	**T (Thai)**	**H (Hybrid)**
Initial Number stocked	75	75	75
Initial Total Weight (g)	453.50^a	451.20^a	452.20^a
Initial Mean Weight (g)	5.28^a	5.24^a	5.24^a
Final Number harvested	120^a	121^a	120^a
Final Total Weight (g)	2240.30^a	2245.60^a	2468.10^a
Final Average Weight (g)	35.90^a	37.92^a	43.03^a
Mean Weight Gain (g)	2022.10^a	2096.10^a	2397.20^a
Specific Growth Rate (%)	23.01^a	23.22^a	25.12^a
Percentage Weight Gain	1455.27^a	1479.03^a	1720.12^a
Condition factor (CF)	3.100^a	3.150^a	3.510^a

Means in the same column (for each section) with different superscripts are statistically different ($p<0.05$).

Table 2: Length-weight relationship regression of Oreochromis niloticus (local tilapia), Thai tilapia, and their hybrids in the study

Treatments	Intercept (a)	Slope (b)	Regression square (R^2)
***Oreochromis niloticus* (local tilapia)**	2.12	2.40	1.20
Thai tilapia	2.16	2.44	1.40
Hybrid	2.55	2.79	1.75

DISCUSSION

Despite the differences in the final total weight, numerically higher values were observed throughout the treatments. The final total weight suggests that treatment H, the hybrid between local O. niloticus and Thai tilapia, as observed on Table 1, exhibited the highest weight at 2468.10g, followed by treatment T (2245.60g), which was the Thai species, and lastly treatment L (2240.30g), representing the local species. A similar study by Correia et al. (2019) documented the potential for increased growth performance in tilapia hybrids even as a lesser amount of dietary protein was required. Their report agreed with the results of this study, enhancing the fact that hybridization aids maximum growth performance. Condition factor as recorded in this study showed the fishes were healthy with values greater than 1. An earlier study by Robert et al. (2019) greatly supports this finding. Length-weight regression values in this study also showed that the fishes grew negatively allometrically with values less than 3. Robert (2021) supports this theory citing b-values of 1.47, 1.87 and 1.89 respectively. However, the b-values in this study, while not being up to 3, were higher than the values obtained in Robert (2021). Physico-chemical parameters of the water during the study were within optimal range for Tilapia culture.

CONCLUSION

While the differences in final total weight and growth parameters suggested potential for hybrid culture, the lack of statistical significance tells the complexity of growth performance dynamics in tilapia culture. The results conclusively highlight the importance of considering feeding as an important prerequisite to a successful study. It is imperative to note that, conducting further research will give more views on the growth potential of Oreochromis niloticus, Thai tilapia, and their hybrids.

REFERENCES

Adeleke, M.L., Al-Kenawy, D., Nasr-Allah, A.M., Dickson, M. and Ayal, D. (2021). Impacts of environmental change on fish production in Egypt and Nigeria: technical characteristics and practice. African Handbook of Climate Change Adaptation. pp. 2820.

Arumugam, A., Jayaraman, S., Sridhar, A., Venkatasamy, V., Brown, P.B., Kari, Z.A.,Tellez-Isaias G. and Ramasamy, T. (2023). Recent advances in tilapia production for sustainable developments in Indian aquaculture and its economic benefits. Fishes, 8(4),176.

Correia, D., Escarcega-Miranda, B., Barreto-Curiel, F., Mata-Sotres, J., Rio-Zaragoza, O.D.,Viana, M.T. and Rombenso, A.N. (2019). Growth performance and body composition of hybrid red tilapia (Oreochromis mossambicus x O.aureus) fed with different protein levels raised in salt water. Latin American Journal of Aquatic Research, 47(5), 853-859.

Omeje, J.E., Sule, A.M. and Aguihe, E.O. (2020). An assessment of aquaculture table-size farmers activities in Kainji Lake Basin, Nigeria. Agro-Science, 19(2), 36-40.

Robert, E.A., Yisa, A.T. and Tsadu, S.M. (2019). Growth performance and survival of monosex cultured Heterobranchus longifilis Juveniles in concrete flow-through and stagnant water systems. Scientific Research Journal (SCIRJ), 7(2), 43-65. doi: 10.31364/SCIRJ/v7.i2.2019.P0219615

Robert, E.A. (2021). Responses of Clarias gariepinus fingerlings fed commercial and local feeds and reared in concrete recirculatory and flow-through water tanks. Proccedings of the 3rd Annual Conference of the Freshwater Biological Association (FBAN), Held on 12th -16th September at University of Uyo, Akwa Ibom state, Nigeria. pp: 69-72.

WATER QUALITY AND AQUACULTURE: AN ASSESSMENT OF THE SUITABILITY OF OGIDEKPE RIVER FOR AQUACULTURE.

[1]Oboh, I. P., [1]N. K. Egun, [2]J. Edoreh and [1]U.C. Olowo.

[1]. TETFund Centre of Excellence in Aquaculture and Food Technology, University of Benin, Nigeria.
[2]. Department of Zoology, Ambrose Alli University, Ekpoma Edo State, Nigeria.

Corresponding Author:
Ijeoma.oboh@uniben.edu.ng, +23408024761724, 0000 0001 5612 4166

ABSTRACT

Source water quality is vital to the successful practice of aquaculture. The increasing practice and establishment of earthen ponds for aquaculture in close proximity to lotic water bodies has necessitated the need for the suitability assessment of their water quality. The aim of this study is to ascertain the suitability of Ogidekpe River as source water for aquaculture practice. Water samples were collected from four (4) designated stations along the Ogidekpe River from September to December 2023, and twenty (20) physico-chemical parameters were analyzed according to standard methods. Observed concentration values were compared with the Nigerian Standard Water Quality Criteria for Fisheries. Concentrations of physico-chemical parameters were within their respective permissible limits, except for turbidity (27 – 30.6 NTU), dissolved oxygen (3.06 – 5.06 mg/L), iron (0.33 – 0.39 mg/L), chromium (0.04 – 0.08 mg/L), lead (0.01 – 0.013 mg/L) and zinc (0.21 – 0.38 mg/L) at all the stations. High water turbidity and heavy metal – iron, chromium, lead and zinc content values which exceeded the water quality criteria for fisheries, makes the river an unsuitable water source for aquaculture. Utilizing the River as source water requires that water retention ponds be constructed to allow for sedimentation and treatment before use for fish culture. There is need also to identify point sources of pollution within the watershed and enforce compliance to environmental laws in order to improve the overall water quality of the river.

Keywords:
Physico-chemical parameters, Fish ponds, Fisheries, Nigeria

INTRODUCTION

Information on source water quality and quantity are indispensable in choosing a location for an aquaculture facility, as fishes are totally dependent on water. Water quality in aquaculture refers to the physico-chemical and biological constituents in water can affects the fish normal health and production performance (Balogun, 2015). Fishes have a limited range of concentration for physico – chemical properties of freshwater in which they can grow optimally). Studies have shown that certain range of water physico-chemical values are essential to a healthy, balanced, and successful freshwater fisheries (DeLong *et al.,* 2009; Abubakar, 2013), as water quality directly affects the fishes' feed efficiency, growth rates, optimal survival and reproduction (ACTFR, 2002). Water quality is of critical importance in aquaculture practice as it significantly influences the physiology, development and nutritional composition of the fish (Himmel *et al.,* 2010; Egun, 2021). As undesirable changes in fish physiology associated with certain fish farms have been linked to the absence of background information on the source of water used. Hence the screening of source water for its physico – chemical properties is an important initial step in determining the suitability of the source water for aquaculture.

In recent times, there has been an increase in the establishment of earthen fish ponds within the watershed of inland freshwater bodies in Nigeria. As these water bodies such as rivers, streams and reservoirs offer a readily available and inexpensive source of water for aquaculture. Although the use of natural surface freshwater sources has been shown to be good sources of zooplankton in aquaculture (Abo-Taleb, 2019), the increasing decline in their water quality due to anthropogenic activities (: Egun and Oboh, 2022; Egun and Oboh, 2023; Biose et al., 2024) has necessitated studies to ascertain their present suitability for continuous use in aquaculture. The prevailing challenge of access to groundwater resources in the study area has placed an increasing demand on Ogidekpe River for freshwater supply for domestic and commercial activities including aquaculture. Therefore, the aim of this study is to ascertain the suitability of Ogidekpe River for aquaculture.

MATERIALS AND METHODS

Study Location: This study was carried out at Ogidekpe River (Latitudes 006o77'87'N and 006o45'78'N and Longitudes 06o15'86'E and 06o86'28'E) which transverses through Esan West Local Government Area and Owan East Local government area in Edo State, Nigeria. It is an oligotrophic lotic freshwater body (Imoobe and Adeyinka 2009), with vegetative canopy occurring laterally for most parts of its bank.

Water Sampling and Analysis: Water samples were collected monthly from four (4) designated stations along the Ogidekpe River from September to December 2023. The designated stations were identified communal access points to the river. Water samples were analyzed for twenty (20) physico-chemical parameters according to the outlined procedures in the Standard Methods for the Examination of Water and Wastewater (APHA, 1998). Observed concentration values were compared with the Nigerian Standard Water Quality Criteria for fisheries (NESRA, 2011).

Data Analysis: Statistical analyses were computed using Microsoft Excel and the Statistical Package for Social Sciences (SPSS 16.0). The data are presented as pooled means ± standard deviation (SD) of the water samples collected from each sampling station.

RESULTS AND DISCUSSION

Results of the physico-chemical parameters of Ogidekpe River are presented in Table 1. Across the four (4) study stations, the range of values for water pH (6.40 – 7.86), electrical conductivity (18 – 30.00 *u*S/cm), biochemical oxygen demand (0.3 – 2.90 mg/L), chloride (7.06 – 21.18 mg/L), sulphate (1.00 – 14.00 mg/L), phosphate (0.15 – 0.30 mg/L), nitrate (0.03 – 0.07 mg/L), calcium (1.60 – 4.01 mg/L), magnesium (0.97 – 4.38 mg/L) and nickel (0.02 – 0.06 mg/L) did not exceed their respective NESRA (2011) permissible limits for water quality criteria for fisheries. The dissolved oxygen levels (2.50 – 5.80 mg/L) were below the minimum acceptable limits of 6.00 mg/L. While mean values for suspended solids (10.92 mg/L), turbidity (21.98 mg/L), and the heavy metals - iron (0.37mg/L), lead (0.01 mg/L), zinc (0.31 mg/L) and chromium (0.06 mg/L) exceeded their respective permissible limits for aquaculture.

Table 1: Summary of the Physico–chemical characteristics of Ogidekpe River and its suitability for Fisheries

Parameters	Mean ± SD	Min.	Max.	Standard Water Quality Criteria for fisheries (NESRA, 2011)	Remarks
pH	6.80 ± 0.35	6.4	7.86	6.5 – 8.5	Satisfactory
E. Conduct. (μS/ cm)	22.33 ± 4.82	18	30	400	Satisfactory
Suspended Solid	**10.92 ± 7.40**	**0**	**28**	**0.25**	**Not Satisfactory**
Turbidity (NTU)	**21.58 ± 11.98**	**1**	**48**	**< 20**	**Not Satisfactory**
DO (mg/L)	**4.69 ± 0.81**	**2.5**	**5.8**	**= 6.0**	**Not Satisfactory**
BOD (mg/L)	1.83 ± 0.76	0.3	2.9	= 3.0	Satisfactory
Chloride (mg/L)	12.36 ± 4.20	7.06	21.18	300	Satisfactory
Sulphate (mg/L)	7.00 ± 3.16	1	14	100	Satisfactory
Phosphate (mg/L)	0.22 ± 0.04	0.15	0.30	3.5	Satisfactory
Nitrate (mg/L)	0.04 ± 0.01	0.03	0.07	= 9.1	Satisfactory
Calcium (mg/L)	2.48 ± 0.61	1.6	4.01	180	Satisfactory
Magnesium (mg/L)	2.15 ± 0.88	0.97	4.38	40	Satisfactory
Iron (mg/L)	**0.37 ± 0.05**	**0.29**	**0.43**	**0.05**	**Not Satisfactory**
Lead (mg/L)	**0.01 ± 0.003**	**0.01**	**0.02**	**0.01**	**Not Satisfactory**
Zinc (mg/L)	**0.31 ± 0.16**	**0.136**	**0.635**	**0.01**	**Not Satisfactory**
Chromium (mg/L)	**0.06 ± 0.03**	**0.03**	**0.116**	**0.001**	**Not Satisfactory**
Nickel (mg/L)	0.04 ± 0.01	0.02	0.058	0.10	Satisfactory

The level of water turbidity is a reflection of the amount of suspended matter such as clay, silt, organic Fmatter, plankton and some other microscopic organisms present in the water (Fondriest Environmental, 2014). High turbidity and total suspended solids levels in surface freshwater bodies inhibits photosynthesis resulting in decreased dissolved oxygen output (Wetzel, 2001; Egun and Oboh, 2022); affect the ability of fish gills to absorb dissolved oxygen from the water and lowers their resistance to diseases and parasites (Fondriest Environmental, 2014; Balogun, 2015). The influence of the observed high total suspended solids and turbidity levels in Ogidekpe River is shown in the depleted dissolved oxygen levels in the surface water. Dissolved oxygen is a very basic requirement for aquaculture and the first limiting factor to occur in pond aquaculture. Low dissolved oxygen levels impede fish reproduction, as a good dissolved oxygen content (= 6.00 mg/L) is needed for eggs and immature development stages (Oram, 2014). Bulbul et al. (2022)reported that good dissolved oxygen levels in grow out aquaculture had a significant positive effect on the growth and fish conversion ratio of fishes.

Iron content in surface freshwater bodies is dependent on the on the geological area and other chemical components of the waterway (Lenntech, 2019). The toxicity of iron to fishes is dependent on the physico – chemical properties of the water such as water temperature, pH and dissolved oxygen. For zinc, the principal mode of action for acute zinc toxicity to freshwater fish is inhibition of calcium uptake, and destroying of gill tissues, thereby inducing stress and death of fish (Bhateria and Jain, 2006; Giardina et al., 2009). The recorded elevated iron, chromium and zinc levels in the river implies that its reliance as source water for fish culture in its untreated form, predisposes the fishes to heavy metal toxicity and physiological stress.

CONCLUSION

The choice of a good source of water that will provide large quantities of high-quality water is one of the paramount undertakings to a successful aquaculture business, as fishes require large quantities of unpolluted water to grow rapidly and maintain their state of well-being. Although Ogidekpe River can provide the volume of water needed for fish culture, the unsatisfactory levels of several key physico-chemical parameters and their attendant effects on the development of fishes makes the water source unsuitable for use in aquaculture. Therefore, utilizing the river as source water requires that water retention ponds be constructed to allow for sedimentation and treatment before use for fish culture. Also, there is need to identify point sources of pollution within the watershed and enforce compliance to environmental laws in order to improve the overall water quality of the river.

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REFERENCES

Abo-Taleb, H. (2019). Importance of Plankton to Fish Community. IntechOpen. doi: 10.5772/intechopen.85769

Abubakar, U. M. (2013) Physico-chemical parameters in relation to fish production of Dadin Kowa Dam, Gombe State, Nigeria. Proceedings of 28th Fisheries Society of Nigeria Annual Conference, Nov. 25 - 30, 2013 page 211 – 213.

APHA (1998). Standard methods for the examination of water and waste water, 20th edition. American Public Health Association/American Water Works association, Water Environment Federation, Washington DC, USA, pp 235-237.

Australian centre for tropical fresh water research (ACTFR, 2002). Water quality for sustainable Agriculture NRM wet tropics.

Balogun, J. K. (2015). Basic Aquaculture. Zaria, Nigeria: Ahmadu Bello University Press Ltd.

Bhateria, R. and Jain, D. (2006). Water quality assessment of lake water: a review. Sustain. Water Resour. Manag., 2: 161 – 173.

Biose, E., Egun, N. K., Uzoh, N. and Omoigberale, M. O. (2024). Assessment of water quality and associated human health risk of a tropical freshwater body in Edo State, Nigeria. African Journal of Aquatic Science, 1 – 12. https://doi.org/10.2989/16085914.2023.2292125 Bulbul, A., Anushka and Abha, M. (2022). Effects of dissolved oxygen concentration on freshwater fish: A review. International Journal of Fisheries and Aquatic Studies, 10(4): 113-127. https://doi.org/10.22271/fish.2022.v10.i4b.2693

DeLong, D. P., Losordo, T. M. and Rakocy, J. E. (2009). Tank culture of tilapia. Online; SRAC Publication No. 282. Southern Regional Aquaculture Center. 2009. Available at https://thefishsite.com/articles/tank-culture-of-tilapia

Egun, N. K. and Oboh, I. P. (2022). Freshwater Source Suitability for Aquaculture: A Case Study of Ikpoba Reservoir, Edo State, Nigeria. International Science and Technology Journal of Namibia, 15: 50 – 56. https://journals.unam.edu.na/index.php/ISTJN/article/view/1647

Egun, N. K. and Oboh, I. P. (2022). Surface water quality evaluation of Ikpoba reservoir, Edo State, Nigeria. International Journal of Energy and Water Resources, 6: 509 – 519. https://doi.org/10.1007/s42108-021-00139-z

Egun, N. K. and Oboh, I. P. (2023). Assessment of water quality for suitability and human health risk: a study of the Owan River, Edo State, Nigeria. African Journal of Aquatic Science, https://doi.org/10.2989/16085914.2022.2156468

Egun, N. K. and Ogiesoba-Eguakun, C. U. (2018). Physico – Chemical and Water Quality Index Analysis of the Okhuaihe River, Edo State Nigeria. African Journal of Aquatic Science, 43: (4): 345 – 351.

Fondriest Environmental, Inc. (2014). Turbidity, Total Suspended Solids and Water Clarity. Fundamentals of Environmental Measurements. 13 Jun. 2014. Web. < https://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/ >.

Giardina, A., Larson, S. E., Wisner, B., Wheeler, J. and Chao, M. (2009). Long-term and acute effects of zinc contamination of a stream on fish mortality and physiology. Environ Toxicol Chem., 28 (2): 287 – 295.

Himmel, D., Goll, S. K., Leito, I. and Krossing, I. (2010). A Unified pH Scale for all Phases. Angew. Chem. Int. Ed., 49: 6885 – 6888.

Imoobe T.O.T. and Koye P. I. (2011). Assessment of the impact of effluent from a soft drink processing factory on the physico-chemical parameters of Eruvbi stream Benin City, Nigeria. Bayero J. of Pure and Appl Sci. 4 (1): 126 – 134.

Lenntech (2019). Iron. https://www.lenntech.com/periodic/elements/fe.htm. Accessed November 13, 2019.

National Environmental Standards and Regulation Enforcement Agency (NESRA) (2011). National Environmental (Surface and Groundwater Quality Control) Regulations. Federal Republic of Nigeria Official Gazette, 24 th May, 2011. Vol. 98, No. 49. Pages B693 – 729.

Oboh, I. P. and Egun, N. K. (2017). Groundwater Suitability for Aquaculture: A case study of Agbor, Delta State, Nigeria. Ethiopian Journal of Environmental Studies and Management, 10 (9): 1193 – 1199.

Oram B. 2014. Water quality terms glossary. http//www.water-resaerch [Accessed 4 April 2017].

Wetzel, R. G. (2001). Limnology: Lake and River ecosystems (3rd ed.) San Diego, CA: Academic press

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ASSESSMENT OF DRIED THYME LEAVES *(Thymus vulgaris)* POWDER AS ANAESTHETIC AGENTS IN DIFFERENT SIZES OF *Tilapia guineensis*

[1]Ogolo, C, 2O.A. Akinrotimi , [3]O.M. Edun , [4]K.N. Owhonda, [5]P.O.Nwosu, , [6]C.A.Akinrotimi , [7]O.M. Isaac , and 8F.A. Omodu

[1, 2,3,4,5,8] Department of Mariculture, Nigerian Institute for Oceanography and Marine Research, Buguma, Rivers State, Nigeria.
[6]Department of Agronomy, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria
[7] African Regional Aquaculture Center, of Nigerian Institute for Oceanography and Marine Research, Port Harcourt, Rivers State, Nigeria.

Corresponding Author:
ojoakinrotimi@gmail.com, +2348065770699, 0000-0003-2775-645X

ABSTRACT

An investigation was conducted on the effectiveness of dried Thyme *(Thymus vulgaris)* leaves powder as anesthetic agents in Tilapia guineensis. A total of 450 *T.guineemsis* comprised of 150 each of fingerlings (mean length 7.22 cm1.08 SD, mean weight 10.53g 3.55 SD) juvenile (mean length 12.43 cm1.37 SD, mean weight 45.44g 6.02 SD) and adult sizes (mean length 17.88 cm3.54 SD, mean weight 170.87g 22.09 SD) were exposed to five concentrations 0.00-control, 10.0, 20.0, 30.0, and 40.0 mg/l of dried thyme leaves. The time for onset of anaesthesia for the exposed fish was measured using a digital stopwatch. The outcomes showed that the extracts of thyme leaves caused a size-related reactions. As the quantities of the thyme extracts increased, the induction time significantly reduced ($P < 0.05$). In general, the recovery times for all three sizes increased as the anesthetic concentrations increased. Furthermore, adult fish showed longer recovery periods across the board; which was followed by juvenile and fingerlings size trailed behind. The findings of this study indicate that dried thyme leaves have the ability to successfully cause anesthesia in fish. The ideal dosage for fingerlings, juveniles, and adults is 20.0, 30.0, and 40.0 mg/L of the extracts respectively.

Keywords:
Aquaculture, Sedatives, Spices, Fish, Anaesthesia

INTRODUCTION

The use of anesthetics in aquaculture is common due to its beneficial effects on reducing fish stress and preventing physical harm to fish during routine procedures like artificial spawning, fish weighing or measuring, fish sorting and tagging, vaccination administration, live transport, gamete collection, blood sampling for gonadal biopsies, and fish collection, to name a few (Can *et al.*, 2019). They also help to lower stress levels and facilitate surgical procedures involving extended immobilization (Kiessling *et al.*, 2019). According to Akinrotimi (2014). The fish must exhibit symptoms including decreased breathing, loss of balance, relaxed muscular tone, and incapacity to react to stimuli in order to be considered to have received an appropriate level of anesthesia. An effective anesthetic medication should not cause harmful side effects, be quickly excreted from the body, and not alter behavior, immunology, or physiology over time (Akinrotimi *et al.*, 2018).An important aspect for a farmer selecting anesthetics is to evaluate the following: the type of experiment being conducted, the species of fish being used, effectiveness, cost, availability, and ease of use (Akinrotimi *et al.*, 2013; Charoenda *et al.*, 2019). The fish should recover quickly from the anesthesia and the anesthetic should work even

at modest dosages (Akar, 2011; dacunha *et al.*, 2020).
The use of natural products in aquaculture has the potential to "shift the demand curve" away from synthetic chemicals. Herbs have been employed by humans for their medicinal properties since the dawn of civilization. Modern medications have been obtained in remarkable quantities from natural sources (Cooke *et al.*, 2004; Bodur *et al.*, 2018). The use of the agents in conventional medicine served as the basis for many of these isolations. In rural parts of Africa, especially Nigeria, ethno veterinary medicine is frequently practiced. Ethno veterinary therapy is most likely the only way to preserve and improve animal species' health in small-holder livestock systems found in developing nations. The majority of rural farmers lack access to synthetic medications as well as the necessary financial means (Akinrotimi *et al.*, 2014; Aydun *et al.*, 2019). Thymus vulgaris appears to be the most popular species of thyme found in Nigeria. It is an herb with a distinct smell. The flowers, leaves, and oil are commonly used to flavour foods and are also used as medicine. Thyme essential oil is rich in thymol, a component that is said to be antispasmodic. This can benefit the body by calming contracting muscles, offering relief and providing comfort from breathing difficulties, it could be very effective against respiratory tract infections like the common cold (Lambooji *et al.*, 2019). The information on the use of thyme in *T.guineensis* is scarce, hence the need for this study. This study therefore assesses the efficacy of dried Thyme leaves (Thymus vulgaris) powder as sedative agent in *T.guineensis*.

MATERIALS AND METHODS

Experimental Location and Fish

The study was carried out in African Regional Aquaculture Center, an outstation of Nigerian Institute for Oceanography and Marine Research, Buguma, Rivers State, Nigeria. A total of 450 *T.guineemsis* comprised of 150 each of fingerlings (mean length 7.22 cm1.08 SD, mean weight 10.53g 3.55 SD) juvenile (mean length 12.43 cm1.37 SD, mean weight 45.44g 6.02 SD) and adult sizes (mean length 17.88 cm3.54 SD, mean weight 170.87g 22.09 SD) were sourced from ponds during the low tide. The fishes were transported in six open 50l open plastic containers to the laboratory and acclimated for a period of seven days.

Preparation of Mustard Seed

Fresh Thyme Leaves (Plate 1) was purchased from fruit garden market at Kaduna Street, D-Line, Port Harcourt in Port Harcourt City Local Government Area of Rivers State. Plant authentication was done using the keys of Agbaje (2008). The thymes were rinsed in clean water, and dried in the laboratory at room temperature. They were tied together on a string and hung upside down and were allowed to stand for a period of two weeks. After the leaves were completely dried (Plate 2) the leaves were removed from the stem, the dried thyme were stored in an airtight container. The leaves were taken to the laboratory and grounded into powder using a kitchen blender (Model H2, Ken Wood, Japan). The milled thyme leaves was sieved using 0.1 micro plastic meshes to obtain the fine powder (Plate 3).

Experimental Design

The design of the experiment was Completely Randomized Design (CRD) having five treatments level each with three replicates for each of the life stages. A total of 45 plastic basins of dimension (52 x 44 x 34 cm3) each were used for the experiments. The 45 basins were labeled based on life stages of the fish, treatment levels and replicates. Each basin was stocked with 10 fish per tank. A total of 450 fish were stocked.

Experimental Procedure

The powder was weighed into different concentrations (10.0, 20.0, 30.0, and 40.0 mg/L) using a sensitive weighing balance (Model 1123HK, Digital Scales, Ltd, Beijing, China). It was applied directly in three replicates into the water (10L) in 30L experimental plastic aquaria. The water in the tanks was stirred vigorously to ensure homogenous mixture. The fish was weighed with 2.0 kg round top weighing scale (Model 1123HK, Digital Scales, Ltd, Beijing, China) which the length was measured with transparent meter rule. They were introduced into prepared experimental aquaria, containing five concentrations of powdered thyme leaves (10.00; 20.00; 30.00; 40.00 and 50.00 mg/L) at the rate of 10 fish per tank in triplicates.

Determination of Induction and Recovery Time

The time for onset of anaesthesia for the exposed fish was measured using a digital stopwatch. Fish behaviour was monitored individually through the induction and recovery stages in each life stage and concentrations. Recovery time which followed the following stages; reappearance of opercula movements, partial recovery of equilibrium, irregular balance, total recovery of equilibrium and lastly, normal swimming was observed (Cooke et al., 2004). Recovery time was then recorded.

Evaluation of Water Quality Parameters

The water pH was determined in situ in each of the aquarium with a pH meter (Hanna Products, Portugal). The temperature of the water was measured by placing the mercury in glass thermometer in the water and taking a reading after five minutes at 15cm depth. Nitrite, ammonia and dissolved Oxygen were evaluated using LaMotte fresh water test kit (Model AQ4, Chestown, Maryland, USA).

Statistical Analysis

The data obtained from this study was collated and analyzed using statistics software SPSS version 22. Data was tested first for normality (Kolmogorov-Smirnov test) and homosesdasticity of variance (Bartts test). When these conditions were met with full satisfactions, a one way analysis of variance (ANOVA) was employed to reveal significant differences in measured variables among control and experimental groups. When a different was detected ($P<0.05$), Tukey's multiple comparison test was applied to identify which treatment should be significantly different

Plate 1: Fresh Thyme

Plate 2: Dried Thyme

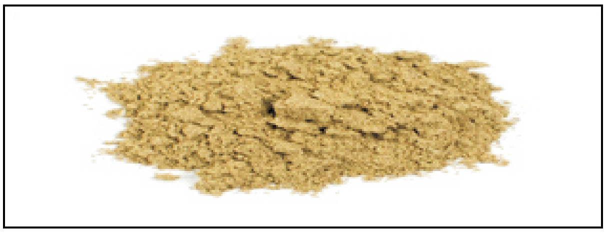

Plate 3: Ground Thyme

RESULTS

The water quality parameters in experimental tanks of T.guineensis exposed to Thyme leaves extracts are presented in Table 1. The results indicated a significant reduction ($P<0.05$) in the values of dissolved oxygen which reduced with increasing concentration of the anaesthetics. While other water quality parameters were within the same range with no significant different in relation to the concentration of the anaesthetics ($P>0.05$). The induction, recovery and survival in fingerlings of T.guineensis exposed to thyme leaves extracts are presented in Tables 2. The results in indicated that the values of induction time significantly ($p<0.05$) reduced with increasing concentrations of the thyme leaves extracts. While the recovery time significantly ($p<0.05$) increased as the concentrations of thyme leaves extracts increased. The survival of the exposed fish was 100.00% between 0.00-20.00mg/l of the extracts. However, 80.00% and 70.00% survival were recorded at 30.00 and

40.00mg/l of the extracts. The same trend were equally observed in juveniles (Table 3) and adults (Table 4) sizes of T.guineensis exposed to different concentrations of thyme leaves extracts. The survival of the exposed fish was 100.00% between 0.00-30.00mg/l of the extracts. However, 80.00% survival were recorded at 40.00mg/l of the extracts for juvenile size (Table 3), while, the adult fish recorded 100.00% survival in all concentrations of exposure (Table 4).

The comparative values of induction time in different sizes of T.guineensis exposed to thyme leaves extracts is shown in Figure 1. The use of Thyme leaves extracts as anaesthetics resulted in different induction times depending on the dosage and size of the fish. Furthermore, the induction times in adult size of T.guineensis were higher than the juveniles, which in turn was higher than that of fingerlings (Figure 1). Comparatively, the recovery time (Figure 2) in T.guineensis exposed to thyme leaves extracts indicated a significant ($P < 0.05$) increase in the recovery time, as the concentrations of the extracts increased. However, the recovery times in adult size of T.guineensis were higher than the juveniles, which in turn was higher than that of fingerlings in all concentrations of the extracts (Figure 2). Comparatively, the results of the survival of the exposed fish during the trial (Figure 3), indicated that the survival rate in adult size of T.guineensis were higher than the juveniles, which in turn was higher than that of fingerlings in all concentrations of the extracts (Figure 3).

Table 1: Water Quality Parameters in Experimental Tanks of T.guineensis exposed to Dried Thyme Leaves Extracts (Mean SD)

	Concentrations (mgL^{-1})				
Parameters	**0.00**	**10.00**	**20.00**	**30.00**	**40.00**
Temperature (°C)	28.11 ± 0.33^{a}	$28.43 \pm 0.^{88a}$	29.41 ± 1.33^{a}	28.02 ± 0.66^{a}	28.09 ± 0.77^{a}
pH	6.02 ± 0.33^{a}	6.71 ± 0.44^{a}	6.23 ± 0.77^{a}	6.71 ± 0.88^{a}	6.65 ± 0.99^{a}
DO(mgL^{-1})	6.88 ± 0.22^{c}	6.41 ± 0.31^{c}	5.71 ± 0.44^{b}	5.01 ± 0.79^{b}	4.31 ± 0.55^{a}
Nitrite (mgL^{-1})	0.001 ± 0.01^{a}	0.050 ± 0.02^{a}	0.055 ± 0.02^{a}	0.058 ± 0.02^{a}	0.067 ± 0.02^{a}
Ammonia (mgL^{-1})	0.20 ± 0.01^{a}	0.20 ± 0.01^{a}	0.20 ± 0.02^{a}	0.20 ± 0.03^{b}	0.21 ± 0.01^{b}

Mean within the row with different superscripts are significant ($P<0.05$)

Table 2: Induction, Recovery and Survival of T.guineensis Fingerlings exposed to Dried Thyme Leaves (Mean SD)

Concentrations (mg/l)	Induction (s)	Recovery (s)	Survival (%)
0.00	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	100.00 ± 0.00^{b}
10.00	415.09 ± 28.39^{c}	301.66 ± 31.22^{b}	100.00 ± 0.00^{b}
20.00	289.68 ± 49.77^{b}	303.77 ± 42.05^{c}	100.00 ± 0.00^{a}
30.00	254.65 ± 32.99^{b}	675.09 ± 30.11^{d}	80.00 ± 0.00^{a}
40.00	232.02 ± 20.04^{b}	692.02 ± 20.22^{d}	70.00 ± 0.00^{a}

Mean within the column with different superscripts are significant ($P<0.05$)

Table 3: Induction, Recovery and Survival of T.guineensis Juveniles exposed to Dried Thyme Leaves (Mean SD)

Concentrations (mg/l)	Induction (s)	Recovery (s)	Survival (%)
0.00	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	100.0 ± 0.00^{b}
10.00	688.44 ± 66.90^{d}	477.04 ± 22.87^{b}	100.00 ± 0.00^{b}
20.00	472.01 ± 22.06^{c}	567.02 ± 33.12^{c}	100.00 ± 0.00^{a}
30.00	321.04 ± 22.06^{b}	699.55 ± 22.11^{d}	100.00 ± 0.00^{a}
40.00	301.02 ± 35.88^{b}	752.11 ± 18.33^{d}	80.00 ± 0.00^{a}

Mean within the column with different superscripts are significant ($P<0.05$)

Table 4: Induction, Recovery and Survival of T.guineensis Adults exposed to Dried Thyme Leaves (Mean SD)

Concentrations (mg/l)	Induction (s)	Recovery (s)	Survival (%)
0.00	0.00± 0.00[a]	0.00± 0.00[a]	100.00± 0.00 [b]
10.00	799.48± 44.02[d]	580.43± 20.02[b]	100.00± 0.00 [a]
20.00	688.75± 32.22[c]	689.99± 30.99[c]	100.00± 0.00 [a]
30.00	500.07± 20.22[b]	799.02± 21.02[d]	100.00± 0.00 [a]
40.00	344.88± 23.02[b]	801.22± 18.44[d]	100.00± 0.00 [a]

Mean within the column with different superscripts are significant

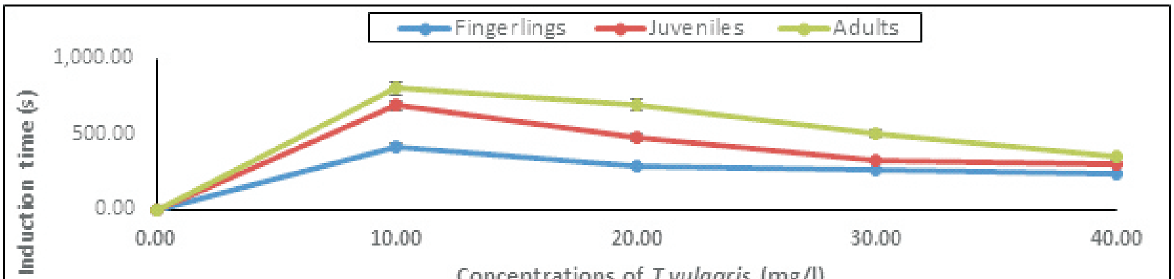

Figure 1: Comparative values of Induction time in different sizes of *T.guineensis* exposed to *T.vulgaris* as anaesthetics

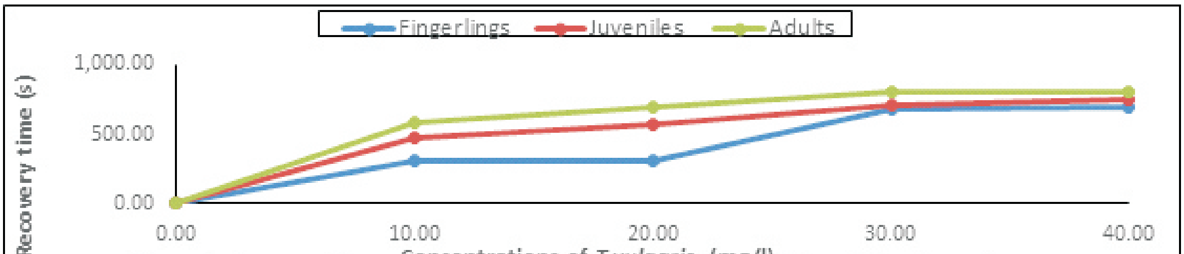

Figure 2: Comparative values of Recovery time in different sizes of *T.guineensis* exposed to *T.vulgaris* as anaesthetics

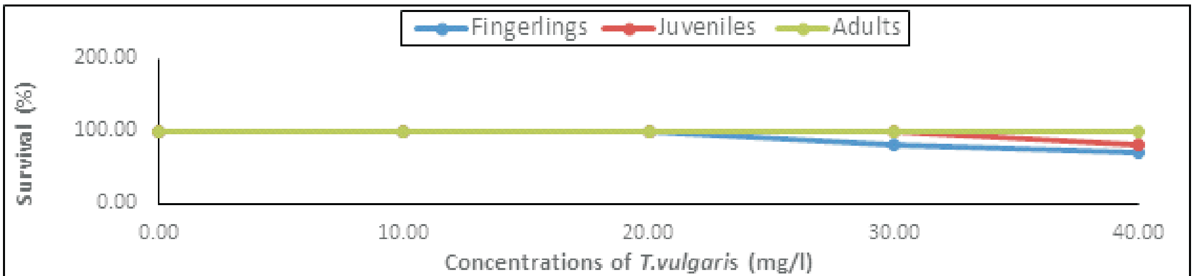

Figure 3: Comparative values of Survival in different sizes of *T.guineensis* exposed to *T.vulgaris* as anaesthetics

DISCUSSION

The water quality parameters in experimental tanks in the three life stages of T.guineensis exposed to thyme extracts indicated a significant reduction (P<0.05) in the values of dissolved oxygen which reduced with increasing concentration of the anaesthetics. While other water quality parameters were within the same range with no significant different in relation to the concentration of the anaesthetics. The decrease in DO with increase in concentration of the plant extracts in this study corroborates the report of Akinrotimi et al. (2018) in the experimental waters of C.gariepinus exposed to clove seed extracts. It also agrees with the findings of Audu et al. (2013) that DO decrease with increase in concentration of C. sativa used as anaethetics, but disagreed with that of Anju et al. (2015) who recorded constant DO concentration as the concentration of Tephropsia vogelii aqueous leaf extract increased. The dissimilarity may be due to the differences in the composition of active ingredients in these plants (Ellis et al., 2022).

In this study, the induction time in T.guineensis exposed to thyme extracts reduced with increasing concentrations of the extracts. These findings are in agreement with other studies (Kiessling et al., 2019) in fish exposed to plant extracts as anaesthetics. When using anesthetics, it is expected that there will be an inverse relationship between the applied concentration and the time required to induce anesthesia to the desired stage, as observed previously for several fish species (Akinrotimi et al., 2016). Additionally, the induction time was related to the size of fish, with more time needed for larger fish to be anaesthetized. This may be because of higher rate of uptake of the anaesthetic through the gills in the smaller fish compared to the larger ones. This is in accordance with the results reported by Woody et al. (2022) for sockeye salmon (Oncorhynchus nerka).

The recovery time obtained in this study increased with increased doses of T.vulgaris. The recovery time varied with the concentration of T.vulgaris for various size groups. An increase in recovery time relative to plant extracts concentration was recorded in roach (Rutilus rutilus) (Sudagara et al., 2019), The recovery time was directly proportional with increasing doses of thyme extracts. The longest recovery time was observed at 40. 00mg/L and the shortest time to reach total recovery stage was detected at 20.0mg/L. Longer recovery time with the increased anaesthetic dosage has been reported in largemouth bass (Cooke et al., 2009). Suggestions might be that the rate of absorption of the anaesthetic as a function of body weight is slower in larger fish which may be reflective of the larger gill surface area relative to body size and, thus, a larger area for drug diffusion (Branson and Gross, 2021). According to Clarke and Johnston (1999), larger fish have relatively lower basal metabolism which may contribute to a slower rate of anaesthetic absorption. Furthermore, an ideal fish anaesthetic should induce deep anaesthesia in less than 180 s or 300s with little or no mortality (Ellis et al., 2022). It should also allow for rapid recovery in less than 600 s and leave little or no residues in the tissues (Branson and Gross, 2021). In the current study, all of the tested concentrations of thyme extracts could induce anaesthesia in T.guineensis. However, 20.00, 30.00 and 40.0mg/L of thyme extracts could be used to sedate fingerlings, juveniles and adult sizes of T.guineensis respectively. These met the criteria for an ideal anaesthetic in aquaculture as they recorded no mortality in these concentrations.

CONCLUSION

The results in this study indicated that applications of thyme extracts as anaesthetics did not affect the water quality parameters. The present study revealed that thyme extracts acted as an anaesthetic agent in sedating T.guineensis. Based on the results from this work: An effective concentration of 20.00, 30.00 and 40.0mg/L of thyme extracts could be used to sedate fingerlings, juveniles and adult sizes of T.guineensis respectively. This should only be used for quick procedures, such as biometric measurements and blood sampling. On the other hand, for lengthy procedures, such as artificial breeding, 40mg/ could be recommended.

REFERENCES

Agbaje, E.O. (2008). Gastro intestinal effects of Syzigium aromaticum in animal model. Nigeria Quarterly Journal of Hospital Medicine, 18(3), 137-141.

Akar, A.M. (2011). Effects of clove oil on the response of blue tilapia (Oreochromis aureus) by transportation stress. Journal of the Arabian Aquaculture society, 6(1), 77-86.

Akinrotimi O.A., Ansa, E.J. and Edun, O.M. (2016). Effectiveness of clove seed extracts as anaesthetics in transportation of Tilapia guineensis juveniles. Journal of Aquaculture Engineering and Fisheries Research, 2(2), 67-75.

Akinrotimi O.A., Edun, O.M. and Ukwe,O.I.K (2018).Effects of Anaesthetics on Metabolic Enzyme Activities in African Catfish, Clarias gariepinus (Burchell, 1822) Journal of FisheriesSciences.com 12(1), 022-028.

Akinrotimi, O.A. (2014). Assessment of the efficacy of synthetic and natural anaesthetics on the African catfish Clarias gariepinus (Burchell, 1822). PhD Thesis. Department of Fisheries and Aquatic Environment, Rivers State University of Science technology Port Harcourt. 260pp.

Akinrotimi, O.A., Edun, O.M. and Mebe, E.D. (2013a). effects of clove seeds as anaesthetic agents in two species of grey mullets Liza falcipinnis and Liza grandisqumis. Journal of Aquatic Science, 1(1), 7-10.

Akinrotimi, O.A., Gabriel, U.U. and Deekae, S.N. (2014). Investigations on the potential of Indian almond free (Terminalia catapaa) leaf extracts as anesthetic agents in African catfish (Clarias gariepinus). Journal of Aquatic Sciences, 29 (IB), 223-231.

Anju T.D, Solomon S.G. and Cheikyula, J.O. (2015). Effects of aqueous crude leaf extract of Tephropsia vogeli as a tranquilizer on the African Catfish, Heterobranchus longifilis Val. (Pisces 1840). American Journal of Research Communication, 3(6), 45-59.

Audu B.S., Adamu K.M. and Ufodike E.B.C. (2013). Behavioural response and opercula ventilation rate of Nile Tilapia (Oreochromis niloticus) fingerlings after anaesthesia with aqueous crude leaf extract of marijuana (Cannabis sativa). Applied Science Research Journal, 1(2), 66-77.

Aydin, B., Akhan, S., Gümü¸S, E. and Özba¸S, M. (2019). Anesthetic efficacy of clove oil and 2-phenoxyethanol on doctor fish, Garra rufa (Heckel, 1843). Boletim do Instituto de Pesca, 45(4), e506.

Bodur, T., Afonso, J. M., Montero, D. and Navarro, A. (2018a). Assessment of effective dose of new herbal anesthetics in two marine aquaculture species: Dicentrarchus labrax and Argyrosomus regius. Aquaculture, 482, 78–82. https://doi.org/10.1016/j.aquaculture.2017. 09.029

Branson, K.L. and Gross, M.E. (2021). Propofol in veterinary medicine, Journal of Animal and Veterinary Medicine Association, 204, 1888–1890.

Can, E., Kizak, V., Can, ¸S. S. and Özçiçek, E. (2019). Anesthetic potential of geranium (Pelargonium graveolens) oil for two cichlid species, Sciaenochromis fryeri and Labidochromis caeruleus. Aquaculture, 491, 59–64. https://doi.org/10.1016/j.aquaculture.2018.03.013

Charoendat, U., Areechon, N., Srisapoome, P. and Chantasart, D. (2019). Efficacy of synthetic eugenol as an anesthetic for Nile Tilapia (Oreochromis niloticus Linn.). Agriculture and Natural Resources, 43(5), 132–140.

Clarke, A. and Johnston, N.M. (1999). Scaling of metabolic rate with body mass and temperature in teleost fish, Journal of Animal Ecology, 68, 893–905.

Cooke, S.J., Sunk, C.D., Ostrand, K.G. and Wahl D.H. (2014). Behavioral and physiological assessment of low concentrations clove oil anaesthetic for handling and transporting largemouth bass. Aquaculture, 239, 509-529.

da Cunha, M. A., de Barros, F. M. C., de Oliveira Garcia, L., de Lima Veeck, A. P., Heinzmann, B. M., Loro, V. L., Emanuelli, T. and Baldisserotto, B. (2020). Essential oil of Lippia alba: A new anesthetic for silver catfish, Rhamdia quelen. Aquaculture, 306(1–4), 403–406. https://doi.org/10.1016/j.aquaculture.2010.06.014.

Dan-kishiya, A. S., Solomon, J. R., and Alhaji, U. A. (2019). Influence of temperature on the respiratory rate of Nile Tilapia, Oreochromis niloticus (Pisces: Cichlidae) in the laboratory. UNED Research Journal, 8(1), 27–30. https://doi.org/10.22458/urj.v8i1.1617

Eames, S., Didinen, B., Kubilay, A., Mesut, P. and ? Ijlal, A. (2020). Bazı tıbbı bıtkılerın gökku¸sagı alabalıkları (? Oncorhynchus mykiss Walbaum, 1792) üzerinde anestezik etkilerinin belirlenmesi. Journal of Limnology and Freshwater Fisheries Research, 1(1), 37–42

Ellis, T., Yildiz, H. Y., López-Olmeda, J., Spedicato, M. T., Tort, L., Øverli, Ø. and Martins, C. I. (2022). Cortisol and finfish welfare. Fish Physiology and Biochemistry, 38, 163–188. https://doi.org/10.1007/s10695-011- 9568-

Iverseen, M., Finstad, B., McKinley, B. and Elliassen, R. (2003). The efficacy of metomidate clove oil as anaestetics in Atlantic salmon (Salmo salar) and their potential stress reducing capacity. Aquaculture, 221, 549-516.

Kiessling, A., Johansson, D., Zahl, I.H. and Samuelsen, O.B. (2019). Pharmokinetices, plasma cortisol and effectiveness of benzocaine, MS-222 and isoeogenol measured in individual dorsal aorta of Atlantic salmon (Salmo salar) following bath administration. Aquaculture, 286, 301-308.

Lambooji, B., Pilarcyzk, M., Bialowas H. and Hens V.D. (2019). Anaesthetic properties of Fish-Culturist 19, 147-157.

Sudagara M, Mohammadizarejabada A, Mazandarania R, and Pooralimotlagha S. (2019). The efficacy of clove powder as an anesthetic and its effects on hematological parameters on roach (Rutilus rutilus). Journal of Aquaculture of Feed Science and Nutrition, 1, 1-5.

Woody C.A, Nelson J. and Ramstad K. (2022). Clove oil as an anaesthetic for adult sockeye salmon: field trials. Journal of Fish Biology, 60, 340-347.

IN VITRO TRIAL OF *Sarcocephalus latifolius* LEAF EXTRACT AGAINST FISH COMMON PATHOGENS.

Olaji, E. D.

Department of Aquaculture, Nigerian Institute for Oceanography and Marine Research, Sapele, Delta state, Nigeria.

Corresponding author:
ebenolaji@gmail.com

ABSTRACT
Aquaculture is an established and growing industry in Nigeria. It is an important contributor to the agriculture and marine economy. It is faced with many challenges among which is disease infections. Plant-based approach to disease control in aquaculture practices is considered to be environmentally friendly and the best alternative to chemotherapy. Bacteria pathogens isolated from the gills of Clarias garipienus collected from NIOMR farm was used to test the antibacterial potential of both the fresh and the dry leaves methanol extracts of Sarcocephalus latifolius plant. The antibacterial test was carried out using agar well diffusion method. The antibacterial screening results revealed that the methanol extracts of fresh and dried leaves from the plant have medium to strong antibacterial activities against all the test organisms with the inhibition diameter ranging from 10-12mm for the fresh while the dried leaves range from 13-21mm. The extract from the dried leaves showed better antibacterial sensitivity to the tested organisms.

Keywords:
chemotherapy,
plant-based,
aquaculture,
disease.

INTRODUCTION

It is evident that our fish demands cannot be adequately met from capture fisheries alone. There is need to bridge the wide gap between fish demand and supply. This can be achieved by strategic investment in aquaculture. The demand for fish protein and the present agricultural development policy of the Federal government of Nigeria emphasizing poverty reduction, food security and employment generation favor fish farming in many places in Nigeria. (Amachi, 2018). However, fish farming industry is faced with several challenges among which is bacterial infection. This constraint to rapid development of aquaculture has to be addressed to maximize fish production potential of the industry. Over times chemical methods have been widely used to control, prevent and treat disease outbreaks in industry. These have multiple negative impacts on the environment and human health. The use of synthetic antibiotics has also been reported to have led to emergence of resistant bacteria strains and residual accumulation of these drugs in tissues and aquatic sediments (Holmes et al., 2016). Therefore, disease management in aquaculture should focus on environmental friendly and lasting approaches. Globally, attention is gradually shifting towards the use of plants and herbs for disease control and prevention in aquaculture as the best alternative to chemotherapy. Plant parts such as roots, stem bark, leaves and fruits contain bioactive compounds like alkaloids, saponin, thiamine, essential oils, peptides, unsaturated long chain aldehydes etc. that make them a rich source of medicine (Kurva and Gadadhar, 2013).

Clarias gariepinus (Burchell, 1822) is one of the most important tropical catfish species for aquaculture in West Africa that is also known as the African sharp tooth catfish. It belongs to the family Claridae. It is commonly found in tropical swamps, lakes, and rivers. Clarias gariepinus has the ability

to grow on a wide range of artificial and natural foods. It can attain a large size within short time, it has high yield potentials and it can tolerate low dissolved oxygen and other aquatic conditions. The colour is usually dark grey or black on the back and white at the belly. It is highly nutritious. Clarias gariepinus, is an omnivore freshwater fish widely cultured in Nigeria because of its high growth rate, ability to withstand stress, disease and ability to spawn easily (Adeniyi et. al.,2021)). Catfish do suffer infections caused by pathogens. Pathogens are an integral part of aquatic environment. They are responsible for disease infections in fish farming. Disease infection if not control can lead to colossal economic loss recovery of which may be practically not easy to come by.
Sarcocephalus latifolius is a shrub of family Rubiaceae that usually grows in humid areas of tropical Africa. Its roots are used for several applications in traditional medicine (Romain et al., 2018). Its anti-radical properties and antibacterial activities against salmonella and other bacteria have been reported by Antia et al., 2014). Studies have shown that extracts of various parts of Sarcocephalus latifolius contain bioactive compounds such as; tannins, flavonoids, alkaloids, saponins and anthraquinones (Anowi et al., 2015).
The objective of this study is to contribute to the search for sustainable, accessible and environmentally friendly alternatives to chemotherapy in the treatment of disease outbreaks and control of farmed fish diseases.

MATERIALS AND METHODS

Extractions and phytochemical tests were carried out in chemistry department laboratory while the microbiological tests were done at the pharmaceutical microbiology laboratory University of Benin. Benin City, Nigeria.

Plant materials

The plant leaves were collected from Ekiadolor town in Ovia North-east local government area of Edo state.
The plant leaves were washed and divided into two parts. One part was ground fresh and extracted while the second part was dried out of the sun at the Laboratory temperature for two weeks before being pulverized into coarse powder.
The extraction was carried out using cold maceration in methanol for 72hrs with intermittent shaking. The mixture was filtered using Whatmann No.1 filter paper and evaporated in rotary evaporator. The extracts were subjected to antibacterial testing using agar well diffusion method described by Castiho et al., (2015) with some modifications. The bacterial used were isolated from the gills of Clarias gariepinus collected from the Nigerian institute for oceanography and marine research (NIOMR) fish farm.
Qualitative phytochemical assay was carried out on the crude methanol extracts following the standard method described by Vishnu et al., (2019).

RESULTS AND DISCUSSION

Table 1: Proximate analysis of dried leaves

Parameter	Percentage of SL
Moisture	15.00
Ash	9.20
Fiber	23.21
Lipids	15.89
Crude protein	3.60
Carbohydrate (nitrogen free extract)	33.10

From table 1, the protein value suggests that the leaves can be ranked as a potential source of plant protein and therefore could be used as protein supplement in fish feed. The ash content observed is an indication of the mineral preserved in the leaves.

Table 2: Phytochemical Screening result of Sarcocephalus latifolius

S/N	Phytoconstituents	Methanol (Fresh leaves)	Methanol (dry leaves)
1	Glycosides	+	+
2	Steroids	+	+
3	Terpenoids	+	+
4	Alkaloids	+	+
5	Saponins	+	+
6	Flavonoids	+	+
7	Phenolics	+	+
8	Tannins	+	+

\+ = Presence: - =Absence

Table 2 shows the results of the qualitative phytochemical analysis of the plant extracts. It showed that the leaves are rich in alkaloids, flavonoids, tannins and saponins. This result agrees with the previous findings of (Stephen et al., 2017) on the presence of alkaloids, flavonoids, tannins and saponins in methanol root extracts of Sarcocephalus latifolius.

Table 3: Inhibition zone diameter (mm) of methanol extract of dried leaves

Zone of inhibition diameter(mm)

	Microorganisms		
Concentration (mg/ml)	*E. coli*	*P. a eruginosa*	*S. aureus*
500	20.0	20.0	21.0
250	19.0	18.5	16.0
125	18.0	16.0	16.0
62.5	13.0	15.0	15.0
31.25	0.0	0.0	0.0
Tetracycline	24.0	24.0	22.0
Distilled water (negative control)	0.0	0.0	0.0

Table 4: Inhibition zone diameter (mm) of methanol extract of fresh leaves

Zone of inhibition diameter(mm)

	Microorganisms		
Concentration(mg/ml)	*E. coli*	*P. aeruginosa*	***S. aureus***
500	12.0	10.0	**12.0**
250	11.0	9.0	**10.0**
125	11.0	8.0	**8.0**
62.5	8.0	0.0	**0.0**
31.25	0.0	0.0	**0.0**
Tetracycline	20.0	24.0	**23.0**
Distilled water (negative control)	0.0	0.0	**0.0**

The antibacterial screening results in tables (3 and 4) revealed that the methanol extracts of fresh and dried leaves from the plant have antibacterial activities against all the test organisms, howbeit with different levels of sensitivities. However, the extract from the dried leaves showed better antibacterial sensitivity to the tested organisms. This may be due to probable high concentration of the bioactive compounds in the extracts of the dried leaves. Again, at 500mg/ml the inhibition was strong while there was no inhibition at concentration of 31.25mg/ml. The no zone recorded at 13.25mg/ml for both extracts suggested that the dose was too small to have an effect on the test organisms. This shows that the concentration of the extracts is an important factor to be considered. This result is in agreement with the findings of Holmes et al., (2016). Furthermore, the bioactive compounds in the plant are broad spectrum in their activity since both the gram-positive bacterium (S aureus) and gram-negative bacteria (E coli and P aeruginosa) were inhibited significantly especially at higher concentrations.

CONCLUSION

From the study, it can be concluded that the selected medicinal plant has great potential as antimicrobial agent against bacteria isolates. Further study on the plant would probably lead to the development of stable, biologically active compounds which can be employed in the formulation of antimicrobial agents for fish farmers.

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REFERENCES

Adeniyi, O., Emikpe, B., Olaifa, F. and Ogunbanwo, S. (2021): Effects of dietary tamarind leaves extract on growth performance, nutrient utilization, gut physiology and susceptibility to Aeromonas hydrophila infection in Nile tilapia: International Aquat. Res.13(1):37-51.

Amachi (2018). Food security and sustainable agricultural development in Nigeria: The journal of social and humanities invention:55) ,4(765-4768.

Anowi, C. E., Cardinal, N. C., Ezugwu, C. O. and Utoh-Nedosa, U. A. (2015): Antimicrobial properties of chloroform extract of the stem bark of Nauclea latifolia; Int.J of pharmacy and pharmaceutical Sci:4(2):744-750.

Antia, B., Okonkon. J, (2014): Phytochemical composition and antidiabetic activity of ethanol root extract of Nauclea latifolia. The journal of phytopharmacology. 3(1):52-56

Castiho, A.L, Califfi, K.R and Canozin, P.H (2015); Detection of drug susceptibility in rapidly growing mycobacteteria by Resazurin broth microdilution assay. Journal of Microbiology methods.111:119-121.

Holmes, A.H., Moore, L.S.P and Sundsfjord, A. (2016); Understanding the mechanisms and drivers of antimicrobial resistance: The Lancet, 387:176-187

Kurva, R.R. and Gadadhar, D. (2013). A Review on Herbal Drugs Against Harmful Pathogens in Aquaculture. American Journal of Drug Discovery and Development, 3: 209 – 219

Romain, H., Marine, P., Basile, P., Maxime, R., Germain, S., Ahcene, B. and Benjamin, B. (2018): Traditional uses, Phytochemical and Pharmacological properties of African Nauclea species (a review): Journal of Ethnopharmacology, 212:106-136.

Stephen, A.E, Oluwatosin, A, and Eseosa, U. (2017): Phytochemical, antimicrobial and nutritional properties of Morinda lucid benth and Nauclea latifolia leaf extracts: International journal of scientific word, 5 (1):62-66.

Vishnu, B., Sheerinfatima, M.A. and Screeithi ,V (2019): A guide to phytochemical Analysis: Inter journal of advance research and innovative ideas in education, 5(1):236-245.

IMPLICATIONS OF ENVIRONMENTAL STRESSORS ON THE PRODUCTION OF TABLE-SIZED FISH FROM EARTHEN PONDS IN SOUTHERN NIGERIA

Nwose, F. O., J.K. Ekelemu and F. O. Nwachi

Department of Fisheries and Aquaculture, Delta State University, Abraka

Corresponding Author:
felixnwose@yahoo.com

ABSTRACT
Aquaculture, particularly in earthen pond systems, have become a crucial component of food security, employment, and economic growth in Southern Nigeria. However, these systems are vulnerable to numerous environmental stressors, such as Replace with "fluctuations, imbalances and degradation in the biological and physic-chemical water quality, all of which significantly affect fish health, growth, and survival rates. The specific conditions of Southern Nigeria, including pollution from oil and gas activities, sedimentation from soil erosion, and run-off from rain, exacerbate these challenges. In interrogating the topic, this paper provides an in-depth review and analysis of these environmental stressors, their effects on table-size fish production, and the economic and social implications for fish farmers. By exploring mitigation strategies such as Integrated Multitrophic Aquaculture (IMTA), the use of sustainable aquafeed, biofilters, and comprehensive water quality management, this study proposes solutions to improve fish farming outcomes and promote sustainable aquaculture practices in Nigeria. The findings underscore the need for collaborative efforts between government agencies, research institutions, and the aquaculture industry to address these challenges and ensure the long-term viability of fish farming in the region.

Keywords:
Environmental, Stressors, Table-sized fish, Earthen ponds

INTRODUCTION

Aquaculture plays a pivotal role in Nigeria's agricultural and economic landscape, with Southern Nigeria emerging as a key region for fish production. The sector contributes significantly to the country's Gross Domestic Product (GDP) while supporting poverty alleviation efforts and improving national food security (Akinrotimi *et al.*, 2019). In particular, earthen ponds are the predominant method used by fish farmers to cultivate table-size fish species such as Nile tilapia (Oreochromis niloticus) and African catfish (Clarias gariepinus). These systems are favored for their adaptability to various environmental conditions, ease of construction, and relative cost-effectiveness (Olukunle *et al.*, 2017).

Despite the potential benefits of earthen pond aquaculture, fish farmers face several environmental stressors that threaten the sustainability of their operations. These stressors include temperature fluctuations, dissolved oxygen (DO) depletion, pH changes, and water quality degradation, all of which negatively impact fish growth, health, and survival. In Southern Nigeria, additional challenges arise from regional factors such as sedimentation, pollution from oil and gas exploration, and seasonal rainfall patterns that cause fluctuations in pond water levels and quality (Ekelemu and Okoro, 2020; Omoregie, 2023). Understanding the specific environmental stressors faced by fish farmers in this region is critical for

developing targeted mitigation strategies and promoting sustainable aquaculture practices. This paper examines the primary environmental challenges affecting earthen pond aquaculture in Southern Nigeria analyzes their implications for fish health and production. It also outline potential strategies to mitigate these stressors and enhance the long-term viability of fish farming.
This paper draws upon a comprehensive review of secondary data from peer-reviewed journals, empirical studies, and industry reports on aquaculture in Southern Nigeria. Information were collected on key environmental stressors, including disease and disease causing organisms, temperature fluctuations, dissolved oxygen levels, pH changes, and water quality degradation, with a focus on their effects on fish health and productivity in earthen ponds. The review also interrogated specific regional challenges in Southern Nigeria, such as pollution from oil and gas activities, sedimentation, run off and seasonal rainfall patterns. In addition, mitigation strategies, including Integrated Multitrophic Aquaculture (IMTA), sustainable aquafeed, biofilters, and water management practices, were reviewed to assess their effectiveness in addressing these challenges.

DISCUSSION

Temperature fluctuations have a significant impact on fish metabolism, immune response, and growth rates. In Southern Nigeria, the climate is characterized by distinct wet and dry seasons, which lead to extreme temperature variations in earthen ponds. During the dry season, high temperatures can elevate water temperatures beyond the optimal range (25–30°C for Nile tilapia and 27–30°C for African catfish), leading to increased metabolic rates and oxygen demand (Omoregie, 2023). Conversely, cold temperatures during the wet season can slow down metabolism and reduce fish growth rates. Research conducted by Adedeji (2021) demonstrated that temperature variations outside the optimal range can lead to significant reductions in growth performance, delayed sexual maturation, and increased susceptibility to diseases in Nile tilapia. To mitigate the effects of temperature fluctuations, farmers can implement strategies such as shading to reduce heat stress during the dry season and use aeration to improve water circulation.
Dissolved oxygen is a critical factor for fish survival and growth, as it supports respiration and metabolic processes. However, earthen ponds are particularly vulnerable to DO depletion, which occurs due to organic matter decomposition, algal blooms, and nutrient loading. Low DO levels (below 2 mg/L) can lead to fish suffocation, mass mortality, and growth retardation, especially in ponds with high stocking densities (Omoregie, 2023). Conversely, supersaturation of DO, often caused by excessive aeration or photosynthetic activity, can result in gas bubble disease, where bubbles form in fish tissues, causing stress and tissue damage. In ponds with high fish densities, the problem is further compounded, as competition for oxygen intensifies. Effective aeration systems, such as paddlewheels and diffusers, are essential to maintain optimal DO levels, ensuring that fish have sufficient oxygen for growth and health.
Fluctuations in pH levels can have adverse effects on fish health, leading to physiological stress and metabolic imbalances. In earthen ponds, pH can be influenced by factors such as organic matter decomposition, sediment composition, and the presence of algae. Fish species such as Nile tilapia and African catfish require specific pH ranges (6.5–9.0 for tilapia and 6.5–8.5 for catfish) to thrive. Extreme pH levels, whether too acidic or too alkaline, can disrupt enzyme activities, impair ion regulation, and reduce feed efficiency (Omoregie, 2023). Acidic conditions can damage fish gills, leading to impaired respiration, while alkaline conditions can cause osmotic stress and increase ammonia toxicity. Regular monitoring of pH levels, along with the use of buffering agents such as lime, can help maintain optimal conditions for fish production.
Water quality degradation is a major concern in earthen pond aquaculture, particularly due to nutrient overload, which can result in eutrophication, algal blooms, and hypoxia. These conditions arise from excessive feeding, waste accumulation, and runoff from nearby agricultural activities (Omoregie, 2023). Eutrophication leads to oxygen depletion as algal blooms decompose, which can severely impair

fish respiration and increase mortality rates. Elevated ammonia and nitrite levels, which are common in nutrient-rich ponds, cause respiratory distress and reduce fish growth performance. Sustainable water quality management practices, such as the use of biofilters, constructed wetlands, and proper pond aeration, are essential to mitigate the adverse effects of nutrient overload and maintain a healthy pond environment.

Southern Nigeria's Niger Delta is heavily impacted by pollution from oil exploration, gas flaring, and industrial wastewater discharges. These activities introduce hydrocarbons and other pollutants into water bodies, which can bioaccumulate in fish tissues and pose health risks to both fish and humans (Fakorede et al., 2020). Sedimentation, exacerbated by deforestation and land-use changes, further reduces water clarity and light penetration, affecting photosynthetic activity and oxygen levels in earthen ponds. High sediment loads can clog fish gills, smother fish eggs, impair respiration, and reduce growth rates (Umehai and Ekelemu 2023, Adedeji, 2021). To address these challenges, fish farmers must adopt soil erosion control measures, reduce deforestation, and implement sustainable land management practices to reduce sedimentation rates.

Addressing the environmental stressors affecting earthen pond aquaculture requires a multifaceted approach. Integrated Multitrophic Aquaculture (IMTA) offers a promising solution by promoting the co-culture of multiple species that enhance nutrient cycling and minimize waste. For example, co-culturing fish with seaweed and shellfish can help absorb excess nutrients and improve water quality (Omoregie, 2023). Sustainable aquafeed practices, including the use of plant-based protein sources and insect meals, can also reduce the environmental footprint of fish farming. In addition, biofilters and constructed wetlands can be used to filter pond water and remove excess nutrients, while regular monitoring of water quality parameters such as DO, pH, and ammonia levels is essential for maintaining optimal conditions for fish growth.

CONCLUSION

The sustainability of earthen pond aquaculture in Southern Nigeria is threatened by numerous environmental stressors, including temperature fluctuations, dissolved oxygen depletion, pH imbalances, and pollution from oil and gas activities. These stressors have significant implications for fish health, growth, and overall productivity, resulting in economic losses for fish farmers. However, effective mitigation strategies such as IMTA, biofiltration, sustainable aquafeed use, and water quality management can help address these challenges. By adopting these practices, fish farmers can improve the resilience of their operations and contribute to the long-term sustainability of aquaculture in Nigeria. Collaborative efforts between government agencies, research institutions, and industry stakeholders are essential to develop tailored solutions that address the unique environmental challenges faced by fish farmers in Southern Nigeria. Further research is needed to explore innovative approaches to aquaculture management and ensure the viability of the sector in the face of climate change and environmental variability.

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REFERENCES

Adedeji, A. A. (2021). Effects of aquacultural practices on the sediment characteristics of certain types of earthen fishponds. Journal of Limnology and Freshwater Fisheries Research, 7(2): 83-91.

Akin-Obasola, B. J., Fapohunda, O. O. and Ogunlade, A. O. (2023). Nutritional composition and gonadal development of Heteroclarias cultured in concrete and earthen ponds. Journal of Aquaculture Nutrition and Feed Science, 15(2: 102-110.

Ekelemu, J.K. and Okoro, K.O. (2020) Bio-accumulation of heavy metals in five fish species in lower River Niger at Illah, Delta State, Nigeria. Nigeria Journal of Fisheries, 17 (1): 1941 – 1945.

Etuk, E. A., Ogban, G. O. and Idiong, C. I. (2021). A comparative economic analysis of aquaculture production systems in Southern Agricultural Zone of Cross River State, Nigeria. African Journal of Aquatic Science, 46(3): 287-295.

Fakorede, C. N. and Fatokun, E. N. (2020). Bacteriological quality and antibiotics' susceptibility profile of small-medium scale commercial fish farms in Nigeria. The Open Aquaculture Journal, 14(1): 76-85.

Iloba, K. I., and Arebun, B. (2020). Comparative study on water variables and plankton diversity of earthen fish ponds along river Ethiope. IOSR Journal of Environmental Science, Toxicology and Food Technology, 14(4): 56-63.

Ogunji, J.and Wuertz, S. (2023). Aquaculture development in Nigeria: The second biggest aquaculture producer in Africa. Water, 15(1): 32.

Omoregie, E. (2023). African aquaculture: Enhancement of water quality for sustainable freshwater finfish culture. Sustainable Aquaculture Innovations in Africa (pp. 341-363).

Thompson, O. A., Arifalo, S. F.and Atejioye, A. A. (2021). Determinants of climate change risk management strategies among the aquaculture fish farmers in Nigeria using multinomial logit model. Fisheries and Aquaculture Journal, 12(6): 416-426.

Umehai, M. C. and Ekelemu, J. K. (2023). Assessment of some Physico-chemical water quality parameters and Prawn Species in Ase River, Delta State, Nigeria. Journal of Aquatic Sciences. 38 (2): 213 – 222

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

A REVIEW OF OVERFISHING AND FISH BIODIVERSITY IN NIGERIA INLAND WATER BODIES

[1]Okojie B. H, [1]P.I Ifejika, [1]M Yisa, [1]K.E Ogbuebunu, [1]A Bello, [1]U.O Bajeh, [2]D.E Abuh, [3]C.E Eze, [1]N.A Abiodu, AND [1]M. Najak

[1]National Institute for Fresh Water Fisheries Research, P.M.B 6006, New Bussa, Niger State, Nigeria.
[2]Eco-Climate Foundation, Social Centre Complex, ABU Zaria, Kaduna State.
[3]Fisheries and Aquaculture Department Federal College of Animal Health and Production, Vom, Plateau State, Nigeria

Corresponding author:
honblejack4u@gmail.com, 07031385207

ABSTRACT
Nigeria's inland capture fisheries face unprecedented threats from overfishing posing significant risk to food security and sustenance of fish biodiversity. This study examines the fish biodiversity, overfishing, and management strategies of capture fisheries in Nigeria's inland water bodies. The study is based on secondary data on published works relevant to the subject. It was found that Nigeria is endowed with extensive inland water bodies of different dimensions that are very rich in fish biodiversity of commercial importance for sustainable fishing. Also, over 230 freshwater fish species have been reported in the country water bodies belonging to about 105 genera and 46 families. How fish depletion in inland water bodies is associated with overfishing with poisons, inadequate regulations, inappropriate gears particularly under mesh size below 5-7.5 mm, weak enforcement of fishing laws, and limited awareness. In view of the foregoing, there is need for sustainable inland fisheries management by government and communities through stock assessment, restocking, community management approach, law enforcement as well as training and awareness creation.

Keywords:
Nigeria, capture, fisheries.

INTRODUCTION

Nigeria has wide varieties of inland water bodies which are rich in diverse finfish and shellfish. About two third of the country lies in the watershed of the Niger River, Benue River, Cross River, Anambra River, Imo River, Kwa Iboe River, Ogun River and Oshun River (Olopade et al. 2017) and innumerable small rivers. The most prominent amidst the networks of rivers in Nigeria is the Niger – Benue system, whereas Lake Chad and kanji are the most important with regards to fish production (Eyo and Ahmed 2005). In Kogi State is a confluence state where two rivers (Niger and Benue) meet in Lokoja, and there exist these water bodies like river Okura, Ochaja spring, Itobe, Bassa, Imabolo (Abuh, 2022). These water bodies have been exploited by artisanal fishers operating in rivers, streams, estuaries, wetlands, brackish water, natural and man-made lakes for various benefits, including food security, livelihoods and employment.

In Nigeria, the inland capture fisheries have been the most neglected by the government notwithstanding the significant contribution of the sub-sector. In Nigeria, over 230 freshwater fish species have been reported in the country water bodies belonging to about 105 genera and 46 families. Over the years, more than 80 species have been identified as commercially important while about 20 has been shown to have aquaculture potential (FISON group chat 2022). The catch of the inland capture fishery is dominated by Lates spp., Tilapia spp., Citharinus spp., Chrysichthys spp., Mormyrus spp. and Clarias spp. (Arawomo 2004). For decades, the catches from the inland water bodies steadily increased with most fish stocks now classified as overfished due to continuous overfishing and use of obnoxious fishing methods such as the use of small mesh, unselective fishing gear, fish poisons and explosive. The overexploitation of the finite resources has led to a drastic reduction in inland rivers and lakes fish production from 213,996 metric tonnes in 1998 to 181,268 and 194,226 metric tonnes in 2000 and 2001 respectively (Eyo and Ahmed 2005).

The status of the inland capture fisheries in Nigeria is largely a result of a failure of the present process of fisheries governance which pose significant threats to the management of fisheries resources. The lack of effective governance can be attributed to outdated, weak and inappropriate regulations and incoherent policy. There is, however, a need to protect and sustainably manage inland capture fisheries in Nigeria that are essential to people. This paper identifies inland water bodies in Nigeria, assess causes of over fishing and ascertain management strategies to control over fishing.

Outline of the review

The derived outline for the study is to;

1. Describe inland water bodies and their fish biodiversity
2. Assess causes of over-fishing in inland water bodies
3. Ascertain management strategies to control overfishing

METHODOLOGY

The study used secondary data sourced from published works in institutional based journals, conference proceedings, among others. Journals were sourced through academic search engines such as Google scholar and other academic platforms like Research gate. Academic journals that fit into the topic were selected and scrutinized based on the reliability of the information therein.

RESULTS AND DISCUSSIONS

Inland Water Bodies and Fish biodiversity in Nigeria

Nigeria is watered from North to South and East to West by a network of rivers and fish diversity. Rivers Niger and Benue that form a big 'Y' right across the middle of Nigeria at Lokoja originate from outside the country (Ajai 2012). The rivers of Nigeria may be divided into four main groups: (1) the Niger-Benue system, (2) the rivers west of the lower Niger, (3) the rivers east of the lower Niger and (4) those flowing into Lake Chad. All rivers flow across the territory to empty into Lake Chad in the North-East corner or the Atlantic Ocean in the South. The major rivers make up about 11.5 percent whereas lakes and reservoirs about 1 percent of the total area of Nigeria (Ajai 2012). The total water bodies, including deltas, estuaries, etc., make up about 15.9 percent of the total area of the country. In Nigeria, over 230 freshwater fish species have been reported in the country water bodies belonging to about 105 genera and 46 families. Table 1 below shows list of inland water bodies with approximate surface area in Nigeria. As shown, Lake Chad is largest natural lake measuring 550,000 hectares whereas lake kainji is the largest man-made lake measuring 127,000 hectares. These inland water bodies are rich in fish biodiversity which provides livelihood, income and fish food security for riverine communities in fishing, gear, fish processing, marketing, inputs and transportation, among others. Lake Chad is found to have between 120 to 140 fish species, 150,000 tonnes of fish worth (tag my fish 2024). Also, Table 2 depicts fish abundance in dams and reservoirs of which lake Lake Njoboliyo (19.10%) has the highest fish species, followed by lake kainji 16.40% and Kiri Reservoir (16.0%) where as the least is Ajiwa Dam and Kontagora with 2.30% fish species. This entails enforcement of sustainable fisheries management of the resources to avoid depletion and overfishing. In view of this, NIFFR had done stock assessment, frame survey and restocking of some lakes and reservoirs like Kaiji, Dadin Kowa, kontagora, Tatabu among others (review work on niffr annual report).

Table. 1: Types of water bodies and Approximate surface area(ha)

Types of water bodies	Approximate surface area (ha)	Reference
Major Rivers		
Anambra River	1,401,000	Ita and Sado, 1985
Benue River	129,000	
Cross River	3,900,000	
Imo River	910,000	
Kwa Iboe River	500,200	
Niger River (less Kainji and Jebba lakes)	169,800	
Ogun River	2,237,000	
Oshun River	1,565,400	
Major Lakes and Reservoirs		
Lake Chad (natural)	550,000	
Kainji Lake (man-made)	127,000	
Jebba Lake (man-made)	35,000	
Shiroro Lake (man-made)	31,200	
Goronyo Lake (man-made)	20,000	
Tiga Lake (man-made)	17,800	
Chalawa Gorge (man-made)	10,100	
Dadin Kowa (man-made)	29,000	
Kiri (man-made)	11,500	
Bakolori (man-made)	8,000	
Lower Anambra (man-made)	5,000	
Zobe (man-made)	5,000	
Oyan (man-made)	4,000	
Types of water bodies	Approximate surface are a (ha)	Reference

Table. 2: Distribution of Fish Families and Abundance in Dams and Reservoirs in Nigeria

Reservoirs	No of Families	No of Fishes	Noof Species	Percentage of Species
Ajiwa Dam	5	390	7	2.30%
Dadin Kowa Reservoir	14	988	28	9.50%
Goronyo Reservoir	11	10,105	19	6.50%
Gurara Reservoir	10	1,239	9	3.00%
Kainji Lake	16	407	48	16.40%
Kiri Reservoir	15	2,179	47	16.00%
Kondo River	13	157	29	9.90%
Kontagora Reservoir	4	256	7	2.30%
Lake Njoboliyo	17	5,067	56	19.10%
Omi Reservoir	10	1,239	14	4.70%
Tatabu Flood Plain	14	259	28	9.50%

Causes of overfishing

Overfishing is one of the major causes of fish depletion in water bodies in Nigeria over the decades causing decline in domestic fish production and consumption as well as increase in fish importation to meet local needs. Obnoxious fishing practice are destructive fishing practice that poses a threat to the ecosystem and they include the use of small mesh size, blast fishing, bottom trawling, cyanide fishing, muro-am and ghost fishing. Obnoxious fishing practices involve fishing with explosives and poisons that damage the ecosystem, killing most of the non-target species and compromising any possibility of sustaining yields in the future. The use of obnoxious fishing practices has been seen as a challenge in conserving the kanji and Jebba lakes (Nwabeze and Erie 2013). Another factor is high demand and consumption due to population increase. As the global demand for fish increases, fishing efforts intensify to meet the demand, often leading to overfishing and obstacles within the ecosystem. Advancements in Fishing Technology: While large-scale trawlers, longlines, and fish finders allow fishermen to catch fish more rapidly and in larger quantities, they also contribute to overfishing. Lack of Effective Fisheries Management: Inadequate or ineffective fisheries management is a major contributor to overfishing. Poorly designed or implemented fishing regulations, weak enforcement, and insufficient monitoring and surveillance can fail to control fishing activities and protect fish populations. Lack of Data and Scientific Knowledge: Insufficient data on fish populations and their reproductive capacities can make it challenging to assess the health of fish stocks accurately. Inadequate scientific knowledge and understanding of ecosystem dynamics can lead to conservative or inaccurate assessments, potentially allowing overfishing to go unnoticed until it becomes a severe problem

Types of overfishing

- Growth overfishing: this occurs where the young fish (recruits) are harvested at an average size that is smaller than the size that would produce maximum yield per recruit.
- Recruitment overfishing: This occurs where the parent stock is so reduced that not enough young are produced by the fishery to maintain itself.
- Ecosystem overfishing: This occurs where species distribution is drastically changed, altering the efficiency of the system. In this situation, the niche inhabited by originally abundant species is not fully taken up by other species, changing the system's productivity.
- Economic overfishing: This occurs where the cost of fishing effort is greater than the revenue generated from the fishing. As fish stocks decline, the effort required to catch a given quantity of fish increases.

Signs of overfishing

- General decline in catch per unit effort and observation that the increase in fishing effort does not result in a proportional increase in the catch.
- Reduction in genetic diversity, especially when the stock size is greatly reduced from natural level.
- Decline in catches in larger mesh net, results into high catch in small mesh net.
- High concentration of fishermen per unit length of shore land per surface area.
- Rise in the cost of catching a unit weight of fish associated with increase in effort without relative increase in catch.
- Mass migration of non-indigene fishermen to other places.
- Decrease in market landing as compared to previous year or season.
- Increase in the price of fish in an area which could be a sign of low harvest resulting from overfishing.

Management strategies to control overused fishing.

As far as fisheries management is concerned in Nigeria, there are two systems are identified namely, government and traditional institutions. Traditional management systems entail the regulation of fisheries activities and resources by traditional authorities or communities approach using common beliefs or norms, prescriptions, religious practices, behaviours, taboos, magic, languages and such systems are still operational in spite of the population growth, changes in legal systems, urbanization, commercialisation and technological change. (Ramazzoti 2008). Under government management system, the following approaches are operational;

Registration and licensing of fishermen:

There is a need therefore to initiate the licensing and registration of fishermen in all the water bodies in Nigeria to increased fish production and gainful employment for full-time fishermen is to be achieved. However, part-time fishermen could willingly give up fishing without any loss of income if compelled to pay licensing and registration fees. Such voluntary withdrawal could result in significant improvements in the overall productivity of the water bodies.

Mesh size regulation:

By increasing the mesh size from 5 to 7.5 mm about 14 out of 30 commercially important species would be allowed to reproduce at least once before they were captured. The investigation revealed that the tilapias, which comprised about 49% of the total standing crop of commercially important species in the lake, often attain sexual maturity long before they grow to the size held by a 7.5 mm mesh net. This law is already operational in Kainji Lake fishery management by Niger state. This mesh size has also been recommended as the standard minimum mesh size for all inland water bodies in Nigeria in view of the fact that the distribution of fish species in most of the inland water bodies in the country follows the pattern of the Niger-Benue River systems and their tributaries. Similarly, a majority of the reservoirs so far surveyed in the country have tilapia as the dominant species.

Gear size regulation:

In order to guard against undue increase in fishing effort, gear size regulations (or quota regulations) must be enforced along with mesh size. The major factors to be considered in gear size regulation, given the stipulated number of boats or fishermen to be allowed to fish a water body and the specified minimum mesh size to be used, are the potential fish yield of the water body, and the observed yield at the time the quota regulation is to be enforced.

Prohibition of the use of poison and explosives:

Generalized laws prohibiting the use of unorthodox fishing methods, such as poisoning and explosives as well as agrochemicals should also be promulgated to guard against indiscriminate killing of juvenile fish and waste of fish biomass.

Closed season and area:

Specific study may be necessary in order to determine the particular area or season to be closed to fishing before regulations are framed. In almost all cases, areas to be closed to fishing are usually the spawning ground of most fishes e.g., shallow floodplain areas of lakes, reservoirs and rivers. Decaying organic matter is the major food of all juvenile fishes and most of the adults. This organic matter also enriches the nutrients in the water giving rise to the production of more food organisms. In addition to providing food, the flooded swamps or bush also provide cover for young fish during their early development, thus protecting them from open predation by carnivores. Such areas are specific to each lake and should be carefully identified before enforcing regulations. The same areas should be closed to fishing during the peak breeding season which often corresponds with the period of the high flood.

CONCLUSION AND RECOMMENDATION

Overfishing in Nigeria's inland capture fisheries poses significant threats to the country's food security, economic development and environmental sustainability. The alarming rate of depletion of fish stocks, degradation of aquatic habitat, and disregard for sustainable fishing practices necessitate urgent attention and collective action. The consequence of overfishing is far reaching that if urgent measures are not taken, then there will be a problem in feature. In kainji lake there has been management practice put in place as far back as 1997 and those management practices has long been forgotten and are no longer practiced.

The following is recommended:

- Education is considered as a key component in the effective management systems of all successful fisheries. Fishers must be educated to use prescribed mesh sized net, so that under sized fishes would not be killed.
- Existing illegal and indiscriminate fishing practice must be strictly checked by imposing stringent laws and penalties.
- Government should allocate more policy attention and resources to develop inland capture fisheries in Nigeria.
- Small scale fisheries development requires special support from government. An integrated approach through, and with the participation of, fishing communities is often the best way of channelling technical, financial and other form of assistance.
- Restocking and stock enhancement programs should be introducing in most inland water by releasing reared juveniles into open waters has proven to be very effective for some species.
- All fishermen should be registered and licenced.
- Mesh size regulation should be enforced.
- The use of obnoxious fishing practices should be banned.

REFERENCES

Abuh, D.E. (2022). Fish species abundance and gear selectivity of river niger in Edeya fishing community at koton karfe (Egbura Igu) Kogi State. Department of fisheries and Aquacultures, Prince Abubakar Audu University, Ayigba, kogi state.

Ajai O. (2012). Law, Water and Sustainable Development: Framework of Nigerian Law. Law, Environment and Development Journal 8(1):89-115.

Arawomo GAO (2004). Self-sufficiency in fish production in Nigeria. Obafemi Awolowo University Inaugural Lecture Series No 165; Ile Ife, Nigeria.

Bailey C. (1987). Social consequences of excess fishing effort. In: Proceedings, Symposium on the Exploitation and Management of Marine Fishery Resources in Southeast Asia. RAPA Report: 1978/10:30-1064.

Berkes F. (1994). Co-management: Bridging the Two Solitudes. Northern Perspectives 22 (2-3):18–20.

Eyo AA. (2004). Provost alerts federal government over foreign fisherman in Lake Kanji. Guardian Newspaper. 21(9):451 pp. 50

Eyo, A.A. and Ahmed (2005). Management of inland capture fisheries and challenges in fish production in Nigeria

Ita and Sado, (1985). A summary of the inventory survey of Nigeria inland waters and preliminary estimates of their fish yield potentials.

Nwabeze, G.O. and Erie (2013). Artisanal fishers Use of Sustainable Fisheries Management Practices in the Jebba Lake Basin, Nigeria

Ramazzoti (2008). Management of Overfishing in the Inland Capture Fisheries in Nigeria

PROPHYLACTIC TREATMENT OF *Clarias gariepinus* FRY USING NATURAL (CLOVE) AND SYNTHETIC (OXYTETRACYCLINE) ANTIBIOTICS

Usman, M., D. S. Bulus and M. Muktari

Department of Fisheries Technology, College of Agriculture, Science and Technology P.M.B 33, Lafia. Nasarawa State.

E-mail:
usmanmanasseh@gmail.com, +234 913 090 6627, 803 971 4004

ABSTRACT
A research was conducted to determine the effects of natural (cloves) and synthetic (oxytetracycline) antibiotics as prophylactic treatment of Clarias gariepinus fry. Five (5) treatments each were used for the natural and synthetic prophylactic treatment of Clarias gariepinus fry. The following treatments were given to both natural and synthetic antibiotics: treatment 1, 00g/l of water, treatment 2, 5g/l of water, treatment 3, 10g/l of water, treatment 4, 15g/l of water, and treatment 5, 20g/l of water. One thousand five hundred (1500) fry of African Catfish (Clarias gariepinus) were used for the experiment which was subdivided in to seven hundred and fifty (750) fry for natural and synthetic groups.The Five (5) treatments for natural antibiotics and synthetic antibiotics havefifty (50) per sample size with two (2) replicates each, giving a total of 150 fry per treatment. The result indicates that natural antibiotics were actually good but the active ingredients in the natural (clove) were strong to the extent that it kills most of the fry. The effect of synthetic (Oxytetracycline) antibiotics was effective in this study at 15g/l of water. the result indicates highest survival rate (92%) of fry treated with synthetic antibiotics. Based on this research, Oxytetracycline-OTC used at 15g/l of water was effective in the treatment of fry.

Keywords:
Cloves, Oxytetracycline, fry, Clarias gariepinus.

INTRODUCTION

Antibiotics are natural or synthetic substances used as antibacterial drugs to kill or inhibit the growth and spread of bacterial pathogens. Antibiotics are employed prophylactically, therapeutically, or metaphylactically in animal husbandry (Patel et al. 2019; Okoye *et al*. 2022b) and aquaculture (Lulijwaet *al*., 2020 and Scharet *al*., 2020).Antibiotics are also utilized to boost growth in aquaculture.The clove (Syzygium aromaticum) is a useful, valuable, and essential household spice belonging to the family Myrtaceae that is used as a food preservative and its medicinal benefits have been known for centuries. Clove has a historical background and it is believed to have originated in the 1st century BC (Hussain et al., 2017). Its unique odor and sweet taste are commonly used as a spice worldwide (Milind and Deepa, 2011; Saeed *et al*., 2021). Clove and its derivatives are used as herbal medicine for the treatment of various diseases world-wide (Saeed *et al*., 2021).

Antibiotics are mixed with feed and feed ingredients with a sub-therapeutic dose to maintain good water quality and appropriate dietary management. One of the most used antibiotics in fish farms is oxytetracycline (OTC) (Rigos and Troisi, 2005). OTC is a broad-spectrum tetracycline based antibiotic with bacteriostatic action produced by Streptomyces spp. fungi used to treat general bacterial infections of fish (Jerbi, 2011). Oxytetracycline (OTC) has been widely used in aquaculture as a therapeutic and prophylactic agent because of its broad-spectrum activity. OTC was the first antibacterial approved by USFDA for use in finfish aquaculture. Oxytetracycline (OTC) is one of the most used antibiotics in aquaculture. This raises concerns due to its effects in human and animal health, the environmental contamination and the consequences arising therefrom (Leal, 2019).

The different classes of antibiotics used in aquaculture include aminoglycosides, quinolones, sulfonamides, tetracyclines, macrolides, chloramphenicols, ß-lactams, nitrofurans, lincosamides, and polymyxins (Sun et al. 2020). Antibiotics usage in aquaculture is largely unregulated in many developing Nations, leading to indiscriminate antibiotic use (Budiati et al.2013), and even where laws do exist, stringent compliance is largely nonexistent. The most often used antibiotics in aquaculture are: oxytetracycline, florfenicol, and sulfadiazine (Lulijwa et al., 2020 and Sun et al. 2020).

MATERIALS AND METHODS

Location of the Study

The experiment was carried out in the Fisheries Unit of the Experimental Farm under the Department of Fisheries Technology, College of Agriculture, Science and Technology, Lafia.

COLLECTION OF FISH

Clarias gariepinus fry were obtained from Department of Fisheries Technology, College of Agriculture, Science and Technology, Lafia and were used for the study respectively.

EXPERIMENTAL DESIGN

There were two types of antibiotics used: synthetic (oxytetracycline) and natural (clove). The natural antibiotics were purchased from Shabu Market in Lafia, and each antibiotic had four treatments with three duplicates. Antibiotic oxytetracycline was purchased from veterinary store in Lafia. The following treatments were given to both natural and synthetic antibiotics: treatment 1, 00g/l of water, treatment 2, 5g/l of water, treatment 3, 10g/l of water, treatment 4, 15g/l of water, and treatment 5, 20g/l of water. One thousand five hundred (1500) fry of African Catfish *(Clarias gariepinus)* were used for the experiment and each of the treatments with 150 fry, seven hundred and fifty (750) fry for natural and seven hundred and fifty (750) fry for synthetic. There five (5) treatments each from natural antibiotics and synthetic antibiotics with three (3) replicates per treatment. The fry were treated for duration of 50 days.

Determination of Survival Rate

Survival rate (%) (SR)

$$SR \leq \frac{100 \times \text{total number of fingerlings that survived}}{\text{Total number of fingerlings stocked}}$$

Determination of Physico-Chemical Parameters

Aerators were employed to provide the necessary amount of dissolved oxygen in water, and Dissolved Oxygen was measured using Dissolved Oxygen meter Model AR8210, pH was measured using Hanna pH meter model HI 96107, temperature was measured using mercury-in-glass thermometer, Hach CO2 Test Kit (model HACH-WT-20) was used to determine carbon dioxide, while Hack Ammonia Test Kit (Model HACH-WT-20) was used to determine ammonia.

Statistical Analysis

Analyses of variance (ANOVA) were used to assess the experiment's data, and a significant mean separation was performed at the 0.05% probability level, in accordance with Steel et al.'s (1997) description.

RESULTS AND DISCUSSION

The result obtained from the experiment on the effect of natural and synthetics antibiotic in the survival of African catfish (Clarias gariepinus) fry, were presented in table 1.

Table 1: shows survival of Clarias gariepinus fry under different doses of natural antibiotics (Cloves) and synthetic (Oxytetracycline) antibiotics for 50 days.

parameters	**treatments g/ l of water natural antibiotics (cloves)**					**treatments g/ l of water . synthetic antibiotics (oxytetracycline)**				
	trt 1	trt 2	trt 3	trt 4	trt 4	trt 1	trt 2	trt 3	trt 4	trt 5
	00g/l	5g/l	10g/l	15g/l	20g/l	00g/l	5g/l	10g/l	15g/l	20g/l
Initial number of fry	50	50	50	50	50	50	50	50	50	50
Mortality rate	5	24	30	34	48	8	10	7	4	20
Survival rate	45	26	20	16	2	42	40	43	46	30
% Survival	90%	52%	40%	32%	4%	84%	80%	86%	92%	60%

The table above shows the comparative effect of using natural and synthetic antibiotics.
Synthetic (oxytetracycline) generally has the highest survival rate(46) at 90%with same massmixture for the feed quantitycompare to that of the natural (cloves) antibiotics (16) with 32%. This could be due to the highsolute concentration of natural antibiotic (cloves) which tend to kill the fry at high exposure period. The natural (clove) antibiotic is more powerful and more effective than the synthetic (oxytetracycline) antibiotic although the survival rate of synthetic antibiotics was higher.

WATER PHYSICOCHEMICAL PARAMETER.

The water quality parameters where within the acceptable range, Dissolved oxygen 5.2 – 6.8 ml/l, temperature 25-27oC, pH 6-7.5 and carbon dioxide ranges between 1.38-1.58ppm

Table 2: Water physicochemical parameters

PARAMETERS	TREATMENTS g/ l of water . NATURAL ANTIBIOTICS (CLOVES)					TREATMENTS g/ l of water . SYNTHETIC ANTIBIOTICS (OXYTETRACYCLINE)				
	TRT 1	TRT 2	TRT 3	TRT 4	TRT 5	TRT 1	TRT 2	TRT 3	TRT 4	TRT 5
	00g/l	5g/l	10g/l	15g/l	20g/l	5g/	5g/l	10g/l	15g/l	20g/l
Temperature ^{O}C	27	26	26	27	26	26	25	26	27	27
pH	7.1	6.5	6.5	6.00	6.00	6.8	7.6	7.5	7.5	6.5
Dissolved Oxygen ml/l	5.2	5.8	5.6	5.00	5.00	6.5	6.8	6.2	6.6	6.2
Carbon Dioxide ppm	1.42	1.45	1.50	1.54	1.58	1.45	1.49	1.43	1.5	1.38

DISCUSSION

it is not uncommon for farmers to use antibiotics during their aquaculture operations (Ali, et al.2016, Kawsar, et al. 2019., Kawsar, et al.2022., Uddin and Kader 2006). it is based on the fact that the use of antibiotics is uncommon that this research was able to look at the natural and synthetic antibiotics in the rearing of fry.the results of the study indicated that the use of synthetic antibiotic (oxytetracycline) at a concentration of 15g/litre of water gave a higher survival rate of 92% compared to the highest survival in natural antibiotics (cloves) of 52% with a concentration of 5g/.litre of water.
in this study, it was observed that correct application of the right dosage has positive effects on the fry.
this is in line with Ali et al. (2016) found that lack of knowledge and awareness of farmers on the proper use of chemicals, was a key driver that led to indiscriminate use of chemicals with dosing and method of application not being followed.
the studies of fish farms have shown that the majority of antibiotics added in feed are not assimilated by fish but go into the environments (Weston, 1996). Le and Munekage (2004) also reported that antibiotics residues may cause harmful effect on ecosystems.

CONCLUSION

The study conducted shows that 15grams of synthetic contributed has the highest surviving rate of fry that were used for the experiment and they were smart and active in the water and they responded to feed actively compare to other experiment, although that of 20 grams of natural antibiotics kills almost all the fry. The use of natural antibiotics is recommended for the treatment of fry. Although there was high mortality rate on the dosage used for this study but lower doses of 5g of cloves/litre of water and below can be tried by other researchers. The use of synthetic (oxytetracycline) in the study gave a good result with a concentration of 15g/l of water and hence recommended for use by fish breeders.We also recommend that more research be carryout on natural means of treating fry rather than the use of synthetic antibiotics. More research is needed in order to determine the consequences of the application of large quantities of antibacterial. Considering the rapid growth and importance of the aquaculture industry in many regions of the world and the widespread, intensive, and often unregulated use of antibacterial agents for fish and shellfish production, additional efforts are required to prevent the development and spread of antibacterial resistance in aquaculture.

REFERENCES

Ali, S. A., Shi, V., Maric, I., Wang, M., Stroncek, D. F., Rose, J. J., ... andKochenderfer, J. N. (2016). T cells expressing an anti–B-cell maturation antigen chimeric antigen receptor cause remissions of multiple myeloma. Blood, The Journal of the American Society of Hematology, 128(13), 1688-1700. https://doi.org/10.1182/blood-2016-04-711903

Budiati, T., Rusul, G., Wan-Abdullah, W. N., Arip, Y. M., Ahmad, R., and Thong, K. L. (2013). Prevalence, antibiotic resistance and plasmid profiling of Salmonella in catfish (Clarias gariepinus) and tilapia (Tilapia mossambica) obtained from wet markets and ponds in Malaysia. Aquaculture, 372, 127-132. https://doi.org/10.1016/j.aquaculture.2012.11.003

Hussain, M., Galvin, H. D., Haw, T. Y., Nutsford, A. N., and Husain, M. (2017). Drug resistance in influenza A virus: the epidemiology and management. Infection and drug resistance, 121-134. https://www.tandfonline.com/doi/full/10.2147/IDR.S105473#d1e133

Jerbi, M. A., Ouanes, Z., Besbes, R., Achour, L., andKacem, A. (2011). Single and combined genotoxic and cytotoxic effects of two xenobiotics widely used in intensive aquaculture. Mutation Research/Genetic Toxicology and Environmental Mutagenesis, 724(1-2), 22-27. https://doi.org/10.1016/j.mrgentox.2011.04.010

Kamal, M., Abo Omirah, M., Hussein, A., and Saeed, H. (2021). Assessment and characterisation of post COVID19 manifestations. International journal of clinical practice, 75(3), e13746. https://doi.org/10.1111/ijcp.13746

Kawsar, M. A., Alam, M. T., Ahamed, S., andMou, M. H. (2019). Aqua drugs and antibiotics used in freshwater aquaculture of North Chittagong, Bangladesh. Int. J. Fish. Aquat. Stud, 7, 28-34. ~ 28 ~ International Journal of Fisheries and Aquatic Studies 2019; 7(1): 28-34.

Kawsar, M. A., Alam, M. T., Pandit, D., Rahman, M. M., Mia, M., Talukdar, A., andSumon, T. A. (2022). Status of disease prevalence, drugs and antibiotics usage in pond-based aquaculture at Narsingdi district, Bangladesh: A major public health concern and strategic appraisal for mitigation. Heliyon, 8(3). https://doi.org/10.1016/j.heliyon.2022.e09060

Le, T. X., andMunekage, Y. (2004). Residues of selected antibiotics in water and mud from shrimp ponds in mangrove areas in Viet Nam. Marine pollution bulletin, 49(11-12), 922-929. https://doi.org/10.1016/j.marpolbul.2004.06.016

Leal, J. F., Santos, E. B., and Esteves, V. I. (2019). Oxytetracycline in intensive aquaculture: water quality during and after its administration, environmental fate, toxicity and bacterial resistance. Reviews in Aquaculture, 11(4), 1176-1194. https://doi.org/10.1111/raq.12286

Lulijwa, R., Rupia, E. J., and Alfaro, A. C. (2020). Antibiotic use in aquaculture, policies and regulation, health and environmental risks: a review of the top 15 major producers. Reviews in Aquaculture, 12(2), 640-663. https://doi.org/10.1111/raq.12344

Milind, P., and Deepa, K. (2011). Clove: a champion spice. Int J Res Ayurveda Pharm, 2(1), 47-54.

Okoye, C. O., Nyaruaba, R., Ita, R. E., Okon, S. U., Addey, C. I., Ebido, C. C., ... and Chukwudozie, K. I. (2022). Antibiotic resistance in the aquatic environment: analytical techniques and interactive impact of emerging contaminants. Environmental toxicology and pharmacology, 96, 103995. https://doi.org/10.1016/j.etap.2022.103995

Patel, M., Kumar, R., Kishor, K., Mlsna, T., Pittman Jr, C. U., and Mohan, D. (2019). Pharmaceuticals of emerging concern in aquatic systems: chemistry, occurrence, effects, and removal methods. Chemical reviews, 119(6), 3510-3673. https://doi.org/10.1021/acs.chemrev.8b00299

Rigos, G., andTroisi, G. M. (2005). Antibacterial agents in Mediterranean finfish farming: a synopsis of drug pharmacokinetics in important euryhaline fish species and possible environmental implications. Reviews in Fish Biology and Fisheries, 15, 53-73. https://doi.org/10.1007/s11160-005-7850-8

Seyfried, E. E., Newton, R. J., Rubert, K. F., Pedersen, J. A., and McMahon, K. D. (2010). Occurrence of tetracycline resistance genes in aquaculture facilities with varying use of oxytetracycline. Microbial ecology, 59, 799-807. https://doi.org/10.1007/s00248-009-9624-7

Schar, D., Klein, E. Y., Laxminarayan, R., Gilbert, M., and Van Boeckel, T. P. (2020). Global trends in antimicrobial use in aquaculture. Scientific reports, 10(1), 21878. https://doi.org/10.1038/s41598-020-78849-3

Sun, P., Lu, X., Xu, C., Sun, W., and Pan, B. (2020). Understanding of COVID-19 based on current evidence. Journal of medical virology, 92(6), 548-551. https://doi.org/10.1002/jmv.25722

Uddin, S. A., and Kader, M. A. (2006). The use of antibiotics in shrimp hatcheries in Bangladesh. J. Fish. Aquat. Sci, 1(1), 64-67.

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PRIMARY PRODUCTIVITY AND SPECIES DIVERSITY OF INTEGRATED RICE CUM FISH CULTURE UNDER DIFFERENT ECOLOGICAL ZONES IN NIGERIA.

[1]Ogunkoya T. F., [1] O.K. Kareem, [2]Amrit Bart, [3]M. Halwart, [1] E. K. Ajani, [1] B. O. Omitoyin, [3]Stankus Austin, [3]Ajayi Femi, [4]L.A. Argungui, [1] O.B. Oduntan, [1] T.B. Akinrinola, [4]M.Y. Abubakar, [5]J.C. Ikuwemesi and [1] O.O. Ajayi

[1].Department of Aquaculture and Fisheries Management, University of Ibadan,Oyo State, Nigeria
[2].University of Georgia, USA
[3].Food and Agriculture Organisation, Rome, Italy.
[4]. Department of Aquaculture and Fisheries Management, Usmanu Danfodiyo University, Sokoto, Sokoto State, Nigeria
[5]. Department of Fisheries and Aquatic Resources, Micheal Okpara University, Umudike, Abia State, Nigeria.

Coresponding Author:
ogunkoyafelicia@gmail.com, +2347039025862, 0009-0006-8638-2987

ABSTRACT

The growing population in Nigeria has led to an increasing demand for fish and animal protein, highlighting the need for sustainable aquaculture systems. Integrated rice-cum-fish (IRF) farming presents a promising solution to meet this demand, however, the fish in this system depends on the naturally available food sources in the field such as plankton and other small organisms. Hence, for this system to benefit society effectively. This study was aimed to assess the key environmental factors, including water and soil quality and the species diversity of plankton and macroinvertebrate in the IRF systems across different ecological zones in Nigeria.

The study was carried out for 16 weeks in Ebonyi, Kebbi, Oyo, and, Sokoto, data were collected biweekly on parameters like water and soil quality, plankton and macroinvertebrates samples for abundance and diversity following standardized methods. Diversity index such as Simpson, Shanon-weiner and Margalef were adopted and One-way ANOVA with SPSS at a significance level of $P<0.05$ was used for statistical analysis.

Results from water and soil quality analysis in Ebonyi, Kebbi, UDUS and UI DO 5.18±0.63(mg/l), 12.12±0.75 (mg/l), 12.656±0.644(mg/l) and 5.206±0.389(mg/l) respectively shows that IRF systems have good dissolved oxygen level for fish culture and soil qualities (pH 7.05±0.5, 6.95±0.26, 6.53±0.46 and 6.84±0.5 (g/kg) respectively shows that the pH level for fish and rice culture is optimum for their growth. The Margalef diversity index for plankton richness indicates that UI had highest 4.962 followed by Ebonyi with 2.851 then Kebbi with 1.868 and Udus with 1.814.

This study revealed that IRF practices in these zones are environmentally sound in terms of better nutrient distribution and diversity.

Keywords:
Plankton
Macroinvertebrates,
Diversity, Water and
Soil quality

INTRODUCTION

In Nigeria, rapid population growth has led to a rising demand for fish and animal protein, to ensure sustainable food access, it is critical to increase food production while balancing the demands of a growing population with environmental sustainability. As a result, transforming food systems has become essential to reduce environmental impacts and sustain livelihoods, while producing sufficient quantities of nutritious food (FAO, 2018). One promising solution is farm diversification, such as integrating rice and fish farming, as integrated rice-cum-fish (IRF) culture offers an environmentally friendly approach to increasing both rice and fish production, the reared fish in this system depends on the naturally available food sources in the field such as planktons, soft aquatic plants and other small organisms (FAO, 2018). Phytoplankton, which is the major primary producer of an aquatic food web, thus, plays a vital role in productivity of the rice-fish ecosystem. Omnivore fishes effectively utilise planktons as fish food (Das, 2018). Thus, for this system to benefit society effectively, vital key environmental factors needs to be documented, these includes water, soil quality, primary productivity, and the diversity of plankton and macroinvertebrates within the IRF system. This study aims to evaluate water and soil quality, abundance and diversity of plankton in an IRF system under different ecological zone in Nigeria.

MATERIALS AND METHODS

The study was conducted for 16 weeks in four selected research sites identified in the Ebonyi, Oyo, Kebbi and Sokoto states; the locations of the sites are as follows; USAID plot in the Department of Aquaculture and Fisheries Management, University of Ibadan, Ibadan, Oyo State, Nigeria, (latitude 7°26'40.35"N and longitude 3°53'58.29" E), Usman Dan Fodio University (latitude 13.1246°N and longitude 5.1994° E), Sokoto (latitude 12.4376°N and longitude 4.2078° E), Ebonyi Latitude 6.2649°N and longitude 8.0137°) Nigeria. The IRF plot was 22mx15m dimension rice field and a 1.5mx1.5m canal for fish refuge, the plot was stocked with Clarias gariepinus at the rate of 4 fish per m2 (at mean weight of 4g at n=1,500) and the fish stocking was done intermittently after paddy rice (FARO 44) was planted following a 20x20cm inter and intra spacing following FAO established standards. Data were collected bi-weekly for four months. plankton net (25 μm mesh size) and fixed in 5% formalin on-site. Quantitative analysis of phytoplankton was carried out using Sedgewick-R after counting chamber (S-R cell) with 1 ml subsample in the counter and counting of plankton units present within 10 random squares of the cells and computed the density with Stirling (1985). The phytoplankton were then identified up to genus level and enumerated using standard identification manual (e.g. Bellinger, 1992; Guiry and Guiry, 2018). Macroinvertebrates samples were collected using the method by Bett, (2019). Diversity indices for plankton and macroinvertebrates were done (Simpson 1949; Shanon-weiner, insert year and Margalef, 1974). Water quality parameters like pH, Dissolved oxygen, nitrate, nitrite, ammonia, were analyzed insitu in each of the rice cum fish production systems using pondlab test-kit in accordance with water quality standards by APHA (1995). Soil quality parameters like Nitrogen, Phosphorus and organic carbon were taken, analysed and recorded monthly using standard methods (APHA, 1989; Biswas, 1993). SPSS statistical software package was used to analyse the experimental data which were subjected to one-way ANOVA.

RESULTS AND DISCUSSION

Table 1: Diversity indices of macroinvertebrates and plankton classification of integrated rice fish farming in all the adaptive sites

MACROINVERTEBRATES	UI	EBONYI	UDUS	KEBBI	PLANKTON	UI	EBONYI	UDUS	KEBBI
Taxa_S	11	12	10	11	Taxa_S	39	24	14	15
Individuals	215	313	148	255	Individuals	2117	3192	1294	1801
Dominance_D	0.1287	0.1727	0.2264	0.2096	Dominance_D	0.1203	0.07551	0.1002	0.09439
Simpson_1-D	0.8713	0.8273	0.7736	0.7904	Simpson_1-D	0.8797	0.9245	0.8998	0.9056
Shannon_H	2.214	2.011	1.83	1.925	Shannon_H	2.755	2.75	2.387	2.492
Equitability_J	0.9233	0.8094	0.7946	0.8026	Equitability_J	0.752	0.8654	0.9046	0.9204
Evenness_e^H/S	0.8321	0.6228	0.6231	0.623	Evenness_e^H/S	0.4031	0.652	0.7773	0.806
Margalef	1.862	1.914	1.801	1.805	Margalef	4.962	2.851	1.814	1.868

Fig 1: Mean abundance of plankton in all the experimental sites

Table 2: Soil quality parameters of all the experimental sites

	UI	EBONYI	UDUS	KEBBI
pH	6.84±0.5[abc]	7.05±0.50[a]	6.53±0.46[bc]	6.95±0.26[ab]
Nitrogen (g/kg)	1.29±0.07[c]	1.86±0.52[bc]	2.01±0.20[ab]	2.42±0.32[a]
Phosphorus (mg/kg)	10.23±0.04[a]	15.9±0.46[c]	5.85±4.78[b]	6.55±7.38[b]
D.o (mg/l)	5.16±0.53	5.17±0.16	5.34±0.21	4.91±0.52
Organic carbon (g/kg)	17.38±0.53[c]	20.22±6.02[a]	17.88±4.02[bc]	17.93±1.25[bc]
Potassium (cmol/kg)	0.18±0.00[b]	0.28±0.34[b]	0.53±0.15[b]	0.98±0.22[a]

*Mean with the same superscript along the row is not significantly different at p>0.05.
*Mean with different superscript along the row is significantly different at p>0.05. Mean with no superscript along the row is not significantly different at p>0.05

TABLE 3: Mean value of all the water quality parameters of pooled cycles in all the experimental sites

	UI	EBONYI	UDUS	KEBBI
General hardness	92.956±30.918[a]	73.742±23.325[b]	32.200±13.810[bc]	44.742±10.488[c]
pH	7.378±0.425[ab]	6.827±0.300[c]	7.656±0.539[a]	7.247±0.568[a]
Nitrate (mg/l)	0.278±0.081	0.080±0.099	0.234±0.063	0.551±0.793
Nitrite (mg/l)	0.556±1.617[a]	0.000±0.000[b]	0.203±0.101[b]	0.401±0.472[b]
Ammonia(mg/l)	0.183±0.134	0.098±0.101	0.119±0.040	0.222±0.162
Alkalinity	107.789±32.578[a]	66.018±8.703[b]	53.388±0.890[c]	66.872±27.686[b]
Dissolved Oxygen (mg/l)	5.206±0.389[a]	5.183±0.629[a]	12.656±0.644[b]	12.122±0.753[b]

*Mean with the same superscript along the row is not significantly different at p>0.05,
*Mean with different superscript along the row is significantly different at p>0.05 *Mean with no superscript along the row is not significantly different at p>0.05

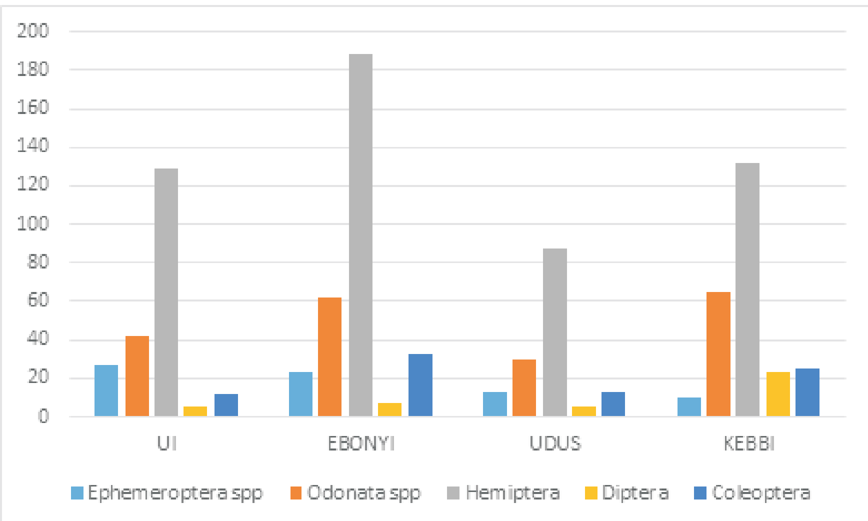

Fig 2: Mean abundance of macroinvertebrates in all the experimental sites

The above table 1 shows the macroinvertebrates and plankton identified and its abundance at various sites. Fig 2: macroinvertebrates classification in all the experimental sites. Macroinvertebrates are used to assess the condition of the aquatic environment or to monitor trends in condition over time (Siddig et al., 2016). A number of families or genera of water beetles (Coleoptera) have shown to be potential bioindicators for fast and cost-efficient monitoring of the overall quality of wetland ecosystems (Foster et al., 2015; Malherbe et al., 2015) regions. For example, dragonflies and damselflies (Odonata) larvae have shown to be good biological indicators of grazing impacts on wetlands (Lee Foote and Rice Hornung, 2005). The plankton abundance of all the location in the individual and the number of species found in all the location. Using shanon-weiner index UI and Ebonyi shows moderate diversity while Udus and Kebbi shows low diversity. Using Simpson index, they are all high in diversity, but species from Ebonyi had the highest diversity (0.925) while UI exhibit the least diversity (0.88). Based on Margalef index all the experimental sites have high diversity, with same diversity same high and low states with Simpson grading.

Fig 1: Phytoplankton are an important source of numerous nutritional components, such as vitamins, mineral elements, and fatty & amino acids for fish larvae (NapiórkowskaKrzebietke, 2017). The most abundant plankton for UI were Euglenaceae, Desmidiaceae, Selenastraceae, Microsporaceae Scenedesmaceae that of Ebonyi is Chydrodea, Fragilariaceae, Closteriaceae, Desmidiaceae, Cyanobacteriaceae, Microsporaceae, Chlorophyecae. Udus is Chlamydomonadaceae, Hydrodictyaceae, Ulotrichaceae, Cyanobacteriaceae, Scenedesmaceae. Kebbi is Chlamydomonadaceae, Scenedesmaceae, Desmidiaceae, ,Selenastraceae, Bacillariophyceae, Stephanodiscaceae For all this study, all the sites most abundant planktons were Euglenaceae, Desmidae, selenastraceae, Microsporaceae, Scenedesmaceae. Which is very similar to the study of Udin et al. (2018) that had most dominant planktonic groups namely Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae and Rhodophyceae. The most dominant group was Chlorophyceae followed by Euglenophyceae, Bacillariophyceae, Cyanophyceae and Rhodophyceae. This result is more or less similar to the results of Rahman (2004) and Hasan (2009)

The Shannon-Wiener diversity index H' is an index of diversity assessment and positively correlated with the water quality, it also takes into account both abundance and evenness of species present in the ecosystem. It reflects the evenness of distribution of each species, mainly ranging from zero (no evenness) to one (complete evenness). D is one of the diversity indices used to measure the richness of community species. Therefore, the more stable communities tend to show higher H', J and D values. According to Fernando et al., 1998, classification scale for the shanon diversity index states value with 3.50 and above to be very high, 3.0-3.49 high, 2.50-2.99 moderate, 2.0-2.49, low and 1.99 below are very low. In Shannon Index (H) shows the higher the value the greater the diversity, In this study, macroinvertebrates was found to be the highest in UI site (2.214) and least in the UDUS site (1.83) while for that of plankton UI site had the highest Shannon index (H) with (2.755) and least in the UDUS site (2.387). The high value of H in UI shows that plankton and macroinvertebrates are more evenly distributed in the site. The analysis of its diversity reflects the ecological and environmental quality of the surveyed waters (Katsiapi et al., 2016). The enhanced percentage of plankton in the IRF system suggests that fish possibly release additional nutrients to the system (Desta et al., 2014), and prey on substantial quantities of plankton as feeds (Wang et al., 2019; Vidal et al., 2019). In the present study, the IRF sites had a large phytoplankton population and this could suggest that the aquatic ecosystem quality in the rice-fish coculture system is better than those in monoculture according to (Vidal et al., 2019)

The Equitability index is simply the Shannon diversity index divided by the maximum diversity. This Equitability index takes a value between 0 and 1. The lower values indicate more diversity while higher

values indicate less diversity. Specifically, an index value of 1 means that all groups have the same frequency. The Equitability Index (EH) for plankton was found to be highest in Kebbi (0.9204) and least in UI (0.752) for macroinvertebrates the highest was found in UI (1.914) and the least was found in UDUS (0.7946).
The Simpson Index value also ranges between 0 and 1, the greater the value, the greater the sample diversity (Simpson,1949). The Simpson Index (D) for plankton was found to be the highest in Ebonyi (0.9245) and lowest in UI (0.8797). Simpson Dominance Index (D) The Dominance Index was measured to determine whether or not particular fisheries species dominate in a particular aquatic system and can be useful index of resource monopolization by a superior competitor, particularly in communities that have been invaded by exotic species (Harper, 1999).

According to Margalef (1956), the higher diversity values reflect the suitability of habitat for the organism and have been reported to be correlated with longer food chain and complex food web of the ecosystems and also more stable community. Margalef (1974) reading value =1 higher and < 1 lower in diversity. Based on Margalef index all the sites are significantly high in diversity. The Margalef Richness Index has no limit value and it shows a variation depending upon the number of species. Margalef Richness Index for phytoplankton was found to be the highest in UI (4.962) and lowest in UDUS (1.814).
Macroinvertebrates are good indicators of trophic levels over time because they are highly sensitive to changes in aquatic ecosystems (Gannon and Stemberger, 1978; Ismail and Adnan, 2016; Jeppesen et al., 2011). In the present study, the species in all the sites belonged to the oligosaprobic to *a*-mesosaprobic indicator species (Fang et al., 2012; Lin et al., 2014). The diversity indices indicated the water quality in from *a*-mesosaprobic zone to polysaprobic zone (Deng et al., 2010; Zeng and Miao, 2012). A number of families or genera of water beetles (Coleoptera) have shown to be potential bioindicators for fast and cost-efficient monitoring of the overall quality of wetland ecosystems (Foster et al., 2015; Malherbe et al., 2015) regions. For example, dragonflies and damselflies (Odonata) larvae have shown to be good biological indicators of grazing impacts on wetlands (Lee Foote and Rice Hornung, 2005).

Table 2 which shows soil quality parameters indicate that mean pH ranged of 6.4 to 6.9 was observed in this study and this is similar with the findings of Abraham et al., (2018) who gave that the optimum soil pH for rice production 5.5 – 8. Total nitrogen(g/kg) result ranged (0.7 to 2.1) showed that there was adequate nutrient for the growth of rice in all the treatment and it was in agreement with the study of Lani et al., (2013), Phosphorus available (5.85 to 15.9) in the paddy across the research sites with UI and Ebonyi having phosphorus value of 10.23±0.04 and 15.9±0.46 respectively which was within the tolerable range (10-20mg/kg) of IRRI (2019). Organic carbon recorded during the production was within the tolerable range of IRRI (2019), having given acceptable organic carbon range for rice 10-15 g/kg as moderate organic carbon, suitable for most paddy rice varieties ranged of 5.206 – 5.8mg/l but this can sustain aquatic life according to Boyd (1998) and it falls within the standard range of 3.0-6 mg/L as suggested by Malik et al., (2020), therefore favorable for the growth of fish. Table 3: The high value in the DO levels in Kebbi and UDUS may be attributed to the continuous movement of the fish in the rice fields which helps with dissolving atmospheric oxygen into the water(backing up citation for you statement, because plant exchange of gases with water can also influence), the high values are considered optimum DO levels and this agrees with study of Abdullahi (2015) in Kebbi, whose DO range falls within 10.5-14.4mg/L in Kebbi. Alkalinity above 100mg/L is classified as high productive and those with <50mgL-1 are oligotrophic (Meera and Nandan, 2010). The mean pH evaluated observed in all the adaptive sites during the period of production ranged (6.8 – 8) throughout the production was good for pond productivity, which agrees with the findings of Fioye et al., (2005). Ammonia (0.1 mg/l - 0.5 mg/l), nitrate and nitrites level in the sites were desirable for aquaculture. Ammonia, nitrite and nitrate values in all the treatments were within recommended range for the growth and survival of both rice and fish. Nitrate converted to nitrite is less toxic and mild to health. The nitrite range was between 0 mg/L- 0.2 mg/L which is the desired range of 0-1mg/L (Omitoyin and Ajani 2007).

CONCLUSION

The study revealed that IRF in these zones are environmentally friendly and with better nutrient distribution within the ecosystem through the abundance of plankton and the macroinvertebrates present in the system and the diversity.

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REFERENCES

Abdullahi, S. A. (2015). Water Quality Assessment of Integrated Fish Ponds in Kebbi State, Nigeria. Journal of Fisheries and Aquatic Science, 10(3), 241-248.

Ahmed, N., Belton, B., and Murshed-e-Jahan, K. (2011). Aquaculture, Employment, Poverty, Food Security and Well-Being in Bangladesh: A Comparative Study. Pp161-166

APHA (1995) Standard Methods for the Examination of Water and Wastewater. American Public Health Association/American Water Works Association/Water Environment Federation, Washington DC.

Deng, H. P., Chen, F., Wang, M. S. and Liu, C. K. (2010). Community structure and species diversity of diatom in downstream of Jialing River. Acta Hydrobiologica Sinica, 34(2), 330-335.

Dobermann, A. and Fairhurst, T. (2000). Rice: Nutrient Disorders & Nutrient Management. International Rice Research Institute (IRRI). ISBN 971-22-0094

Fang, Y.H., Huang, D.M., Wang, W.J., Jian, D., Xie, S. and Yang, H.Y., (2012). Characteristics of community structure of zooplankter in autumn at estuary of Dadu River. J. Hydroecol. 33 (5), 34–40.

FAO 2018. The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable development goals. Rome. Licence: CC BY-NC-SA 3.0 IGO.

FAO, 2019. Cultured Aquatic Species Information Programme. Oreochromis niloticus. Cultured Aquatic Species Information Programme. Text by Rakocy, J. E. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 18 February 2005. [Cited 23 December, 2019].

HARPER, DAT (ed.) Numerical Palaeobiology. Computer-Based Modelling and Analysis of Fossils and their Distributions. John Wiley & Sons. 1999; 137(4):468. 16.

IRRI. (2019). Rice Soil Fertility Management. International Rice Research Institute. ISBN 978-971-22-0344-4

Jeppesen, E., Noges, P., Davidson, T.A., et al., (2011). Zooplankton as indicators in lakes: a scientific-based plea for including zooplankton in the ecological quality assessment of lakes according to the European Water Framework Directive (WFD). Hydrobiologia 676 (1), 279–291.

Lin, Q., You, W., Xu, F., Yu, Q. and Yu, H., (2014). Zooplankton community structure and its relationship with environmental factors in Dishui Lake. Acta Ecol. Sin. 34 (23), 6918–6929.

Margalef R. Information and diversity specifies the communities of organisms. Invest Pesg. 1956

Margalef, R. (1974). Estimating quantity and quality of biomass 2: In: Vallen Welder, R. A manual for environment. IBP handbook No 2: 225 pp.

Muhammad, A., et al. (2019). Physico-Chemical Parameters of Water in Fish Ponds in Kebbi State, Nigeria. Journal of Water and Environmental Engineering, 11(1), 1-8.

Nesar Uddin, Abu Syed Md. Kibria and Mohammad Mahfujul Haque(2018). International Journal of Fisheries and Aquatic Studies 2018; 6(3): 306-314

Ojo, S. O. (2020). Nutrient Dynamics in Integrated Rice-Cum-Fish Ponds in Kebbi State, Nigeria. Journal

of Agricultural and Food Science, 18(2), 1-8.
Omitoyin B. O. and Ajani E.K. (2007). Introduction to Fish Farming in Nigeria. Nigeria: Ibadan University Press. 2007; 35-40
Simpson E.H. (1949). Measurement of diversity. Nature. 1949; 163:688. doi:10.1038/163688a0
Simpson E.H.1949 Measurement of diversity. Nature 163:688
SOP 1994. Grace Analytical Lab 536 South Clark Street 10th Floor Chicago, IL 60605 December 15, 1994
Vidal, T., Santos, J.I. and Queiros, ´ L., (2019). Environmental benchmarks based on ecotoxicological assessment with planktonic species might not adequately protect benthic assemblages in lotic systems. Sci. Total Environ. 668, 1289–1297.
Wang, Y., Sen, K., He, Y., et al., 2019. Impact of environmental gradients on the abundance and diversity of planktonic fungi across coastal habitats of contrasting trophic status. Sci. Total Environ. 683, 822–833.
Zeng, Y. and Miao, M.S. (2012). Evaluation of water quality improvement in Wenyuhe River based on the analysis of diversity of macro-zooplankton. Environ. Sci. Technol. (China) 35 (3), 200–205.

CYCLICAL STARVATION AND FEEDING PROVOKE COMPENSATORY GROWTH IN SEX-REVERSED AFRICAN CATFISH

1Adenigba, I.A., 1B. O. Musa and A. E. 2Serrano, JR.
1 Department of Fisheries Technology, Federal College of Fisheries and Marine Technology, Lagos
2 University of the Philippines, Visayas

babatunde.musa@fcfmt.edu.ng, +2348023700813, https://orcid.org/0000-0002-4472-2035

ABSTRACT
This study investigated the effects of starvation and subsequent refeeding on growth, feed utilization of sex-reversed African catfish SRAC (Clarias gariepinus) fingerlings. The fingerlings were randomly stocked in 12 tanks at 25 fingerlings tank-1. The fish were subjected to 4 feeding regimes: continuous feeding control group: (T1); 2 days starvation followed by 8 days refeeding (T2 2:8); 4 days starvation followed by 16 days refeeding (T3 4:16) and 8 days starvation followed by 32 days refeeding (T4 8:32), respectively. After 80 days of feeding trial, results showed there were no significant differences in the final average body weight (FABW), weight gain (WG), specific growth rate (SGR) and survival between the deprived and the control (P =0.05). However, cyclic feeding showed a significant effect on feed intake (FI), protein efficiency ratio (PER), food conversion ratio (FCR). The results indicated that SRAC fingerlings subjected to 2, 4 and 8 days of feed deprivation and refeeding exhibited compensation for WG with a coefficient of 1.21, 1.17, and 1.15 for T2, T3, T4, respectively. In general, the species could recover in growth performance following short periods of starvation.

Keywords:
All-male African catfish; nutrition; feed deprivation; compensatory growth

INTRODUCTION

Aquaculture has experienced remarkable growth as its share in total global production has increased to 50.9 percent in 2022, up from 20 percent in the 1990s and 49.4 percent in 2020 (FAO, 2024). One of the key reasons for its growth is the recent move toward more intensive culture systems which are characterized by high stocking density as well as enormous feed input. However, the phenomenal cost of aquafeed is a major challenge impeding the profitability of aquaculture production. One of the feeding strategies that could be used to optimize fish cultivation is cyclical feed denial and feed restoration resulting in compensatory growth. The trend has been reported to be a replica of natural cycle of availability of food and prey as well the growth pattern in the wild. As a biological phenomenon, the compensatory or catch-up growth is a phase of accelerated growth in a period where favourable conditions have been restored after a period of growth depression when food or prey are often more scarce, for instance, during the winter months (Jobling 1994), due to seasonal changes in water temperature, reproductive migrations, tidal and long-term ecological changes. Under growth compensation, fish can grow faster than expected, catching up for the lost growth and quickly reaching similar size as conspecifics that have been fed continuously (Mommsen 1998).

Compensatory growth has been studied in various cultivated fishes, such as cyprinids (van Dijk *et al.*, 2002, percids (Hayward & Wang 2001), channel catfish, Ictalurus punctatus (Gaylord & Gatlin 2000), hybrid tilapia, Oreochromis mossambicus × O. niloticus (Wang *et a*l., 2000), gibel carp (Carassius auratus gibelio) and Chinese long snout catfish (Leiocassis longirostris) (Zhu *et al.*, 2004), Milk fish (Chanos chanos) juvenile (Llameg and Serrano Jr. 2014), Clarias gariepinus (Ofor et al., 2013, Aderolu et al. 2010). Feed deprivation can be short-term or long term and repeated in cycles, over the culture period, and the fish can undergo partial or full growth compensation during subsequent re-alimentation. It has been shown that the phenomenon of compensatory growth can be exploited for economic benefits, by applying less amount of feed, leading to optimal biological productivity.

In the present study, compensatory growth performance and nutrient utilization in sex-reversed African catfish (SRAC) C. gariepinus subjected to different cycles of food deprivation and subsequent refeeding was investigated.

MATERIALS AND METHODS

Experimental Design: The study was conducted at the Laboratory of the National Institute of Molecular Biology and Biotechnology (NIMBB), University of the Philippines Visayas, Miagao, Iloilo, Philippines in indoor plastic tanks in a closed recirculation system. An 80-day growth trial was conducted with approximately 25 fingerlings tank-1 of SRAC (C. gariepinus) in 54-L tanks. Fish was allowed to acclimate for 2 weeks during which time they were fed with formulated pellet feed of 40% crude protein, twice daily at 5% body weight and starved for one week before the experiment. Each plastic tank was randomly assigned to one of 4 cyclic feeding regimes (with 3 replicates for each treatment), namely, a control treatment (T1) which was fed continuously; T2 (2:8), two days fasting followed by 8 days refeeding; T3 (4:16), four days fasting followed by 16 days refeeding; and T4 (8:32), 8 days fasting followed by 32 days refeeding in a completely randomized experimental design. Fish in 2:8 group was exposed to 8 cycles, 4:16 to 4 cycles while 8:32 groups for 2 cycles throughout the 80-day experimental period. In all experimental feeding regimes, feeding/refeeding was done three times daily (0800, 1200 and 1600) at a sliding feeding rates (3% - 2% body weight). Bulk sampling of fish was carried out every twenty days interval, i.e. on the 20th, 40th, 60th and 80th days corresponding to 3, 6, 9 and 12th weeks, respectively. Following a 16 h starvation, sampling was done and the amount of feed for the next feeding period considering mortality was adjusted accordingly.

Dissolved oxygen (DO), pH, temperature of culture water medium were measured daily (06:00-07:00) using a multi parameter checker. Ammonia, nitrite and phosphorus content of the water were checked twice a week using commercially available kits (AQUA- NITETM and AQUA-AMTM, respectively). The water quality was maintained at 5 to 6 ppm (DO), 6.8 to 7.2 (pH), 27 to 29oC (temperature), and 0.08 to 0.12 mgL-1 (Ammonia) in all tanks all through the experiment.

Diet preparation: A basal practical diet was formulated to provide 45% crude protein (Table 1). The ingredients were purchased from SEAFDEC, Tigbauan, Iloilo, powdered and sieved through 150 μm screen prior to mixing. All dried ingredients were thoroughly mixed using an electric-driven mixer (Spar mixer-5MX-J),and the liquid ingredients together with gelatinized bread flour were added just before pelletizing. The dough was pelleted (2 mm) in an electric meat grinder and oven-dried at 600C for 36 h to reduce moisture to about 10 %. Diets were then crumbled to appropriate sizes (0.3 to 2.0 mm) and stored at 40C until use.

Table 1
Composition and proximate analysis of experimental diets for C. gariepinus used in the feeding trial

Ingredients	%
Danish FM	235.6
Vitamin mix 1	10.0
Mineral mix 2	10.0
Dical. Phosphate	10.0
BHT	0.5
Bread flour	177.7
Cod liver oil	40.0
Soybean oil	40.0
Lecithin	5.0
Soyabean meal	235.6
Shrimp meal	117.8
Squid meal	117.8
Total	1000.0
Proximate Analysis (%) of experimental diets	
Moisture	8.72
Crude Protein	42.72
Crude Fat	13.22
Crude Fibre	1.98
NFE	20.74
Ash	9.62
Gross Energy (Kcal g^{-1})	3.85

NFE= Nitrogen free extract

Proximate composition of the experimental diets was analysed following standard methods (AOAC 2002).

Growth performance and nutrient utlization indices

Calculations were carried out using the following formulae to assess the growth performance and feed efficiency:

Weight gain, WG (g) =FABW – IABW

where FABW = Final average body weight (g) and IABW = Initial average body weight (g)

Specific Growth Rate, SGR (% day-1) = ((ln FABW–ln IABW)/ T)x100 where T = time in days

FCR = FI (g) /WG (g) where FI= feed intake (g)

PER = WG / (FI x feed crude protein (in decimal))

Survival rate (%) = 100*(final count/initial count)

Compensatory coefficient of WG(CCWG)= (FABW in the cycled fish (g)/number of feeding days)/(FABW in the control group (g)/number of feeding days)

Statistical Analysis: Data from the study were presented as mean ± standard error of the mean (SEM), and were tested for normality and variance homogeneity using Shapiro-Wilk test and Levene's test respectively (SPSS v. 20). Those data that did not pass the two tests were subjected to transformation. Thereafter, One-way analysis of variance (ANOVA) was conducted at a=0.05 and the post hoc analyses were done using Duncan multiple range test to rank the means.

RESULTS AND DISCUSSION

Table 2: Growth performance and feed utilization values of SRAC C. gariepinus subjected to four feeding regimes after 80 days rearing (n=25; 3 replicates)

Parameters	Treatments				SEM	p-value
	T1 (Control)	T2 (2:8)	T3 (4:16)	T4 (8:32)		
IABW (g)	15.01± 0.07^{a}	15.01± 0.13^{a}	15.00± 0.06^{a}	15.01± 0.13^{a}	0.05	1
FABW (g)	55.08± 1.8 ^{a}	53.50± 1.2^{a}	51.63±1.0^{a}	50.66± 1.6^{a}	0.80	0.21
WG (g)	40.07± 1.8 ^{a}	38.49± 1.2^{a}	36.63±1.0^{a}	35.65±1.8^{a}	0.81	0.23
SGR (%day^{-1})	1.63± 0.04^{a}	1.59± 0.03^{a}	1.54±0.03^{a}	1.52±0.05^{a}	0.02	0.3
FI (g)	57.04± 2.7 ^{b}	47.36± 1.5^{a}	44.61±0.64^{a}	42.84±0.54^{a}	1.79	0.00
FCR	1.42± 0.01 ^{b}	1.23± 0.05^{a}	1.22±0.04^{a}	1.21±0.05^{a}	0.03	0.02
PER	1.56± 0.01 ^{a}	1.81± 0.08^{b}	1.83±0.06^{b}	1.85±0.07^{b}	0.04	

All values on the same row with the different superscripts are significantly difference ($P < 0.05$).

The growth performance indicators (weight gain WG and specific growth rate SGR) and the survival did not show significant differences among the treatment ($P > 0.05$). In contrast, nutrient utilization indices (feed conversion ratio FCR and protein efficiency ratio PER) along with feed intake FI differed significantly among the treatment $P<0.05$. The significantly lower FI and FCR for all SRAC subjected to cyclical starvation and refeeding compared to that of the control group pointed to accomplishment of the desired effects of efficient conversion of food as well as the concomitant reduction in the cost of feeding. The high % survival (94.67±3.5 to 97.33±1.3) in all treatments indicate that SRAC can withstand relatively long periods of starvation without severe consequences such as mortality.

Results obtained from this study indicated that SRAC subjected to cyclical 2, 4 and 8 days of food deprivation and refeeding, was able to show full growth compensation. Liu et al. (2011) and Abolfathi et al. (2012) observed full and partial compensation in Chinese sturgeon and roach respectively. Kim and Lovell (1995) reported that channel catfish deprived of feed for 3 weeks required only 3 weeks to catch up with the control group in an 18-week feeding trial. In starved fish, the resulting increase in nutrient intake due to increased appetite and decreased maintenance costs allow for more rapid growth, particularly in the form of muscle tissue. This is because high food and energy uptake would lead to large amount of energy available for growth. It is also possible that catabolic processes slowed down while anabolic processes were accelerated which resulted in the rapid growth in the compensatory phase (Jobling 1994).

David and Gerrard (2002) stated that homeostatic and homeorhetic processes are involved in the abnormally high growth rates. Homeostatic processes usually affect compensatory growth in the short term, whereas homeorhetic processes usually have a long-term effect (Scanes, 2003). Though it is clear that in some animals the endocrine system is involved in the metabolism and nutrient partitioning in the tissues, the gut tissues are the first to increase in weight, followed by muscle tissue and finally adipose tissue (Tony et al., 2002). The compensatory growth exhibited in the present study could be related to the statements that, among the factors, that, if switched from unfavourable to favourable levels, can induce CG, are: the quantity of food given to the fish (Nikki et al., 2004), the quality of food provided (Schwarz et al., 1985), and the stocking density (Salas-Leiton et al., 2010). The length in time or the severity of the feed restriction equally has an effect on the outcome of trials and whether the fish can partly or fully compensate for the weight loss when reverted to full feeding (Jobling and Koskela, 1996). Growth spurt often allows fish to catch-up to, or even overshoots the size of normally-growing fish. In the present study, no overshoots was observed but rather normal compensatory growth. Compensatory growth could be achieved by hyperphagia (Abolfathi et al., 2012), improved feed efficiency or combination of hyperphagia and improved feed efficiency (Qian et al., 2000; Gaylord and Gatlin, 2001). In the present study, it could be assumed that the main mechanism involved in compensatory response in T2 to T4 was the improved feed efficiency without becoming hyperphagic.

CONCLUSION

The present results indicate that the SRAC in all deprived groups had the ability to achieve full compensatory growth during the starvation-refeeding cycles. SRAC adapted well to feeding strategies with longer periods of starvation (8 days) resulted in the lowest FI, FCR and highest PER among the deprived fish.

REFERENCES

Abolfathi, M., Hajimoradloo, A., Ghorbani, R., and Zamani, A. (2012). Compensatory growth in juvenile roach Rutilus caspicus: effect of starvation and re-feeding on growth and digestive surface area. J. Fish Biol. 81, 1880 1890.

Aderolu, A. Z., M. O. Lawal, B. M. Seriki and A. L. Apatira (2010). Compensatory growth effects on previously starved fingerlings and juveniles of African catfish (Clarias gariepinus, Burchell 1822). African Journal of Food Science Vol. 5(11): 637-642

Adewolu, M.A. and Adoti A.J. (2010). Effects of mixed feeding schedules with varying dietary levels of crude protein on the growth and feed utilization of Clarias gariepinus (Burchell, 1822) fingerlings. Journal of Fisheries and Aquatic Science 5:304-310. https://scialert.net/abstract/?doi=jfas.2010.304.310

David, E. & Gerrard Alan, L., (2002). Principles of Animal Growth and Development. Kendall Hunt Publishing Company, Iowa, US

FAO. (2022). The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome, FAO. https://doi.org/10.4060/cc0461en

Gaylord, T. G., MacKenzie, D. S. and Gatlin, D. M. III. (2001). Growth performance, body composition and plasma thyroid hormone status of channel catfish (Ictalurus punctatus) in response to short-term feed deprivation and refeeding. Fish Physiology and Biochemistry, 24, 73–79. https://doi.org/10.1023/A:1011199518135

Jobling, M. (1994). Fish Bioenergetics. Chapman & Hall, London, 309 p.

Jobling, M. and Koskela, J. (1996). Interindividual variations in feeding and growth in rainbow trout during restricted feeding and in a subsequent period of compensatory growth. Journal of Fish Biology. 49, 658-667. https://doi.org/10.1111/j.1095-8649.1996.tb00062.x

Kim, M.K. and Lovell, R.T. (1995). Effect of restricted feeding regimens on compensatory weight gain and body tissue changes in channel catfish Ictalurus punctatus in ponds. Aquaculture 135:283-293. DOI:10.46989/001c.20418

Liu, W., Wei, Q.W., Wen, H., Jiang, M., Wu, F. and Shi, Y. (2011). Compensatory growth in juvenile Chinese sturgeon (Acipenser sinensis): effects of starvation and subsequent feeding on growth and body composition. J. Appl. Ichthyol. 27, 749–754. hpps://doi.org/10.1111/j.1439-0426.2011.01723.x

Llameg, M and Serrano Jr, A. E. (2014). Effect of cyclic feeding on compensatory growth in milkfish Chanos chanos juvelines. ELBA Bioflux.6:1, 22-28

Mommsen, T.P. (1998). Growth and metabolism. In: Evans, D.H. (Ed.) The Physiology of Fishes, pp. 65–97. 2nd ed. CRC press, LLC, USA.

Nikki, J., Pirhonen, J., Jobling, M., and Karjalainen, J. (2004). Compensatory growth in juvenile rainbow trout, Oncorhynchus mykiss (Walbaum), held individually. Aquaculture 235: 285 https://doi.org/10.1016/j.aquaculture.2003.10.017

Ofor, Chukwuma, O. and Ukpabi, C. (2013). Effect of short-term cyclic feed deprivation on growth and economic limit of commercial feed-based in-door grow-out of Clarias gariepinus(Burchell, 1822). International Journal of Fisheries and Aquaculture. Vol. 5(11): 303-309 DOI:10.5897/IJFA2013.0369

Qian, X., Cui, Y., Xiong, B., and Yang, Y. (2000). Compensatory growth, feed utilization and activity in gibel carp, following feed deprivation. J. Fish Biol. 56: 228–232. DOI:10.1111/j.1095-8649.2000.tb02101.x

Salas-Leiton, E., Anguis, V., MartIn-Antonio, B., Crespo, D., Planas, J. V., Infante, C., CaNavate, J. P. and Manchado, M. (2010). Effects of stocking density and feed ration on growth and gene expression in the Senegalese sole (Solea senegalensis): potential effects on the immune response. Fish and Shellfish Immunology, 28: 296–302. DOI: 10.1016/j.fsi.2009.11.006

Scanes, C. G. (2003). Biology of growth of domestic animals. Wiley-Blackwell. p. 352. ISBN 978-0-8138-2906

Schwarz, F. J., Plank, J. and Kirchgessner, M. (1985). Effects of protein or energy restriction with subsequent realimentation on performance parameters of carp (Cyprinus carpio L.). Aquaculture, 48, 23–33. https://doi.org/10.1016/0044-8486(85)90049-3

Tony, L., John, L., Fowler, V.R. (2002). Growth of farm animals. CABI. pp. 229–254. ISBN 978-0-85199-484-0.

Van Dijk, P.L.M., Staaks, G., and Hardewig, I. (2002). The effect of fasting and refeeding on temperature preference, activity and growth of roach, Rutilus rutilus. Oecologia 130, 496-504 https://doi.org/10.1007/s00442-001-0830-3

Wang, Y., Cui, Y., Yang, Y., and Cai, F. (2000). Compensatory growth in hybrid tilapia, Oreochromis mossambicus x O. niloticus, reared in sea water. Aquaculture 189, 101-108. DOI:10.1016/S0044-8486(00)00353-7

Zhu, X, S. Xie, W. Lei, Y. Cui, Y. Yang and R.J. Wooton (2005). Compensatory growth in the Chinese longsnout catfish Leiocassis longirostris following feed deprivation: temporal patterns in growth, nutrient deposition, feed intake and body composition. Aquaculture 248, 1-4, 307-314 DOI:10.1016/j.aquaculture.2005.03.006

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

MARINE CONSERVATION AND BIODIVERSITY (MBC)

ABUNDANCE AND DISTRIBUTION OF PRAWN SPECIES IN THE CALABAR AND GREAT KWA RIVERS, NIGERIA

Odum, C. J., P. J. Udo and P. E. Asuquo

Department of Fisheries and Aquaculture, Faculty of Agriculture, University of Calabar, Nigeria

Corresponding Author:
carolinejoseph289@gmail.com +234 7033 490 563

ABSTRACT

This study investigates the abundance and distribution of prawn species in the Calabar and Great Kwa Rivers, Cross River State in Nigeria. Prawn samples were collected from artisanal fishermen across multiple sites along the river, from upstream to downstream regions, over different seasons (November 2020 to January 2022) to assess comprehensive data on prawn species diversity and abundance. Results revealed six species across the rivers: Macrobrachium rosenbergii (40%), Macrobrachium vollenhovenii (30%), Macrobrachium macrobrachion (10%), Caridina africana (15%), and Caridina nilotica (5%). Upstream areas, characterized by cooler temperatures (average 20°C) and higher oxygen levels (average 8 mg/L), exhibited a lower density of prawn species (average 25 prawns per sampling event) compared to midstream (average 70 prawns per sampling event) and downstream regions (average 50 prawns per sampling event). The highest abundance was recorded in midstream regions, where a mix of moderate water flow (average 1.5 m/s), suitable habitat structures, and optimal water quality conditions prevail. Downstream areas showed a decline in prawn numbers, likely due to increased pollution (average pH 7.8) and habitat disruption. Environmental parameters such as water temperature ($r = 0.65$, $p < 0.01$), dissolved oxygen ($r = 0.58$, $p < 0.05$), and substrate type were critical determinants of prawn distribution. Seasonal changes also influenced prawn abundance, with peak populations observed during the dry season (average 80 prawns per sampling event), correlating with favorable breeding conditions. The study highlights the importance of maintaining water quality and habitat integrity for sustainable prawn populations.

Keywords:
Abundance, Diversity, Distribution, Prawn Species

INTRODUCTION

The Calabar and Great Kwa Rivers are significant freshwater systems that support a diverse array of aquatic organisms, including various prawn species (Ifon and Asuquo, 2021). Prawns play a crucial role in the riverine ecosystem, contributing to biodiversity and the local economy through fisheries (Enin, 1998). Understanding the abundance and distribution of prawn species within this river is essential for effective management and conservation efforts. Prawn species distribution in river systems is influenced by numerous environmental factors, including water temperature, pH, dissolved oxygen levels, and habitat structures (Benzie, 1982). These parameters vary spatially along the river's course and temporally across different seasons, leading to distinct patterns in prawn populations. The upstream, midstream, and downstream regions of the river each present unique environmental conditions that affect prawn abundance and diversity (Olawusi-Peters and Ajibare, 2014). Previous studies have highlighted the importance of habitat quality and water parameters in determining the distribution of aquatic species (Tampo et al., 2024). However, comprehensive data specifically addressing prawn populations in the Calabar and Great Kwa Rivers are lacking. This study aims to fill this gap by systematically examining the spatial and temporal variations in prawn abundance and distribution and identifying key environmental factors that influence these patterns. In Nigeria waters shrimps are widely distributed in both fresh and brackish waters. According to Williams (2006), shrimps are universally accepted as food organisms and support a substantial number of local fisheries. Oyekanmi (2000) reported Macrobrachium spp. Accounted for up to 60% of the prawn landings in Lagos Lagoon while Macrobrachium vollenhovenii are usually absent from clear water rivers which are generally acidic, extremely transparent, lack of mollucs fauna and show little seasonal change in level

MATERIALS AND METHODS

Study Area

The study was conducted along the Calabar and Great Kwa Rivers in Nigeria, spanning approximately 200 kilometers from their sources in the mountainous upstream regions to their confluence with the Calabar and Great Kwa estuaries. The rivers are characterized by diverse habitats, including sandy and muddy areas as well as vegetated banks.

Sampling Sites and Design

A total of 15 sampling sites were selected, with five sites each in the upstream, midstream, and downstream sections. Sites were chosen based on habitat diversity, accessibility, and representativeness of each section. Sampling was conducted over one year to account for seasonal variations in prawn abundance and distribution.

Sampling Procedure

Surber sampler was used in shallow, vegetated areas to collect benthic prawns. The sampler covers a standard area of 0.1 square meters and is effective in capturing small and juvenile prawns. Kick nets were employed in shallow, sandy or muddy areas. The nets were used to disturb the substrate and capture prawns dislodged by the disturbance. Baited traps were set overnight in deeper sections to capture larger, mobile prawn species. Traps were baited with small fish to attract prawns.

Data Collection

Prawn samples were collected from the nets and baited traps and identified to species level using standard taxonomic keys. The number of individuals of each species was counted to determine their abundance. At each site, water temperature, pH, dissolved oxygen, and substrate type were measured using a Portable Multi-Meterdevice(HQ430d) also known as a Water Quality Meter manufactured in Hach Quality (HQ), a US-based company with manufacturing facilities in Loveland, Colorado, USA, and Düsseldorf, Germany (for European markets)Portable

Data Analysis

Abundance and distribution data were analyzed to identify spatial patterns (upstream, midstream, downstream) and seasonal variations. Statistical tests (ANOVA) were used to determine significant differences in prawn abundance across sites and seasons. Correlation analyses were conducted to identify relationships between prawn abundance and environmental parameters (water temperature, pH, dissolved oxygen, substrate type). Level of significance was set at $P<0.05$.

RESULTS

Species Composition and Abundance

A total of 2,345 prawns were collected from the Calabar and Great Kwa Rivers during the study period, representing five distinct species: Macrobrachium rosenbergii, Macrobrachium vollenhovenii, Macrobrachium macrobrachion, Caridina africana, and Caridina nilotica. The most abundant species was Macrobrachium rosenbergii, accounting for 40% of the total catch, followed by Macrobrachium vollenhovenii at 30%, Caridina africana at 15%, Macrobrachium macrobrachion at 10%, and Caridina nilotica at 5% (Fig. 1).

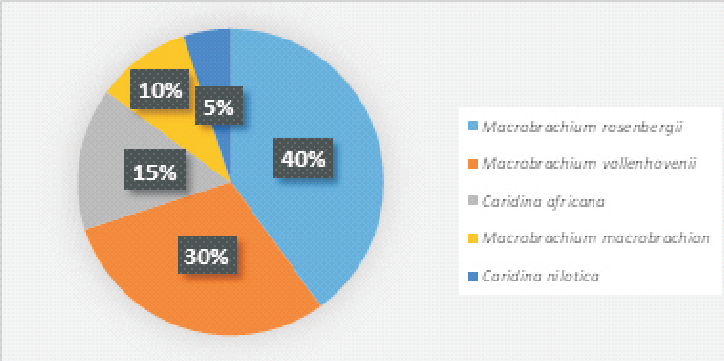

Figure 1: Abundance of Prawn Species in the Calabar and Great Kwa Rivers

Spatial Distribution

The upstream sites recorded the lowest prawn abundance, with an average of 25 prawns per sampling event. The species composition was dominated by Caridina africana and Caridina nilotica, which prefer cooler, oxygen-rich waters. Midstream region showed the highest prawn abundance, with an average of 70 prawns per sampling event. Macrobrachium rosenbergii and Macrobrachium vollenhovenii were the dominant species, thriving in the moderate flow and diverse habitat structures. The downstream sites had a moderate prawn abundance, averaging 50 prawns per sampling event. Species composition included all five species, with a noticeable presence of Macrobrachium macrobrachion. Seasonal variations significantly impacted prawn abundance. The highest densities were observed during the dry season, with a peak average of 80 prawns per sampling event, coinciding with the breeding season of several prawn species. The lowest densities occurred during the wet season, with an average of 20 prawns per sampling event, likely due to lower water temperatures and reduced metabolic activity.

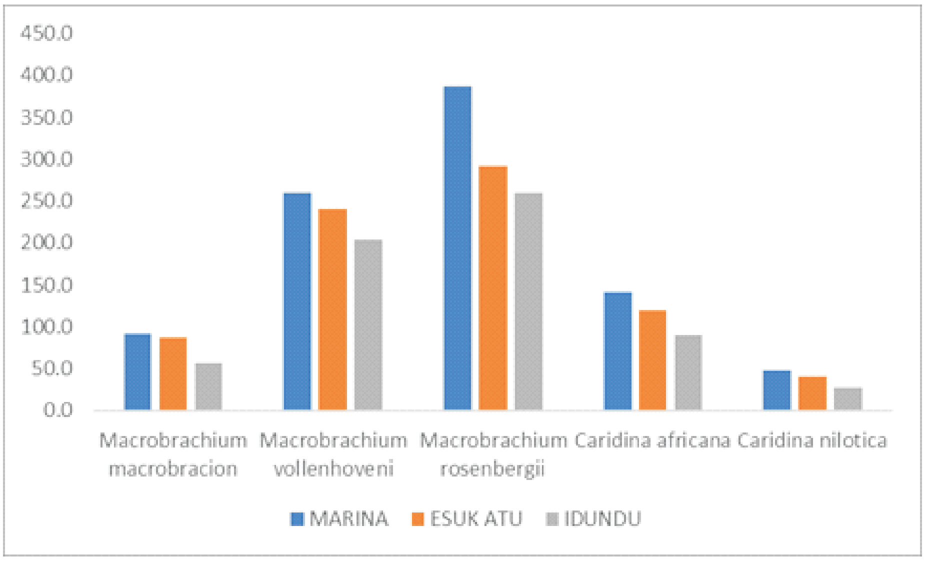

Figure 2 Spatial Distribution of prawn species in Cross River State

Environmental Correlations

Water Temperature was positively correlated with prawn abundance ($r = 0.65$, $p < 0.01$), higher temperatures supported greater prawn activity and growth. Dissolved Oxygenalso showed a positive correlation ($r = 0.58$, $p < 0.05$), with higher oxygen levels supporting more robust prawn populations (Table 1). While pH showed no significant correlation, substrate type was crucial, with sandy and vegetated substrates supporting higher prawn densities than muddy substrates.

Table 1: Correlations of prawn species abundance with environmental factors

	M. macrobracion	*M.vollenhoveni*	*M.rosenbergii*	*C.africana*	*C.nilotica*
Temperature	0.65	0.65	0.67	0.64	0.64
pH	0.32	0.34	0.31	0.32	0.34
Oxygen	0.58	0.57	0.56	0.58	0.58

DISCUSSION

The study on the diversity and abundance of prawns species in Calabar and Great Kwa River reveals significant spatial and temporal variations in their abundance and distribution. The midstream region's optimal environmental conditions—moderate water flow, diverse habitat structures, and suitable water quality—promote higher prawn densities, particularly for Macrobrachium rosenbergii and Macrobrachium vollenhovenii. These findings align with previous research indicating that midstream sections often provide ideal conditions for a variety of aquatic species due to the balance of physical and chemical parameters (Enin, 1998, Olawusi-Peters and Ajibare, 2014). The upstream region's lower prawn abundance can be attributed to cooler temperatures and faster water flow, which are less favorable for most prawn species except for those specifically adapted to such conditions, like Caridina species. Conversely, the downstream region, although rich in species diversity, faces challenges such as increased pollution and habitat disturbance, which may limit prawn abundance despite suitable temperatures and flow rates.

Seasonal variations play a critical role in prawn population dynamics. The pre-monsoon peak in abundance corresponds with the reproductive cycles of many prawn species, suggesting that breeding conditions significantly influence population size. Winter declines highlight the impact of temperature on metabolic and growth rates, as prawns are ectothermic and their physiological processes are temperature-dependent (Benzie, 1982).Environmental factors such as water temperature and dissolved oxygen are key determinants of prawn distribution. The positive correlation with these parameters underscores the importance of maintaining water quality for sustaining prawn populations. Substrate type's role further emphasizes the need for habitat diversity in supporting robust prawn communities.

CONCLUSION

This study provides an understanding of the factors influencing the abundance and distribution of prawn species in the Calabar and Great Kwa Rivers. The findings highlight the importance of midstream regions and seasonal patterns in shaping prawn populations. Effective management and conservation strategies should focus on maintaining water quality and habitat diversity to support sustainable prawn fisheries in the river. Future research should explore the long-term impacts of environmental changes and human activities on prawn populations to inform adaptive management practices.

REFERENCES

Benzie, J. A. H. (1982). The biology of the giant prawn, Macrobrachium rosenbergii (de Man). Aquaculture Research, 13(4), 265-288.

Enin, U. I. (1998). The Macrobrachium fishery of the Cross River estuary, Nigeria. Arch. Fish. Mar. Res., 46(3), 263-272.

Ifon, H. T. and Asuquo, P. E. (2021). Assessment of Calabar River using marine crabs as bio-indicator of pollution. International Journal of Natural and Applied Sciences, 14, 23–31.

Olawusi-Peters, O. O. and Ajibare, A. O. (2014). Species abundance and distribution patterns of some shellfishes in coastal waters of Ondo State, South West, Nigeria. International Journal of Fauna and Biological Studies, 1(4), 19–24.

Tampo, L., Kaboré, I., Mande, S. L. A. S. and Bawa, L. M. (2024). Water Quality and Aquatic Ecosystem Assessment Using Water Quality Indices in West Africa: Challenge and Perspectives. In IntechOpen eBooks. https://doi.org/10.5772/intechopen.109137

Williams, N.S (2006). Species profiles; Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest), U.S Fish and Wildlife Service Biological reports (U.S Army Corps of Engineers).82(11.47): TR EL-82-4, 10-47

Oyekanmi, F.B (2000). Nutritional value and Flesh Yield of Some Crustaceans in Southwest Nigeria. M. TECH. Thesis, The federal University of Technology, Akure, Nigeria, 11-23

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

PHYTOPLANKTON COMPOSITION, ABUNDANCE AND DIVERSITY OF DOWNSTREAM SECTION OF CHANCHAGA RIVER MINNA, NIGER STATE, NIGERIA.

[1]Ismaila, S. A., [2]U. P. Yakubu, [1]A.O. Afolabi and [1]A. A. Ayeloja.

[1] Department of Fisheries Aquaculture and Wildlife, University of Abuja, P.M.B 117, Abuja Nigeria.
[2] Department of Water Resources, Aquaculture and Fisheries Technology, Federal University of Technology Minna, P.M.B 65, Minna, Niger State.

Corresponding author:
sophzee@gmail.com, +234 7034935448

ABSTRACT
The significance of phytoplankton in fresh water environment cannot be over emphasized, Phytoplankton is the primary producer of any ecosystem and function as suitable indicator for water quality evaluation. This study was carried out to determine the phytoplankton abundance and community structure of downstream region of Chanchaga river in Niger state for period of four months twice each month (March-June 2017) at four stations. sampling of phytoplankton was carried out using plankton net of 30cm diameter with 50μm mesh size and transported to the laboratory for identification using microscope and guide. Results showed Six phytoplankton groups recorded; dominated by Chlorophyceae (74.14%), Baccillariophyceae with (9.5%) Dinophyceae with (9.76%), Cyanophyceae with (7.45%), Chrysophyceae with (0.79%), and Euglenophyceae with (1.06%). The diversity of species of phytoplankton showed marked differences the lowest values of the diversity (Hs) were recorded for Chlorophyta and Dinophyta while Cyanophyta and Bacillariophyta had the highest value. Margalef species richness (d) showed Chrysophyta with the highest and lowest was in Chlorophyta and Dinophyta, Chlorophyta has the lowest evenness despite been the most abundant group. Pediastrum specie was the most dominant, and presence of this specie is an indication of a water body having high amount of organic waste indicating potential pollution which could be as a result of direct discharge of waste from the water treatment plant, anthropogenic activities around the river. thus, further monitoring and regulation of human activities is important in order to prevent further environmental pollution.

Keyword:
Phytoplankton, species composition, abundance, diversity indices, Chanchaga river.

INTRODUCTION

Phytoplankton are microscopic flora (plant) matter which does not have independent movement capability but they drift by the mercy of wind, currents and tides (Sivashankar, and Bai, 2015). They are the initial biological components from which energy is transferred to higher organisms through food chain (Sharma *et al.*, 2015). Phytoplankton composition influences various processes such as nutrient recycling, grazing, particle sinking and food webs (George *et al.*, 2013). Most phytoplankton are too small to be seen by naked eyes while others are large enough to be seen by single-handed eyes e.g Diatom (Salisu 2017), They are a source of food to almost all aquatic life either directly or indirectly

(Moncheva and Parr, 2010).

Species composition of phytoplankton community is an efficient bio-indicator for water quality assessment, beside algal bloom led to reduction of oxygen in water column which may cause fish and other animal death (George et al., 2013). Chlorophyta (green algae), Cyanophyta (blue green algae), Bacillariophyta(diatom) make up the three major group.

Plankton has been reported by researchers as the reflection of the hydro-environmental condition per time, hence acting as bio-diagnostic components that point to the health status of the aquatic ecosystem, phytoplankton assemblages are generally, more sensitive to pollution than other assemblages (George et al., 2013; Otene et al 2023) the study aim to provide baseline data on phytoplankton composition, abundance and species diversity of the downstream section of Chanchaga river.

MATERIALS AND METHODS

Description of the study area

Chanchaga River is located on Latitude 9° 31' 60"N and Longitude 6° 34' 60"E in Paikoro Local Government area in southwest zone of Minna Niger State, Nigeria but part of the river falls under Bosso Local Government area. The river is under the care of Niger State water board, four sampling station was use throughout the study for period of four months.

Plate 1.1: Google Earth Image of the Study Area Indicating the Sampling points

Plate 1: 2The Study Area Indicating Station 2

Phytoplankton sampling and identification

Monthly sampling of phytoplankton was carried out using plankton net of 30cm diameter with 50μm mesh size. The water sample was poured into labeled one-liter plastic jar and fixed with lugols solution to preserve the sample. The sample was transported to the laboratory for identification using a microscope. The sample was left for 24 hours to settle down $^2/_3$ of the contents was poured out and the remaining $^1/_3$ was used for identification. The species identify was compared with catalogue Perry (2003) for the physicochemical it was analyzed according to (APHA 2008).

Phytoplankton community structure

Diversity indices: Margalef species richness(d), Equitability Shannon wiener diversity (Hs) of the entire study area were analyzed as described by Ogbeibu (2005).

RESULTS

Phytoplankton composition and abundance

Phytoplankton community in Chanchaga River was characterized by six families which are Chlorophyceae with the highest number of individual specie which make (74.14%). Baccillariophyceae with (9.5%) Dinophyceae with (9.76%) Cyanophyceae with (7.45%) Chrysophyceae with (0.79%) and Euglenophyceae with (1.06%) pediastrum was the specie of the groups that had the highest number of individual (262) while syruna and strobomonas had the lowest number of individual (Table 1).

Table 1:Phytoplankton composition and relative abundance of downstream Chanchaga river.

Phytoplankton groups	Species	species abundance	Phytoplankton group abundance	Percentage (%)
Chlorophyta	*Pediastrum sp*	262		
	Spirogyra sp	9	281	74.14
	Ankyra sp	3		
	Coelastrum sp	7		
Dinophyta	*Peridinium sp*	34		
	Sphaerodinium	3	37	9.76
Chrysophyta	*Mallomonas sp*	2		
	synura	1	3	0.79
Euglenophyta	*Euglena sp*	3		
	Strobomonas sp	1	4	1.06
Cyanophyta	*Anabaena sp*	6		
	Cylindrospermopsis sp	5	18	4.75
	Microcystis sp	7		
Bacillariophyta	*Eunotia sp*	21		
	Navicula sp	7	36	9.50
	Nitzshia sp	6		
	Diatom sp	2		
Total		**379**	**379**	**100**

Diversity of species of phytoplankton of downstream Chanchaga Reservoir

The diversity of species of phytoplankton showed marked differences as represented in the table. The lowest values of the diversity (Hs) were recorded for Chlorophyta and Dinophyta while Cyanophyta and Bacillariophyta had the highest value. Margalef species richness (d) showed Chrysophyta with the highest value and followed closely with Bacillariophyta. Phytoplankton with the lowest value of species richness was the Chlorophyta and Dinophyta (Table 2).

Table2: Biodiversity of phytoplankton of downstream section of Chanchaga reservoir

Phytoplankton	Individual	Taxa(s)	Simpson Index (D)	Shannon-weiner Index (Hs)	Margalef species richness(d)	Equitability (j)
Chlorophyta	281	4	0.87	0.31	0.53	0.22
Dinophyta	37	2	0.84	0.28	0.27	0.40
Chrysophyta	3	2	0.33	0.63	0.91	0.91
Euglenophyta	4	2	0.50	0.56	0.72	0.81
Cyanophyta	18	3	0.30	1	0.69	0.99
Bacillariophyta	36	4	0.39	1	0.83	0.78

DISCUSSION

Phytoplankton community in Chanchaga river was characterized by six families which are dominated Chlorophyceae then Dinophyceae, followed by Baccillariophyceae, Cyanophyceae, Euglenophyceae and Chrysophyceae been the least representative in the river. The abundance of Chlorophyta indicated that the water is productive.

The observation of more Chlorophyta than Bacillariophyta agrees with the findings of (Kolo et al.,2010; Sarmah and Baruah 2014 and Ahmed 2015) which could be due to the fact of it accommodating more environmental stress than most fast-growing species, it could also be due to results of physico-chemical parameters been within the recommended limits (NESREA) for drinking water and aquatic life thus healthy water high abundance of Chlorophyta. the result disagrees with the results of Mustapha (2009); Adesalu and kurunmi (2012); Zakariya et al., (2013) and Sharma et al., (2015) which Baccillariophyceae was the dominant phytoplankton group in their study which could be due to the results of the physico-chemical parameters not been within the recommended limits of the National Environmental Standards and Regulations Enforcement Agencies (NESREA) for drinking water and aquatic life. The increase in nitrate and phosphate level in the river may be due to human activities close to the bank of the river and washing of fertilizer from the nearby farm. High abundance is not similar with high diversity just as seen in Chlorophyta, Shannon-Weiner index value state that the greater the value the more the diversity so diversity is higher in Bacillariophyta and Cyanophyta, examining the index in terms of pollution value less than 2 is an indication of polluted water (Shekhar et al., 2008). However, the value in the study is less than 2. the equitability index is a measure of the evenness, the value lies between 0 and 1, the closer the value to 1, the more even the population of phytoplankton the Cyanophyta group has the highest value that means is more evenly distributed, Chrysophyta has the highest value of specie richness in the study.

CONCLUSION

The dominance of Chlorophyta than other species indicated that the water is productive though Pediastrum species is the most abundant in the group and abundance of such species is an indication of pollution thus adequate monitoring and regulation of anthropogenic activities is essential to see if any changes has occurred.

REFERENCES

Adesalu, T and Kunrunmi, O. (2012). Effects of Physico-chemical Parameters on Phytoplankton of a Tidal Creek, Lagos, Nigeria. Journal of Environment and Ecology, Vol. 3, (1),119-129.

Ahmed, U. (2015), Determination of Physico-Chemical Parameters and Plankton Composition of Wawan-Rafi Lake in Kazaure, Nigeria, Department of Biological Sciences, Faculty of Science, Ahmadu Bello University, Zaria, Nigeria.IOSR Journal of Environmental Science, Toxicology and Food Technology Volume 2(4): PP 31-37.

American Public Health Association (APHA 2008): Standard methods for the examination of water and waste-waters, and potable water, 22th edition AHWA-WPCP Washington DC.

Federal Ministry of Environment (FMENV) (2000): National Guidelines and Standards for Water Quality in Nigeria (First edition).

George B, Nirmal K and Rita K (2013) Study on The Influence of Hydro-Chemical Parameters on Phytoplankton Distribution Along Tapi Estuarine Area Of Gulf Of Khambhat, India. Egyptian Journal of Aquatic Research 38, 157–170.

Kolo, R.J. Ojutiku, R.O and Musulmi, D.T (2010). Plankton Communities of Tagwai dam Minna, Nigeria. Continental Journal of Fisheries and Aquatic Science 4: 1.

Moncheva,S. and Parr, B.(2010). Manual for phytoplankton sampling and Analysis in the Black Sea pp. 68.

Mustapha, M. K, (2009), Limnological evaluation the fisheries potentials and productivity of a small shallow tropical African reservoir.

Ogbeibu, A.E, (2005). Biostatistics -A practical approach to research and data handling.1st EDn.,Mindex press,Benin city, Nigeria page 276.

Otene, B.B., Simbi-Wellington W. S and Robinson, N (2023)' Limnological properties and phytoplankton as indicator of pollution, Choba segment, New Calabar River, Port Harcourt Nigeria. World Journal of Advanced Research and Reviews 17(02), 500–511.

Perry R (2003). A Guide to the MARINE PLANKTON of southern California UCLA Ocean GLOBE and Malibu High School.3rd Edition page 3-9.

Salisu, A (2017) "aspects of physico-chemical parameters and phytoplankton assemblage of river Saye, Zaria, Kaduna State, Nigeria by Department of biology faculty of life sciences Ahmadu Bello University, Zaria, Nigeria.

Sharma R.C., Neetu S, Anita C (2015) the Influence of Physico-Chemical Parameters on Phytoplankton Distribution in A Head Water Stream of Garhwal Himalayas: A Case Study National Institute of Oceanography and Fisheries Egyptian Journal of Aquatic Research 42:11-21.

Shekhar, T.R.S., B.R.Kiran,E.T.Puttaiah,Y.Shivaraj and K.M.Mahadevan (,2008.)Phytoplankton as index of water quality with reference to industrial pollution. Environ. Biol.,29:233-236.

Sivashankar, N. And Bai, T. Ch. Jhansi Lakshmi (2015). The Influence of Environmental Parameters on the Phytoplankton Distribution in Clambeds in Atropical Estuary. Journal of Environmental Science Volume 10:172-175.

Zakariya, A., Michael A. A and Yahuza T (2013). Physico-Chemical Characteristics and Phytoplankton Abundance of the Lower Niger River, Kogi State, Nigeria. IOSR Journal of Environmental Science, Toxicology and Food Technology Volume 2, Issue 4 PP 31-37.

PLANKTON DIVERSITY OF KANTSANKWA STREAM IN LAFIA LOCAL GOVERNMENRT AREA OF NASARAWA STATE NIGERIA

[1]Osuagbalende, O.B., [1] H.D. Mudi, [1] M. T. Nafisat [1] N. A. Agbason [3] S. Y. Olem, [1] M. T. Rabo, [2] W. D. Adamu, [4] O.E. Adaba

[1]Department of Fisheries Technology, College of Agriculture, Science and Technology Lafia, Nasarawa State
[2]Department of Aquaculture and Fisheries Management, Nasarawa State University Keffi
[3]Department of Zoology, Nasarawa State University Keffi, Nasarawa State
[4]Department of Fisheries and Aquaculture, Adekunle Ajasin University Akungba Akoko Ondo State Nigeria

Corresponding Author:
nelsonatsema@gmail.com, 08058873831

ABSTRACT
The study was carried out to determine the monthly plankton diversity of Kantsankwa stream in Lafia Local Government Area of Nasarawa State Nigeria. Collection of plankton was done using a plankton net. The study recorded three families of phytoplankton, nine (9) species among which five (5) were found present in all the months during the study period. Four families of zooplankton (Rotifera, Cladocera, Copepoda, and Protozoan) were also recorded and nine species were identified. Five of the species were present throughout the study period. There is indication from the study that Knsakwa river is less polluted and showed a sign of aquatic productivity due to the number of plankton families identified. There is a need to properly manage wastes in the study area and also monitor human activities in order to maintain good condition of the stream. Care must be taken by inhabitants to avoid eutrophication in the stream.

Keywords:
Phytopankton, Zooplankton, Diversity, Pollution

INTRODUCTION

Water quality has a significant impact on water supply and oftentimes determines supply options. It is the chemical, physical, and biological characteristics of water based on the standards of its usage (Okeke and Adinna, 2013). Rivers are vital and vulnerable freshwater ecosystems that are critical for the sustenance of all life. However, the declining water quality of rivers threatens biota sustainability and is therefore a matter of serious concern (Akpan-Idot et al., 2012). Plankton are a mixed group of tiny, living plants and animals that float, drift freely or feebly Swim in water column independent of the shore and bottom (Adelakun et al., 2016) and occupy the base level of food chains (autotrophs) that lead up to commercially important fisheries. Most of the fresh water bodies especially at locations where anthropogenic activities are highly pronounced, are getting deteriorated, due to release of substance by flood, wind and human activities. This in turn affect the food chain of capture fisheries. The study of the water quality and assessment of zooplankton of Kantsakwa stream is important. This study was conducted to address the pollution status of Kansakwa stream in order to draw relevant conclusions and recommendations. By doing so, human lives and aquatic biota will maintain stable polluted free environment.

MATERIALS AND METHODS

Description of the Study Area

Kantsakwa stream is located in Kantsakwa town about 30km away from Lafia town along Lafia-Shendam road Nasarawa State Nigeria. The town is known for farming and processing of food products. The community uses the river as a source of washing and bathing. Human activities such as irrigation, fertilizer, pesticides and herbicide application take place which may reduce the quality of the water and affect aquatic biota.

Sampling Site

Three (3) sampling sites of the stream were selected for the study and will be designated as site 1, 2 and 3.

Plankton Collection

Plankton collection was done using a conical net of bolting nylon of 0.069mm mesh and mouth ring diameter of 35 cm. The net was towed for ten minutes for surface hauls. The filtered samples were fixed and preserved in 4% formalin with a few drops of Lugol's iodine solution for quantitative analysis of plankton. Numerical plankton analysis was carried out using an inverted microscope to count for phytoplankton and zooplankton.

Statistical analysis

Descriptive statistic was used for plankton species abundance and results were presented in charts.

RESULTS

Phytoplankton Species recorded in Kansakwa Stream

The results of phytoplankton identified in Kansakuwa stream is presented in Table 1. Three families of phytoplankton (Chlorophyceae, Cynophyceae and Baccillariophaceae) and nine species under the families. The family chlorophyceae had the highest occurrence (23) of phytoplankton followed by Cynophyceae (17) while Baccillariophaceae (12) was the lowest. In the family chlorophyceae, four species were identified in which scenedesmus spp and spirogyra spp were found present throughout the period of study. Chlorella spp was present in July and September but absent in August while Straurastrum spp were present in July, September but absent in September. In the family Cynophyceae, three species (Anabaena spp, Microcystis spp and Aphanocapsa spp) were identified. Anabaena spp and Microcystis spp were found present throughout the period of the study while Aphanocapsa spp was absent in July and present in August and September. In the family Baccillariophaceae, two species (Navicular spp and Flageria spp) were identified. Flageria spp was found present throughout the period of the study while Navicular spp was present in July and September but absent in August.

Table 1: Phytoplankton Species recorded in Kansakwa Stream

Families	Species	June	August	September	Total
Chlorophyceae	*Scenedesmus spp*	+	+	+	
	Chlorella spp	+	_	+	
	Spirogyra spp	+	+	+	
	Straurastrum spp	_	_	+	
	Subtotal	7	4	12	23
Cynophyceae	*Anabaena spp*	+	+	+	
	Microcystis spp	+	+	+	
	Aphanocapsa spp	_	+	+	
	Subtotal	6	4	7	17
Bacillariophyceae	*Navicula spp*	+	_	+	
	Flageria spp	+	+	+	
	Subtotal	5	3	4	12

+ = present; - = absent

Zooplankton Species recorded in Kansakwa Stream

The results of zooplankton identified in river Kansakuwa is presented in Table 2. The study revealed four families (Rotifera, Cladocera, Copepoda and Protozoan) of zooplankton with nine species identified under those families. The family Cladocera had the highest (22) number of occurrence of species of zooplankton followed by Rotifera (16) Copepoda (9) while Protozoan was the lowest (5). In the family Rotifera, three species (Daphnia spp, Moina spp, and Polyarthra spp) were recorded. Daphnia spp and Moina spp were found present throughout the period of the study while Polyarthra spp was present in July and August but absent in September. In the family Cladocera, three species (Bosmina spp, ceriodaphnia spp and macrothrix spp) were recorded. Bosmina spp and ceriodaphnia spp were present throughout the period of the study while macrothrix spp was present in August and September but absent in July. In the family Copepoda, two species of zooplankton (cyclop spp and calanoid spp) were recorded. Cyclop spp was present throughout the period of the study while calanoids spp was present in August and September but absent in July. In the family Protozoan, one specie was recorded (Amoeba spp) and was found present throughout the period of the study.

Table 2: Zooplankton Species recorded in Kansakwa Stream

Families	Species	July	August	September	Total
Rotifera	*Daphnia* spp	+	+	+	
	Moina spp	+	+	+	
	Polyarthra spp	_	_	+	
	Subtotal	6	3	7	16
Cladocera	*Bosmina* spp	+	+	+	
	Ceriodaphnia spp	+	+	+	
	Macrothrix spp	_	+	+	
	Subtotal	8	5	9	22
Copepoda	*Cyclops* spp	+	+	+	
	Calanoids spp	_	+	+	
	Subtotal	3	2	4	9
Protozoan	*Amoeba* spp	+	+	+	
	Subtotal	2	1	2	5

+ = present; - = absent

DISCUSSION

Phytoplankton Species recorded in Kansakwa Stream

Phytoplankton are suitable organisms for the determining the impact of toxic substances on the aquatic environment because any effects on the lower levels of the food chain will also have consequences for the higher level (Ogbuagu et al., 2011). The study conducted in Kansakwa stream revealed nine (9) species of phytoplankton which were found from three families (chlorophyceae, cynophyceae and bacillariphyceae). It was observed that five of the species (Scenedesmus spp, Chlorella spp, Anabaena spp, Microcystis spp, and Flageria spp) identified were found throughout the study period. The existence of those species in Kansakwa stream implies that they can survive during high and low tide and also showed that the stream water is productive in nutrient content. The spatial distribution of phytoplankton species showed that they could be transported by flooded water to the study site at the time of study. Most of the phytoplankton species were found in the family chlorophyceae and cynophyceae. This study is similar with the report of Adelakun et al. (2016) who recorded phytoplankton in a tropical river basin Nigeria with the most abundant species recorded in the family cynophyceae. As stated by Ojo (2011), monthly variation in abundance of phytoplankton in river water depends on changes in water currents, water level transparency, and the amount of nutrient available.

Zooplankton Species recorded in Kansakwa Stream

The study of plankton species in Kansakwa stream recorded four identified families of zooplankton (rotifer, chadocera, copepod and protozoan). Nine (9) species of zooplankton were identified and the most abundance number of species were found in cladocera and rotifer. It was observed that Daphnia spp, Moina spp, Bosmina spp, Ceriodaphnia spp, Cyclop spp and Ameoba spp occurred throughout the period of the study. The presence of these species recorded in the study shows improvement in the water quality of the tream and also indicate low effluent discharge into the river. The study is in agreement with assertion of Emmanuel and Tonye (2013) reported high diversity of rotifer and cladocera in Awba stream and reservoir of University of Ibadan. Many factors may have contributed to the dominance of rotifer and cladocera which probably may be a confirmation of the shallow nature of the stream. High number of individuals recorded for the river could be because the study was conducted in wet season. This is in conformity with Imoobe (2011) who stated that flooding during the rainy season may have contributed positively to zooplankton population growth as a result of species recruitment from other flooded water bodies and the inflow of nutrients.

CONCLUSION

There is indication from the study that kansakwa river is less polluted and showed sign of productivity due to the number of plankton families identified.

RECOMMENDATION

There is a need to monitor human activities near the stream in order to maintain the condition of the river. Care must be taken by inhabitants to avoid eutrophication in the stream water.

REFERENCES

Adelakun, K.M., Mu'azu, M.M., Amali, R.P. and Omotayo, O.L. (2016). Diversity of Phytoplankton Communities in a Tropical River Basin, Nigeria. issue NO. 19 Pp56.

Akpan – Idot, A. U., Ibrahim, A. and Udo, J. A. (2012). Water Quality assessment of Okpauku Otamirioche River for Drinking and Irrigation uses in Yala Cross Otamiri-oche River State, Nigeria. Research Journal of Environmental Science, 6(2): 210-221.

Emmanuel, T. T. and Tonye, O. (2013). Studies on the distribution and abundance of plankton in Awba stream and reservoir, University of Ibadan. Open Journal of Ecology 3(4): 6.

Imoobe, T.O.T. (2011) Diversity and Seasonal Variation of Zooplankton in Okhuo River, a Tropical Forest River in Edo State, Nigeria. Centrepoint Journal 17 (1): 37-51.

Ogbuagu, D. H., Ayoade, A. A., and Chukwuocha, N. B. A. C. (2011). Spatial dynamics in physicochemistry and bacterio and myco-plankton assemblages of Imo River in a Niger Delta community in Nigeria. African Journal of Microbiology Research 5(8): 872-887

Ojo, O.O. (2011). Plankton Estimation and Diversity of Lower Basin of Ogun River at Isheri Olofin Area, Ogun state, Southwestern, Nigeria. A research project submitted for the award of Bachelor of Aquaculture and Fisheries Management to the Department of Aquaculture and Fisheries Management, University of Agriculture, Abeokuta, Ogun state, Nigeria. 4.

Okeke, P. N. and Adinna, E. N. (2013). Water Quality Study of Otamiri Otamiri-oche River in Owerri, Nigeria. Universal Journal of Environmental Research and Technology, 3(6):641-649.

SEASONAL PARASITE SPECIES SPECTRUM AND PREVALENCE OF Labeo senegalensis AND Momyrus senegalensis FROM LOWER RIVER BENUE, MAKURDI. NIGERIA

[1]Alabi-Shauntell O. O., [2]I. K. Alabi, [3] I. Noah Ndianaobong, [1] F. Mopho, [4] M. A. Raji, and [5] A. D. Ameh

[1]Department of Fisheries Technology, Federal College of Land Resources Technology, Kuru-Jos. Nigeria
[2]Department of Agricultural Extension and Management, Federal College of Forestry, P.M.B 2019, Jos. Nigeria
[3]Department of General Studies, Federal College of Land Resources Technology, P.M.B 2025, Kuru-Jos. Nigeria
[4]Department of Land and Range management, Federal College of Land Resources Technology, Kuru-Jos. Nigeria
[5]Department of Agricultural Extension and Management, Federal College of Land Resources Technology, Kuru-Jos. Nigeria

Corresponding Author's:
talk2ocholioyigene@gmail.com, +2348036537857, 0009-0005-9976-9139

ABSTRACT
This study investigated the seasonal parasite species spectrum and prevalence of Labeo senegalensis and Momyrus senegalensis from Lower River Benue, Nigeria. Two hundred and forty (240) specimens of Labeo senegalensis and Momyrus senegalensis (120 each) were examined for this study. Lengths, body weight, sex, stomach, gut, lining of the gut lumen and the intestine were measured, weighed, dissected, examined and observed on HP Laptop using a Zd pix 640 digital microscope for parasites. Results revealed that, they were infested with 637 parasites comprising of nematodes (Procamellanus sp., Camellanus sp., Eustrongyllus sp.,Spinitectus mormyri) and acanthocephalus (Neoechinorhynchus africanus,Pomphorhynchus sp.) in dry and rainy seasons. 51(42.5%) Labeo senegalensis were infected with 445 parasites species of Nematode (Camellanus sp., Eustrongyllus sp) and Acanthocephalus (Neoechinorhynchus africanus, Pomphorhynchus sp.). Parasite prevalence and mean intensity were 42.5 and 8.7 respectively. 40(30.3%) Momyrus senegalensis recorded 192 parasitic Nematode (Procamellanus sp.,Camellanus sp.,Spinitectus mormyri) while parasitic prevalence and Mean Intensity were 33.3 and 4.8 respectively in rainy and dry seasons. Camellanus sp (Nematode) was the most abundant species infesting both fish species during the study period. There was significance difference ($P<0.05$) in percentage Parasite infestation in both seasons for Labeo senegalensis. Intestine had the highest percentage (63.12%) parasite density while the female (55.30%) recorded a higher rate of infestations than male (44.70%). It was concluded that, Lower River Benue, Makurdi, Nigeria is rich in parasitic fauna and nematodes were the most prevalent parasite.

Keywords:
Prevalence, intensity, Labeo senegalensis, Momyrus senegalensis, Acanthocephalus, Nematode

INTRODUCTION

Fish has continued to be the most easily affordable source of animal protein to the average Nigerian family (Ocholi and Alabi, 2019). Nigeria has an estimated 12.5mha of freshwater surface area of lakes, reservoirs and ponds which are capable of producing 521,000 metric tons of fish but have not succeeded in attaining fish food sufficiency (Abdel-Gaber et. al., 2015). Due to the importance of fish as one of the major source of obtaining cheap protein, studies on parasitic prevalence and diseases of fish is very important. The propagation of Fish provides a large reservoir of parasitic pathogen common to both cultured and wild fish. Presently, no epidemic has been reported in Nigeria but it is likely that as the culture of fish becomes intensive and more widespread, parasites will be liable to become a menace (Kawe et. al., 2016). Parasites are organisms that live on another organism either permanently or for a part of their lives (Omeji et. al., 2017). they are the most diverse and common pathogens the aquaculturist may likely encounter and parasite diseases are very common in fish all over the world, especially in the tropics (Ocholi and Alabi, 2019). Parasites of fish are of great importance, since they often produce a weakening of the host immune system thereby increasing their susceptibility to secondary infections. This results in the nutritive devaluation of fish and subsequent economic losses (Anthony et al., 2014). The possibility of disease transmission from fish to humans through fish consumption is a public health concern (Omeji et. al., 2017). The commonest infection are caused by trematodes Clinostomum specie., Euclinostomum species and nematode Procamellanus sp. Earlier workers, Ukoli, (2005) and (Omeji et. al., 2017) has subscribed to this observation. The negative impact of parasites on host-growth and survival has been demonstrated in several parasite-fish host system both in aquaculture and in natural population (Ugbor et. al., 2014). Profound pathological changes associated with piscine parasites cause low growth rhythm considerably, affect the quality of the fish and often leads to death of fish resulting in enormous economic losses to the fish industry. Some piscine parasites are transmissible to man and other fish-eating domestic and non domestic animals (Klinger and Francis-Floyd, 2012). Documented information on fish diseases is scanty in Nigeria and work carried out in limited number of water systems. Some of which were in Kainji lake and associated tributaries of River Niger by Ukoli, (2005); in Gwagwalada, Abuja by Dankishiya, and Zakari, (2007); in Zaria Area by Ugbor et. al.,(2014). The Bagridae families are the most caught and sought for fish from lower river Benue. The study was conducted to determine the parasites diversity, their infection intensity and prevalence in Labeo senegalensis and Momyrus senegalensis from Lower River Benue, Nigeria.

MATERIALS AND METHODS

Sample collection

Fish samples were obtained from River Benue at Makurdi. Two hundred and forty (240) live samples of 120 Labeo senegalensis and Momyrus senegalensis each of various sizes were randomly examined. 10 samples of each species were collected twice monthly for the period of 6months. The samples were identified using as described by Omeji et al. (2017).

Fish examination and Parasite collection

Total and standard lengths of each fish were measured in centimeters (cm) using meter rule, while the fresh weight of each of the fishes were recorded in grams (g) using an electronic weighing balance. The stomach, gut and the intestine of the fish species were dissected and examined. The lining of the gut lumen were scrapped out and placed in 0.09% normal saline solution. Two drops of the preparation was placed on slide covered with slips and observed on the HP Laptop using a Zd pix 640 digital microscope for parasites. The parasites were identified by taking and saving their pictures on the Laptop as observed on the Zd pix 640 digital microscopes, and compared with the pictorial guide on fish parasites by Poudre et al. (2005). All measurements were taken and parasites observed on the binocular microscope were counted and recorded.

Parameters Test

Mean intensity= Total no of parasites in lt/wgt group/No of fish infected in lt/wgt group, Mean abundance=Total no of parasites in lt/wgt group/No of fish examined in lt/wgt group, Percentage Parasites =Total no of parasites /Total parasites X 100, Percentage infestation = Total no infested/ No of fish examined X 100

Data analysis

Parasite prevalence, mean intensity and mean abundance were determined according to Omeji et al. (2017). The data obtained was subjected to statistical analysis using SPSS 17.0 software to determine the significance mean difference.

RESULTS AND DISCUSSION

Results of the Parasite distribution of Labeo senegalensis and Momyrus senegalensis from River Benue are presented in Table 1. Of the 120 Labeo senegalensis examined, 51 (42.5%) were infected and observed to harbour a total number of 445 parasites belonging to two species of Nematode (Camellanus sp., Eustrongyllus sp) and Acanthocephala (Neoechinorhynchus africanus and Pomphorhynchus sp). The prevalence (%) and mean intensity were recorded as 42.5 and 8.72 respectively. The survey found a wide spectrum of parasites distributed throughout the study period. The parasite diversity indices obtained in the present study revealed that fish samples harbored different classes and species of parasites in rainy and dry seasons. A recovery of Five (5) species of parasites from two fish species collected from Lower River Benue is a clear indication of a high species diversity characteristic of productive lotic water bodies (Dankishaya et al., (2013). Results of the 120 Momyrus senegalensis examined revealed that 40 (33.3%) were infested with 192 parasitic nematodes (Procamellanus sp., Camellanus sp and Spinitectus mormyri) while prevalence (%) and mean intensity were 33.3 and 4.8 respectively. Camellanus sp was found to be the most abundant species infesting both fish species examined in rainy and dry seasons, while Procamellanus sp, Eustrongyllus sp, Neoechinorhynchus africanus, Spinitectus mormyri and Pomphorhynchus sp where observed to infest fish in either of the seasons. The parasites harboured were tropically and free-living transmitted species that were present in relatively high numbers. The variation in parasite populations in the hosts may reflect habitat and diet of the fish (Omeji et. al., 2017).

Table 1: Parasites distribution of Labeo senegalensis and Momyrus senegalensis from Lower River Benue, Makurdi

Fish species	Number of fish Examined	Number of fish Infected	Total Number of Parasite recovered	Prevalence (%)	Mean Intensity
Labeo senegalensis	120	51 (42.50%)	445 (69.86%)	42.50	8.72
Momyrus senegalensis	120	40 (33.33%)	192 (30.14%)	33.33	4.80
Total	**240**	**91**	**637**		
X^2			1.68		
P-value			0.89		

TNP- total number of parasite, MI- mean intensity, MA- mean abundance

Results of the percentage parasite infestation of Labeo senegalensis and Momyrus senegalensis in rainy and dry season are shown in table 2. It was observed that, Labeo senegalensis had 27.1+0.11

percentage infestation in dry season and 24.5+0.19 in the rainy season. The results indicated a significant difference (P=<0.05) in the parasite density of Labeo senegalensis between the raining and dry seasons. However, there was no observed significant difference (P=>0.05) in Momyrus senegalensis in the dry and rainy seasons as presented in Table 2. The overall parasite density for all species selected for this study was more prevalent culminating in high mean intensities in the rainy season than the dry season. This observation agrees with the findings of Agababiaka et al., (2017) on the seasonal occurrence of parasite which could be attributed to the omnivorous behavior of fish species resulting into continuous intake of infected intermediate hosts and increase in water volume.

Table 2: Percentage infestation of Labeo senegalensis and Momyrus senegalensis in rainy and dry season

Fish species	**Parasite Infestation**		P-value
	Dry season (%)	Rainy season (%)	
Labeo senegalensis	27.1±0.11	24.5±0.19	0.04*
Momyrus senegalensis	15.0±0.36	9.9±0.07	0.19**

Table 3 presents the results of the Parasite species and site of infection on Labeo senegalensis from Lower River Benue, Makurdi. Among the body parts examined for Labeo senegalensis as presented in table 3, stomach and intestine harbored the isolated parasites. It was also observed that intestine had the highest number of parasites 295 (66.29%) while stomach had the least 150 (33.71%).

Table 3: Parasite species and site of infection on Labeo senegalensis from Lower River Benue

Parasites species	Phyla	Organ infested	No (%) fish infested	TNP (%)
Camalanus species	Nematoda	Intestine	11 (21.57%)	135 (30.34%)
Eustrongyllus species	Nematoda	Stomach	17 (33.33%)	150(33.70%)
Neoechinorhynchus africanus	Acanthocephala	Intestine	13 (25.49%)	143 (32.13%)
Pomphorhynchus sp).,	Acanthocephala	Intestine	10 (19.61%)	17(3.82%)

Results of the Parasite species and site of infection for Momyrus senegalensis is presented in Table 4. The result was observed to follow the same trend as the highest parasites 108(56.25%) were found in the intestine. Generally, intestine had the highest parasite density among the body parts of the fish examined for this study. The highest percentage parasites density recorded for intestine compared to other body parts of the fish species used in this work could be attributed to the fact that most digestion activity took place in the intestine resulting in the release of parasite ova/cysts in food particles. This agrees with the reported works of Onyedineke et al., (2010), Omeji, et al., (2017) who reported higher number of parasites in the intestine compared to other organs. Also, Dankishaya et al., (2013) reported higher number of parasites in the intestine than the stomach and attributed it to several factors among which is the presence of digested food or due to the greater surface area presented by the intestine.

Table 4: Parasite species and site of infection on Momyrus senegalensis from Lower River Benue

Parasites species	Phyla	Organ infested	No (%) fish infested	TNP (%)
Procamalanus species	Nematoda	Intestine	15 (37.50%)	60(31.25%)
Camallanus species	Nematoda	Stomach	18(45.00%)	84(43.75%)
Spinitectus momyrii	Nematoda	Intestine	7(17.50%)	48(25.00%)

A

B

Plate A: Larval stage of a Nematode (Eustrongyllus species) recovered from the stomach Labeo senegalensis
Plate B: Larval stage of Camallanus sp. found in the stomach of Momyrus senegalensis (x100)

CONCLUSION AND RECOMMENDATION

The findings from this study revealed the richness of Lower River Benue in parasitic fauna. This indicated that, it has high parasitic load as exhibited by the high rate of infection on the fishes. The study also revealed the seasonal parasitic variation of the examined fish species. L. senegalensis and M. senegalensis examined in this study were parasitized and Nematodes were the most prevalent parasites species recorded. However, L. senegalensis had the highest percentage parasitic density among them in both rainy and dry seasons. Among the body parts of the fish studied, intestine had the highest parasitic infection. Due to the diversity of parasites species infesting fish, complete elimination of parasites from fish may not be feasible; however, it is important to ensure that measures to reduce parasitic composition in the aquatic ecosystem and mitigate the risks of infection to man is in place. Creation of awareness on the zoonotic nature of fish parasites and danger of consumption of raw or undercooked fish to human should be emphasized while Landed fish from the Lower River Benue should be properly degutted and cleaned to remove the intestine, stomach, gills and other organs that parasites are found.

REFERENCES

Abdel-Gaber R., El Garhy M., and Morsy K. (2015). Prevalence and Intensity of Helminth Parasites of African Catfish Clarias gariepinus in Lake Manzala, Egypt. Advance Bioscience Biotechnology 6: 464-469.

Agbabiaka, L. A, Akande, T. T. and Ekeocha C. A. (2017). Assessment of parasites associated with African catfish farmed at Owerri Federal Constituency, Imo State, Nigeria. Agriculture and Biology Journal of North America. 8(5): 168-172.

Anthony, E. O., Christopher E. O. and Blessing J. O. (2014). Gastrointestinal Helminths parasites in a community of fish species in a Niger Delta Tidal Creek, Nigeria.Journal of Ecosystems;10Pp.

Dankishiya, A. S. and Zakari, M. (2007). Study on the gastrointestinal helminth parasites of Clarias gareipinus (teugels) in Gwagwalada, FCT Nigeria. Best Journal. 4(2):79-81

Dan-kishiya, A. S., Oboh, A. and Ibrahim, U. B. (2013). The prevalence of Helminth parasites in the gastro-intestinal tract of wild African sharptooth catfish Clarias gariepinus in Gwagwalada, Nigeria. Research. Journal. of the Costa Rican Distance Education University. 5(1): 83-87.

Kawe S.M., God'spower R.O., Balarabe M.R., and Akaniru R.I. (2016). Prevalence of gastrointestinal helminth parasites of Clarias gariepinus in Abuja, Nigeria. Sokoto Journal of Veterinary Science14:26-33.

Klinger, R. and Francis-Floyd, R. (2012). Introduction to Freshwater Fish Parasites. Institute of Food and Agricultural Sciences (IFAS) University of Florida.Pp 123

Ocholi O.S. and Alabi. K.I., (2019). Helminth Parasites of Bagrus filamentosus from Lower River Benue, Nigeria. International Journal of Modern Science and Technology, 4(1):19-25. ISSN: 2456-0235.

Omeji, S., Obande, R.A., and Solomon, S.G. (2017). Morphological and Parasitological Variations of African Lungfish, Protopterus Annectens in Dry and Rainy Seasons. Journal of Research in Forestry, Wildlife & Environment. 9(1): 104-113.

Onyedineke N.E, Obi U., Ofoegbu P.U, and Ukogo I. (2010). Helminth Parasites of some Freshwater Fish from River Niger at Illushi, Edo State, Nigeria. Journal of American Sciences 6(3): 16-21.

Poudre, D. B, Curtis, E. W. and Yanong, R. P. E. (2005). Common Freshwater Parasites Pictorial Guide. (online). http://edis.ifas.ufl.edu.

Ugbor, O. N., Odo, G. E., Nwani, C. D., Ochang, S. N., Somdare, P. O., and Agbakwuo C. A. (2014). Parasitic fauna of two dominant clariid (Siluriformes) catfishes in a tropical freshwater ecosystem, Nigeria. Nigerian Journal of Fisheries, 11 (1&2):744-752.

Ukoli, F.M.A. (2005). Preliminary report on the helminthic infection of fish in the river Niger- Shagunu, In: White E. Ed. First Scientific Report of the Kainji Biological Research team. Liverpool Biology Research team, Kainji,; p. 70-73.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

NUTRITIONAL COMPOSITION OF *Macrobrachium eqidens* OBTAINED FROM CALABAR RIVER, CROSS RIVER STATE

Opeh, P. B[1]., [2]H. T. Ifon, [3]P. A. Okeke and [4]S. O. Ohaturuonye

[1]Fisheries and Aquaculture Unit, Institute of Oceanography, University of Calabar, Nigeria
[2]Department of Fisheries and Aquaculture, Faculty of Agriculture, University of Calabar, Nigeria
[3,4]Department of Fisheries and Aquaculture, Nnamdi Azikiwe University Akwa, Nigeria

Corresponding Author:
asikpor2013@gmail.com, +234 804 575 9817

ABSTRACT

The nutritional value of *Macrobrachium equidens*, a species of freshwater shrimp found in the Calabar River, Cross River State, is not well-documented. Understanding its nutrient composition and antioxidant activity can provide insights into its potential health benefits. This study analyzed the proximate composition, mineral content, vitamin levels, and fatty acid profile of *M. equidens* obtained from the Calabar River. Various cooking methods—grilling, boiling, frying, and fresh consumption—were used to evaluate their impact on antioxidant activity. Nutrient values were measured using standard analytical methods. The proximate composition of M. dux revealed 76.5 ± 1.8% moisture, 16.2 ± 0.9% protein, and 2.8 ± 0.4% fat. Mineral content included 280.5 ± 15.2 mg/100g phosphorus, 110.3 ± 8.9 mg/100g calcium, 42.1 ± 3.7 mg/100g magnesium, and 140.6 ± 11.3 mg/100g potassium. Vitamin A was present at 1200 ± 150 µg/100g, vitamin C at 18.4 ± 2.1 µg/100g, and vitamin E at 10.5 ± 1.2 µg/100g. Omega-3 and omega-6 fatty acids were measured at 1.8 ± 0.2 g/100g and 2.4 ± 0.3 g/100g, respectively. *Macrobrachium equidens* from the Calabar River offers substantial nutritional benefits, with high protein and essential minerals. Grilling is the most effective cooking method for preserving antioxidant activity and nutritional value. Incorporating grilled M. dux into the diet can enhance nutritional intake and promote health benefits.

Keywords:
Nutritional value, antioxidant activity, freshwater shrimp

INTRODUCTION

Macrobrachium equidens, a species of freshwater prawn, is prevalent in the aquatic ecosystems of Cross River State, Nigeria, particularly in the Calabar River. This species is known for its ecological and economic significance, as it contributes to local fisheries and serves as a valuable food source for communities in the region (Holzlohner and Nwosu, 2013). Despite its importance, there is limited detailed research on the nutritional profile of M. dux, especially in the context of its habitat in the Calabar River.

Nutritional analysis of aquatic species is crucial for understanding their potential health benefits and their role in human diets (Oginni et al., 2019; Opeh and Udo, 2024). Prawns like *M. equidens* are known to be rich in proteins, essential fatty acids, vitamins, and minerals, which are vital for human health (Jana and Chakrabarti, 2017). However, variations in nutrient content can occur based on factors such as geographic location, environmental conditions, and seasonal changes (Ukpatu and Udoh, 2017). This study aims to fill the gap in knowledge by providing a comprehensive assessment of the nutritional composition of M. dux from the Calabar River. Understanding the nutrient profile of this species will contribute to its better utilization in local diets and may support its inclusion in nutritional and therapeutic applications. Moreover, this research will add to the existing data on the nutritional value of freshwater prawns from Nigerian waters, potentially informing fisheries management and public health strategies.

MATERIALS AND METHODS

Sample Collection

Fresh specimens of *Macrobrachium equidens* (Plate 1) were collected from artisanal landings at Nsidung beach of the Calabar River, Cross River State, Nigeria. The prawns were harvested using local fishing techniques, including baited traps and scoop nets, during the months of July and August 2023 to ensure seasonal consistency. The collected samples were immediately placed in coolers with ice to preserve their freshness and transported to the laboratory for analysis.

Plate 1: Picture of *Macrobrachium equidens* from the Calabar River

Sample Preparation

Upon arrival at the laboratory, the prawns were cleaned thoroughly with distilled water to remove any debris and contaminants. The exoskeletons were removed, and the flesh was separated from the heads and other non-edible parts. The cleaned prawn meat was then dried using a freeze dryer to ensure the preservation of its nutritional components. The dried samples were ground into a fine powder using a laboratory grinder and stored in airtight containers at -20°C until further analysis.

Nutritional Analysis

Moisture content was determined by drying the samples in an oven at 105°C until constant weight was achieved, as described by AOAC (2005). Crude protein was measured using the Kjeldahl method (AOAC, 2005), where nitrogen content was converted to protein using a conversion factor of 6.25. Crude fat was extracted with petroleum ether using the Soxhlet extraction method. Ash content was obtained by incinerating the samples in a muffle furnace at 550°C until constant weight. Carbohydrates was calculated by difference, subtracting the sum of moisture, protein, fat, and ash from 100%. Minerals (P, Ca, Mg, K, Cu, Fe, Zn, Na) were analyzed using Atomic Absorption Spectroscopy (AAS) following the procedures outlined by AOAC (2005). Samples were digested with concentrated nitric acid before analysis. Vitamins (A, C, E) were quantified using High-Performance Liquid Chromatography (HPLC) methods adapted from existing protocols. Fatty acids were determined using Gas Chromatography (GC) with a flame ionization detector (FID). Fatty acids were extracted and methylated before analysis according to established procedures (Inyang-Etoh et al., 2024).

Statistical Analysis

Data were analyzed using descriptive statistics to determine means and standard deviations. Differences between groups were assessed using one-way analysis of variance (ANOVA), with post hoc comparisons made using Tukey's test. Statistical significance was set at $p < 0.05$. All analyses were conducted using SPSS software (version 26.0).

RESULTS

Proximate Composition

The proximate analysis of Macrobrachium dux revealed a high moisture content of 76.5 ± 1.8%. The crude protein content was 16.2 ± 0.9%, while the crude fat content was relatively low at 2.8 ± 0.4%.

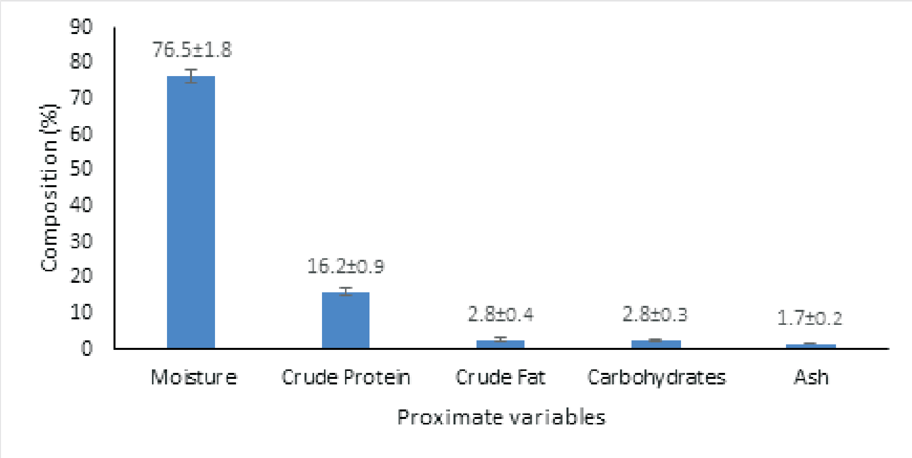

Figure 1: Proximate Composition of Macrobrachium equidens

Mineral Content

The mineral analysis showed significant concentrations of essential minerals in Macrobrachium dux. The mean phosphorus (P) content was 280.5 ± 15.2 mg/100g, while calcium (Ca) was 110.3 ± 8.9 mg/100g. Magnesium (Mg) was found at 42.1 ± 3.7 mg/100g, and potassium (K) measured 140.6 ± 11.3 mg/100g. The mean concentrations for copper (Cu), iron (Fe), zinc (Zn), and sodium (Na) were 1.5 ± 0.2 mg/100g, 1.2 ± 0.3 mg/100g, 2.1 ± 0.4 mg/100g, and 450.8 ± 20.5 mg/100g, respectively (Table 1).

Table 1: Mineral, Vitamin and Fatty Acid Profile of Macrobrachium equidens

Mineral	Mean ± SD
Phosphorus (P)	280.5 ± 15.2
Calcium (Ca)	110.3 ± 8.9
Magnesium (Mg)	42.1 ± 3.7
Potassium (K)	140.6 ± 11.3
Copper (Cu)	1.5 ± 0.2
Iron (Fe)	1.2 ± 0.3
Zinc (Zn)	2.1 ± 0.4
Sodium (Na)	450.8 ± 20.5
Vitamin A	1200 ± 150
Vitamin C	18.4 ± 2.1
Vitamin E	10.5 ± 1.2
Omega-3 (x3)	1.8 ± 0.2
Omega-6 (x6)	2.4 ± 0.3
Saturated Fatty Acids	0.9 ± 0.1
Monounsaturated Fatty Acids	0.6 ± 0.1

Units: minerals (mg/100g), vitamins (µg /100g), fatty acid (g/100g)

Vitamin Content

The vitamin analysis indicated that Macrobrachium dux is a good source of essential vitamins. The mean vitamin A content was 1200 ± 150 μg/100g. Vitamin C was present at 18.4 ± 2.1 μg/100g, and vitamin E was measured at 10.5 ± 1.2 μg/100g (Table 1).

Fatty Acid Profile

The fatty acid profile of Macrobrachium dux demonstrated notable amounts of omega-3 (x3) and omega-6 (x6) fatty acids, with mean values of 1.8 ± 0.2 g/100g and 2.4 ± 0.3 g/100g, respectively. Saturated fatty acids were present at 0.9 ± 0.1 g/100g, while monounsaturated fatty acids were found at 0.6 ± 0.1 g/100g (Table 1).

DISCUSSION

The nutritional profile of Macrobrachium dux obtained from the Calabar River, Cross River State, reveals several important characteristics that align with and diverge from findings in previous studies on shrimp and other crustaceans. The proximate composition of Macrobrachium dux shows a high moisture content, which is consistent with the general findings for crustaceans. For instance, high moisture content in shrimp species such as Penaeus monodon and Penaeus semisulcatus has been well documented, typically ranging from 70% to 80% (Musaiger and D'Souza, 2008). The crude protein content of 16.2 ± 0.9% in M. dux is comparable to that reported for P. monodon (17.5%) and higher than values for Farfantepenaeus indicus (14.8%) (Dayal et al., 2013). The mineral content analysis of M. dux indicates significant concentrations of essential minerals. Phosphorus and calcium levels are higher than those reported for P. monodon. The magnesium and potassium levels are also comparable to those found in P. semisulcatus and other similar species (Golgolipour et al., 2019). The copper and zinc concentrations in M. dux are within the range reported for other shrimp species, reinforcing its mineral richness. Notably, the sodium content is higher than values typically found in other shrimp species, which could be attributed to environmental factors or specific dietary intake.

The vitamin content of M. dux reflects its role as a significant source of essential nutrients. The mean vitamin A content is comparable to levels found in P. monodon and F. indicus (Karuppasamy et al., 2013). The vitamin C content is slightly lower than that reported for P. semisulcatus (25 μg/100g), but still contributes to the shrimp's overall nutritional value (Luzia et al., 2003). Vitamin E levels are consistent with values found in other crustaceans, supporting the role of M. dux in providing antioxidants. The fatty acid profile of M. dux demonstrates a healthy balance of omega-3 and omega-6 fatty acids, which is consistent with the beneficial profiles reported for P. monodon (Sowmya and Sachindra, 2012). The levels of saturated and monounsaturated fatty acids are lower compared to those found in other shrimp species, which typically have higher saturated fat content (Alfaris et al., 2021). This profile indicates that M. dux is a good source of essential fatty acids, contributing to a healthy diet.

CONCLUSION

The nutritional profile of Macrobrachium dux from the Calabar River, Cross River State, reveals that this species is a rich source of essential nutrients, including high levels of protein, vitamins, and minerals. The study found that M. dux has a favorable macronutrient composition with low fat content but significant amounts of omega-3 and omega-6 fatty acids. The mineral content, including phosphorus, calcium, magnesium, and potassium, is notably high compared to other crustacean species.

REFERENCES

AlFaris, N. A., Alshammari, G. M., AlTamimi, J. Z., AlMousa, L. A., Alagal, R. I., AlKehayez, N. M., Aljabryn, D. H., Alsayadi, M. M., and Yahya, M. A. (2021). Evaluating the effects of different processing methods on the nutritional composition of shrimp and the antioxidant activity of shrimp powder. Saudi Journal of Biological Sciences, 29(1), 640–649.

AOAC. (2005). Official Methods of Analysis of AOAC International (18th ed.). AOAC International.

Dayal, J., Ponniah, A.G., Khan, I., Babu, E., Kondusamy, A., and Vasagam, K. (2013). Shrimps - a nutritional perspective. Current Science, 104,1487-1491.

Folch, J., Lees, M., and Sloane Stanley, G. H. (1957). A simple method for the isolation and purification of total lipids from animal tissues. Journal of Biological Chemistry, 226(1), 497-509.

Golgolipour, S., Khodanazary, A., and Ghanemi, K. (2019). Effects of different cooking methods on minerals, vitamins and nutritional quality indices of grass carp (Ctenopharyngodon idella). Iranian Journal of Fisheries Science/? Iranian Journal of Fisheries Science, 18(1), 110–123.

Holzlohner, S., and Nwosu, F. M. (2013). Fisheries survey in Cross River State, Nigeria. Proceedings of 28th FISON Annual Conference, Nov. 25-30, 335 – 337.

Inyang-Etoh, A. P., Eteng, S. U., and Ifon, H. T. (2024). African Winged Termite meal can also Promote Growth of Sharp Tooth Catfish (Clarias gariepinus). Innovations, 77(03), 1370 – 1392.

Jana, U., and Chakrabarti, S. (2017). Comparative analysis of nutrient content between Prawn (Fenneropenaeus indicus) and Lobster (Portunus sanguinolentus), preserved and cooked under different conditions. International Journal of Food Sciences and Nutrition, 2(1), 90–96.

Luzia, L.A., Sampaio, G.R., Castellucci, C.M.N., and Torres, E.A.F.S. (2003). The influence of season on the lipid profiles of five commercially important species of Brazilian fish. Food Chemistry, 83, 93–97

Musaiger, A.O., and D'Souza, R. (2008). Chemical composition of raw fish consumed in Bahrain. Pakistan Journal of Biological Science, 11, 55-61.

Oginni, O. (2019). Evaluation of the nutritional qualities of edible portions of two commercially important prawns in southwest Nigeria. International Journal of Agriculture and Plant Science, 1(2), 18 – 23.

Opeh P.B., and Udo, P.J. (2024). Proximate Composition and Mineral Contents of the Flesh and Shell of Tympanotonus Fuscatus (Linnaeus, 1758) (Gastropoda: Potamididae) of the Cross River, Nigeria. African Scientist, 25(1), 11-14.

Sowmya, R., and Sachindra, N. (2012). Evaluation of antioxidant activity of carotenoid extract from shrimp processing byproducts by in vitro assays and in membrane model system. Food Chemistry, 134(1), 308–314.

Ukpatu, J. E., and Udoh, J. P. (2017). Seasonal variation in the proximate composition of size groups of Nematopalaemon hastatus in Okoro River estuary, southeast Nigeria and the influence of environmental factors. International Journal of Fisheries and Aquatic Studies, 5(4), 210–216.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

WATER QUALITY AND PHYTOPLANKTON ABUNDANCE IN EARTHEN PONDS AT THE UNIVERSITY OF CALABAR FISH FARM, CROSS RIVER STATE

Ogbin, I. M[1]., [2]E. M Ayim., [3]P. B. Opeh, [4]J. U. IDung and [5]P. N. Obialor

[1]Ministry of Agriculture and Irrigation Development, Cross River State, Nigeria
[2] Department of Animal and Environmental Biology, Faculty of Biological Sciences, University of Cross River State, Calabar, Nigeria
[3]Fisheries and Aquaculture Unit, Institute of Oceanography, University of Calabar, Nigeria
[4]Department of Science and Laboratory Technology, Faculty of Biological Sciences, University of Calabar, Nigeria
[5]Department of Biological Oceanography, Faculty of Oceanography, University of Calabar, Nigeria

Corresponding Author:
asikpor2013@gmail.com, +234 804 575 9817

ABSTRACT
Phytoplankton abundance and diversity are essential indicators of water quality in aquatic ecosystems, inflencing primary productivity and overall health. This study aimed to evaluate the relationship between water quality parameters and phytoplankton abundance in selected ponds at the University of Calabar Fish Farm, Cross River State, Nigeria. Water quality was measured by analyzing pH, temperature, dissolved oxygen, nitrate, phosphate, and ammonia, while phytoplankton species were identified and quantified. The study utilized standard field sampling techniques, followed by laboratory analyses. Mean water quality parameters across the ponds showed pH values ranging from 6.9 ± 0.3 to 7.8 ± 0.1, temperatures from 27.8 ± 0.5°C to 29.0 ± 0.4°C, and dissolved oxygen from 6.5 ± 0.4 mg/L to 7.2 ± 0.3 mg/L. Phytoplankton abundance varied across ponds, with values ranging from 32,000 to 40,500 cells/mL, and the Shannon-Wiener diversity index ranged from 2.4 to 2.8. Correlation analysis revealed significant positive relationships between phytoplankton abundance and temperature (r = 0.72), phosphate (r = 0.70), and dissolved oxygen (r = 0.68), while ammonia showed a negative correlation (r = -0.30). The findings indicate that water quality parameters significantly affect phytoplankton dynamics, with higher temperatures and nutrient levels promoting growth. It is recommended that pond management practices focus on optimizing temperature and nutrient inputs to maintain healthy aquatic ecosystems, while also mitigating ammonia levels to prevent negative impacts on phytoplankton communities.

Keywords:
Phytoplankton abundance, water quality, aquatic ecosystems, nutrient dynamics, pond management.

INTRODUCTION

Water quality plays a crucial role in maintaining aquatic ecosystems, particularly in fish farming environments. The health of such systems is directly influenced by the abundance and diversity of phytoplankton, which are primary producers at the base of aquatic food webs (George *et al.*, 2016). Phytoplankton not only support fish populations by providing a natural food source but also regulate critical processes such as nutrient cycling and oxygen production (Ekpo *et al.*, 2022). The success of aquaculture systems, including fish farms, depends on the delicate balance of these factors, with water quality being a primary determinant of phytoplankton productivity and diversity. The University of Calabar Fish Farm, located in Cross River State, Nigeria, operates several ponds that support different species of fish. These ponds are subject to varying environmental conditions, which influence water quality parameters such as pH, dissolved oxygen, temperature, and nutrient concentrations. These parameters, in turn, affect the abundance and diversity of phytoplankton populations (Dan et al., 2019). Poor water quality can lead to a reduction in phytoplankton, which may negatively impact fish growth and overall pond productivity (Akindele and Olutona, 2017).

Previous studies have demonstrated that specific water quality factors, such as nutrient levels and light availability, are crucial for the growth and sustainability of phytoplankton communities (Andriyani et al., 2020). However, the effects of these factors in tropical aquaculture settings, particularly in Nigeria, remain underexplored. Understanding the relationship between water quality and phytoplankton abundance in such environments is essential for the effective management of fish farms, as it can guide strategies to optimize productivity while maintaining ecological balance. This study aims to assess the effect of water quality on phytoplankton abundance in selected earthen ponds at the University of Calabar Fish Farm. By analyzing key water quality parameters and their correlation with phytoplankton populations, this research seeks to contribute valuable insights into the management of aquaculture systems in tropical regions.

MATERIALS AND METHODS

Study Area

The study was conducted at the University of Calabar Fish Farm, located in Cross River State, Nigeria. The farm comprises several earthen ponds used for rearing different species of fish, including catfish and tilapia. The selected ponds vary in size, depth, and water management practices.

Sample Collection

Water samples were collected from five selected ponds within the fish farm over a four-month period (April to July 2023). Samples were taken at three different points within each pond—near the inlet, in the center, and near the outlet—to ensure comprehensive coverage of water conditions. Sampling was conducted biweekly, with a total of 30 samples collected per pond throughout the study. Phytoplankton samples were obtained using a 20-micron plankton net, and water samples were collected using sterile plastic bottles (Boyd, 1998).

Water Quality Analysis

Key water quality parameters, including pH, temperature, dissolved oxygen (DO), and nutrient concentrations (nitrates, phosphates, and ammonia), were measured for each sample. A digital pH meter was used to measure pH levels, while temperature and DO were measured using a multiparameter probe (APHA, 2005). Nitrate and phosphate concentrations were determined using a spectrophotometer. Ammonia concentrations were measured using the Nessler method (Wetzel, 2001). All analyses were conducted within 24 hours of sample collection to ensure accuracy.

Phytoplankton Identification and Counting

Phytoplankton abundance was assessed by counting the number of cells in each sample under a light microscope at 400x magnification. Subsamples were drawn from the plankton concentrate, fixed with Lugol's iodine solution, and allowed to settle for 24 hours in a sedimentation chamber (Reynolds, 2006). Phytoplankton species were identified using standard taxonomic keys (Prescott, 1978), and the abundance of each species was recorded in cells per milliliter (cells/mL). Phytoplankton diversity indices, such as the Shannon-Wiener index, were also calculated to evaluate the ecological health of the ponds.

Data Analysis

Mean values and standard deviations were calculated for each water quality parameter and phytoplankton count. Pearson's correlation analysis was used to determine the relationship between water quality parameters and phytoplankton abundance. One-way analysis of variance (ANOVA) was employed to test for significant differences in water quality and phytoplankton abundance across the different ponds (Zar, 2010). Statistical significance was set at $p < 0.05$.

RESULTS

The water quality parameters measured in the selected ponds at the University of Calabar Fish Farm revealed significant findings. The pH levels ranged from 6.9 ± 0.3 in Pond 3 to 7.8 ± 0.1 in Pond 2, with all ponds falling within the acceptable range of 6.5–8.5 for aquatic life. Temperature varied slightly among the ponds, with mean values between 27.8 ± 0.5°C in Pond 3 and 29.0 ± 0.4°C in Pond 2. These temperatures align with the optimal range of 25–30°C recommended for aquaculture systems. Dissolved oxygen levels ranged from 6.5 ± 0.4 mg/L in Pond 3 to 7.2 ± 0.3 mg/L in Pond 2, exceeding the minimum threshold of 5 mg/L necessary to sustain aquatic organisms. Nutrient concentrations also varied across the ponds. Nitrate levels were relatively low, ranging from 1.9 ± 0.2 mg/L in Pond 2 to 2.4 ± 0.2 mg/L in Pond 3, all within the environmental standard of less than 5 mg/L. Phosphate concentrations were similarly modest, with values between 0.09 ± 0.02 mg/L in Pond 2 and 0.15 ± 0.03 mg/L in Pond 3, remaining well below the threshold of 0.5 mg/L that could trigger excessive algal blooms. Ammonia concentrations were minimal, ranging from 0.02 ± 0.01 mg/L in Pond 3 to 0.05 ± 0.02 mg/L in Pond 2, all within safe levels of less than 0.1 mg/L.

Table 1: Water Quality Parameters in Selected Ponds

Pond ID	pH	Temp(^{o}C)	DO(mg/L)	NO_3(mg/L)	PO_4(mg/L)	NH_3(mg/L)
Pond 1	7.3 ± 0.2	28.5 ± 0.3	6.8 ± 0.4	2.1 ± 0.1	0.12 ± 0.01	0.03 ± 0.01
Pond 2	7.8 ± 0.1	29.0 ± 0.4	7.2 ± 0.3	1.9 ± 0.2	0.09 ± 0.02	0.05 ± 0.02
Pond 3	6.9 ± 0.3	27.8 ± 0.5	6.5 ± 0.4	2.4 ± 0.2	0.15 ± 0.03	0.02 ± 0.01
Pond 4	7.5 ± 0.2	28.2 ± 0.2	6.9 ± 0.3	2.3 ± 0.1	0.10 ± 0.01	0.04 ± 0.01
Pond 5	7.1 ± 0.2	28.7 ± 0.3	6.7 ± 0.3	2.0 ± 0.2	0.14 ± 0.02	0.03 ± 0.01

*Values are Means ± SD

Phytoplankton abundance and diversity varied notably among the ponds. Abundance was highest in Pond 2 at 40,500 cells/mL, dominated by Oscillatoria sp., and lowest in Pond 3 at 32,000 cells/mL, where Navicula sp. was most prevalent. The Shannon-Wiener Diversity Index ranged from 2.4 in Pond 3 to 2.8 in Pond 2, indicating moderate to high diversity. These findings highlight the ecological variability across the ponds and provide insights into their phytoplankton community structure.

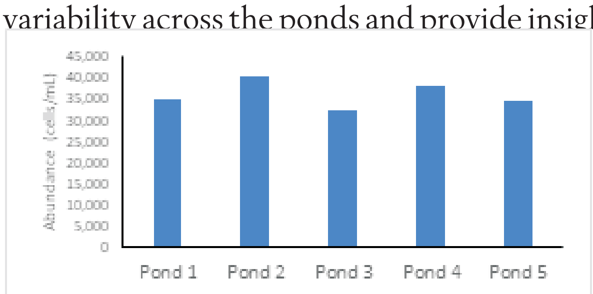

Fig. 1: Total Phytoplankton Abundance (cells/mL) in selected earthen ponds

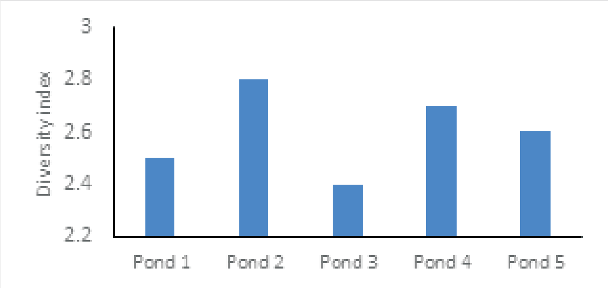

Fig. 2: Shannon-Wiener Diversity Index of phytoplankton in selected earthen ponds

Correlation analysis showed significant relationships between water quality parameters and phytoplankton abundance. Temperature exhibited the strongest positive correlation with abundance (r = 0.72), followed closely by phosphate (r = 0.70) and dissolved oxygen (r = 0.68). pH levels also correlated positively with abundance (r = 0.65), while nitrate showed a moderate positive correlation (r = 0.55). Conversely, ammonia demonstrated a negative correlation (r = -0.30), indicating a potential inhibitory effect on phytoplankton growth at higher concentrations. These correlations underscore the importance of water quality parameters in shaping phytoplankton dynamics in aquaculture ponds.

Table 2: Correlation Between Water Quality Parameters and Phytoplankton Abundance

Water Quality Parameter	Correlation Coefficient (r)
pH	0.65
Temperature (°C)	0.72
Dissolved Oxygen (mg/L)	0.68
Nitrate (mg/L)	0.55
Phosphate (mg/L)	0.70
Ammonia (mg/L)	-0.30

DISCUSSION

The results from the water quality and phytoplankton abundance analysis at the University of Calabar Fish Farm highlight the significant role of environmental factors in influencing phytoplankton dynamics in aquaculture ponds. The pH values observed across the ponds (ranging from 6.9 to 7.8) indicate that the water quality in the selected ponds falls within the acceptable range of 6.5 to 8.5, as recommended by the WHO (2017). This range is optimal for phytoplankton growth, which thrives in neutral to slightly alkaline conditions. Pond 2 exhibited the highest pH, suggesting that this pond may have slightly more favorable conditions for the growth of species requiring higher pH levels, such as Oscillatoria sp. On the other hand, Pond 3, with a lower pH value, likely reflects different biological or chemical processes that may be affecting the species composition, especially the prevalence of Navicula sp. Temperature, ranging from 27.8°C to 29.0°C, also falls within the optimal range (25-30°C) for both phytoplankton and fish growth in aquaculture systems (FAO, 2016). The higher temperatures in Pond 2 may contribute to a more favorable environment for phytoplankton growth by enhancing metabolic processes, as reflected in the higher abundance of phytoplankton in this pond. The relatively consistent temperature values across the ponds further suggest that the temperature was not a limiting factor for phytoplankton growth during the study period.

Dissolved oxygen (DO) concentrations ranged from 6.5 to 7.2 mg/L, with Pond 2 showing the highest DO level. This is within the minimum requirement of = 5 mg/L for sustaining aquatic life (WHO, 2017). The positive correlation between dissolved oxygen and phytoplankton abundance suggests that oxygen availability, influenced by photosynthesis, supports phytoplankton growth and overall pond health. The relatively low concentrations of nitrates (<5 mg/L), phosphates (<0.5 mg/L), and ammonia (<0.1 mg/L) observed across the ponds are indicative of low eutrophication risk and generally good water quality. Nitrate and phosphate are essential nutrients for phytoplankton, and their low concentrations, particularly in Pond 2, suggest that nutrient availability is not limiting phytoplankton growth. Ammonia, however, showed a negative correlation with phytoplankton abundance, which could indicate that elevated ammonia levels at higher concentrations may inhibit phytoplankton growth, as ammonia toxicity can stress algae and reduce overall community health (Andriyani et al., 2022).

The total phytoplankton abundance across the ponds was relatively high, ranging from 32,000 to 40,500 cells/mL. Pond 2 exhibited the highest abundance of phytoplankton, dominated by Oscillatoria sp., while Pond 3 had the lowest abundance, with Navicula sp. being the dominant species. The dominance of Oscillatoria sp. in Pond 2 may be attributed to favorable conditions such as nutrient availability, particularly phosphorus, which is known to support the growth of blue-green algae (Ekpo et al., 2022). In contrast, the lower phytoplankton abundance in Pond 3 may reflect nutrient limitations or competitive interactions between phytoplankton species, which could inhibit the growth of certain species such as Oscillatoria sp. Phytoplankton diversity, as measured by the Shannon-Wiener Diversity Index, ranged from 2.4 to 2.8, indicating moderate to high diversity across the ponds. Pond 2, with the highest diversity index, suggests a well-balanced phytoplankton community with a variety of species coexisting, which is beneficial for ecosystem stability (George et al., 2016). In contrast, Pond 3, with a lower diversity index, may be more prone to environmental changes, and its lower diversity could reduce its resilience. Furthermore, the presence of Microcystis sp. in Pond 4 raises concerns about potential harmful algal blooms (HABs), which can be detrimental to fish health and water quality.

The analysis of correlations between water quality parameters and phytoplankton abundance revealed some interesting trends. Temperature and phosphate levels showed the strongest positive correlations with phytoplankton abundance, with correlation coefficients of 0.72 and 0.70, respectively. These findings highlight the importance of temperature and phosphorus in driving phytoplankton growth, as both factors support metabolic activities and nutrient assimilation, respectively (Dan et al., 2019). The positive correlation between dissolved oxygen and phytoplankton abundance ($r = 0.68$) further supports the notion that the oxygen produced by phytoplankton during photosynthesis sustains their own growth and the overall health of the pond ecosystem. In contrast, the moderate correlation between nitrate concentration and phytoplankton abundance ($r = 0.55$) suggests that while nitrate is an essential nutrient, its impact on phytoplankton growth may be influenced by other factors, such as competition among species or variations in nutrient assimilation rates (Ekpo et al., 2022). The negative correlation between ammonia and phytoplankton abundance ($r = -0.30$) further suggests that elevated ammonia levels could potentially inhibit phytoplankton growth, possibly due to the toxic effects of ammonia at higher concentrations (Andriyani et al., 2022).

CONCLUSION

The present study indicates that water quality parameters significantly influence phytoplankton abundance in the selected ponds. The strong positive correlations of temperature, phosphate, pH, and dissolved oxygen with phytoplankton growth highlight the importance of maintaining favorable environmental conditions to support healthy aquatic ecosystems. Further studies could focus on the mechanistic pathways through which these parameters affect phytoplankton dynamics and the implications for pond management practices.

REFERENCES

Akindele, E. O., and Olutona, G. O. (2017). Water quality and biodiversity of potamoplankton in an African sacred grove and world heritage site. Zoology and Ecology, 27(3–4), 292–303.

American Public Health Association (APHA). (2005). Standard methods for the examination of water and wastewater (21st ed.). American Public Health Association.

Andriyani, N., Mahdiana, A., Hilmi, E., and Kristian, S. (2020). The Correlation Between Plankton Abundance And Water Quality in Donan River. Omni-Akuatika, 16(3), 14.

Boyd, C. E. (1998). Water quality in warmwater fish ponds. Auburn University Press.

Dan, S. F., Liu, S., Udoh, E. C., and Ding, S. (2019). Nutrient biogeochemistry in the Cross River estuary system and adjacent Gulf of Guinea, South East Nigeria (West Africa). Continental Shelf Research, 179, 1–17.

Ekpo, P. B., Umoyen, A. J., Akpan, N. G., Ekpo, I. P., Sunday, C. J., Abu, G., and Ekpenyong, B. B. (2022). The Distribution and Seasonal Variation of Zooplankton Species of the Great Kwa River, Calabar, Nigeria: A Reassessment Approach. Annual Research and Review in Biology, 10–20.

FAO. (2016). Guidelines for the management of freshwater fish farming. Food and Agriculture Organization of the United Nations.

George, Uwem, U., Opeh, and Bassey, P. (2016). Spatial distribution and abundance of bacteria and phytoplankton in Calabar River, cross river state, Nigeria. International Journal of Fauna and Biological Studies, 3(3), 45–51.

Prescott, G. W. (1978). How to know the freshwater algae (3rd ed.). Wm. C. Brown Company Publishers.

Reynolds, C. S. (2006). The ecology of phytoplankton. Cambridge University Press.

Wetzel, R. G. (2001). Limnology: Lake and river ecosystems (3rd ed.). Academic Press.

WHO (2017). Guidelines for drinking-water quality: Fourth edition incorporating the first addendum. World Health Organization.

Zar, J. H. (2010). Biostatistical analysis (5th ed.). Pearson Prentice-Hall.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

DETERMINATION OF THE INFLUENCE OF PHYSICAL AND CHEMICAL PARAMETERS ON DISTRIBUTION AND ABUNDANCE OF FOUR COMMERCIAL FISH STOCKS IN A TROPICAL LAGOON

[1]Gbaior, T. S., [2]D. O. Odulate, [3]K. O. Ademolu, [1]S. E. Jeiyol and [4]I. U. Muhammad

[1]Department of Fisheries and Aquaculture, Joseph Sarwuan Tarka University, P.M.B. 2373, Makurdi-Nigeria.
[2]Department of Aquaculture and Fisheries Management, Federal University of Agriculture, Abeokuta, Nigeria.
[3]Department of Applied Zoology, Federal University of Agriculture, P.M.B. 2240, Abeokuta, Nigeria.
[4]Department of Fisheries and Aquaculture, Federal University Dutsin-Ma, Nigeria

Corresponding Author:
gbaiorsamuel@gmail.com, +234 802 723 5094, 0009-0003-4615-7548

ABSTRACT

This study evaluated the influence of physical and chemical parameters on the distribution and abundance of four commercially important fish species (Chrysichthys nigrodigitatus, Coptodon zillii, Ethmalosa fimbriata and Elops lacerta) from Lekki Lagoon, Southwest. Samples were collected between January and December, 2022 from five landing sites (Wharf, Agbalegiyo, Ebute-Oni, Ilumofin and Luboye) using proportional sampling which depends on the level of fishing activities. Environmental variables such as temperature, salinity, dissolved oxygen, and nutrients were monitored using standard methods, and their relationship with fish abundance was analyzed. Results revealed that C. nigrodigitatus and C. zillii dominated the catch, contributing 45 % and 53 % of total landings, respectively. Mean values of physico-chemical parameters were temperature (28.55±0.730C), transparency (4.62±1.07 m), electrical conductivity (251.53±94.65 μScm-1), pH (6.84±0.54), total alkalinity (26.68±6.56 mg/L), dissolved oxygen (7.02±0.46 mg/L), salinity (3.77±1.17 ‰), nitrate (0.28±0.08 mg/L) and phosphate (0.26±0.06 mg/L). The first axis of the canonical correspondence analysis showed that 84% of the environmental variables positively influenced the distribution and abundance of fish species with temperature, salinity and dissolved oxygen having the major effects. There is need for continuous monitoring of the water quality of the lagoon for sustainable management of the fish populations.

Keywords:
Multivariate, Estuary, Climate Change, Fish stocks

INTRODUCTION

Fish distribution and abundance in aquatic ecosystems are largely determined by physical and chemical parameters (Opadokun *et al.*, 2015). Different fish species exhibit varying tolerances to water quality. For instance, tilapia thrive in conditions that may be detrimental to species like Clarias. This emphasizes the need for species-specific water quality assessments (Diana *et al.*, 2017). It is important to have a good understanding of these environmental influences for effective and sustainable management of fish populations (Odulate *et al.*, 2014; Abdul, 2015). Pollution and environmental deterioration have also contributed to a decline in the productivity of coastal ecosystems. Therefore, it is generally accepted that inadequate management of these ecosystems is to blame for the demise of numerous coastal fisheries (Akinsanya et al., 2021; Amponsah et al., 2023). Nonetheless, there is mounting evidence that human pressures and climatic fluctuations are among the external factors adversely affecting coastal ecosystems (Gradilla-Hernández et al., 2020). Previous studies have shown that fluctuations in these parameters can lead to changes in fish behavior, reproduction, and overall population dynamics (FAO, 2022). This paper aims to determine the water quality parameters of Lekki Lagoon, with a focus on their effects on the selected fish species. The findings of the study will contribute to effective fishery management by identifying key environmental factors that influence fish distribution in this important ecosystem.

MATERIALS AND METHODS

Study area

The location of the study was Lekki lagoon. It is situated on latitude 4°00' and 4°15' E and longitude 6°25' and 6°37' N in Nigeria (Figure 1). The lagoon is about 64 m deep with a surface area of 247 m2 and extends about 200 km from Dahomey border to the Niger Delta (Adekoya, 1995). The freshwater Epe lagoon is connected to it to the east, while the brackish water Lagos lagoon runs into the coastal water body from the west. Major activities of the rural inhabitants around the lagoon include fishing, farming, mining and transportation of goods and humans using engine powered boats. The area is characterized with two different seasons (dry and rainy seasons) which is typical of southern Nigeria (Adesalu and Nwanko, 2012). The main vegetation of Lekki lagoon comprise of shrubs, oil, raffia and coconut palms (Nwanko and Onitiri,1992). It is a major source of fishery resources in Nigeria and is connected by many rivers which include River Oni, River Oshun and River Saga (Famoofo and Abdul, 2020).

Sampling procedures

Data for the current study was collected from five landing sites (Wharf, Agbalegiyo, Ebute-Oni, Ilumofin and Luboye) using proportional sampling which depended on the level of fishing activities. Sampling was carried out between January – December, 2022. The selected fish stocks were collected from the local commercial fishers immediately after harvesting using various fishing gear types which were seine nets, gillnets, cast nets and traps. Fish identification keys (Olaosebikan and Raji, 2013) were used in identifying samples to species level. Fish weighed using an electronic weighing balance (MH-999) according to Dienye et al. (2021) and subsequent estimation was done by batch-weighing.

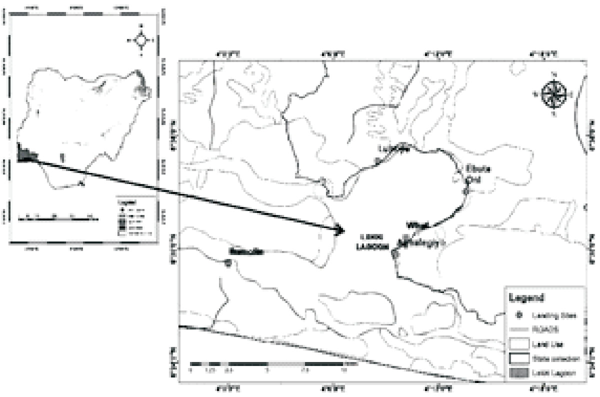

Fig. 1: Study area showing sampling sites

Water quality parameters

Monthly assessments were conducted at each sampling site to ascertain the physico-chemical parameters of Lekki lagoon, both in-situ and ex-situ. A multi parameter water proof HANNA instrument (H19829) was used to determine temperature (0C), hydrogen ion and electrical conductivity (μS/cm) in-situ at the sampling sites. A Secchi disc was used to determine water transparency (m). Across the five sampling locations, water samples were gathered into pre-washed and sterilized plastic bottles for laboratory analysis. Standard procedures were then used to analyze the samples for a variety of physical and chemical characteristics (APHA, 1998). The Department of Environmental Resources Management and Toxicology Laboratory, Federal University of Agriculture, Abeokuta was used for determination of parameters that could not be measured in-situ.

Statistical analyses

Summary statistics were performed using R software while multivariate analysis was done using Paleontological Statistics (PAST) software

RESULTS AND DISCUSSION

Total fish landings during the study period was dominated by C. zillii and C. nigrodigitatus with 53 % and 45 %, respectively while E. fimbriata and E. lacerta accounted for 1 % each to the total catch (Figure 2). This is similar to the report of Abdul et al. (2019) on their research in Lekki Lagoon that C. nigrodigitatus accounted for the highest catch followed by C. zillii. In the current study however, C. zillii dominated in weight followed by C. nigrodigitatus. Table 1 shows that catches were higher at Wharf which could be as a result of more sophisticated fishing gears that were used. According to Odulate et al. (2014), water quality affects fish and other aquatic organisms' ability to reproduce, grow, survive, and produce nearly all biological and ecological products. It plays a significant role in determining whether or not such water is suitable for aquatic life to live in. All water quality parameters except temperature and pH monitored supported the claims made by UNEP and Gems Water Programme (2006) that water quality fluctuates in every aquatic system and cannot be determined by looking at just one parameter. Because water quality varies with time and space, it necessitates continuous observation to identify spatial patterns and changes over time (APHA, 2005; UNEP and Gems Water Programme, 2006). Ranges of water quality parameters monitored during the study (Table 2) were similar to reports of Opadokun et al. (2015). The first axis of the canonical correspondence analysis showed that majority of the water quality parameters had much bearing on the distribution of fish fauna in the lagoon. Temperature, salinity and dissolved oxygen had the most pronounced influence on the distribution of the fish species, this could be that fish being highly responsive to these environmental changes undergo remarkable changes in metabolism, growth and overall performance.

Table 1: Catch distribution and abundance of selected stock in Lekki lagoon

	Catch (kg)					
Fish species/landing sites	**Whaf**	**Ebute-Oni**	**Agbalegiyo**	**Ilumofin**	**Luboye**	**Total**
Chrysichthys nigrodigitatus	53429.62	51723.42	24630.59	40512.51	45034.35	215330.49
Coptodon zillii	65192.91	64121.66	14423.27	54017.96	56591.62	65192.91
Ethmalosa fimbriata	906.12	668.04	1047.08	852.32	827.64	4301.20
Elops lacerta	686.57	362.86	249.77	741.27	707.08	2747.55

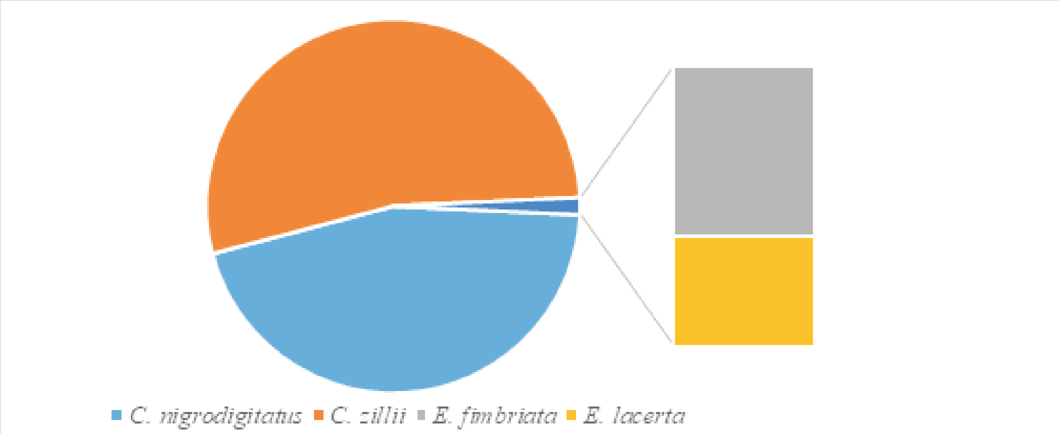

Fig. 2: Catch composition of the selected fish species from Lekki lagoon

Table 2: Mean monthly water quality parameters of Lekki lagoon

Month	Temp. (^{0}C)	Trans. (m)	EC (µS/cm)	pH	TA (mg/L)	DO (mg/L)	N (mg/L)	P (mg/L)	Salinity (‰)
Jan	28.4±0.36	5.76±1.93^b	328.94±2.04^c	6.36±0.36	19.06±0.83^f	6.62±0.28^b	0.19±0.02^d	0.23±0.04^b	4.47±1.25^b
Feb	28.92±0.75	5.91±2.13^b	350.76±43.28^b	6.86±0.57	20.08±0.49^f	6.94±0.17^a	0.23±0.03^c	0.24±0.03^b	5.67±0.54^a
Mar	28.44±0.37	6.12±3.07^a	380.24±41.92^a	6.38±0.28	20.32±1.51^f	6.96±0.29^a	0.21±0.03^c	0.26±0.03^b	6.02±0.40^a
Apr	29.82±1.03	5.23±3.11^c	385.68±8.20^a	6.86±0.42	25.52±3.60^d	6.98±0.40^a	0.23±0.04^c	0.25±0.05^b	4.21±1.01^b
May	28.80±1.33	4.46±4.40^e	246.84±6.76^{ef}	6.56±0.37	26.82±2.69^d	7.60±0.42^a	0.30±0.02^b	0.31±0.06^a	4.05±1.00^b
Jun	27.22±0.83	3.69±2.52^f	224.44±6.41^f	6.80±0.56	32.82±5.31^b	7.32±0.44^a	0.29±0.04^b	0.35±0.05^a	2.70±0.04^c
Jul	27.58±0.57	3.30±2.31^f	178.32±23.10^h	7.84±0.51	41.38±3.25^a	7.50±0.75^a	0.44±0.06^a	0.37±0.04^a	2.59±0.09^d
Aug	28.90±1.25	3.16±0.93^f	134.86±13.85^g	7.78±0.60	30.94±2.26^b	7.82±0.59^a	0.38±0.05^a	0.29±0.03^b	2.57±0.12^d
Sep	28.60±0.85	3.43±1.41^f	131.48±1.18^g	7.38±0.76	29.72±1.87^c	6.96±0.50^a	0.28±0.04^b	0.26±0.04^b	2.88±0.37^c
Oct	28.72±1.11	4.15±2.97^e	134.60±2.08^g	6.58±0.36	29.12±3.29^c	6.58±0.74^b	0.33±0.08^b	0.23±0.05^b	3.02±0.38^c
Nov	29.36±1.14	4.88±3.31^d	252.20±62.94^{cd}	6.32±0.50	23.20±2.40^{de}	6.38±0.56^b	0.23±0.04^c	0.19±0.03^b	3.18±0.29^c
Dec	27.82±1.10^a	5.35±4.08^c	269.96±38.95^d	6.38±0.65	21.14±1.92^f	6.56±0.69^b	0.21±0.04^c	0.19±0.02^b	3.92±0.23^b
Mean± SD	**28.54±0.73**	**4.63±1.07**	**251.53±94.65**	**6.84±0.54**	**26.68±6.56**	**7.02±0.46**	**0.28±0.08**	**0.26±0.06**	**3.77±1.17**

Hint: Temp. = Temperature, Trans. = Transparency, EC=Electrical Conductivity, TA = Total Alkalinity, DO = Dissolved Oxygen, N = Nitrogen, P = Phosphorus
*Means with different superscript across the columns are significantly (P<0.05) different

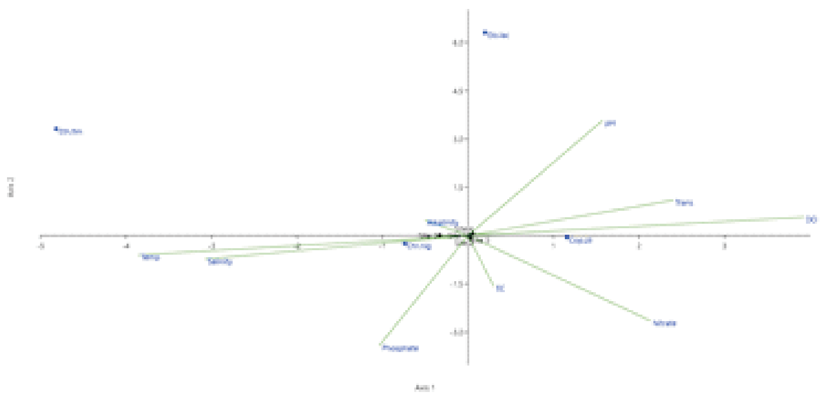

Fig. 3: Canonical correspondence analysis (CCA) ordination diagram with the selected 4 fish species and 9 quantitative environmental parameters (lines). Hint: Temp= Temperature, Trans= Transparency, pH= Hydrogen ion concentration, EC= Electrical conductivity, DO= Dissolved oxygen. The four fish species are Chr.nig = Chrysichthys nigrodigitatus, Cop.zil = Coptodon zillii, Eth.fim= Ethmalosa fimbriata, Elo.lac= Elops lacerta.

CONCLUSION

The physical and chemical parameters of Lekki Lagoon significantly influenced the distribution and abundance of fish species, more specifically, Chrysichthys nigrodigitatus and Coptodon zillii, which showed dominance in catches. Temperature, salinity, and dissolved oxygen are the major environmental factors that are critical to the distribution of the four fish species. There is need for the long-term monitoring of environmental variables and fish stocks in the lagoon for informed fisheries management.

REFERENCES

Abdul, W.O. (2015). Life history in silver catfish, Chrisichthys nigrodigitatus, Family Bagridae in Ogun State Coastal lagoon, Nigeria. Ife Journal of Science 17(3): 691 – 700.

Adekoya, B.B. (1995). A Report on the Diagnostic Survey of Small Capture and Culture Fisheries in Ogun State. OGADEP, Abeokuta, p. 17.

Adesalu, T.A. and Nwankwo, D.I. (2012). Successional pattern of phytoplankton (>55 m) in Lekki lagoon, Nigeria. Rev. de Biol. Trop. 60 (1): 143–155.

Akinsanya, B., Olaleru, F., Samuel, O. B., Akeredolu, E., Isibor, P. O., Adeniran, O. S. and Akhiromen, D. I. (2021). Bioacumulação de pesticidas organoclorados, infecções por Procamallanus sp. (Baylis, 1923) e colonização microbiana em peixes africanos Snakehead coletados na lagoa Lekki, Lagos, Nigéria. Brazilian Journal of Biology, 81, 1095-1105.

Amponsah S. K. K. (2023). Length based-stock assessment and Spawning Potential Ratio (LB-SPR) of exploited tilapia species (Coptodon zillii, Gervais, 1848) in Lake Volta, Ghana. LimnoFish. 9(1): 29-36. doi: 10.17216/LimnoFish.1153315

APHA (1998). Standard Methods for the Examination of Water and Wastewater. 20th Edition, American Public Health Association, Washington DC.

Diana, J. S., Szyper. J. P., Batterson, T. R., Boyd, C. E. and Piedrahita, R. H. (2017). Water Quality in Ponds. Dynamics of Pond Aquaculture, CRC Press 19p.

Dienye, H. E., Olopade, O. A. and Amadiree, E. T. (2021. Growth parameters and exploitation of endangered Ladyfish (Elops lacerta Valenciennes, 1847) in the Obama Creek, Rivers State, Nigeria. Journal of Aquatic Biology and Fisheries 9: 92 – 98.

Famoofo, O.O. and Abdul, W. O. (2020). Biometry, condition factors and length-weight relationships of sixteen (16) fish species in Iwopin freshwater ecotype of Lekki Lagoon, Ogun State, Southwest Nigeria. Heliyon 6 e02957

FAO 2022. Fishery and Aquaculture Country Profiles. Nigeria. Country Profile Fact Sheets. Fisheries and Aquaculture Division [online]. Rome.

Gradilla-Hernández, M. S., de Anda, J., Garcia-Gonzalez, A., Meza-Rodríguez, D., Yebra Montes, C. and Perfecto-Avalos, Y. (2020). Multivariate water quality analysis of Lake Cajititlán, Mexico. Environmental monitoring and assessment, 192(1), 5.

Nwankwo, D. I. and Onitiri, A.O. (1992). Periphyton on submerged aquatic macrophytes (Hornwort and Bladderwort) in Epe Lagoon. Journal of Agriculture Science and Technology, 2 (2): 135-141.

Odulate, D. O., Akegbejo-Samsons, Y. and Omoniyi, I. T. (2014). Multivariate Analysis of Fish Species and Environmental Factors in Marine Coastal Waters of the Gulf of Guinea, Southwest Nigeria. Croatian Journal of Fisheries 72: 55 – 62.

Olaosebikan, B. D. and Raji, A. (2013). Field guide to Nigerian freshwater fishes. Federal College of Freshwater

Fisheries Technology, New Bussa, Revised Edition, pp. 73–74.

Opadokun, I. O., Falaye, A. E. and Ajari, E. K. (2015). Seasonal variation in physicochemical parameters of Lekki Lagoon and the conservation of its ecosystem. Journal of Geoscience and Environmental Protection 3: 11 – 17.

UNEP and Gems Water Programme, 2006. Water Quality for Ecosystem and Human Health, Ontario Canada 24pp.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

SEASONALVARIATION OF SOME PHYSICO-CHEMICAL PARAMETERS AND ZOOPLANKTON ABUNDANCE OF RIVER RIMA IN KWALKWALWA PORTION OF SOKOTO STATE, NIGERIA

[1]Rabi'u, M., [2] L. A. Argungu, [2] I. Magawata and [3] I.M. Magami

[1]Department of Fisheries and Aquaculture, Faculty of Agriculture, Umaru Musa Yar'adua University, Katsina State, Nigeria.
[2]Department of Fisheries and Aquaculture, Usmanu Danfodiyo University, Sokoto,
[3]Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto

Corresponding Author:
rabiumusamls@gmail.com, +2348147518460

ABSTRACT

The studies on seasonal variation of physico chemical parameters and zooplankton abundance of River Rima in Kwalkwalwa area of Sokoto, Sokoto state, Nigeria. Three sampling stations were identified as station A (shoreline site), B (Fishing activities. area) and C (Farming and irrigation site). The sampling was carried out monthly, between April 2019 to March 2020. The mean average of seasonal physico chemical parameters were, DO (4.41 mg /L), water temperature (27.03 0C), pH (6.83), TDS (6.0 mg/L), Turbidity (19.58 cm)), EC (127.05 *u*S/cm), phosphate (0.19mg/L) and nitrate (1.01 mg/L). The difference in physicochemical parameters between the three stations of the river was not significant except for turbidity, where there were significant ($P<0.05$) differences between stations B (20.39) and C (25.71). The percentage relative abundance of each zooplankton groups from all the seasons recorded was in the following order, Copepods > Rotifers > Cladocerans. This study revealed that the zooplankton productivity was found to be higher during late wet season when the nutrients accumulated from freshwater run-off due to rainfall in these months. The result showed that water quality parameters exhibited great seasonal variation and controlled the structure of zooplankton community in the river.

Keywords:
Ecosystems, plankton, waterfowl, deterioration and harvest net.

INTRODUCTION

Zooplankton represents one of the most prominent biotic components in aquatic systems and is diverse (Xiong et al., 2016). Freshwater zooplankton plays an important food chain role in ponds, lakes and reservoirs ecosystems (Manickam *et al.*, 2015). Zooplankton occupies an intermediate position in the food web. Manickam *et al.* (2018) reported changes of zooplankton species densities as affected by changes in physico-chemical parameters in different seasons. Due to seasonal distribution of rainfall, River Rima experiences seasonal flooding which introduces a lot of detritus and pollutants from the land. The River presently serves as a major drainage channel receiving domestic wastes as well as industrial effluents from industries in the area. These interferes couples with the seasonal fluctuation in surface water level and have the tendency to influence the status of these parameters which may produce significant changes in the quality of the river water and the trophic state of an ecosystem (Yakubu *et al.,* 2000). Owing these identified problems, the tendency of zooplankton to respond to slight changes in the physical and chemical compositions of aquatic environment has made it a veritable tool in evaluating the seasonal variation of some water quality parameters and the trophic state of zooplankton abundance (Zhao et al., 2019).

MATERIALS AND METHODS

The study was carried out in three stations of Kwalkwalwa area of River Rima in Wamakko Local Government Area of Sokoto state, Nigeria. Sokoto lies between longitudes 408'E and 605'E, and latitudes 120N and 13058'N (Umar and Ismaila, 2017). The climate of Sokoto is tropical continental, with much of the rains between June and September, while the long dry season is from October and May (Shinkafi, 2013). Sokoto lies between longitudes 408'E and 605'E, and latitudes 120N and 13058'N. The climate of Sokoto is tropical continental, with much of the rains between June and September, while the long dry season is from October and May (Umar and Ismaila, 2017).

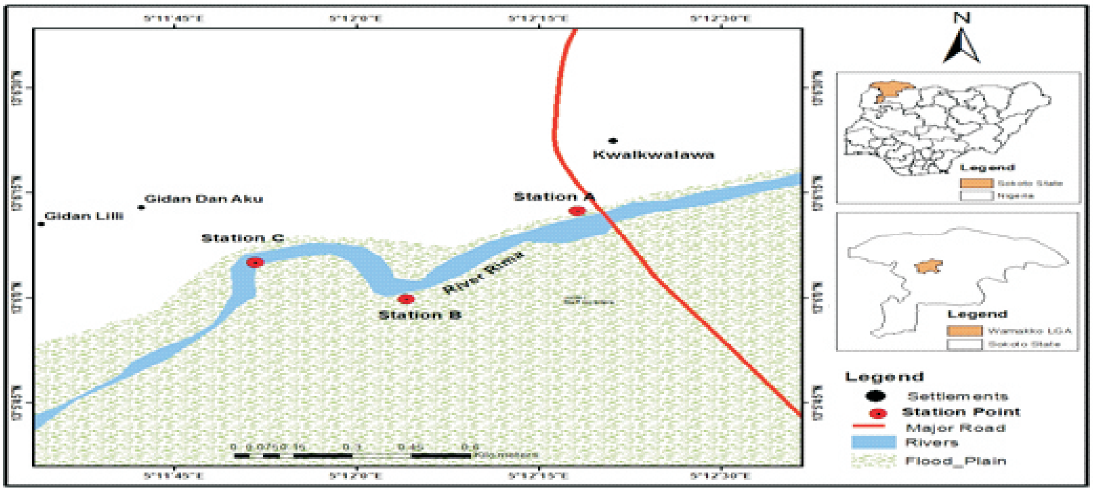

Figure 1: Map o study area.
Source: OSGOF Drawn by GIS Lab. Department of Geography UDUS 2019

Samples and water sample collection

Sampling at the selected stations was carried out monthly, for a year. Water and zooplankton were collected from these sampling stations for the period of the study. Water samples were collected in one litre capacity plastic bottles, between 6 to 7 am, from all the sampling locations, for a period of 12 months. The bottle was immersed into the river to collect water at the hypolimnion layer early in the morning. Temperature, pH and turbidity of the water were measured immediately at the field. Water sample collected was taken to Agrichemical laboratory Usmanu Danfodiyo University, Sokoto, for the determination of dissolved oxygen (DO), Conductivity, presence of Total Dissolved Solids (TDS), Nitrate-Nitrogen ($NO3^{-N}$) and Phosphate – Phosphorus (PO_4^{-F}) (Maishanu et al., 2011). The plankton and water sample were collected from the selected stations in the river for 12 months. Samples were collected once every month in the morning hours (6.00 A.M to 7.00 A.M).

Zooplankton collection and identification

Standard plankton net was used. It's conical in shape. A nylon material was attached to it (which is the filtering area of the net). The harvest net was towed vertically over the river water to collect the sample. The content was then transferred into 100ml plastic bottles and was fixed using 5% of formalin (10 ml), the aqueous solution of formaldehyde to preserve the zooplankton. The bottles were kept in cooler boxes and transported to the Biological science laboratory Usmanu Danfodiyo University, Sokoto, for identification. Different groups of zooplanktons, Rotifer, Cladocera and Copepoda were segregated and separated under a binocular stereo zoom dissection microscope using a fine needle and brush. Individual species of plankton was mounted on microscopic slides with a drop of 20% glycerin after staining with eosin and rose Bengal. The identification of zooplankton was made referring the standard manuals, text books and monographs (Edmondson, 1959; Sharma et al., 1987; Altaff, 2004). Using a compound microscope and photomicrograph with Inverted

Biological Microscope for quantitative zooplankton study, A sedge-wick rafter cell was used which is 50 mm long, 20mm wide and 1mm deep. 1 ml of zooplankton sample was transferred to the cell with a dropper. The air bubbles were avoided while transferring the sample to the cell. Before counting the zooplankton, it was ensured that all the organisms have settled down and counted under light microscope. At least 3 such counting was made for each group. The average values were taken of each month for one year, (i.e., during 2019-2020). Total number of plankton present in 1 litre of water sample was calculated (Santhanam et al., 1989) using the following formula: $N = n \times v / V$

Statistical Analysis

Seasonal-wise data were subjected to statistical analysis through one-way ANOVA in each of the station and subsequent post hoc multiple comparison with DMRT by adopting SPSS (v20.0). The different diversity indices such as, Shannon's diversity index (H'), species evenness and species richness were calculated using PAST (Paleontological Statistics) software package (PAST, v2.02). The $P<0.05$ were considered statistically significant by 95%.

RESULTS

Physicochemical Parameters

Table 2 showed the mean variations in water quality parameters in River Rima, Kwalkwalwa area during the study period. One-way ANOVA (posthoc test) of physicochemical parameters showed statistically significant differences ($p < 0.05$) for the physicochemical parameters.

Physicochemical Parameters for Stations.

The mean of physicochemical recorded from three sampling stations are presented in Table 3. The highest turbidity value of 27.91 cm was recorded on the farming and irrigation area while the lowest value of 20.39 cm was recorded on the undisturbed area. The difference in physicochemical parameters between the three stations of the river was not significant except for turbidity, where there was significant ($P<0.05$) differences between stations B (20.39) and C (25.71).

Seasonal Variation of Zooplankton Taxa Abundance.

Table 4 shows the Variation of zooplankton taxa abundance. The most occurred taxa were copepoda with 48.39 percent to the total zooplankton abundance during the late wet season, Followed by rotifer 35.26 and then cladoceran 19.35.). There was significant variation in zooplankton abundance between the seasons.

Table 2: Physico-chemical characteristics of River Rima, Kwalkwalwa area during the study period

Parameters	Early Wet Season (Apr' 2019- Jun' 2019)	Late Wet Season (Jul' 2019- Sep' 2019)	Early Dry Season (Oct' 2019- Dec' 2019)	Late Dry Season (Jan'2020 Mar' 2020	Overall average
WT (°C)	30.2 ± 0.23^{a}	25.5 ± 1.22^{b}	22.8 ± 0.57^{c}	29.63 ± 0.59^{ab}	27.03 ± 0.65
pH	6.66 ± 0.36^{ab}	7.05 ± 0.22^{a}	7.08 ± 0.08^{a}	6.54 ± 0.49^{ab}	6.83 ± 0.28
DO (mg/l)	5.01 ± 0.26^{a}	5.25 ± 0.33^{a}	3.93 ± 0.46^{ab}	3.45 ± 0.40^{bc}	4.41 ± 0.36
EC(μScm^{-1})	136.9 ± 23.3^{ab}	94.5 ± 2.91^{b}	115.83 ± 3.35^{b}	161 ± 26.92^{a}	127.05 ± 14.12
Turb (cm)	20.33 ± 0.11^{a}	20 ± 0.75^{a}	18.66 ± 0.6^{ab}	19.33 ± 0.98^{ab}	19.58 ± 0.61
TDS (mg/l)	6.66 ± 0.02^{a}	5.23 ± 0.71^{b}	5.89 ± 0.94^{ab}	6.22 ± 1.17^{ab}	6.0 ± 0.71
Nitrite (mg/l)	1.05 ± 0.49^{a}	0.89 ± 0.37^{ab}	1.05 ± 0.08^{a}	1.08 ± 0.41^{a}	1.01 ± 0.33
Phosphate (mg/l)	0.18 ± 0.02^{a}	0.19 ± 0.01^{a}	0.20 ± 0.01^{a}	0.20 ± 0.01^{a}	0.19 ± 0.01

Each season-wise value is overall average of mean ± SD (3 stations × 3 months). Mean values within the same row sharing different superscript are significantly different ($P<0.05$). Mean values within the same row sharing same superscript are not statistically significant ($P>0.05$)

Table 3: Means of the physicochemical parameters of the sampling stations

Stations	Means of Physicochemical							
	Temperature (°C)	pH	DO (mg/l)	EC µS/cm	Turb (cm)	TDS (mg/l)	Nigrate (mg/l)	Phosphate (mg/l)
A	27.48^{a}	6.97^{a}	4.81^{a}	139.88^{a}	25.71^{ab}	5.83^{a}	0.96^{a}	0.15^{a}
B	26.96^{a}	6.91^{a}	4.75^{a}	121.67^{a}	20.39^{b}	5.75^{a}	0.98^{a}	0.19^{a}
C	26.78^{a}	6.74^{a}	4.93^{a}	118.57^{a}	27.91^{a}	6.43^{a}	0.94	0.18
S.E	0.04	1.76	1.00	43.97	0.01	2.22	1.23	0.62

Mean ± SD;One-way ANOVA, post-hoc,*ab values with the same letters in the column did not differ significantly at P<0.05

Table 4: Zooplankton taxa, abundance and percentage relative Abundance of River Rima, Kwalkwalwa area during the study period

Family and Species	Abundance (ind L-1) and Relative Abundance (%)			
	Early Wet Season (Apr' 2019-Jun' 2019)	Late Wet Season (Jul' 2019-Sep' 2019)	Early Dry Season (Oct' 2019-Dec' 2019)	Late Dry Season (Jan' 2020-Mar' 2020)
Cladocera	90^{b} (18.75%)	120^{a} (19.35%)	50^{d} (18.75%)	80^{c} (19.35%)
Moina brachiate	30^{b} (6.24%)	100^{a} (16.12%)	20^{c} (6.24%)	30^{b} (3.23%)
Moina *micrura*	60^{a} (12.51%)	20^{d} (3.23%)	30^{c} (12.51%)	50^{b} (16.12%)
Copepod	260^{b} (54.17%)	300^{a} (48.39%)	190^{d} (54.17%)	250^{c} (48.39%)
Eucyclops speratus	100^{b} (21.75%)	110^{a} (17.73%)	70^{c} (14.58%)	100^{b} (17.83%)
Thermocyclops hyalinus	40^{b} (9.46%)	70^{a} (11.27%)	20^{d} (6.25%)	30^{c} (6.44%)
Heliodiaptomus viduus	40^{b} (9.46%)	50^{a} (8.06%)	40^{b} (10.42%)	40^{b} (8.04%)
Mesocyclops hyalinus	50^{a} (11.42%)	30^{c} (4.83%)	30^{c} (8.33%)	40^{b} (8.04%)
Mesocyclops leuckarti	50^{a} (11.42%)	40^{b} (6.5%)	30^{c} (8.33%)	40^{b} (8.04%)
Rotifer	150^{b} (32.26%)	200^{a} (35.26%)	90^{d} (27.08%)	130^{c} (27.08%)
Filinia longiseta	60^{b} (13.22%)	120^{a} (20.67%)	50^{c} (14.48%)	60^{b} (12.5%)
Asplanchna intermedia	90^{a} (19.04%)	80^{b} (17.73%)	40^{c} (12.6%)	80^{b} (16.65%)

Each season-wise value is overall average of mean ± SD (5 stations × 3 months).
Mean values within the same row sharing different superscript are significantly different (P<0.05).

DISCUSSION

Similar to that of the present study, fluctuations in Physico-chemical parameters and plankton population density have been reported by (Ahmad et al., 2012). Physico-chemical parameters and quantity of nutrients in water play a significant role in the distribution patterns and species composition of plankton (Jose et al., 2015). In this study, higher water temperature was recorded during the late dry season and early wet season, which accounted for more plankton productivity. The natural water is generally alkaline in nature due to the presence of carbonates and bicarbonates. In this study, the higher pH recorded in late wet season and early dry season accounts for good primary and secondary productivity. The minimum DO recorded in late dry season was due to its utilization for decomposition of organic matter and respiration of organisms including zooplankton. An excess amount of TDS in water tends to disturb the ecological balance due to suffocation of aquatic fauna even in the presence of fair quantity of DO (Dhanasekaran, et al., 2017). In this study, the higher TDS recorded during early wet season and late dry season associated with other water quality supports production of zooplankton.). EC is a good indicator of the overall water quality. In the present study, the higher EC recorded during late dry season and early wet season supported plankton production. The turbidity in late wet season was significantly higher than other seasons; this could probably be due to improper agricultural practices and deforestation. Agricultural activities along the catchment of the river lead to erosion and hence high turbidity in the river from the runoff, but the water became more transparent (less turbid) from early dry season therefore, there was relatively equal reception of sun light and this could be the reason for the abundance of zooplankton in the late wet season. High turbidity has been reported in Birim river basin in Ghana (Ansa and Asante, 2000) and in Lake Victoria (Sehgal et al., 2013) due to improper agricultural activities. Conversion of land to agriculture has been reported as one of the drivers to deterioration of aquatic systems (e.g. Yakubu et al., 2011) in India and Ghana respectively.

CONCLUSION AND RECOMMENDATION

Overall, this river was organically polluted since no significant fluctuation in species composition was recorded and all the species appeared in all the four seasons. However, the nutrient status of the river ensures plankton productivity. This case was most obvious in early wet season and late wet season. The effect of over fishing might have led to higher population density of zooplankton in these seasons. The present study also revealed that Copepod was the most dominant and diversified group of zooplankton in River Rima, It is concluded that abundance and distribution of species were greatly influenced by season as well as the physicochemical parameters. However, further studies are warranted on the continuous monitoring of this water body to know the future impact of climate change on distribution of zooplankton which can help to identify the sensitive and sentinel species to formulate the effective conservation strategies

REFERENCE

Ahmad, U., Parveen, S., Mola, H. R. A., Kabir, H. A., & Ganai, A. H. (2012). Zooplankton population in relation to physico-chemical parameters of Lal Diggi pond in Aligarh, India. Journal of environmental biology, 33(6), 1015.

Altaff, K. (2004). A Manual of Zooplankton. Department of Zoology, the New College, Chennai. Tamil Nadu, India. 19-145 pp.

Ansa-Asare, O. D. and Asante, K. A. (2000). The water quality of Birim river in south east Ghana. West African Journal of Applied Ecology 1: 23 - 33.

Dhanasekaran, M., Bhavan, P. S., Manickam, N., & Kalpana, R. (2017). Physico-chemical characteristics and zooplankton diversity in a perennial lake at Dharmapuri (Tamil Nadu, India). Journal of Entomology and Zoology Studies, 5(1), 285-292.

Edmondson W. T. (1959). Freshwater Biology. Edn 2, John Wiley and Sons Inc, London-Chapman and Hall Limited, New York, USA, 1248.

Jeppesen, E., Noges, P., Davidson, T. A., Haberman, J., Noges, T., Blank, K., ... and Amsinck, S. L. (2011). Zooplankton as indicators in lakes: a scientific-based plea for including zooplankton in the ecological quality assessment of lakes according to the European Water Framework Directive (WFD). Hydrobiologia, 676, 279-297.

Jose, E. C., Furio, E. F., Borja, V. M., Gatdula, N. C., and Santos, D. M. (2015). Zooplankton composition and abundance and its relationship with physico-chemical parameters in Manila Bay. Oceanography, 3(1), 1-6.

Manickam, N., Bhavan, P. S., Santhanam, P., Muralisankar, T., Srinivasan, V., Vijayadevan, K., and Bhuvaneswari, R. (2015). Biodiversity of freshwater zooplankton and physico-chemical parameters of Barur Lake, Krishnagiri District, Tamil Nadu, India. Malaya J Biosci, 2(1), 1-12.

Manickam, N., Bhavan, P. S., Santhanam, P., Bhuvaneswari, R., Muralisankar, T.,Srinivasan, V., & Karthik,

M. (2018). Impact of seasonal changes in zooplankton biodiversity in Ukkadam Lake, Coimbatore, Tamil Nadu, India, and potential future implications of climate change. The Journal of Basic and Applied Zoology, 79, 1-10.

Santhanam P, Velayutham R, Jegathesan G (1989) A manual of freshwater ecology. Daya Publishing House, New Delhi

Sehgal, K., Phadke, G. G., Chakraborty, S. K., and Reddy, S. V. K. (2013). Studies on zooplakton diversity of Dimbhe reservoir, Maharashtra, India. Advances in Applied Science Research, 4(1), 417-420.

Sharma BK, Michael RG.(1987). Review of taxonomic studies on freshwater Cladocera from India with remarks on biogeography. Hydrobiologia.; 145:29-33.

Shinkafi, B. A., Salim, A. M., and Yusuf, M. A. (2013). Some Aspects of the Biology of Distichodus rostratus (GUNTHER, 1864) in River Rima, North-western Nigeria. Greener Journal of Biological Sciences, 3(4), 136-145.

Umar, A. T., and Ismaila, A. (2017). Analysis of monthly rainfall variations: further evidence of climate change in Sokoto state, Nigeria (1926-2015). Ethiopian Journal of Environmental Studies and Management, 10(6).

Xiong, W., Li, J., Chen, Y., Shan, B., Wang, W., and Zhan, A. (2016). Determinants of community structure of zooplankton in heavily polluted river ecosystems. Scientific Reports, 6(1), 22043.

Yakubu, A. F., Sikoki, F. D., Aboweri, J. F. N. and Hart, S. A. (2000). A Comparative Study of Phytoplankton Communities of Some Rivers, Creeks and Burrow pits in the Niger Delta Area. Journal of Applied Science and Environmental Management, 4: 41-41

Zhao, C. S., Yang, Y., Yang, S. T., Xiang, H., Wang, F., Chen, X., ... and Yu, Q. (2019). Impact of spatial variations in water quality and hydrological factors on the food-web structure in urban aquatic environments. Water Research, 153, 121-133.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

BIODIVERSITY OF FISHES IN THE RIVER BENUE AND ITS IMPACT ON PROMOTING AQUACULTURE PRACTICES IN NIGERIA

Kwaplong S.S., C. Obetta, A.F. Babalola , P. Okunola

Department of Fisheries and Aquaculture, Agricultural Research Council of Nigeria, P.M.B. 5026, Abuja.

ABSTRACT
The River Benue, one of Nigeria's major inland water bodies, supports a diverse array of fish species that play a crucial role in the local ecosystem and economy. This study aimed to review the biodiversity of fish species in the River Benue system. A systematic literature review of articles was used to carry out this research by synthesizing existing literature to provide a comprehensive understanding of the fish biodiversity in the River. Four articles were reviewed along the River Benue Basin up to the confluence. The articles covered Adamawa, Taraba, Benue and Kogi States. Twenty most occurring species in the catches were documented for each article. A total of 42 species from 17 families of fish were documented from the four articles reviewed. A study in Adamawa State, revealed Alestes baremoze and Schilbe intermedius, as two most abundant species. The second article on Taraba State observed Synodontis gambiensis, Siluranodon auratus, Mormyrus rume and Schilbe mystus to be the most abundant in that region. Clarias gariepinus and Coptodon zilli, were observed to be the most abundant species from the third article on Benue State. Hyperopisus bebe and Citharinus citharus were the two most common species observed in the fourth research conducted in Kogi State at Idah town. Clarias gariepinus and Synodontis schall were observed to be readily available in all four locations reviewed. Further research on the domestication of these freshwater species in the River Benue system is recommended for more species diversity in our aquaculture sector to boost fish production.

Keywords
River Benue, inland water bodies, fish species, biodiversity, ecosystem.

INTRODUCTION

Fishes are most researched species of aquatic organisms and they are the only food source harvested from natural populations(Negi, and Sheetal, 2013). Fish are important because they contribute as much as 17% of the global animal protein reaching over 50 percent in several countries in Asia and Africa (National Research Council, 2005). The sector employs an estimated 58.5 million people in primary production alone – approximately 21% are women (FAO, 2022). Furthermore, fishes are often considered as engineers of aquatic ecosystems, not only react to physical and chemical changes in their environment, but they can also drive such changes and have important roles in cleansing and detoxifying their environment (Ostroumov, 2005). Tropical freshwater small-scale artisanal fisheries provide cash income and animal proteins to many people in rural and urban areas of developing countries (Amos and Linus, 2017).

Fish and fisheries have been increasingly threatened by man-made induced environmental changes, such as pollution, clearance for farmlands and cutting of trees for firewood (deforestation), habitat alteration like river impoundment, poor management and over exploitation, these decrease resource availability, resulting in poor income generation for fishing households and community (Amos and Linus, 2017).

The population of fishes in tropical water bodies experience fluctuations due to factors such as food composition and availability, spawning rate and changes in environmental factors (Ipinmoroti 2013; Rodrigues and Cunha 2017). Welcomme (2001) identified fishing, pollution and eutrophication among others as factors that could bring about series of changes in fish size, species composition and abundance in the aquatic environment. Over the past few decades, fish resources decreased dramatically, and endemic species have faced continuous threats globally(Guo et al., 2018). It is a known fact that Overfishing, water diversion, pollution, global climate change, land erosion and other anthropogenic activities are considered as the main threats to fish biodiversity (Arthington et al., 2016; Fu, 2003).

The Benue River basin has undergone several changes caused by deforestation, overgrazing and land use change. For in- stance, deforestation for the purpose of large-scale agriculture which entails the cutting down of deep-rooted trees increases surface runoff. Intensification of agricultural practices on wetlands (which are floodplains) popularly known as Fadama has played a strong role in modifying the flow regime in the ecosystem. The Fadama ecosystem in Nigeria is very vast and rich in nutrients for cultivating crops like rice, sugarcane, and vegetables. As such, farmers usually are attracted to the area (Mayomi et al., 2013).

Therefore, the conservation of fish biodiversity has become more imperative and of utmost importance. The biodiversity of fish species in the river Benue plays a crucial in the development of aquaculture in the country. Local species of fish can easily be cultured and monitored because these species have adapted to various environmental challenges in its natural habitat. Thus aquaculture can be more viable when local species are cultivated to boost inland fish production. This study will help in highlighting the abundant fish species available. Also, identify suitable local species of fish that can be cultured to increase aquaculture productivity.

MATERIALS AND METHODS

River Benue is an international river flowing into Nigeria, originating from the highlands of northern Cameroon (Toro, 1997). Only 350 km of the entire 1400 km length of River Benue is within the Cameroon territory. The river runs for about 950 km from the border to the confluence with River Niger at Lokoja, Kogi State. River Benue has two major hydrological water provinces in Nigeria - the Upper Benue and the Lower Benue. In Nigeria, River Benue is fed by tributaries from the two water provinces. Some of the major tributaries are Rivers Gongola, Kilunga, Mayo Ini, Mayo Belwa, Taraba, Donga, Ankwe and Katsina-Ala (FMWR, 1994). These rivers flow into the Benue before joining River Niger at Lokoja.

A systematic literature review of articles was used to carry out this research.

The search engine 'Bing and Google Scholar' were used to browse the net for articles relating to the study. Keywords such as Articles, Biodiversity,River Benue,River Kogi Fish and Aquaculture, aided in streamlining the research articles acquired. A number of 18 articles were acquired from the net. Articles further were categorized based on location of study. Randomized sampling was used select four articles representing Four states (Adamawa, Taraba Benue and Kogi) which the river Benue flows through. inclusion criteria include articles must directly address or contribute to answering the research question or objective of the review, articles and journals published from the year 2014 till date, peer- reviewed articles published in reputable journals and articles reported in English language

Exclusion criteria includes articles published in languages other than English, articles published before the the year 2014, unpublished articles and research articles that were not carried out in the River Benue region in Nigeria and do not contribute to the objectives of the research.

RESULTS AND DISCUSSION

The river Benue is rich in various species of fresh water fishes comprising of multiple families. Four studies which were conducted along the River Benue Basin up to the confluence in Kogi State. Twenty most abundant fish species identified out of a total of a 42 species from 17 families of fin-fish encountered.

Table i: 20 most abundant fish species Compiled from from four Articles (Modibbo, 2022; Danba, 2020; Iber and Ojutiku, 2018; Abiodun and John, 2017).

S/N	River Benue Valley, Adamawa State		Riverine wetlands Mayo Ranewo,Taraba State		River Fete Benue State		Confluence, Kogi State	
	Species	percent	Species	percent	Species	percent	Species	percent
1	*Alestes baremoze*	*9.24%*	*Synodontis gambiensis*	*11.77%*	*Coptodon zilli*	*5.22%*	*Hyperopisus bebe*	*13.25 %*
2	*Schilbe intermedius*	*9.12%*	*Siluranodon auratus*	*10.32%*	*Heterotis niloticus*	*5.16%*	*Citharinus citharinus*	*11.84 %*
3	*Hydrocynus forskali*	*8.26%*	*Mormyrus rume*	*9.45%*	*Auchenoglanis biscutatus*	*5.09%*	*Distichodontus rostratus*	*9.82%*
4	*Oreochromis niloticus*	*8.22%*	*Schilbe mystus*	*8.91%*	*Tilapia guntheri*	*5.09%*	*Clarias garienpinus*	*9.13%*
5	*Synodontis schall*	*7.76%*	*Labeo senegalensis*	*7.38%*	*Mormyrus rume*	*5.05%*	*Alestes baremoze*	*5.87%*
6	*Schilbe mystus*	*7.28%*	*Synodontis clarias*	*5.43%*	*Oreochromis niloticus*	*5.05%*	*Lates niloticus*	*5.48%*
7	*Labeo coubie*	*6.81%*	*Distichodontus rostratus*	*4.89%*	*Mormyrops deliciosus*	*5.04%*	*Alestes nurse*	*5.06%*
8	*Barbus macrops*	*6.37%*	*Bagrus bayad*	*4.72%*	*Sarotherodon galilaeus*	*5.04%*	*Synodontis nigritta*	*4.98%*
9	*Clarias gariepinus*	*6.10%*	*Petrocephalus bane*	*4.60%*	*Hemichromis faciatus*	*5.03%*	*Oreochromis niloticus*	*3.67%*
10	*Mormyrus rume*	*5.68%*	*Auchenoglanis occidentalis*	*4.23%*	*Bagrus bayad*	*5.02%*	*Schilbe mystus*	*3.55%*
11	*Synodontis budgetti*	*5.11%*	*Mormyrus macrophthalmus*	*4.23%*	*Bagrus decimac*	*5.00%*	*Synodontis membranaceus*	*3.41%*
12	*Synodontis nigritta*	*4.85%*	*Clarias garienpinus*	*4.19%*	*Petrocephalus bovei*	*5.00%*	*Coptodon zilli*	*3.29%*
13	*Clarias angullaris*	*4.82%*	*Marcuseniusa badii*	*4.06%*	*Clarotes laticeps*	*4.99%*	*Protopterus annectens*	*3.11%*
14	*Mercusenius senegalensis*	*4.16%*	*Alestes nurse*	*3.52%*	*Synodontis nigritta*	*4.98%*	*Clarias angullaris*	*2.92%*
15	*Auchenoglanis occidentalis*	*1.84%*	*Synodontis schall*	*2.74%*	*Gymnarchus niloticus*	*4.96%*	*Mormyrops deliciosus*	*2.84%*
16	*Heterotis niloticus*	*1.21%*	*Hyperopisus bebe*	*2.20%*	*Clarias angullaris*	*4.93%*	*Heterotis niloticus*	*2.84%*
17	*Bagrus bayad*	*1.11%*	*Clarotes laticeps*	*2.03%*	*Clarias garienpinus*	*4.90%*	*Synodontis gambiensis*	*2.40%*
18	*Auchenoglanis biscutatus*	*0.97%*	*Synodontis membranaceus*	*1.95%*	*Alestes nurse*	*4.82%*	*Channa Obcura*	*2.32%*
19	*Citharinus citharinus*	*0.62%*	*Alestes baremoze*	*1.74%*	*Synodontis schall*	*4.82%*	*Synodontis schall*	*2.22%*
20	*Sarotherodon galilaeus*	*0.48%*	*Coptodon zilli*	*1.66%*	*Citharinus citharus*	*4.80%*	*Labeo Senegalensis*	*2.00%*

Table i highlights 20 most abundant fishes captured during the research in each article reviewed.

The first article (Modibbo, 2022) conducted its study in River Benue Valley Adamawa State, at five locations namely;Kochiel, Parda, Gongola/Benue Gwakra and Wuro-Bokki. Table i highlights 20 most abundant fishes captured during the research, Alestes baremoze, Schilbe intermedius, Hydrocynus forskali, Oreochromis niloticus and Synodontis schall were observed to be the five most abundant species respectively. The second study (Danba, 2020) was conducted in the Riverine wetlands of Mayo Ranewo Taraba State, Mayo Ranewo Local government area. In this article, Synodontis gambiensis, Siluranodon auratus, Mormyrus rume, Schilbe mystus, Labeo senegalensis had the highest population respectively. The third study (Iber and Ojutiku, 2018) was conducted in River Fete Benue state, 20 most abundant species were extracted from the research where by Clarias garienpinus, Coptodon zilli, and Oreochromis niloticus were observed to be the most abundant species. The fourth article (Abiodun and John, 2017) carried out its research in Lower Niger river Idah Kogi state. Table i highlights 20 most abundant fishes captured during the research in each article reviewed. Hyperopisus bebe, Citharinus citharus, Distichodontus rostratus, Clarias garienpinus and Alestes baremoze were the five most populated fish species.

Table ii: 20 most abundant fish species across four articles conducted at Adamawa, Taraba, Benue and Kogi State respectively (Modibbo, 2022; Danba, 2020; Iber and Ojutiku, 2018; Abiodun and John, 2017).

S/N	Class	Order	Family	Species	River Benue Valley Adamawa	Riverine wetlands Mayo Ranewo, Taraba	River Fete Benue	Confluence Kogi State
1.	*Actinopterygii*	*Characiformes*	*Alestidae*	*Alestes baremoze*	+	+	-	+
2.				*Hydrocynus forskali*	+	-	-	-
3.			*Characidae*	*Alestes nurse*	-	+	+	+
4.		*Siluriformes*	*Bagridae*	*Bagrus bayad*	+	+	+	-
5.				*Bagrus docmak*	-	-	+	-
6.			*Claridae*	*Clarias angullaris*	+	-	+	+
7.				*Clarias gariepinus*	+	+	+	+
8.			*Clarotidae*	*Auchenoglanis occidentalis*	+	+	-	-
9.				*Auchenoglanis biscutatus*	+	-	+	-
10.				*Clarotes laticeps*	-	+	+	-
11.			*Mochochidae*	*Synodontis budgetti*	+	-	-	-
12.				*Synodontis clarias*	-	+	-	-
13.				*Synodontis schall*	+	+	+	+
14.				*Synodontis gambiensis*	-	+	-	+
15.				*Synodontis membranaceus*	-	+	-	+
16.				*Synodontis nigritta*	+	-	+	+
17.			*Schilbeidae*	*Schilbe intermedius*	+	-	-	-
18.				*Schilbe mystus*	+	+	-	+
19.				*Siluranodon auratus*	-	+	-	-
20.		*Perciformes*	*Centropomidae*	*Lates niloticus*	-	-	-	+
21.		*Cichliformes*	*Cichlidae*	*Oreochromis niloticus*	+	-	+	+
22.				*Sarotherodon galilaeus*	+	-	+	-
23.				*Coptodon zilli*	-	+	+	+
24.				*Tilapia guntheri*	-	-	+	-
25.				*Hemichromis faciatus*	-	-	+	-
26.		*Osteoglossiformes*	*Gymnarchidae*	*Gymnarchus niloticus*	-	-	+	-
27.			*Osteoglossidae*	*Heterotis niloticus*	+	-	+	+
28.			*Mormyridae*	*Mormyrus rume*	+	+	+	-
29.				*Mercusenius senegalensis*	+	-	-	-
30.				*Hyperopisus bebe*	-	+	-	+
31.				*Petrocephalus bane*	-	+	-	-
32.				*Mormyrus macrothalmus*	-	+	-	-
33.				*Marcusenius abadii*	-	+	-	-
34.				*Petrocephalus bovei*	-	-	+	-
35.				*Mormyrops deliciosus*	-	-	+	+
36.		*Cypriniformes*	*Cyprinidae*	*Labeo coubie*	+	-	-	-
37.				*Barbus macrops*	+	-	-	-
38.				*Labeo senegalensis*	-	+	-	+
39.		*Anabantiformes*	*Channidae*	*Channa obcura*	-	-	-	+
40.		*Characiformes*	*Distichodontidae*	*Distichodontus rostratus*	-	+	-	+
41.			*Citharinidae*	*Citharinus citharus*	+	-	+	+
42.	*Dipnoi*	*Ceratodontiformes*	*Lepidosirenidae*	*Protopterus annectens*	-	-	-	+

Legend:
+ ≤ Dominant specie present - ≤ Dominant specie absent ≤ Dominant in Kogi and 2 of 3 studies at River Benue ≤ Dominant in all 3 studies at river Benue excluding Kogi
≤ Dominant in all four for articles (river Benue and Kogi)

Two fish species as observed in table ii (highlighted in red) namely; Clarias gariepinus and Synodontis schall were discovered to be readily available in all four articles reviewed in this study. Synodontis schall has been reported to be able to adapt to many different kinds of food and habitats, increasing the chances of survival (Abu-Gideiri and Nasr, 1973). Clarias gariepinus has only been documented for being the most cultivated fish specie in Nigeria, although it was endemic to Africa, commercial culture of this catfish only started in the early 1970s (Beveridge and Haylor, 1998)). The findings of this review aligns with the report that Clarias gariepinus has all the qualities of an aggressive and successful invasive species. Its high fecundity, flexible phenotype, rapid growth, wide habitat preferences, tolerance to extreme water conditions and the ability to subsist on a wide variety of prey can devastate indigenous fish and aquatic invertebrate populations (Bruton, 1986).

Nine species (table ii: highlighted in green) were readily available at the confluence in Kogi and two of three articles conducted along River Benue Basin in Nigeria. These species were Alestes baremoze, Schilbe mystus, Alestes nurse, Clarotes laticeps, Synodontis nigritta,Coptodon zilli, Clarias angullaris, Heterotis niloticus and Citharinus citharus.

Two fish species namely; Mormyrus rume and Bagrus bayad as observed in table ii (highlighted in yellow) were found to be readily available in all three article research conducted in the river Benue Basin but were not readily available at the confluence in Kogi.

A study (Nhan et al., 2007) postulates that, habitat heterogeneity and fragmentation, land use change, climate change, eutrophication and invasive species are the most prevalent driving factors in freshwater biodiversity studies. Fish species (highlighted in table ii) were observed to be readily available in at least three of four articles reviewed for this study, signifying that these species have good adaptive, locomotive and reproductive ability to withstand factors influencing biodiversity. These characteristics make them suitable for aquaculture production.

The Order Siluriformes (Catfish) was the most diverse in this study. Families of this order such as Claridae, Clarotidae, Mochochidae and Schilbeidae can be further studied to improve inter- species polyculture in the country.

CONCLUSION.

The Anthropocene has brought numerous threats to freshwater systems including rapid population decline and high risk extinction of local species. Freshwater habitats offer highly valuable ecosystems services to nature and human beings. Therefore, it is paramount for a fast growing population of the country to improve aquaculture yield to meet demand. Culture of local species can be engineered to meet the protein demand of the populace, provide farmers with variety of local species for aquaculture, regulate overfishing and human influence to preserve biodiversity of aquatic species and its habitat.

In Nigeria, the most cultivated fish family for aquaculture purposes is Claridea due to its good adaptive features to environmental change and growth rate. Therefore, more research into the adaptive features of the many identified freshwater finfish species is encouraged for possible domestication.

REFERENCES

Abiodun, J.A. and John, P. (2017). Biodiversity And Abundance Of Fish And Some Processing Methods In Lower niger River Idah, Kogi State, Nigeria. Nigeria Journal of Fisheries and Aquaculture.5(2), p.20-25. ISSN-2350-1537.

Abu-Gideiri, Y. B. and Nasr, D. H.(1973).Sound production by synodontis schall (Bloch-Schneider)". Hydrobiologia. 43 (3–4), p.415–428. doi:10.1007/bf00015360

Amos, S.O. and Linus, B.G. (2017). Fish Biodiversity and Fishing Activities at Njoboliya Lake, Adamawa State, Nigeria. Journal of Fisheries and Livestock Production, 5(2),p. 1 – 6.

Arthington, A.H, Dulvy, N.K, Gladstone, W. and Winfield, I.J. (2016). Fish conservation in freshwater and marine realms: status, threats and management. Aquatic Conservation Marine & Freshwater Ecosystems.; 26(5), p. 838–857.

Beveridge, M.C and Haylor, G.S .(1998). Warm-water farmed species. In: Black K.D, Pickering A.D, eds. Biology of Farmed Fish. Sheffield Academic Press, pp 393-394.

Bostock, J., McAndrew, B., Richards, R.., Jauncey, K., Telfer, T., Lorenzen, K., Little, D., Ross, L., Handisyde, N. (2010) Aquaculture: Global status and trends. Philosophical Transactions of Royal Society B Biological Science. 365, p 2897–2912.

Bruton, M.N. (1986). The life history styles of invasive fishes in southern Africa. In: Macdonald I.W, Kruger F.J, and Ferrar A.A, eds. The Ecology and Management of Biological Invasions in southern Africa. Oxford University Press, pp 201-209.

Clark, M.R., Althaus, F., Schlacher, T.A., Williams, A., Bowden, D.A. and Rowden, A.A., (2015) The impacts of deep-sea fisheries on benthic communities: A review. ICES J. Mar. Sci. , 73,p.i51–i69

Danba, E.P, Ja'afaru A., Abubakar, K.A., Zira J.D., Kefas, M. and Barau, B.W.(2020) Fish Biodiversity And

Abundance In River Taraba, Taraba State, Nigeria.Ethiopian Journal of Environmental Studies & Management 13(5), p. 535 – 544. ISSN:1998-0507

FAO. (2022). The State of World Fisheries and Aquaculture. Towards Blue Transformation. Rome, Available from: https://doi.org/10.4060/cc0461en.

FMWR (1994). The study on the national water resources master plan, Draft Final report, Federal Ministry of Water Resources and Rural Development (FMWR), Abuja, Nigeria.

Fu, C., Wu, J., Chen, J., Wu, Q., and Lei, G., (2003) Freshwater fish biodiversity in the Yangtze River basin of china: patterns, threats and conservation. Biodiversity and Conservation. 12, p. 1649–1685.

Guo Q., Liu X., Ao X., Qin J., Wu X & Ouyang S. (2018).Fish diversity in the middle and lower reaches of the Ganjiang River of China: Threats and conservation. PLoS, 13(11) p. 205116. https://doi.org/10.1371/journal.pone.0205116.

Iber, B.T. and Ojutiku, R.O.(2018).Sustainable Fisheries and Diversity in River Fete, Benue State, Nigeria. Journal of Agriculture and Ecology Research International 16(1), p.1-9. ISSN: 2394-1073.

Ipinmoroti M.O. (2013). Ichthyofauna diversity of Lake Asejire. Ecological implications. Int. J. Fish. Aquaculture. 5(10), p. 248-252.

Mayomi, I, A. Dami, A. and Maryah U.M.(2013) GIS based assessment of flood risk and vulnerability of communities in the Benue floodplains, Adamawa State. Nigeria Journal of Geography and Geology. 5(4), p.148

Modibbo, U. (2022)Fish Biodiversity in Relation to Water Quality in River Benue Valley Adamawa State, North Eastern Nigeria. Journal of Fisheries Sciences.16(7). DOI: 10.36648/1307 234X.22.16.104

National Research Council. (2005).Valuing Ecosystem Services: Toward Better Environmental Decision-Making. Washington, DC: The National Academies Press. https://doi.org/10.17226/11139 .

Negi, R.K and Sheetal, M.(2013).Species Diversity, Abundance and Distribution of Fish Community and Conservation Status of Tons River of Uttarakh and State, India. Journal of Fisheries and Aquatic Science. 8, p. 617-626

Nhan,D.K., Phong, L.T., Verdegem, M.J. Duong, L.T. Bosma, R.H. and Little, D.C.(2007) Integrated freshwater aquaculture, crop and livestock production in the Mekong delta, Vietnam: Determinants and the role of the pond. Agricultural Systems. 94, p 445–458.

Ostroumov, S.A(2005). On the multifunctional role of the biota in the self purification of aquatic ecosystem. Russia Journal of Ecology. 36, p. 452-459.

Rodrigues, C. and Cunha, M.Â. (2017). Assessment of the microbiological quality of recreational waters: indicators and methods. Euro-Mediterr. Journal of Environmental Integration. 2, p. 25. https://doi:/10.1007/s41207-017-0035-8.

Toro, S.M.(1997) Post-construction effects of the Cameroonian Lagdo Dam on the River Benue, J. CIWEM, 11 p109–p113 .

Welcomme, R.L. (2001). Inland Fisheries: Ecology and Management FAO/Blackwell Science, 358pp.

PHYSICO-CHEMICAL PARAMETERS AND ZOOPLANKTON ABUNDANCE OF AGUR STREAM, GUMA LOCAL GOVERNMENT AREA, BENUE STATE

Ikongbeh, O. A., G. A. Ataguba and O. H. Aveyima
Dept of Fisheries and Aquaculture, Joseph Sarwuan Tarka University, Makurdi, P.M.B. 2373, Makurdi, Benue State Nigeria

Corresponding Author:
tonikongbeh@gmail.com

ABSTRACT
The physico-chemical parameters and zooplankton samples of Agur Stream were examined between November 2020 and February 2021. Standard analytical methods were used to analyze the Physico-chemical parameters and zooplankton samples collected from Agur stream. Physico-chemical parameters of the stream were all found to be within optimal range according to WHO which indicates that water of Agur stream is convenient for the growth of aquatic organisms and also for domestic purposes. The overall mean of Water temperature (29.21±0.76 0C), Transparency (47.74±6.24 cm), pH (6.63±0.08), Dissolved oxygen (5.44±0.20 mgL-1), BOD (4.15±0.25 mgL-1), Free carbon dioxide (6.93±0.62 mgL-1), Total alkalinity (16.50±0.85 mgL-1), Total hardness (7.19±0.40 mgL-1) and Conductivity (4.30±0.21 µScm-1). A total of 317 zooplankton samples were identified using identification key and recorded within the study period. Zooplankton samples were collected by filtering 100 litres of water fetched with a bucket and poured through a 55µm mesh plankton net. The samples were immediately fixed in 4% formalin and transported to the laboratory for analysis. In the laboratory, concentrated plankton were viewed under a binocular dissecting microscope. Zooplankton individuals belonging to (6) six taxonomic groups were also identified during the study. The groups represented were Rotifera (39.12 %), Cladocera (36.28 %), Copepoda (8.83 %), Cilliata (5.36 %), Ostracoda (5.68 %), and Decapoda (4.73 %). Ecological indices revealed that physico-chemical and plankton assemblages were diversified and stable. The high number of zooplankton species recorded in this study may be due to available nutrients.

Keywords:
Physico-chemical parameter, Diversity, zooplankton, Agur Stream

INTRODUCTION

Water quality assessment is among the most important approaches for understanding the environmental status of rivers and streams (Begum *et al.*, 2023). One of the key challenges in managing water utility in industries is the disposal of wastewater. The discharge of industrial effluents into water bodies can cause pollution, leading to severe environmental and health consequences (Tong *et al.*, 2022). Industrial wastewater is a major environmental concern due to its high pollutant load and potential impacts on water quality and public health (Mekuria *et al.*, 2021).

The healthy aquatic ecosystem is depended on the physic-chemical and biological characteristics of water bodies (Enerosisor *et al.*, 2020). The distribution and productivity levels of organisms in any water body are largely determined by physic-chemical parameters (Kennie *et al.*, 2017). Zooplankton consist of mainly microscopic organisms such as protists, rotifers, copepods, and cladocerans. These organisms are indicators and fast responders to environmental stressors such as nutrients and pesticides accumulation (Pawlowski et al., 2016); (Xiong et al., 2019). Zooplankton contribute to the biodiversity of aquatic ecosystems. Thus, the assessment of factors that affect the distribution of zooplankton is necessary because zooplankton are widely accepted and irreplaceable bioindicators in the ecological conservation and management of aquatic ecosystems (Xiong et al., 2020.

There is paucity of information on the biology of Agur stream. Therefore, the aim of this research is to provide information on the physico-chemical parameters and zooplankton abundance of Agur Stream.

MATERIALS AND METHODS

Study Area

The study was carried out in Agur Stream in Mbawa of Guma Local Government Area of Benue State. Agur Stream is along Makurdi to Lafia road near Daudu Market in Mbawa. The study area is located between longitudes 80 35 and 80 04 East and latitudes 70 45 and 70 55 North (Figure 1). Agur stream starts its origin at Goma in Guma Local Government Area of Benue state and flows through Mbawa of the same local government. The water is used for agriculture, human consumption and domestic purposes.

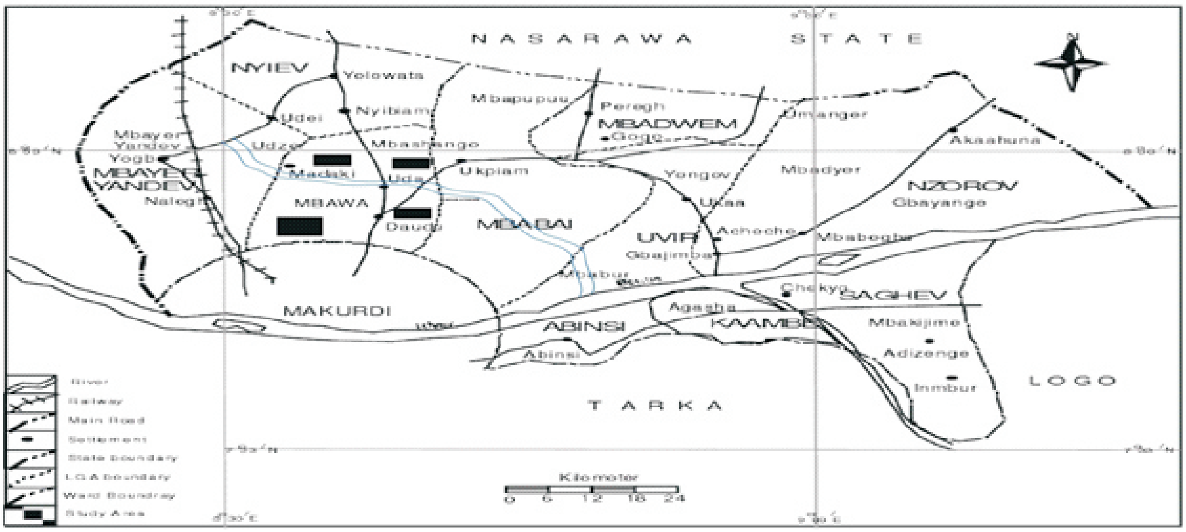

Figure 1: Map of Study Area

Water Sample Collection

Water samples were taken from three different stations along Agur Stream, designated as stations A, B, and C, with a 30-meter interval between each station. Water sample was collected on a monthly basis between 08:00 – 10:00 hours from each sampling station in 1 litre plastic containers and 250ml reagent bottles. Prior to sampling the plastic containers were washed with tap water and later rinsed with 10% nitric acid 24 hours before use to remove contaminants which may affect the values of the physico-chemical parameters that will be evaluated (APHA et al., 1998). The three reagent bottles per site were immersed at the water surface, middle and bottom at a depth of 3m and filled to capacity, brought out of water and properly corked.

Zooplankton Sampling

Sampling of planktons was carried out in the morning between the hours of 06:00am-08:00am using plankton nets or traps. It has a polyethylene filter of 55 μm mesh size and a graduated measuring bottle attached to the other end. A handle holds the net. Plankton samples were collected at each site by filtering 100 litres of surface water samples fetched with a bucket and poured through 55 μm mesh plankton net. The samples were collected in 250 mL bottles then immediately fixed and preserved in

4% buffered formalin solution in the field. In the laboratory, the preserved plankton samples were allowed to settle down and 5 mL of the sample was withdrawn with a dropping pipette (to place the concentrated plankton) on a glass slide, covered with a cover slip and viewed under a binocular dissecting microscope. Specimens were sorted and dissected where necessary under a binocular dissecting microscope (American Optical Corporation, Model 570), while counting and identifications were done with an Olympus Vanox Research Microscope (mag X60) Model 230485. Identification was done using standard keys (APHA, 1995)

Determination of Physico-Chemical Parameters

Temperature was determined in situ by using a PHT-027 Multi-parameter water quality checker. Transparency was measured by the Secchi disc method.

Dissolved oxygen and Biological oxygen demand were determined in situ using dissolved oxygen meter (Lutron model: DO-5509). Free carbon-oxide, alkalinity and total hardness were determined by using a freshwater aquaculture test kit (MODEL AQ-2). Hydrogen ion concentration (pH) was determined by using a PHT-027 Multi-parameter water quality monitor.

Conductivity was determined using a multipurpose electronic Jenway 4520 conductivity meter.

Determination of Zooplankton Abundance and Diversity of Agur stream

(i) Shannon-Wiener Diversity Index (H'): This measures faunal diversity and gives the degree of uncertainty involved in predicting the species identified from randomly selected individuals. It was calculated using the following equation as repored by Magurran (2004):

$$H1 = -? \left[\left(\frac{ni}{N}\right) x \; ln\left(\frac{ni}{N}\right)\right]$$

Where:

ni = number of individuals or quantity of each species (the ith species)

N = total number of individuals for the site

(ii) Simpson's Index (D): is a measure of dominance and was calculated using the formula of Simpson (1949):

$$D = \frac{ni(ni - 1)}{N(N - 1)}$$

Where:

ni = number of individuals or amount of each species (i.e., the number of individuals of the ith species) and

N = total number of individuals for the site.

This was then transformed into a measure of species heterogeneity using the complement of D as recommended by Lande (1996): 1 - D

RESULT

Physical and Chemical Parameter of Water Samples of Agur Stream

Physical and chemical parameter of water samples from the three stations in Agur Stream are presented in (Table 1),

The mean water temperature was 29.21±0.76 0C. The highest average temperature value of (29.38 0C) was recorded in station B, while the lowest average temperature value of (29.02 0C) was recorded in station A (Table 1). There were significant difference ($p<0.05$) in water temperature observed across the three stations.

The mean Transparency was 47.74±6.24 cm. Transparency value of (62.55 cm) was highest at Station A, while lowest value of (35.77 cm) was recorded in Station C (Table 1). There were significant difference ($p<0.05$) in transparency observed across the stations.

The mean water pH was 6.63±0.08. The maximum average value of pH (6.92) was recorded in station B, while the minimum pH value of (6.40) was recorded in station C. Slightly acidic pH was recorded for all stations (Table 1). There were significant difference ($p<0.05$) in pH observed in the three stations.

The mean Dissolved oxygen value was 5.44±0.20 mgL-1. There was a distinct seasonal pattern but there was spatial variation in the oxygen concentration of the lake. The maximum dissolved oxygen value (5.78 mgL-1) was recorded in station A, while minimum dissolved oxygen value observed was (4.95 mgL-1) station C (Table 1). There were significant difference ($p<0.05$) in Dissolved oxygen concentration observed in the stations

The mean Biological oxygen demand value was 4.15±0.25 mgL-1. The highest Biological oxygen demand value of (4.38 mgL-1) was recorded in Station B, while the lowest value of (3.92 mgL-1) was recorded in Station C (Table 1). There were no significant difference ($p>0.05$) in Biological oxygen demand observed in the three stations.

The mean Free carbon-dioxide value was 6.93±0.62 mgL-1. The highest value of (8.53 mgL-1) was recorded in Station C. The lowest value of (5.95 mgL-1) was recorded in Station B (Table 1). There were significant difference ($p<0.05$) in free carbon-dioxide observed across the stations

The mean Total alkalinity was 16.50±0.85 mgL-1. The maximum average alkalinity value of (17.75 mgL-1) was highest at station C, while the minimum alkalinity value of (16.25 mgL-1) was recorded at station A (Table 1). There were significant difference ($p<0.05$) in Total alkalinity observed amongst the stations.

The mean Hardness value was 7.19±0.40 mgL-1. Maximum hardness value of (7.75 mgL-1) was observed in Station A, while Minimum value of (6.15 mgL-1) was observed in Station B (Table 1). There were significant difference ($p<0.05$) in Hardness concentration observed in the stations.

The mean Conductivity was 4.30±0.21 *u*Scm-1 The highest conductivity value of (4.80 *u*Scm-1) was recorded in Station C, while the lowest value of (3.96 *u*Scm-1) was recorded in Station B (Table 1). There were significant difference ($p<0.05$) in conductivity observed in the stations

Table 1. Water quality parameters of Agur Stream

Parameters	Station A Mean±SE	Station B Mean±SE	Station C Mean±SE	Overall Mean Mean±SE
Water temperature(^{0}C)	29.02 ± 1.35^a	29.38 ± 1.51^a	29.23 ± 1.32^a	29.21±0.76
Transparency (cm)	62.55 ± 13.1^c	44.90 ± 6.06^b	35.77 ± 7.75^a	47.74±6.24
pH	6.55 ± 0.09^a	6.92 ± 0.07^b	6.40 ± 0.04^a	6.63±0.08
Dissolved oxygen (mgL^{-1})	5.78 ± 0.41^b	5.60 ± 0.15^b	4.95 ± 0.28^a	5.44±0.20
Biological oxygen demand (mgL^{-1})	4.15 ± 0.61^a	4.38 ± 0.06^a	3.92 ± 0.44^a	4.15±0.25
Free carbon dioxide (mgL^{-1})	6.30 ± 1.00^a	5.95 ± 0.65^a	8.53 ± 1.08^b	6.93±0.62
Total alkalinity (mgl^{-1})	16.25 ± 31.3^b	17.00 ± 1.66^a	17.75 ± 1.30^a	16.50±0.85
Hardness (ppm)	7.75 ± 0.25^b	6.15 ± 0.98^a	7.68 ± 0.23^b	7.19±0.40
Conductivity(µScm^{-1})	4.15 ± 0.35^a	3.96 ± 0.44^a	4.80 ± 0.11^b	4.30±0.21

Mean values with different superscript within rows differed significantly ($p<0.05$)

In terms of zooplankton diversity index, the highest value of Shannon-Wiener Index (2.72) was recorded in station C, while lowest (2.70) value was recorded in station B (Table 2). The Simpson's index of dominance (D) for zooplankton were (0.93) amongst the stations (Table 2).

Table 2: Zooplankton Diversity Indices of Agur Stream

Indices	Station A	Station B	Station C
Shannon-Wiener diversity index (H')	2.68	2.70	2.72
Simpson's Index (D)	0.93	0.93	0.93

Zooplankton abundance from Agur stream

The results of this study showed that (317) zooplankton species belonging to 6 families were recorded in the stream. These comprised of 102, 112, and 103 individual specimens at station A, station B, and

station C respectively.
The most abundant familes sampled were Rotifera (39.12 %), Cladocera (36.28 %), Copepoda (8.83 %), Cilliata (5.36 %), Ostracoda (5.68 %), and Decapoda (4.73%).
Table 3 shows Zooplankton species from the three stations in Agur Stream

Table 3: Zooplankton species from the three stations in Agur Stream

Species	Station A Mean±SE	Station B Mean±SE	Station C Mean±SE	Over all Mean Mean±SE
Rotifera				
Aplanchna spp	1.75±0.48^{b}	0.50±0.40^{a}	1.50±0.50^{a}	3.75±1.03
Branchionus spp	2.25±0.75^{a}	1.50±0.65^{b}	2.00±0.41^{a}	5.75±1.18
Filinia spp	0.25±0.25^{b}	1.76±0.48^{b}	1.75±1.11^{a}	3.75±1.80
Keratella spp	1.75±1.44^{a}	2.00±0.82^{a}	2.25±0.75^{a}	6.00±2.86
Lechane spp	2.13±0.85^{a}	2.25±0.48^{a}	2.00±0.41^{a}	6.50±0.65
Testidunella spp	2.00±0.41^{a}	2.00±0.71^{a}	1.25±0.48^{a}	5.25±0.63
Cladocera				
Chydorus spp	1.25±0.25^{b}	2.00±0.91^{a}	1.00±0.41^{a}	4.25±1.03
Cyclops spp	2.75±0.25^{a}	2.50±0.87^{a}	1.25±0.25^{a}	6.50±0.50
Daphnia spp	2.25±0.95^{a}	2.25±1.31^{a}	2.00±0.41^{b}	6.50±2.53
Nauplius spp	1.50±0.29^{a}	3.00±0.91^{a}	0.75±0.25^{a}	5.25±0.95
Simocephalus Spp	2.00±0.58^{b}	2.25±0.25^{b}	2.00±0.58^{b}	6.25±1.03
Copepoda				
Diaptonus spp	1.75±0.48^{b}	1.25±0.95^{a}	1.00±0.03^{a}	4.00±1.41
Metacylopss Spp	0.75±0.48^{a}	1.20±0.63^{a}	1.00±0.41^{a}	3.00±o.82
Ostracoda				
Cypridopsus spp	1.25±0.75^{b}	1.75±0.48^{a}	1.50±0.87^{a}	4.50±1.55
Decapoda				
Peneaus spp	1.00±0.58^{b}	1.00±0.71^{a}	1.75±0.63^{a}	3.75±1.03
Cilita				
Paramecium spp	0.75±0.57^{a}	0.75±0.48^{a}	2.75±1.11^{a}	4.25±2.10

Mean values with different superscript within rows differed significantly ($p<0.05$)

Zooplankton species from the three stations in Agur Stream

Rotifera sample from Agur Stream

The mean for Asplanchna spp was 3.75±1.03. The maximum average value for Asplanchna spp (1.75) was highest at station A, while the minimum Asplanchna spp value of (0.50) was recorded at station B (Table 3). There were significant difference ($p<0.05$) in Asplanchna spp observed in the stations. The mean for Branchionus spp was 5.75±1.18. The maximum average Branchionus spp value of (2.25) was highest at station A, while the minimum Branchionus spp value of (1.50) was recorded at station A (Table 3). There were significant difference ($p<0.05$) in Branchionus spp observed across the stations.
The mean for Filinia spp was 3.75±1.80. The maximum average Filinia spp value of (1.76) was highest at station B, while the minimum Filinia spp value of (0.25) was recorded at station A (Table 3). There were no significant difference ($p>0.05$) in Filinia spp observed amongst the stations.
The mean for Keratella spp was 6.00±2.861. The maximum average Keratella spp value of (2.25) was highest at station C, while the minimum Keratella spp value of (1.75) was recorded at station A (Table 3). There were no significant difference ($p>0.05$) in Keratella spp observed amongst the stations.
Lechane spp ranged between 8.00-43.00. The mean for was 6.50±0.65. The maximum average Lechane spp value of (2.25) was highest at station B, while the minimum Lechane spp value of (2.00) was recorded at station C (Table 3). There were no significant difference ($p>0.05$) in Lechane spp observed across the stations.

DISCUSSION

It was observed that physico-chemical parameters of Agur Stream were within the recommended range for most aquatic organisms. In the present study, High water temperature could be due to high atmospheric temperature and high sun intensity (Medudhula et al., 2012). Low water temperature is due to the cool dry North East trade wind effect (Waziri et al., 2015).

In Agur Stream, transparency was measured with a secchi disc which had a mean range of 35.77 – 62.55 across the stations which is a good indication for aquatic organisms to inhabit. According to Enerosisor et al., (2020), transparency is higher in the absence of surface run-offs.

In the present study, Oxygen concentration was high especially during the day as a result of the abundant oxygen contributed by absorption directly from the atmosphere or by aquatic plants during photosynthetic activity, which contributed in oxygenating the water column. Low dissolved oxygen could be due respiration by aquatic organisms and nutrient input from sewage and industrial discharges, agricultural and urban run-off often leads to excessive algal growth; when they die, the organic matter is decomposed by bacteria, a process which consumes oxygen that could lead to oxygen depletion (Jadhav et al., 2013).

The mean Biological Oxygen Demand observed in all the stations ranged between 3.63 – 4.87 mg/l. Unpolluted and natural waters will have a BOD of 5mg/l or less. The BOD value in Agur Stream was below 7.0 mg L-1, the values recommended by World Health Organization.

Carbondioxide increases when organic wastes reduce the oxygen available, making it difficult for fish to use the limited amount of oxygen present. The CO2 recorded in this study was within the acceptable limit of <10 ppm that is not harmful to aquatic organisms (Ikongbeh et al., 2014).

Conductivity gives an indication of the amount of total dissolved solids in water. Conductivity range 3.20 – 4.98 μS/cm recorded in this study is below the permissible range when compared with the WHO guideline of 400-600 uScm-1 (Zaigham et al. 2012).

According to WHO normal range of pH for water is 6.5-8.5 (Zaigham et al. 2012). The range of value recorded for pH in Agur stream fall within the range recommended by the World Health Organization for the culture of fish. The high alkalinity recorded in in the study could be as a result of decay process of organic materials that settle at the bottom of the river. The range of alkalinity recorded in the present study was lower than that reported in Ado-Ekiti Reservoir in Southwest region of Nigeria (Idowu et al., 2013).

The high values of total hardness may be due to the addition of calcium and magnesium salts. The increase in hardness can be attributed to the decrease in water volume and increase in the rate of evaporation at high temperature (Imaobong et al. 2012) .

The zooplankton assemblage of Agur Stream is attributed to several biotic and abiotic factors such as temperature, transparency, and nutrient and food availability interacting together. This agrees with Enerosisor et al., (2020) who stated that the distribution and diversity of zooplankton in aquatic ecosystem depends mainly on the physico-chemical properties of water.

The relative predominance of Cyclops sp, Lechane spp and Daphnia spp among other species could have arisen due to their large body size which enable them to graze on large quantity and diverse forms of phytoplankton. (Arazu and Ogbeibu, 2017). The genus Peneaus and Paramecium were found in low numbers. This could be due to flowing nature of the stream and low organic composition. Sixteen (16) zooplankton species from six (6) families were identified from Agur Stream. Agur Stream has high abundance and diversity of zooplankton.

REFERENCE

APHA (American public Health Association) (1998). Standard methods for the examination of water and waste water. 20th,edition. American public Health Association Inc, New York. 1193pp.

Arazu, V. D. N. and Ogbeibu, A. E. (2017). The Composition, Abundance and Distribution of Zooplankton of River Niger at Onitsha Stretch, Nigeria. Animal Research International, 14(1): 2629–2643

Begum, W., Goswami, L. and Sharma, B.B. (2023). Assessment of Urban River Pollution using the Water Quality Index and Macro-Invertebrate Community Index. Environment, Development, Sustainability 25: 8877–8902 (2023). https://doi.org/10.1007/s10668-022-02369-5

Enerosisor, M. S., Ugbomeh, A. P. and Miebaka, M. (2020). Abundance and Diversity of Zooplankton in the Lower Reach of the Opobo River, Rivers State Nigeria. African Journal of Environment and Natural Science Research, 3(2): 49- 59.

Idowu, E.O., Ugwumba, A.A.A., Edward, J.B. and Oso, J.A. (2013). Study of the seasonal variation in the physico-chemical parameters of a Tropical Reservoir. Greener Journal of Physical Sciences, 3(4): 142-148.

Ikongbeh, O.A., Tiamiyu, L.O., Ayuba, V.O. and R.G. Okayi (2014). Water Quality Parameters of Lake Akata, Benue State, Nigeria. Proceedings of the 29th Annual Conference of the Fisheries Society of Nigeria (FISON), 24th-29th November, 2014. 278-285 pp.

Imaobong, E. E., Louis, A. C, Grace, C. O., and James, P. U. (2012). Studies on the physico-chemical characteristics and nutrients of a tropical rainforest river in southeast Nigeria. International Journal of the Bioflux Society, 5(3): 142-162.

Jadhav, R.N., Mukesh, R.P. and Shruti, H. (2013). Seasonal variations in physicochemical characteristics of Nirmal Lake, Vasai, District- Thane, Maharashtra, India. IOSR Journal of Pharmacy and Biological Sciences, 8: (6) 48-51.

Kennie, A.M.., Akinade, G.T., Ogialekhe P. and Mohammed N. (2017). Zooplanktons Assemblage along Jebba Upper Basin, Nigeria. International Journal of Pure and Applied Zoology. 5(3): 100-103.

Lande, R. (1996). Statistics and partitioning of species diversity, and similarity among multiple communities. Oikos, 76: 5–13.

Medudhula, T., Samatha, C.H., and S. Chintha (2012). Analysis of water quality using physiochemical parameters in Lower Manair Reservoir of Karimnagar district, Andhra, Pradesh. International Journal of Environmental sciences. 3(1): 369-378.

Mekuria, D.M., Kassegne, A.B. and Asfaw, S.L. (2021). Assessing Pollution Profiles Along Little Akaki River Receiving Municipal and Industrial Wastewaters, Central Ethiopia: Implications for Environmental and Public Health Safety Heliyon, 7(7) (2021), Article e07526, 10.1016/j.heliyon.2021.e07526.

Pawlowski, J., Lejzerowicz, F., Apotheloz-Perret-Gentil, L., Visco, J. and Esling, P. (2016). Protist Metabarcoding and Environmental Biomonitoring: Time for Change. European Journal of Protistology. 55(Pt A):12–25.

Simpson, E. H. (1949). Measurement of Diversity. Nature, 163: 688.

Tong, Y., Huang, Z., Huang, A.B.G., Janssen, M., Wishart, W., He, X., and Wang, Y. Z. (2022). Influence of Social and Environmental Drivers on Nutrient Concentrations and Ratios in Lakes: a Comparison between China and Europe. Water Reseach 227 (2022), Article 119347, 10.1016/j.watres.2022.119347.

Waziri, M., Baba, N.M., Audu, A.A. and Zakaria, Z.I. (2015). Seasonal Variations in Physicochemical Properties of Water, Sediment and Fish of Tiga Dam, Kano-Nigeria. Nigerian Journal of Chemical Research, 20: 39-45.

Xiong, W., Ni, P., Chen, Y., Gao, Y., Li, S. and Zhan, A. (2019). Biological Consequences of Environmental Pollution in Running Water Ecosystems: A Case Study in Zooplankton. Environmental Pollution. 252:1483–1490.

Xiong, W., Huang, X., Chen, Y., Fu, R., Du, X., Chen, X. and Zhan, A. (2020). Zooplankton Biodiversity Monitoring in Polluted Freshwater Ecosystems: A Technical Review. Environmental Science and Ecotechnology. 1:1–11.

Zaigham, H., Zubair, A., Khalid, U.K., Mazhar, I., Rizwan, U.K. and Jabar, Z.K.K. (2012). Civic pollution and its effect on water quality of River Toi at district Kohat, NWFP. Research Journal of Environmental and Earth Sciences. 4(3): 334-339.

FISH DIVERSITY BASELINE FOR MANGROVE RESTORATION OF BOMU CREEK, OGONILAND

[1]Zabbey, N., 2 S. [A]. Nwafili, and [2]G. S. Nkuene

[1] Project Coordination Office, Hydrocarbon Pollution Remediation Project (HYPREP), 8 Ken Saro-Wiwa Road, Port Harcourt, Rivers State, Nigeria.
[2]Department of Fisheries, Faculty of Agriculture, University of Port Harcourt, Choba, PMB 5323, Rivers State, Nigeria.

Correspondence:
sylvanus.nwafili@uniport.edu.ng

ABSTRACT
The study aimed to determine the habitat use of three Stations that would measure the effectiveness of the Hydrocarbon Pollution Remediation Project pilot mangrove rehabilitation project in attracting fish to the shorelines of Ogoni. Fishing nets of 35mm were used to capture fish from 3 Stations (November 2023 - February 2024). A total of 908 individual specimens belonging to 13 families and 19 finfish species were captured. The shellfish sampled comprised three families and three species. The diversity indices offered valuable insights into the creek's condition, particularly regarding species richness and distribution evenness. Specifically, station 3 had the highest Margalef's, Shannon-Weiner, and Simpson indices, suggesting the greatest species richness and well-balanced distribution of individuals among species. The highest relative fish richness and abundance were recorded on the tidal flat with high mangrove nursery seedlings and dissected by a deeper channel.

Keywords:
Baseline study, Bomu Creek, mangrove restoration, species richness

INTRODUCTION

One of the most pressing environmental challenges in the Niger Delta Region (NDR) is the degradation of the mangrove ecosystems by crude oil spills. The NDR mangroves provide essential ecosystem services, including shoreline stabilization, carbon sequestration (Sam et al., 2023, Hamilton and Fries, 2018), and critical habitats for the breeding and nursery of commercial fishes, among other ecosystem services. It is believed that 60% of wild fish harvested between the Gulf of Guinea breed in the Niger Delta's mangroves (Sam et al., 2023). Globally, 37% of oil impact on mangroves had occurred in the Niger Delta, including over 4000 ha in Ogoniland (Duke, 2016). The Hydrocarbon Pollution Remediation Project (HYPREP) was established to remediate oil-impacted environments in Ogoniland and other communities and restore livelihoods. HYPREP's remediation now include mangrove restoration and shoreline cleanup of about 2000 ha of oil-degraded shores of Ogoniland and the pilot restoration of mangroves of 560 ha of naturally attenuated oil-degraded mangrove areas in the Bomu Creek. Before the mangrove rehabilitation through assisted planting, there was a need to establish the fish stock baseline of the Bomu Creek to enable the future assessment of the return of ecosystem goods and services, including fisheries enhancement.

The objective of this study was to establish a pre-restoration fin fish baseline that will serve as reference data for comparing post-planting fish stocks in Ogoniland.

MATERIAL AND METHODS

Study Area: Bomu is a coastal community in the Gokana LGA of Rivers State, where HYPREP is piloting mangrove restoration of 560 ha of oil-degraded mangroves. It involves assisted planting of the common red, black, and white species in the region.

For the study, three sampling stations were delineated (Fig. 1). Station 1 consisted of a dense bed of red mangrove saplings raised in the nursery. These were not transplanted until they developed prop roots in the poly-pots and became established. Station 2 was a mangrove nursery site with thousands of plants still in black poly-pots for transplanting. The shorelines of Station 3 comprised of sparsely distributed mangroves that regenerated naturally after the crude oil pollution.

Collection of Samples: Fish samples were obtained from (November 2023 to February 2024) from the three delineated Stations (Fig. 1, Plate 1) in Bomu Creek using a 35mm mesh-size synthetic fishing net set during high tide at 2:00 a.m. in each station and the stations demarcated. The entrapped fish were caught using indigenous methods for local fisher folk. Data analysis: The number of species and individuals were recorded. A chi-square test was performed to determine if there was a significant difference in the fish counts between the stations. For each Station, the following were determined: Species richness, diversity, and evenness were calculated using the Margalef, Shannon-Weiner, and Simpson indices, respectively.

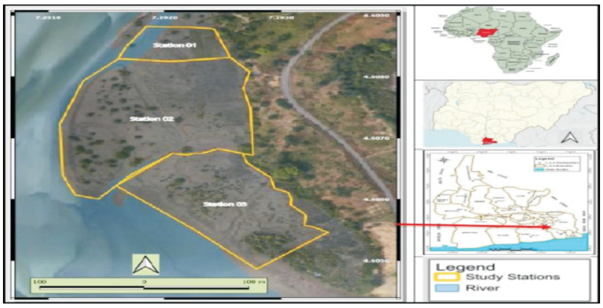

Fig. 1. Study location showing sampling locations

Plate. 1 Fish identification in the field

RESULTS AND DISCUSSION

A total of 908 finfish specimens were documented, comprising 13 families and 19 species. The shellfish captured belonged to 3 families and 3 species (Table 1). The highest number of fish was caught in Station 2 (386), followed by Station 3 (339), while Station 1 with 183 had the least abundance (Table 1). Station 1 attracted 9 species while 14 and 19 species were attracted to Stations 2 and 3, respectively. Therefore, Stations 2 and 3 attracted more fish, likely due to the higher density of mangroves. Moreover, the channel dissecting the stations was deeper at Stations 2 and 3, which may provide more favourable habitat.

Table 1: Checklist of Species, composition, abundance, and contribution to the fishery of Bomu Creek

				STATIONS	Total Catch	Percentage Contribution (%)
Finfish	Species	1	2	3		
Cichlidae	*Sarotherodon melanotheron*	137	231	165	533	58.70
	Coptodon guineensis	5	12	14	31	3.41
	Coptodon mariae	0	3	3	6	0.66
Mugilidae	*Liza falcipinnis*	3	13	35	51	5.62
	Liza grandisquamis	23	35	20	78	8.59
	Mugil cephalus	2	18	5	25	2.75
Haemilidae	*Pomadasys jubelini*	2	28	27	57	6.28
	Pomadasys perotiti	0	0	3	3	0.33
Lutjanidae	*Lutjanus gorensis*	0	1	2	3	0.33
Carangidae	*Caranx crysos*	0	14	6	20	2.20
Claroteidae	*Chrysichthys nigrodigitatus*	1	0	1	2	0.22
Dorosmatidae	*Ethmalosa fimbriata*	0	5	11	16	1.76
Sphyraenidae	*Shyraena afra*	0	0	1	1	0.11
Eleotridae	*Eleotris Africana*	1	1	3	5	0.55
Gobidae	*Bostrychus africanus*	0	1	0	1	0.11
	Gorogobius nigricinatus	1	0	0	1	0.11
Lobotidae	*Lobostes sp*	0	0	5	5	0.55
Cynoglossidae	*Cynoglossus menody*	0	0	1	1	0.11
Bothidae	*Sycacium micrurum*	0	0	1	1	0.11
	Total	175	364	303	840	
Shellfish						
Ocypodinae	*Ocypode qfricana*	0	2	0	2	0.22
Pontinudae	*Callinectes amnicola*	8	22	35	65	7.16
Penaidae	*Penaeus monodon*	0	0	1	1	0.11
	Total	8	24	36	68	
		183	386	339	908	100

This ichthyofauna composition was lower than reports from adjacent creeks of the Andoni River System, Bodo, Bonny, and Luubara Creek (Chinda, 1994; Francis and Sikoki, 2003; Nwibari et al., 2019). The study duration, season, and pollution level may account for the differences since those reports predated the oil pollution of the studied creek.

Six species accounted for 84% of the total biomass, namely, Sarotherodon melanotheron (57.97%), Pomadasys jubelini (8.64%), Mugil cephalus (7.50%), Liza falcipinnis (5.31%) and Coptodon guineensis (5.24%) (Table 2). These species' abundance and contribution to biomass can be attributed to their euryhalinity trait and tolerance to hypoxia conditions (Rutjes et al., 2007; Richards, 2014).

Indices of diversity: The Margalef, Shannon-Wiener Diversity Indices (H), and Simpson's Index of Diversity values are presented in Table 3. This dataset reveals gradients in diversity and richness across the Stations, with Station 3 being the most biodiverse and Station 1 being the least. The environmental conditions occurring in Stations 2 and 3 support a more diverse range of species, possibly due to better habitat quality, higher density of mangroves, resource availability, or other favorable ecological factors.

Table 2: Total weight. Mean length of species caught using gillnet in Bomu Creek (November 2023 to February. 2024)

Species	Station 1 Weight (g)	TL cm (range)	Station 2 Weight (g)	TL cm (range)	Station 3 Weight (g)	TL cm (range)	GT (g)
Sarotherodon melanotheron	4756	11.37 (8.0 -18.5)	9600	12.62 (7.3-19.8)	7079	12.53 (7.0-16.6)	21,435
Coptodon guineensis	321	13.8 (13.0-15.0)	802	14.53 (12.1-16.5)	813	13.84 (11.0-18.0)	1,938
Coptodon melanop	0	0	116	13.9 (13.5-14.3)	133	12.53 (9.0-15.0)	249
Mugil cephalus	482	24.9 (17.0-32.8)	1096	18.64 (14.0-24.4)	1197	25.96 (15.3-33.5)	2,775
Liza falcipinnis	299	25.55 (21.5-29.6)	420	15.33 (11.1-23.0)	1243	15.42 (13.0-22.5)	1,962
Liza grandisquamis	899	16.08 (12.4-21.6)	1243	15.61 (12.2-23.2)	654	15.04 (10-21.3)	2,796
Caranx crysos	0	0	120	9.63 (8.2-12.2)	145	11.4 (3.1-14.5)	265
Chrysichthys nigrodigitatus	213	29	0	0	295	30	508
Eleotris Africana	31	12.9	25	12.1	91	13.27 (12.2-14.6)	147
Lutjanus gorensis			16	9.9	290	21.9 (21-22.8)	306
Pomadasys jubelini	259	20.6 (19.7-21.5)	1465	15.28 (12.5-18.0)	1429	15.51 (9.8-20.6)	3,193
Pomadasys perotiti	0	0	0	0	185	16.4 (15.2-18.0)	185
Ethmalosa fimbriata	0	0	190	14 (7.0-15.8)	553	16.2 (13.0-22.6)	743
Bostrychus africanus	0	0	20	11	0	0	20
Cynoglossus menody	0	0	0	0	119	31	119
Sycacium micrurum	0	0	0	0	9	10.4	9
Penaeus monodon			91	16 (15.4-16.5)	34	17	125
Loboste species					112	9.88 (8.6-12)	112
Gorogobius nigricinatus	22	12.2	0	0	0	0	22
sphyraena afra (Barracuda)	0	0	0	0	70	23.2	70
Total							36,979

TL – mean total length; GT = Total for each species over the three stations that were sampled.

Table 3: Diversity indices of fish species during the period of study

Diversity Index	Station 1	Station 2	Station 3
Taxa_S	10	14	19
Individuals	183	386	339
Dominance D	0.577	0.379	0.270
Simpson_1-D	0.423	0.621	0.730
Shannon-Weiner, H	0.989	1.548	1.895
Margalef	1.728	2.183	3.09

CONCLUSION

The shorelines covered most with mangrove seedlings attracted more fish as shown by the high Marg alef's index. Evidently, the ongoing HYPREP pilot mangrove restoration of 560 ha of oil-degraded mangroves will attract more species to Ogoniland coastal shorelines

REFERENCES

Chinda, A. C. (1994). The Fish Assemblage of the Lower Bonny River African Journal of Ecology, 32: 55-65

Duke, N.C., 2016. Oil spill impacts on mangroves: recommendations for operational planning and action based on a global review. Mar. Pollution Bulletin 109,700e715.

Francis, A. and Sikoki, F. D. (2003). Studies of the Ichthyofauna of the Andoni River System in Niger Delta Nigeria. African Journal of Interdisciplinary Studies; 5(1): 123-130.

Nwibari, M. W., Sikoki, F.D. and Wala, C. (2019). Ichtyofaunal Composition and Seasonal Occurrence in the Bodo Creek, Niger Delta, Nigeria, Advances in Life Science and Technology, 74:41-45.

Richards, J.G. (2014). Physiological, Behavioral and Biochemical Adaptations of Intertidal Fishes to Hypoxia.

The Journal of Experimental Biology, 214:191-199.
Rutjes, H. A., Nieveen, M. C., Weber, R. E., Witte, F. and Van den Thillart, G. E. E. J. M. (2007). Multiple Strategies of Lake Victoria Cichlids to Cope with Lifelong Hypoxia Include Hemoglobin Switching. American Journal of Physiology, 293, R1376-R1383.
Sam, K., Zabbey, N., Gbaa, N.D., Ezurike, J.C. and Okoro, C.M (2023). Towards a Framework for Mangrove Restoration and Conservation in Nigeria.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

SMALL SCALE FISHERIES MANGEMENT (SSFM)

LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR OF BAGRUS BAYAD (FABRICIUS, 1775, BAGRIDAE) FROM WUDIL RIVER, KANO STATE, NIGERIA

Usman, B. I., M. S. Isiyaku, V. F. Akinjogunla and Z. R. Mudi

Department of Fisheries and Aquaculture, Bayero University, Kano

Corresponding Author: biusman.faq@buk.edu.ng

ABSTRACT

The study assessed the length-weight relationship and condition factor of Bagrus bayad in Wudil River. A total of 364 fish were sampled for a period of 6 months (January to June, 2023) and the length and weight were measured. The mean total length and total weight of males B. bayad were 32.26 ± 1.04 (cm) and 175.92 ± 7.29 (g) respectively. Whereas the mean total length and total weight of females B. bayad were 26.31 ± 0.35 (cm) and 104.50 ± 2.53 (g) respectively. Furthermore, the mean total length and total weight of combined sex of B. bayad were 28.86 ± 0.51 (cm) and 135.11 ± 3.90 (g) respectively. The mean The length -weight regression analysis showed b-values of 1.44, 1.09 and 1.42, in males, females and combined sex respectively which indicated negative allometric growth. The significant linear relationships (r2) of 0.67, 0.43 and 0.63 were recorded in both males, females and combined sex respectively. The condition factor (K) of 1.10, 1.04 and 1.07 were reported for the males, females and in the combined sex. Condition factor "K" values recorded greater than 1 in the study showed that both the males and females B. bayad from Wudil River were in good and healthy condition. The condition factors of all fish species sampled fall within the range recommended as suitable for matured fresh water fish species in the tropics.

Keywords:
Length-weight relationship, condition factor, allometric growth, Wudil River, Kano State

INTRODUCTION

Bagrus bayad (B. bayad) is a commercially important species found in Nigeria freshwaters especially in rivers Niger, Kaduna, Benue, Lake Chad and other inland waters (Tsadu et al., 2014). The bayad's body is generally elongated in shape. The dorsal fin has a smooth spine, and the pectoral fins have spines with serrations on the inside. There are four pairs of barbels. The maxillary barbels usually reach to the ventral fin or pelvic fins. This fish is yellow-greenish or blackish with a white belly. The fins are darker, sometimes reddish purple. Juveniles have little black spots on the sides (Froese et al., 2023).

Length weight relationship (LWR) of fish is widely recognized as an important tool in fisheries science, especially in ecology population dynamic and stock management. This is so because the relationship permits estimating the weight of a specimen easily when total length is known and the relationship estimates condition factor of the fish species and fish biomass through length frequency (Getso et al., 2017). LWR has a number of important applications in fish stock assessment, among which are estimating the standing stock biomass and comparing ontogeny of fish population from different regions. This information improves management, conservation and culture of these species, further allowing comparisons between populations of the same species In LWR, when 'b' is equal to 3 or close to 3, growth in fish is said to be isometric (fish becomes more robust with increasing length). When 'b' is far less or greater than 3, growth in fish is said to be allometric (fish becomes thinner with increasing length) (Ude et al., 2011).

Condition factor is calculated with the aim of describing the condition of a particular fish from the relationship drawn between weight of the fish and its length. Condition factor expressed as coefficient of condition denoted by 'K', is also known as Fulton's condition factor (Getso et al., 2017). When the condition factor value is higher, it means that the fish has attained a better condition. Condition factor of fish can be affected by a number of factors such as stress, sex, season, availability of feeds and other water quality parameters (Alex et al., 2012). This study was carried out with the aim of assessing the length-weight relationship and condition factor of B. bayad from River Wudil in Kano State. The information will be useful for sustainable management of B. bayad fisheries resources.

MATERIALS AND METHODS

Study area: The study was carried out in Wudil River; which is a tributary of River Hadejia and obtains its water from River Challawa, River Kano and their tributaries (Fig. 1). It flows northeast as River Hadejia and finally into Lake Chad. It is an important part of the Hadejia and the Jama' are river system. The Wudil River is situated in Wudil Local Government Area, east-central area of Kano State, Nigeria, with an estimated land area of 458 km2 with longitude 8° 45 E and 8° 57 E, as well as between latitude 11° 37 N and 11° 56 N (Getso et al., 2017). The river basin occupies a total land area of about 16386.0136 km2 and is part of the inland drainage system of the Chad Basin (Olofin, 2005).

Sample Collection: Fish samples were collected from fishermen catches at the landing site for a period of six months (January to June, 2023). A total of three hundred and sixty four (364) fish samples were collected and were transferred into an ice box packed with ice and immediately transported to the Fish Biology laboratory of the Department of Fisheries and Aquaculture, Bayero University, Kano for further measurements and analyses.

Measurements

The total length (TL) and standard length (SL) of the fish were measured in centimeter (cm) using measuring board. TL was measured from the snout to the extreme end of the caudal fin; SL was measured from the snout to the starting point of caudal fin. The weight (W) of the fish was measured in gram (g) using digital weighing balance (Simon TH-5000).

Data Analysis

The parameter of length-weight relationship (LWR) of the sampled fish were evaluated using the equation W = aLb (Le Cren, 1951), where W= body weight in g, L= total length in cm, a = constant and b = relative growth coefficient. Logarithmic transformation of the formula (W = aLb) into Log W = Log a + b Log TL was done, while each value of 'a' and 'b' was determined empirically employing common statistics. Whereas condition factor (K) was computed using the formula: K=100W/L3, where, W= observed body weight (g), L = total length (cm) (Amin, 2001; Zorica et al., 2006). Variations of K between the sites were quantified using one way ANOVA (Mahmood et al., 2012). All statistical analyses were performed using Microsoft Excel, MINITAB version 17 and SPSS version 22 statistics software.

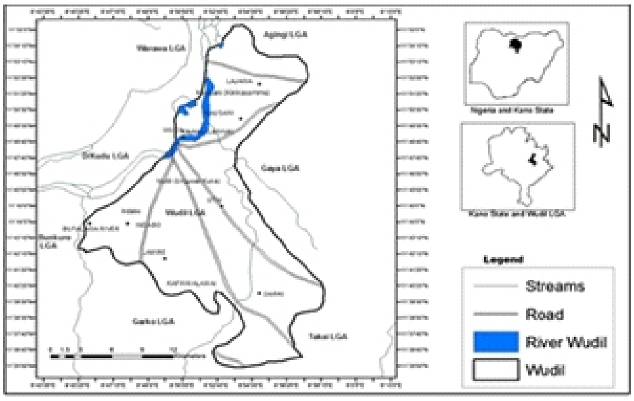

Fig. 1: Map of the Study Area

RESULTS

Table 1 presents the mean total length and total weight of males B. bayad were 32.26 ± 1.04 (cm) and 175.92 ± 7.29 (g) respectively. Whereas the mean total length and total weight of females B. bayad were 26.31 ± 0.35 (cm) and 104.50 ± 2.53 (g) respectively. Furthermore, the mean total length and total weight of combined sex of B. bayad were 28.86 ± 0.51 (cm) and 135.11 ± 3.90 (g) respectively.

Table 1: Descriptive Statistics of Body Measurements of B. bayad from Wudil River

Sex	N	Total Length (cm)		Body Weight (g)	
		Range	**Mean ± SD**	**Range**	**Mean ± SD**
M	156	12.04 – 60.03	32.26 ± 1.04	28.00 – 305.00	175.92 ± 7.29
F	208	17.00 – 37.02	26.31 ± 0.35	59.00 – 172.00	104.50 ± 2.53
C	364	12.04 – 60.03	28.86 ± 0.51	28.00 – 305.00	135.11 ± 3.90

Note: M, male; F, female; C, combined sex; N, number of individuals; TL range, minimum and maximum total length (cm); BW range, minimum and maximum total weight (g).

Table 2 depicts the computed parameters of LWR and Condition Factor of B. bayad. The estimated allometric coefficient value (b) of B. bayad was estimated to be 1.44; in males, 1.09 in females, whereas that of combined sex was 1.42. The coefficient (b) indicated that males, females and combined sex exhibited negative allometric growth pattern.

Table 2: Computed Parameters of Length-Weight Relationship and Condition Factor of B. bayad from Wudil River

Sex	N	a	B	r^2	Growth type	LWR Equation	K
M	156	1.07	1.44	0.67	Allometric (-)	LogW = 1.44 LogTL + 0.03	1.10
F	208	2.88	1.09	0.43	Allometric (-)	LogW = 1.09 LogTL + 0.46	1.04
C	364	1.05	1.42	0.63	Allometric (-)	LogW = 1.42 LogTL + 0.02	1.07

Note: M, male; F, female; C, combined sexes; N, number of individuals; a, intercept; b, slope; r2, coefficient of determination; K, mean condition factor.

DISCUSSION

In LWR, b-value is used to examine the type of growth exhibited by fishes. It has been shown that when b is equal to 3 or close to 3, growth in the fish is said to be isometric i.e. fish become more robust with increase in length similarly when b is far less or less than 3, growth is said to be negative allometric i.e. the fish become thinner with increase in length; however when b is far more than 3, growth is said to be positive allometric i.e. the fish become rounder with increase in length. Additionally, when b is equal to 3, the fish grow isometric, resulting in the ideal shape of the fish (Kefas et al., 2020; Taheri Mirghaed et al., 2021; Ali et al., 2022). The negative allometric growth reported in the present study corresponds with those observed in earlier studies by Dambatta et al. (2022) and for B. bayad in Wudil River and Dan-Kishiya et al., (2018), for B. bayad from Zobe reservoir, Dutsin-Ma, Katsina State. LWR parameters affected by availability of food, seasonal changes, health condition among others as well as biological and environmental factors (Getso, 2017; Laurat et al., 2019; Taheri Mirghaed et al., 2021; Buzhdygan, et al., 2022). The value of (r2) ranged from 0.43 to 0.67. The LWR equations were established as LogW = 1.44 LogTL + 0.03 for males, LogW = 1.09 LogTL + 0.46 for females and LogW = 1.42 LogTL + 0.02 for combined sex (Figures 2, 3 and 4). The r2 values indicated strong correlation between the length and weight.

The condition factor (K) of B. bayad indicated a trend of fluctuation of K values in both males, females and combines sex. The condition factors were 1.10, 1.04 and 1.07 for the males, females and in the combined sex. These values recorded were greater than 1 (Table 1). Condition factor provides information on the physiological condition of fish in relation to its welfare. It is often used to describe the well-being or condition of fatness of a fish and gives information about physiological state of a fish in relation to some environmental changes (Laurat et al., 2019). Ujanial et al. (2012) reported condition factor greater than or equal to1 (≥1) is good, indicating a good level of feeding and suitable environmental condition. The present research is in line with the finding of Dambatta, (2022) who obtained a condition factor of around 1.00 for B. bayad from River Wudil. Condition factor is affected by both biotic and abiotic environmental conditions and can be used as an index to assess the status of the aquatic ecosystem in which the fish live (Anene, 2005; Taheri Mirghaed et al., 2021; Buzhdygan et al., 2022). Change in condition factor of fishes could be used to interpret various biological factors such as fatness, food availability, reproductive activities and environmental health (Dadzie et al., 2000; Laurat et al., 2019). Fishes with low factor values are presumably believed to have suffered insufficient nutrition or adverse physical environmental conditions (Getso, 2017; Laurat et al., 2019; Buzhdygan, et al., 2022; Sulaiman et al., 2022). Increase in K values sometimes suggests gonadal development and accumulation of fat (Ahmad et al., 2015; Sulaiman et al., 2022).

CONCLUSION

Based on the present study, it can be concluded that B. bayad indicated negative allometric growth pattern. The condition factor "K" values recorded were greater than 1 in both, males, females and combined sex. This is an indication that the fish were in good and healthy condition. This information will help to know the state of the fish stock as well as for proper fishery management and sustainable exploitation of the stock.

REFERENCES

Tsadu S. M., Lamai S. L., Yisa T. A. and Ibrahim S. U (2014). Gonad development and histology in bagrus bayad cultured in outdoor earthen ponds. Biological and Chemical Research, 2014: 52-65.

Froese, R., and Pauly, D. (2023). FishBase 2021 world wide web wlectronic wublication.

Getso, B. U., Abdullahi, J. M. and Yola, I. A (2017). Length-weight relationship and condition factor of clarias gariepinus and oreochromis niloticus of Wudil River, Kano, Nigeria. Journal of tropical aquaculture, food, environment and extension. 16(1): 1-4.

Ude, E. F., L. L. C. Ugwu, B. O. Mgbenka and C. D. Nwani. (2011). Evaluation of length-weight relationship of fish species of Ebonyi River, Nigeria. Nigerian Journal of Fisheries. 8(1).

Alex Nehemia, Justin D. Maganira and Cyrus Rumisha. (2012). Length-weight relationship and condition factor of tilapia species grown in marine and fresh water ponds. Agriculture and biology journal of North America. 3(3): 117-124.

Olofin, E. A. (2005). Impact of dams construction on storm channel morphology. Local Field Course Lecture Series, Kano, Department of Geography, Kano University of Science and Technology, Wudil, Kano State, Nigeria.

Amin, S. M. N. (2001). Studies on age and growth, VPA analysis and relative condition factor of Harpodon nehereus (Ham-Buch) from the neritic water of Bangladesh. Online Journal of Biological Sciences, 1, 192-194.

Zorica, B., Sinovčić, G., Pallaoro, A., and Čikeš Keč, V. (2006). Reproductive biology and length–weight relationship of painted comber, Serranus scriba (Linnaeus, 1758), in the Trogir Bay area (middle-eastern Adriatic). Journal of Applied Ichthyology, 22(4), 260-263.

Mahmood, K., Ayub, Z., Moazzam, M. and Siddique, G. (2012) Length-weight relationship and condition factor of Ilisha melastoma (Clupeiformes: Pristigasteridae) off Pakistan. Pakistan Journal of Zoology, 44, 71-77.

Kefas, M., Jidauna, S. B., Michael, K. G. and Wasa, G. F (2020). Length-weight relationship, condition factor and feeding habits of Oreochromis niloticus from Lake Geriyo, Yola, Adamawa State, Nigeria. International Journal of Research in Agriculture and Forestry. 7(3), 13-20.

Taheri Mirghaed, A., Ghodrati Shojaei, M., Taghavi Motlagh, S. A., Mashhadi Farahani, M. and Weight, M. (2021). Length-weight and length-length relationships of eight fish species from Hara Biosphere Reserve; a mangrove swamp in the Persian Gulf. Iranian Journal of Fisheries Sciences, 20(1), 292-297.

Ali, A. M., Usman, B. I. and Umar, K. M. (2022). Growth pattern and condition factor of three important fish species of Challawa Gorge Reservoir, Kano State, Nigeria. FUW Trends in Science and Technology Journal, 7(3), 18-22.

Dambatta, M. A., Muhammad, A. A, Ityumbe, M. S., Dauda, A. B. and Sogbesan, A. O. (2022). Biological condition of Bayad (Bagrus Bajad, Forsskal 1775) in River Wudil, Kano, Northwest, Nigeria. 37th Annual Conference Proceedings of the Fisheries Society of Nigeria (FISON). Oct. 30th–Nov. 4th, 2022 Adamawa 2022 Nigeria: 311-317.

Dan-kishiya, A. S., Bichi, A. H. and Nababa, A. S. (2018). Length-weight relationship and condition factor of silver catfish (Bagrus bayad forskal, 1775) in Zobe reservoir, Dutsinma Local Government Area, Katsina State, Nigeria. FUDMA Journal of Sciences, 2(1), 178-182.

Laurat, H. T., Isiyaku, M. S. and Akange, E. T. (2019). Length-weight relationship and condition factor of Oreochromis niloticus and Citharinus citharus in lower River Benue, Nigeria. International Journal of Fisheries and Aquatic Studies. 7(6), 21-25.

Taheri Mirghaed, A., Ghodrati Shojaei, M., Taghavi Motlagh, S. A., Mashhadi Farahani, M. and Weight, M. (2021). Length-weight and length-length relationships of eight fish species from Hara Biosphere Reserve; a mangrove swamp in the Persian Gulf. Iranian Journal of Fisheries Sciences, 20(1), 292-297.

Buzhdygan, O. Y., Stojković Piperac, M., Stamenković, O., Čerba, D., Ostojić, A., Tietjen, B. and Milošević, D. (2022). Human impact induces shifts in trophic composition and diversity of consumer communities in small freshwater ecosystems. In Small Water Bodies of the Western Balkans (pp. 389-418): Springer.

Ujjania, N. C., Kohli, M. P. S. and Sharma, L. L. (2012). Length-weight relationship and condition factors of Indian major carps (C. catla, L. rohita and C. mrigala) in Mahi Bajaj Sagar, India. Research Journal of Biology, 2(1), 30-36.

Anene, A. (2005): Condition factor of four cichlid species of a man-made lake in Imo state, South-eastern Nigeria. Turkish Journal of Fisheries and Aquatic Sciences, 5, 43-47.

Dadzie, S., Wangila, B. C. C. and Garcia, C. B. (2000). Reproductive biology, length-weight relationship and relative condition of pond raised Tilapia zillii (Gervais). Journal of Fish Biololy, 17, 243-253.

Sulaiman, M. S., Imam, T. S., Usman, B. I., Ibrahim, A. and Bagari, H. (2022). Size composition, growth pattern and condition factor of Nile Tilapia (Oreochromis niloticus Linnaeus, 1758) from Wasai Reservoir, Kano State-Nigeria. FUDMA Journal of Agriculture and Agricultural Technology, 8(2), 115-122.

Ahmad, M. K., Baba, H. A., Haruna, M. A., Abubakar, S. and Danba, E. P. (2015). Some aspects of the biology of Tilapia zilli in Kanye Dam, Kabo Local Government, Kano State, Nigeria. International Journal of Agriculture, Forestry and Fisheries, 3(2), 32-36.

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CONSTRUCTION AND TESTING OF CIRCULAR RING LIFT NET FOR FISHING CALLINECTES AMNICOLA IN OKERENKOKO FISHING COMMUNITY IN ESCRAVOS ESTUARY, DELTA STATE, NIGERIA

[1]Binyotubo, T.E., [2] O.I. Binyotubo, [2] K. Kwen and [2] N.D. Ago

[1]Department of Fisheries and Aquaculture, Nigeria Maritime University, Okerenkoko, Delta State, Nigeria
[2]Department of Research Operations, National Institute for Freshwater Fisheries Research, New-Bussa, Niger State, Nigeria

Corresponding Author: tonybinyo@gmail.com

ABSTRACT
Construction and testing of circular ring lift-net in Okerenkoko fishing community in Escravos Estuary. Delta State, Nigeria. Testing was conducted from May to July, 2023. Nine circular ring lift-nets were used and baited with dead-fish and mudskipper. Fish samples were obtained twice monthly bases on the mesh sizes. Data obtained were subjected to Descriptive Statistical Analysis and Analysis of Variance. Results showed that circular ring lift-nets had length of 45 to 95cm, diameter of 40cm, length of bridle ropes of 0.5m, mesh size of 12.50 to50.00mm.It has conical shape with netting materials of synthetic fibre. A total of 603 Callinectes amnicola were caught, with female Callinectes amnicola constituting the highest percentage (56.55%) and males the lowest percentage (45.45%). Circular lift-nets with large mesh sizes caught the highest percentage (47.76%), followed by medium mesh (28.36%) and small mesh the lowest percentage (23.88%). Station two recorded more catch (43.12%) than station three (35.16%) and the least was in station one (21.56%). The month of May (45.27%) recorded the highest percentage of crab caught, followed by June (33.66%) and July (24.38%) the lowest percentage. It is concluded that ring lift-nets with large mesh sizes caught more Callinectes amnicola than the small and medium mesh sizes. The month of May had the highest percentage catch rate and July had the lowest catch rate. The study therefore recommends that circular lift nets with large mesh sizes are more suitable for Callinectes amnicola fisheries in the study area.

Keywords:
Circular ring lift-net, Construction, Escravos Estuary and testing.

INTRODUCTION

Ring lift net is one commonly fishing gear used in creeks, rivers, estuaries and lagoons for capturing fish. This particular fishing gear is more effective at the low tidal areas. In Nigeria, ring lift nets are mainly used along the coastal region to catch shellfish especially the swimming crabs such as Callinectes species. Ring lift nets are among the most widely used artisanal fishing gear in the brackish and coastal waters of Nigeria and often constitute approximately 50-60% of the total fishing gear used by artisanal fishers (Udolisa et al, 1994). According to Binyotubo (2011) circular ring lift net has a funnel shape, and is made of metal ring at the top and nets throughout the length and base of the fishing gear. The metal ring diameter is about 45-95cm, fitted with 30-45mm mesh netting which is either drawn tight or a bit loose to form a small bag.

. Despite the important role of the circular ring lift net in the study area. No study has been conducted on circular ring lift nets, in respect to their construction, mode of operations and efficiency in the Escravos Estuary, around Okerenkoko axis of Delta State. It was based on this reason this study was carried out. The findings of the study would be useful to fishery extension workers and the management of Escravos Estuary around Okerenkoko axis of Delta State, Nigeria.

MATERIALS AND METHODS

Study Area

The study area is located in Okerenkoko in the Escravos Estuary of Delta state, Nigeria. Escravos Estuary is situated between latitude 50301011N and 50501011N and longitude 50101011E and 401011E (Ewutanure et al., 2021) (Fig 1). The surrounding of Escravos Estuary is characterized by a tropical climate with well demarcated rain and dry season. The dry season stretches from November to April while the rainy season is usually from May to October (Opule, 2000).

Selection of Station

Three stations were selected and labelled ST1 (Station 1), ST2 (Station 2) and ST3 (Station 3). The stations are 100-200 meters apart and are the major crab fishing sites in Okerenkoko community.

Materials for the construction

The materials used for construction of the experimental circular ring lift nets were circular metal ring of 45-95cm diameter, ropes, synthetic twine (210d/9), netting material of 30 mm and 45 mm mesh size, netting needle, meter rule, matchet and razor blade

Experimental Design

The design of the experiment was based on a completely randomized design with mesh size as the factor of comparism. A total of 9 circular ring lift nets were used, three each at each station. The nets were baited with dead-fish and mudskipper.

Field Sampling Procedures

The study was carried out between May and July, 2023, using nine circular ring lift nets. Fish samples were obtained twice monthly at the three stations: ST1, ST2 and ST3 along the bank of Okerenkoko community. The baited ring lift nets were set at the bottom of the estuary and retrieved at intervals of 3-5 minutes with the help of the bridle and hauling ropes. Crab species caught were sorted and counted based on the number caught according to the mesh size.

Statistical Analysis

The data obtained on number of crab species was subjected to Descriptive Statistical Analysis and Analysis of Variance (ANOVA) using the Statistical Package for the Social Sciences (SPSS) version 20.

RESULTS AND DISCUSSION

Construction specifications of net

The construction specifications of the circular ring lift net used for the study in the Escravos Estuary around Okerenkoko axis are presented in Table 1. The circular ring lift nets had length 45-95 cm, diameter 40cm, length of bridle ropes 0.5m and mesh size 12.50-50.00mm. The length of hauling 3m, hanging ratio 3-7, the length of steeping Colum 2-7cm, shape type conical, netting materials synthetic fiber, type of frame circular ring .

Table 1: Specifications of circular ring lift net used in the study

Type of Mesh Size (mm)	CRLN	CMR (cm)	HGR	LSC (cm)	NMSC	MS (mm)	TD	NHLR	LHLR (m)	NBR	LBR (m)	FL
Small (12.50)	Ply 3 (75tex)	45	3	2	30	12.5	Z	1	3	3	0.5	1
Medium (37.50)	Ply 9 (230tex)	65	5	5	20	37.50	Z	1	3	3	0.5	1
Large (50.00)	Ply 18 (540tex)	95	7	7	10	50.00	Z	1	3	3	0.5	1

Key: CRLN = Circular Ring Lift Net, CMR = Circumference of Ring, HGR = Hanging Ratio, LSC = Length of Steeping Colum, NMSC = Number of Meshes in Steeping Colum, MS = Mesh Size, TD = Twist Direction, NHLR = Number of Hauling Rope, LHLR = Length of Hauling Rope NBR = Number of Bridle Ropes, LBR = Length of Bridle Ropes, FL = Float

Catch composition of fish (Crab)

Number of Callinectes amnicola species caught

The number of Callinectes amnicola (Plate 1) caught in circular lift nets based on their sexes is represented in Table 2 with the female Callinectes amnicola recording the highest percentage number (56.55%) and males recording the lowest percentage (45.45%). The possible reasons for this record could be attributed to the following reasons; probability more females were schooling, were in search of food and were migrating in search for areas to spawn during the study period. Lawal- Are (2009) and Ambrose and Isangedighi (2016) also reported that fishes are found more in water bodies when they are in search of food, schooling and looking for areas for spawning.

Table 2: Number of Callinectes amnicola caught in circular left based on the sex

	Sex					
Net mesh size	Male	%	Female	%	Total no. of crab caught	% of total crab caught
Small mesh size	60	22.90	82	24.63	144	23.88
Medium mesh size	62	23.66	93	27.27	155	25.70
Large mesh size	140	53.44	164	48.09	304	50.41
Total no. of crab caught	262	43.45	341	56.55	603	

Source: Field Survey, 2023.

Plate 1: Photograph of Callinectes amnicola caught during the study

Number of fish (crab) caught at different stations

Table 3 shows the total percentage of Callinectes amnicola caught by the different mesh sizes from the stations. The circular lift net with large mesh size had the highest total percentage number in all the stations, Station one (University Jetty (UJ), Station two (Zion Jetty (ZJ), and Station three (Vigilantly Jetty (VJ), (21.56%, 43.12% and 35.16%) respectively and lowest was recorded in circular lift net with small mesh size in UJ, ZJ, and VJ (23.85%, 23.85% and 24.06%) respectively. The observed high percentage number of crab caught by the circular lift net with large mesh size is in consonance with the results of Ambrose and Isangedighi (2016) who worked on similar traps and investigated the comparative fishing trials of pot and ring traps for catching blue crab in Elechi Creek, Nigeria, Emmanuel (2008) on the fishery and bionomics of the swimming crab, Callinectes amnicola (De Rocheburne, 1883) from a tropical Lagoon and its adjacent creek, south West Nigeria and Lawal- Are (2009) on the food and feeding habits of the blue crab, Callinectes amnicola (De Rocheburne) from three difference interconnecting Lagoons in south-west, Nigeria. In terms of the three stations, there was variation ($P < 0.05$) in the total number of crab caught between station one (University Jetty), station two (Zion Jetty) and station three (Vigilantly Jetty).

Table 3: Number of Callinectes amnicola species caught in circular left based on the various stations

	Stations							
Net mesh size	UJ	%	ZJ	%	VJ	%	Total no. of crab caught	% of total crab caught
Small mesh size	31	23.85	62	23.85	51	24.06	144	23.88
Medium mesh size	35	26.92	73	28.08	63	29.72	171	28.36
Large mesh size	64	49.23	125	48.08	99	46.70	288	47.76
Total no. of crab caught	130	21.56	260	43.12	212	35.16	603	

Source: Field Survey, 2023.

Key: UJ = University Jetty, ZJ = Zion Jetty, VJ = Vigilantly Jetty

Number of Callinectes amnicola caught in different months

Table 4 showed the total percentage number of Callinectes amnicola caught in the different months. The month of May, 2023 recorded the highest percentage value of crab caught (45.27%), followed by June (33.66%) and July (24.38%) the lowest percentage. In terms of the different mesh sizes irrespective of the different months, the circular lift net with large mesh size (46.43%) also had the highest percentage value, followed by circular lift net with medium mesh size (30.68%) and circular lift net with small mesh size (22.89%) had the lowest value. The results obtained from the different months revealed that, there was variation ($P<0.05$) between number of crabs caught in the month of May and other months. The observed highest catch rate by the circular lift net with large mesh size (280), over the other mesh sizes could be attributed to the fact that the circular lift nets with large mesh size permit water to drain off from the fishing gear faster than the other mesh sizes as a result catching more crabs than the other mesh sizes. Ambrose and Isangedighi (2016) also observed the same trend in their study in Elechi Creek with similar pot and ring traps for catching blue crab in Rivers State, Nigeria.

Table 4: Number of Callinectes amnicola caught in circular left based on the various months

	Months							
Net mesh size	May	%	June	%	July	%	Total no. of crab caught	% of total crab caught
Small mesh size	67	24.54	45	22,17	26	17.69	138	22.89
Medium mesh size	81	29.67	61	30.05	43	29.25	185	30.68
Large mesh size	105	38.46	97	47.78	78	53.06	280	46.43
Total no. of crab caught	273	45.27	203	33.66	147	24.38	603	

Source: Field Survey, 2023.

Catch efficiency of fishing nets

Table 5 shows the catch efficiency of fishing nets used during the study in the study area. The circular lift net with large mesh size caught more Callinectes amnicola (0.69±1.42) than the other fishing nets (circular lift net with medium mesh size 0.45±0.17 and circular lift net with small mesh size 0.48±0.12). There was significant difference ($P<0.05$) between the mean number of crab caught by the circular lift net with large mesh size and the other mesh sizes. This similar trend was observed by Ambrose and Isangedighi (2016) in their study on the comparative fishing trials of pot and ring traps for catching blue crab in Elechi Creek, Nigeria that recorded more catch with ring traps with larger mesh sizes.

Table 5: Catch efficiency of the circular lift nets in the study area

Mesh size	Total fish (crab) caught	Mean±SE
Small mesh size (12.50mm)	144	0.48 ± 0.12^{b}
Medium mesh size(37.50mm)	155	0.45 ± 0.17^{b}
Large mesh size(50.00mm)	304	0.69 ± 1.42^{a}

Large mesh size(50.00mm)3040.69±1.42aMeans with different superscripts in the same column are significantly different ($P<0.05$).

CONCLUSION

It is obvious from the results that, circular lift net with large mesh size caught more crabs (Callinectes amnicola) than the other circular lift nets with small and medium meshes. The percentage monthly catch rate from ring nets showed that May had the highest percentage catch rate of crab and July had the lowest catch rate.

Recommendations

Based on the study results, it is recommended that:

1. The circular lift net with large mesh size caught more of Callinectes amnicola in the study area thus is suitable for Callinectes amnicola fisheries in the area.
2. This is a pilot study in the area for circular ring net fisheries, but more studies are still needed to provide tangible recommendations.

REFERENCES

Ambrose, E. and Isangedighi, I. (2016). Comparative fishing trials of pot and ring traps for catching blue crab in Elechi Creek, Nigeria. Academia Arena;8(10): 38-42.

Binyotubo, T.E. [2011]. A guide to fishing gear Technology. Publication 1th edition Remithoma printer, Ilorin, Nigeria.60pp.

Emmanuel, B. E. (2008). The fishery and bionomics of the swimming crab, Callinectes aminicola (De Rocheburne, 1883) from a tropical Lagoon and its adjacent creek, south West, Nigerian Journal of Fishereis and Aquatic Science. 3 (2); 114-125.

Ewutanure, S. J, Eyo, V.O, Binyotubo, T.E, Eriegha, O, J. [2022]. Phytoplankton abundance and diversity of Okerenkoko Estuarine, Delta State; Nigeria. Advances in Multidisciplinary and Scientific Research Journal, Vol, Pp63-74.

SPSS (1999) Statistical Package for Social Science SPSS for windows. Release 10.01 standard versions.

Udolisa, R. E. K. Solarin, B.B. Lebo P. and Ambrose E. E. (1994) A catalogue small scale fishing gear in Nigeria. RAFR Publication RAFR/014/02. 142.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

SMALL SCALE FISHERIES MANAGEMENT

[1]Eyo, V. O., [1]O. J., Eriegha, [2]A. Michael, [3]G. O. Nwabeze, [3]D. C. Nwangwu, and [4]N. F. Aladetohun
[1]Department of Fisheries and Aquaculture, Faculty of Environmental Management, Nigeria Maritime University, P.M.B. 1005, Okerenkoko, Delta State, Nigeria
[2]Department of Environmental Management and Pollution, Faculty of Environmental Management, Nigeria Maritime University, P.M.B. 1005, Okerenkoko, Delta State, Nigeria
[3]National Institute for Freshwater Fisheries Research, New Bussa, Niger State, Nigeria
[4]Department of Fisheries Technology, Federal College of Fisheries and Marine Technology, PMB 80063, Victoria Island, Lagos State, Nigeria

Corresponding Author: sirvick2003@yahoo.com, +2348065162221, 0000-0001-6700-5525

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ABSTRACT
This study was conducted to evaluate the ectoparasites of C. nigrodigitatus from the Escravos Estuary, highlighting the public health implications on fish consumers within the area. A total of 180 Chrysichthys nigrodigitatus specimens were purchased from artisanal fishers in Okerenkoko community. The fish specimens were examined for ectoparasites at the Fisheries and Aquaculture Laboratory, Nigeria Maritime University, Okerenkoko. Results showed a low overall prevalence of 8.33 %. The highest prevalence (2.78 %) was recorded in monogenea (Gyrodactylus sp.) and least (2.22 %) in protozoan cyst. Abundance and intensity were highest (0.10 and 4.50) in protozoan cyst and least in Dactylogyrus sp. (0.04 and 1.33). Findings revealed that prevalence, abundance, and intensity of ectoparasites in C. nigrodigitatus were higher (9.17 %, 0.23 and 2.55) in rainy season than dry season. Size class of 40.00 – 49.90 cm recorded the highest prevalence, abundance, and intensity (12.50 %, 1.44 and 11.50) of ectoparasites. Female C. nigrodigitatus had a higher prevalence, abundance, and intensity of ectoparasites (8.87 %, 0.23 and 2.55) compared to the males. In relation to organ, prevalence and abundance of parasites were highest (4.44 % and 0.12) in the skin whereas intensity was highest (2.80) in the gills. In conclusion, the prevalence of ectoparasites in C. nigrodigitatus from the Escravos Estuary is low indicating the healthy state of the estuary and the low risk of zoonosis among inhabitants of the estuary who consume C. nigrodigitatus. Therefore, to completely eliminate the risk of zoonosis, hygienically prepared and properly cooked C. nigrodigitatus should be consumed.

Keywords:
Ectoparasites; Chrysichthys nigrodigitatus; Zoonosis; Escravos Estuary; Prevalence; Intensity

INTRODUCTION

The livelihood of many people depends on fish, especially in regions of the world designated as 'developing countries'. In Nigeria, fish is a significant source of animal protein, accounting for over 40% of the total protein intake (Ogunji and Wuertz, 2023). This high consumption is due to the availability and affordability of fish, making it a staple in many Nigerian diets. Fish and fishery products are not only the main resource for protein and micronutrients but are also of enormous economic importance, especially for the leading fish-exporting countries, with a total estimated value of US$ 217.5 billion

(FAO, 2012). With the importance of fishery products for the daily human diet increasing, research into harmful organisms in fish products has also become more important. Fish can serve as possible hosts for a variety of parasites, making parasites a common occurrence in both commercial and recreational fishing (Michael et al., 2024). Fish-attacking parasites are typically linked to unfavorable environmental conditions including salinity and temperature fluctuations (Yusni et al., 2022). In Nigeria, parasitic diseases of fish pose a serious economic and public health concern in the fishing industry due to the risk of transmission of parasite from fish to fish consumers (Eyo and Effanga, 2018; Khalid et al., 2021; Asuquo and Eyo, 2023). In addition to zoonosis, parasite infection in fish can have a detrimental effect on fish species' acceptance value and flesh quality (Michael et al., 2024). Fish infections have directly endangered the health and growth of the fishes and have indirectly endangered human physiology and morphology (Khalid et al., 2021). Ectoparasites are parasites that are found on the external body part of the fish. According to Ekanem et al., (2014), ectoparasitic diseases affects the normal health and physiological conditions of fish leading to poor growth, abnormal metabolic activities and subsequently, death of affected fish. Because of its superior nutritional value, fish is essential to human nutrition. For humans and other livestock, fish is a great source of protein (Onoja-Abutu et al., 2021; Asuquo & Eyo, 2023). In addition to protein, fish are a good source of minerals, fats, and vitamins that help maintain food and nutrition security. Chrysichthys nigrodigitatus which is commonly known as the silver catfish is an important food fish that is popularly consumed by the inhabitants of the Escravos Estuary. C. nigrodigitatus is consumed because of its firm flesh, nice taste and flavor, appreciable size, and nutritional profile. There was no information on the parasites of C. nigrodigitatus in the Escravos Estuary until recently where Michael et al., (2024) conducted a survey on the endoparasites of this species in the Escravos Estuary. However, information provided by Michael et al., (2024) is still lacking some crucial information on the ectoparasites of C. nigrodigitatus in the Escravos Estuary which is an indicator that inhabitants of the Escravos Estuary are still exposed to the risk of zoonosis. Therefore, this study was conducted to evaluate the ectoparasites of C. nigrodigitatus from the Escravos Estuary, highlighting the public health implications on fish consumers within the area.

MATERIALS AND METHODS

Study Area description

This study was carried out in Okerenkoko which is a fishing community along the Escravos Estuary (Fig. 1), located in Warri South-West Local Government Area of Delta State. The Escravos Estuary is located geographically at latitude 5.6° N and longitude 5.3° E.

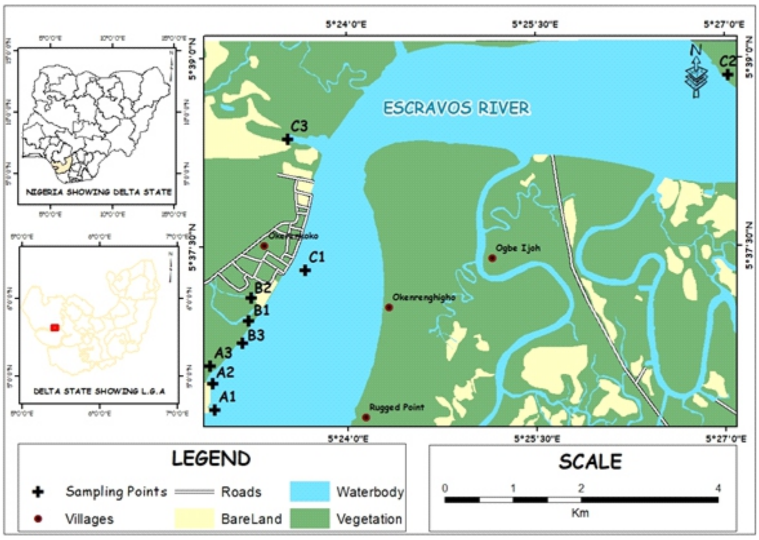


Fig. 1: Map of the study area showing sample collection points (Michael et al., 2024)

Collection transportation and identification of fish specimens

One hundred and eighty (180) fresh specimens of C. nigrodigitatus were purchased from landings of fishermen in Okerenkoko community. C. nigrodigitatus was caught using a gill net and handled carefully by the fishermen to minimize stress and prevent secondary infections. The fish were then immediately transported in containers filled with water from their natural habitat to the Fisheries and Aquaculture Laboratory at Nigeria Maritime University, Okerenkoko Campus. The fish species was identified using the guide by Idodo-Umeh (2003).

Measurement of biometric parameters

For each C. nigrodigitatus specimen, the biometric parameters including body weight in grams and total length in centimeter were measured according to the methods in Asuquo and Eyo (2023). The total weight was measured using a OHAUS SPX622 electronic scale while the total length was measured from the tip of the snout to the tip of the caudal fin to the nearest 0.1 cm using a measuring board. The fishes were grouped into three length classes including 20.00 – 29.90 cm, 30.00 – 39.90 cm, and 40.00 – 49.90 cm.

Sex differentiation

The sexes of C. nigrodigitatus were differentiated by dissecting the fish to examine the type of gonads (ovaries for female and testes for male) following the procedure in Osimen and Anagha (2020).

Examination of fish and identification of ectoparasites

For each fish specimen, gill, fin, eye, and skin biopsy were prepared and examined for ectoparasites. To prepare the gill biopsy, scrapping from second gill arch was collected according to Roohi et al., (2014). For fin biopsy, scrapping from the caudal and dorsal fin was obtained while scrapping from the eyes and the entire length of the lateral body wall was obtained for eye and skin biopsy. Wet mounts of all the prepared biopsied tissues were examined under MEDICA OLYMPUS binocular microscope for ectoparasites. Stereo dissecting microscope (MSC-ST45) was used to examine the gill for protozoan cyst. The ectoparasite were identified using parasites identification guide by Parpena (1996).

Parasitological indices assessment (PIA)

Formulas given by Upadhyay et al., (2012) were used in calculating the parasitological indices as follows:

$$\text{Prevalence} = \frac{\text{No of fish infected}}{\text{Total number of fish examined}} \times \frac{100}{1}$$

$$\text{Intensity} = \frac{\text{number of collected parasites}}{\text{number of infected fish}}$$

$$\text{Abundance} = \frac{\text{Total number of parasite recovered}}{\text{Total number of fish examined}}$$

Statistical Analysis

Statistical analysis done using Predictive Analytical Software (PASW) version 20.0. Student T-test and Analysis of Variance (ANOVA) was used in data analysis at 0.05 probability level.

RESULTS AND DISCUSSION

Prevalence, abundance, and intensity of ectoparasites in C. nigrodigitatus from the Escravos Estuary

Results obtained for prevalence, abundance, and intensity of ectoparasites in C. nigrodigitatus from the Escravos Estuary is presented in Table 1. Prevalence was highest (2.78 %) in monogenea (Gyrodactylus sp.) and least (2.22 %) in protozoan cyst, abundance and intensity were highest (0.10 and 4.50) in protozoan cyst and least in Dactylogyrus sp. (0.04 and 1.33). However, the overall prevalence of ectoparasites was low (8.33 %) and according to Michael et al., (2024) the Escravos Estuary is in good hygienic conditions. Also, the tidal rhythm of estuaries lowers the concentration of contaminants, keeping the estuary clean (Nzeako et al., 2014).

Prevalence, abundance, and intensity of ectoparasites in relation to season

Findings revealed that prevalence, abundance, and intensity of ectoparasites in C. nigrodigitatus were higher (9.17 %, 0.23 and 2.55) in rainy season than dry season.

Table 1: Prevalence, abundance, and intensity of ectoparasites in C. nigrodigitatus from the Escravos Estuary

Parasites	Host examined (%)	Host infested (%)	No. of parasites collected	Prevalence (%)	Abundance	Intensity
Monogenea (*Gyrodactylus sp.*)	180	5 (33.33)	12	2.78	0.07	2.40
Monogenea (*Dactylogyrus sp*.)	180	6 (40.00)	8	3.33	0.04	1.33
Protozoan Cyst	180	4 (26.67)	18	2.22	0.10	4.50
Total		15 (100.00)	38	8.33	0.21	2.53

Table 2: Prevalence, abundance, and intensity of ectoparasites in relation to season

Season	Host examined (%)	Host infested (%)	No. of parasites collected	Prevalence (%)	Abundance	Intensity
Rainy	120 (66.67)	11 (73.33)	28	9.17	0.23	2.55
Dry	60 (33.33)	4 (26.67)	10	6.67	0.17	2.50
Total	180 (100.00)	15 (100.00)	38	8.33	0.21	2.53

Prevalence, abundance, and intensity of ectoparasites in relation to size class

Findings showed that prevalence, abundance, and intensity of ectoparasites increased with increase in size class (Table 3). Size class of 40.00 – 49.90 cm recorded the highest prevalence, abundance, and intensity (12.50 %, 1.44 and 11.50) of ectoparasites in C. nigrodigitatus from the Escravos Estuary. These findings are consistent with that of other authors that prevalence, abundance, and intensity of parasites is higher in bigger fishes than smaller ones in Nigerian water bodies (Ekanem et al., 2014; Akinsanya et al., 2019; Effanga and Eyo, 2018). These findings may be attributed to the fact that older and larger fishes have longer exposure period in the aquatic environment than younger fishes, and also that larger fishes have increased surface area for parasites to thrive (Effanga and Eyo, 2018).

Table 3: Prevalence, abundance, and intensity of ectoparasites in relation to size class

Size class (cm)	Host examined (%)	Host infested (%)	No. of parasites collected	Prevalence (%)	Abundance	Intensity
20.00 – 29.90	60 (33.33)	4 (26.67)	4	6.67	0.07	1.00
30.00 – 39.90	104 (57.77)	9 (60.00)	11	8.65	0.11	1.22
40.00 – 49.90	16 (20.00)	2 (13.33)	23	12.50	1.44	11.50
Total	180 (100.00)	15 (100)	38	8.33	0.21	2.53

Prevalence, abundance, and intensity of ectoparasites in relation to sex

Female C. nigrodigitatus had a higher prevalence, abundance, and intensity of ectoparasites (8.87 %, 0.23 and 2.55) compared to the males (Table 4). These findings may be due to resistance to infections is sex-related (Emere, 2000). Also, the physiological states of female fish is another factor as females especially gravid ones are more susceptible to infection (Effanga & Eyo, 2018). These findings are in agreement with that of Effanga and Eyo (2018), and Akinsanya et al., (2019) and in disagreement with Ekanem et al., (2011), and Akinsanya et al., (2014).

Table 4: Prevalence, abundance, and intensity of ectoparasites in relation to sex

Sex	Host examined (%)	Host infested (%)	No. of parasites collected	Prevalence (%)	Abundance	Intensity
Male	56 (31.11)	4 (26.67)	10	7.14	0.18	2.50
Female	124 (68.89)	11 (73.33)	28	8.87	0.23	2.55
Total	180 (100.00)	15 (100)	38	**8.33**	**0.21**	**2.53**

Prevalence, abundance, and intensity of ectoparasites in relation to organs

In relation to organ, prevalence and abundance of parasites were highest (4.44 % and 0.12) in the skin whereas intensity was highest (2.80) in the gills. Organ specificity was observed in this study as Dactylogyrus sp. and protozoan cyst were only found in the gills whereas Gyrodactylus sp. was found in the skin and fins. This findings agrees with that of Eyo et al., (2015) and Asuquo and Eyo (2023). No parasite was recovered from the eyes indicating that the eyes of C. nigrodigitatus may not be a preferred organ for ectoparasites.

Table 5: Prevalence, abundance, and intensity of ectoparasites in relation to organs

Fish organ	Host examined (%)	Host infested (%)	No. of parasites collected	Type of parasites	Prevalence (%)	Abundance	Intensity
Gills	180 (100.00)	5 (33.33)	14	*Dactylogyrus sp.* and Protozoan cyst	2.78	0.08	2.80
Fins	180 (100.00)	2 (13.33)	3	*Gyrodactylus sp.*	1.11	0.02	1.50
Eyes	180 (100.00)	0 (0.00)	0	Nil	0.00	0.00	0.00
Skin	180 (100.00)	8 (53.34)	21	*Gyrodactylus sp.*	4.44	0.12	2.63

Conclusion and Recommendation

In conclusion, the prevalence of ectoparasites in C. nigrodigitatus from the Escravos Estuary is low indicating the healthy state of the estuary and the low risk of zoonosis among inhabitants of the estuary who consume C. nigrodigitatus. Therefore, to completely eliminate the risk of zoonosis, hygienically prepared and properly cooked C. nigrodigitatus should be consumed.

REFERENCES

Akinsanya, B., Isibor, P. O., Pentho, K. M., Mulikat, K. and Saliu, J.K. (2019). Parasite Prevalence and Bioaccumulation of Polycyclic Aromatic Hydrocarbons as Stressors in the Silver Catfish, Chrysichthys nigrodigitatus (Siluriformes: Claroteidae), Scientific African, doi: https://doi.org/10.1016/j.sciaf.2019.e00225

Akinsanya, B., Ukwa, U. D. and Hassan, A. A. (2014). Effect of Host Condition on intestinal parasite load and prevalence in Malapterurus electricus, Gmelin 1789, (Siluriformes: Malapteridae) In Lekki Lagoon, Lagos, Nigeria. Nigeria Journal of Parasitology, 35: 59-64.

Asuquo, P. E. and Eyo, V. O. (2023). Comparative Study On The Prevalence Of Trichodiniasis And Monogeniasis In Clarias gariepinus (Burchell, 1822) Of Different Age Groups In The University Of Calabar Fish Farm And Its Implication To Fish Farmers. Journal of Survey in Fisheries Sciences, 10(2) 01-06.

Effanga, E. O. and Eyo, V. O. (2018). Endoparasitic Infestation of the Nile Squeaker, Synodontis schall (Bloch and Schneider, 1801) from the Cross River Estuary, Nigeria. Asian Journal of Advances in Agricultural Research, 6(3): 1-10.

Ekanem, A. P., Eyo, V. O. and James, P.O. (2014). Endoparasites of Food-fish Landing From the Calabar River, Cross River State, Nigeria. Journal of Scientific Research and Reports, 3(6):810-817.

Ekanem, A. P., Eyo, V. O., and Sampson, A. F. (2011). Parasites of landed fish from Great Kwa River, Calabar, Cross River State, Nigeria. International Journal of Fisheries and Aquaculture. 3 (12):225-230.

Eyo V.O., Edet, T. A. and Ekanem, A. P. (2015). Monogenean parasites of the African catfish Clarias gariepinus cultured in Calabar, Cross River State Nigeria. Journal of Coastal Life Medicine, 3(6): 930-934.

Eyo, V. O. and Effanga, E. O. (2018). Ectoparasitic infestation of the Nile Squeaker, Synodontis schall (Bloch and Schneider, 1801) from the Cross River Estuary, Nigeria. International Journal of Aquatic Biology, 6(1): 37-43.

FAO (2012). The state of the world fisheries and aquaculture. FAO, Rome. 230 pp.

Idodo-Umeh, G. (2003). Freshwater Fishes of Nigeria (Taxonomy, Ecological notes, Diet and Utilization). Idodo Umeh Publishers Limited. Pp 408.

Khalid, S., Khanb, W., Dasc, S. N., Ahmada, A., Mehmoodd, S. A., Pahanware, W. A. Ahmedd, S., Kamalf, M., Waqasd, M., Waqasd, R. M., Hassang, H. U., Zahoorh, S. and Maqboola, A. (2021).

Evaluation of ecto and endo parasitic fauna of Schizothorax plagiostomus inhabitants of river Swat, Khyber PakhtunKhwa, Pakistan. Braz. J. Biol., 81(1): 98-104. https://doi.org/10.1590/1519-6984.222215.

Michael, A., Eyo, V. O. and Eriegha, O. J. (2024). Baseline survey on endoparasitic fauna of the Silver Catfish (Chrysichthys nigrodigitatus) from Escravos Estuary, Delta State Nigeria, and its zoonotic implication for fish consumer's health. FUDMA Journal of Sciences (FJS), 8 (1): 286 292.

Nzeako, S., Uche, A., Imafidor, H. and Abraham, N. (2014). N. Endoparasitic fauna of Chrysichthys nigrodigitatus (Lacepede, 1802) in the new Calabar river, Choba, Rivers State, Nigeria. International Journal of Fisheries and Aquatic Studies. 1(6): 208-212.

Onoja-Abutu, A. E., Okpanachi, M. A., Alkazmi, L., Yaro, C. A. and Batiha, G. E. (2021). Branchial Chamber and Gastrointestinal Tracts Parasites of Fish Species in Benue and Niger Rivers, North Central, Nigeria. International Journal of Zoology, vol. 2021, Article ID 6625332, 10 pages, https://doi.org/10.1155/2021/6625332

Ogunji, J. and Wuertz, S. (2023). Aquaculture Development in Nigeria: The Second Biggest Aquaculture Producer in Africa. Water, 15(24):4224. https://doi.org/10.3390/w15244224

Osimen, E. C. and Anagha, L. I. (2020). Endoparasites of fresh water fishes from rivers in Edo State, Nigeria. Sokoto Journal of Veterinary Sciences, 18 (4): 197 – 204. http://dx.doi.org/10.4314/sokjvs.v18i4.3

Paperna, I. (1996). Parasites infections and disease of fishes in Africa. CIFA Technical paper no. 31 food and agriculture organization, Rome.

Roohi, J. D., Sattari, M., Asgharnia, M. and Rufchaei, R. (2014). Occurrence and intensity of parasites in European catfish, Silurus glanis L., 1758 from the Anzali wetland, southwest of the Caspian Sea, Iran. Croat J Fish., 72(1): 25-31.

Upadhyay, J., Jauhari, R. K. and Devi, N. P. (2012). Parasitic incidence in a cyprinid fish Labeo rohita Ham.) at river Song in Doon valley (Uttarakhand). Journal of Parasitic Diseases, 36(1): 56-60.

Yusni, E., Batubara, A. & Frantika, C. (2022). Detection of endoparasites in mackerel tuna (Euthynnus affinis) in north Sumatra province, Indonesia. Iraqi Journal of Veterinary Sciences, 36(2): 519 – 524. 10.33899/ijvs.2021.130703.1867.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

ASPECTS OF BIOLOGY AND POPULATION DYNAMICS OF *Bagrus bayad* (FORSKAL, 1775) IN RIVER GALMA, ZARIA-NIGERIA

[1]WASE D.G., [1] A. DAMBO AND [2]P. I. BOLORUNDURO
[1]Department of Biology, Ahmadu Bello University, Zaria-Nigeria
[2]National Agricultural Extension and Research Liaison Services,
Ahmadu Bello University, Zaria-Nigeria
Corresponding Author: denengabriel3@gmail.com, +2348060547683

ABSTRACT
The length-weight relationship, condition factor and population indices of Bagrus bayad was investigated following standard procedures. Specimens with mean standard length of 13.401±0.52, 12.09±0.43 and weight 55.23±8.21, 38.05±6.09 forfemales and males were collected from River Galma between July and December 2019. Length-Weight regressions showed that growth occured allometrically (b=2.4763, 2.4272, 2.6347) for females, males and combined sex. Standard length and body weight was positively correlated ($r^2 \geq 0.700$). Assessment of condition factor (K) showed all studied specimens were in good condition (1.90±0.09, 1.83±0.07).
The VBGF fitted to length frequency data revealed asymptotic length of 34.65cm. Total instantaneous, natural and fishing mortalities were 2.632, 1.622 and 1.010. There were numerically more males than females with no significant difference (P≤0.05).

Key words:
B. bayad, condition factor, length-weight, sex ratio, population.

INTRODUCTION

Fish morphometric have been pivotal to successful ichthyologic studies over the years (Froese, 2006). Length-Weight Relationship (LWR) is commonly used to convert length measurement into weight to ascertain the growth characteristics related to these variables. These variables are also used in estimating the well-being (condition) of fish (Rodriguez et al., 2017) and thus required in fisheries assessments. Condition factor (K) is the measure of the overall health of fish. The condition index depends on the amount of food resources available to the fish in relation to expended energy. Sex ratio can be defined as the number of females to males in a population. Mortality refers to fishes of all sizes and age groups which die within a defined period in time. Mortality estimates are essential for modeling population dynamics of fish stocks and ecosystems as they contain information on the biology and ecology of populations under study, thus indicating its renewal and productivity or otherwise (depletion). Relative yield per recruit defines the biomass of individuals recruited into a fishery per unit time while exploitation rate is an index used to describe the extent to which a fishery is utilized. In fisheries stock assessment, these parameters are essential in understanding if a fishery is under fished or overfished as well as the degree of replenishment. Bagrus bayad is one of the three species of the genus Bagrus from the family Bagridae. It forms a great proportion of the commercial catches in Nigerian freshwaters (Malami and Magawata, 2010).

MATERIALS AND METHODS

Study Area

River Galma belongs to the North-Eastern part of Kaduna River basin which borders the Chad basin to the North. It is one of the main tributaries of river Kaduna with its headwaters near the North-Western edge of the Jos plateau and falls near the Magami village into Kaduna plains.

Sample Collection, Identification and morphometric measurment

Specimens of B. bayad (n=159) were obtained from fishermen of River Galma during the first week of every month at 7:00-9:00hrs and transported to Fisheries Laboratory, Department of Biology, Ahmadu Bello University, Zaria for analysis. Fish samples were identified using the keys of Idodo-Umeh (2003). Standard length (SL), total length (TL) and total body weight of the individual fish samples were taken according to the method of Akombo et al. (2015) and recorded appropriately.

Sex Ratio, Length-Weight Relationship and Condition factor (K)

Sex determination was based on visual observation of genitals (Ikongbeh et al, 2012). Sex ratio was determined following Akombo et al. (2014). Length-weight relationship was calculated using the equation

W = aLb (Bagenal, 1978) which was transformed into straight line relationship as Log W = Log a + bLog L (Akombo et al, 2015). Condition factor was calculated using K = 100w/Lb (Akombo et al, 2014)

Growth parameters

Asymptotic length (L∞) and growth coeficient (K) were calculated using Fish Key Facts 4 (Froese and Binohlan, 2000). These parameters were fitted into the Von Batterlanffy's model.

Mortality, Relative yield per recruit (Y/R) and exploitation ratio

Natural mortality (M) was calculated following Pauly, (1980) while total mortality (Z) was calculated on FiSAT 2 from length of fish samples using the Beverton and Holt model. Fishing mortality (F) was derived from F = Z-M. FiSAT 2 was used to calculate relative yield per recruit (Y/R) and exploitation ratio (Gayanilo and Pauly, 1997).

Data analysis

Microsoft excel (2013) was used in computing means, standard errors (ES) and standard deviations (SD) from morphometric data. Length-weight data was subjected to least square regression. Student t-test was used to test for significant differences between total and standard lengths, weight and condition factor as well as significant difference in sex ratio. All data was tested at 5% level of significance ($P \leq 0.05$).

RESULTS AND DISCUSSION

Sex ratio

Sampling of B. bayad in River Galma ensured a representative distribution of females and males. Sex ratio is described as the percentage of females to males and is generally considered in the study of reproduction to understand the sexual behavior of fish under consideration at different months of the year (Shenouda et al. 1994). According to Hashem (1981), the ideal value of sex ratio in fish is 1:1. Sex ratio may vary according to year, season, type of gear, month (Laleye, 2006) and length group (Dulcic et al.,2003). Geographical location and ecological habitat are among possible factors influencing sex ratio. In this study, B. bayad had a sex ratio of 1:1.21 (Table 1) for females and males indicating that males were numerically higher than females with no significant difference ($P \leq 0.05$).

Table 1: Sex Ratio of specimens collectred from river Galma between July 2019 to December 2019

Fish species	Male	Female	Sex Ratio (M:F)	x^2	P-value
B.bayad	**87**	72	1.21:1	0.0063	0.9

Length-Weight Relationship

The length-weight equation revealed varied b values below 3 (Figure 1-3) indicating negative allometric growth pattern This observation is in agreement with Atama et al., (2013) on tilapia zilli. Midhat et al., (2012) also reported similar b values in River Nile at Gizza Egypt. Generally, an ideal fish which maintains dimensional equality, the isometric value of b would be 3. A value of b less or greater than 3 indicates negative and positive allometric growth respectively. The values of correlation coefficient (r2) for the fishes were higher than 0.700 which is an indication of strong positive correlation showing positive relationship between fish standard length and body weight.

Condition Factor (K)

The mean condition factor for females within the study period was observed to be 1.90 ±0.09 while that of male was 1.83±0.07 (Table2) with no significant difference ($P \leq 0.05$). Condition factor reflects the wellbeing of fish (Abowei, 2010). It reveals information when comparing two populations living in a particular environment with similar conditions to verify if they are making good use of the resource (Igwela et al., 2011) The value of condition factor in this study was found to be 1.90±0.09, 1.83±0.07 for females and males implying that specimens were in good condition (Table 2). Condition factor less than 1.0 shows that fish are not in good condition while K values above 1.0 imply that fish are in good physiological condition. The condition factor obtained in this study agrees with Midhat et al., (2012) who reported that males of S. schall in River Nile at Gizza were in better condition (1.83) than females (1.64). Adeyemi (2011b) also reported K values between 2.32 and 2.36 in Idah area of River Niger.

Table 2: Variation of Morphometric Measurements of B. bayad

Parameter	**Sex**		**df**	**T-Value**	**P-Value**
	Female	**Male**			
Total Length (cm)	16.56±0.66	15.07±0.59	150	1.68	0.09
Standard Length (cm)	13.40±0.52	12.09±0.43	145	1.91	0.05*
Weight (g)	55.23±8.21	38.05±6.09	121	1.78	0.07
Condition Factor	1.90±0.09	1.83±0.07	148	0.61	0.54

***indicates statistical significance at p≤0.05**

Table 3: Mortality parameters for the sampled fishes

Fish species	Mortality parameter		
	Natural (M)	Fishing (F)	Total (Z)
B. bayad	1.622	1.010	2.632

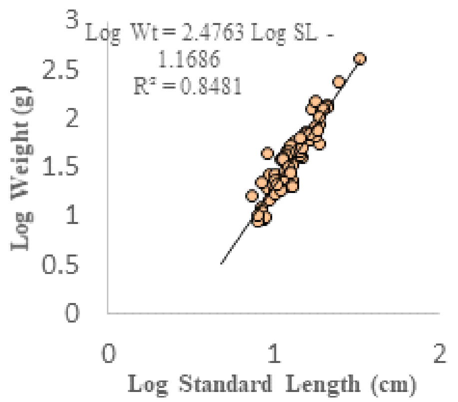


Figure 1: Relationship between logWT and log SL of Bagrus bayad females

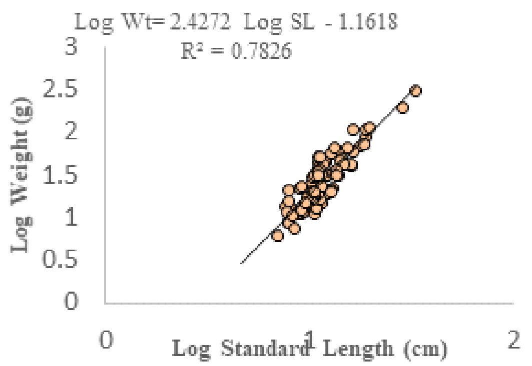


Figure 2: Relationship between logWT and log SL of Bagrus bayad males

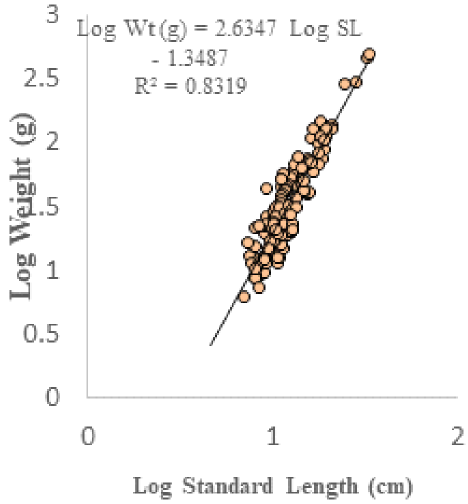


Figure 3: Relationship between logWT and log SL of (L∞): 34.65 (K): 0.920Bagrus bayad combined sex

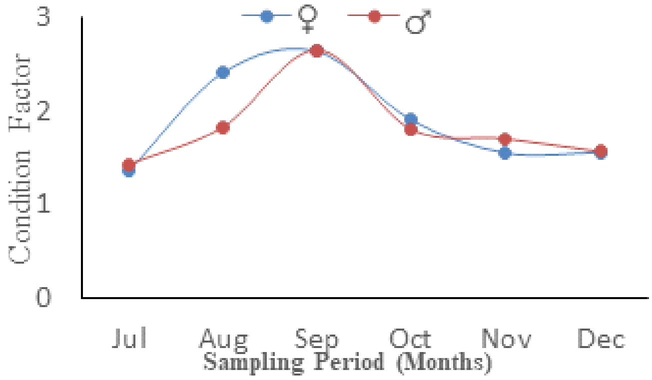


Figure 4: Monthly Variation of Condition Factor of B. bayad collected from River Galma

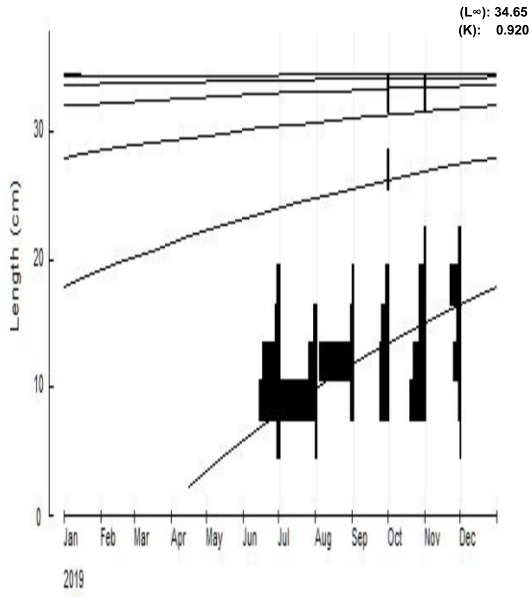


Figure 5: Von Batterlanffy growth function for B. bayad

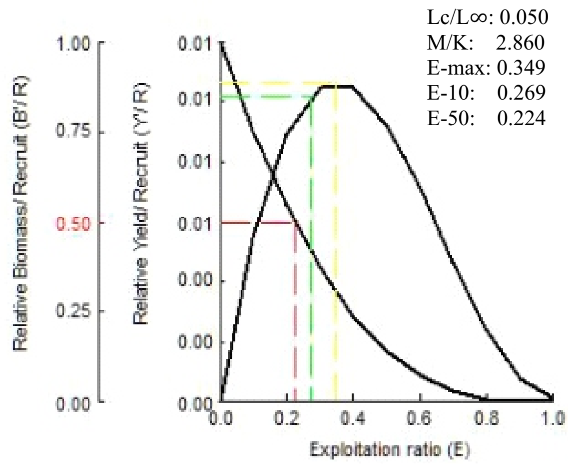


Figure 6: Relative yield per recruit for B. bayad collected from River Galma

Growth parameters

The monthly length frequency distribution within the study period is presented in figure 5. Asymptotic length of 34.65cm and 31.50cm was estimated while the VBGF had K value of 0.920. L∞ obtained (figure 5) in this study was above the maximum length of all fish samples in this study. This implies that improved environmental conditions and reduced mortality would permit larger sizes of these species. Araoye (1997) reported L∞of S. schall to be 49.5cm in Asa lake while Abowei and Hart (2009) reported L∞ of 38.7cm for the same species in Niger Delta. These variations may be as result of genetic, environmental and population (density) factors.

Mortality

In this study, natural mortality of 1.622 (Table 3) was observed. The higher natural mortality witnessed suggests fragility of the species. Generally, fish species with higher natural mortality have higher growth rates and reproduction thus generating more biomass per unit time.

Exploitation rate (E)

Exploitation rate operates with the assumption that the optimal value (E) equals 0.5. Thus, the use of E or 0.5 as optimal value for the exploitation rate is based on the assumption that maximum sustainable yield is obtained when fishing mortality equals natural mortality (F=M) (Pauly, 1998). In this study, the E_{max} obtained was 0.349, $E_{0.5}$ was 0.224 while the $E_{0.1}$ was 0.329. The estimation of the exploitation rate showed that this species is not overfished based on the optimum value of E ($Em_{ax=}$ 0.349) (figure 6). The low E_{max} recorded in this study may be as a result of minimum fishing activities or gear selectivity by fishers in River Galma.

CONCLUSION

B. bayad in River Galma exhibited negative allometric growth. Fish body weight positively correlated with standard length. The physiological wellbeing of fish expressed by condition factor (K) showed that B. bayad was in good condition. Males outnumbered females with higher natural mortality than fishing mortality with high growth.

REFERENCES

Akombo, P.M.; Akange, E.T. and Atile, J.I. (2015). Age and growth of catfish synodontis schall (Bloch and Schneider, 1801) in lower Benue River at Makurdi, Nigeria.International journal of Fisheries and Aquatic science, 2(5) 184-190.

Araoye, P.A. (1997). Bio-Ecology of a Mochokid Synodontis Schall (Bloch and Schneider, 1801) in Asa Lake, Ilorin, Nigeria.Ph. D. Thesis, University of Ibadan, 201.

Atama, C. I.; Okeke, O. C.; Nzenwaji, N. E.; Onah, I. E.; Ivoke, N.; Onoja, U. S. and Eyo, J. E. (2013). Length-Weight relationship and condition factors of six Cichlid (Cichlidae: Perciformis) species of Anambra River, Nigeria. Journal of Fisheries and Aquaculture, 4 (2):82-86.

Dulcic, J.; Pallroro A.; Cetinic P.; Kraljevic M.; Soldo A and Jardas,J. (2003). Age, growth and mortality of pickerel, Spicarasmaris L. (Piscea: Centracnthidae), from the Eastern Andriatic (Croatian coast). Journal of Applied Ichthyology. 19:10-14.

Froese, R. (2006). Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. Journal of Applied Ichthyology, 22: 241-253.

Hashem, .MT. (1981).The feeding and fatness of Bargus bayad.Bull.Inst. Oceanogr.Fish.A.R.E., 7:442-454.

Idodo-Umeh, G. (2003). Freshwater fishes of Nigeria (Taxonomy, Ecological notes, Diet and Utilization). Idodo-Umeh Publishers Ltd. Benin City, Edo State, Nigeria, 11-218.

Ighwela A.; Ahmed B and Abol-Munafi B (2011). Condition factor as an indicator of growth and feeding intensity of Nile Tilapia fingerlings (Oreochromis niloticus) fed on different levels of Maltose. American-Eurasian Journal of Agriculture and Environmental Sciences; 11:559- 563.

Ikongbeh, O.A.; Ogbe, F.G and Solomon, S.G (2012). Length weight relationship and condition factor of Bagrus docmac from lake Akata, Benue state Nigeria. Journal of animal and plant science 15(3) 2267-2274.

Lalèyè, P.; Chikou A.; Gnohssou P.; Vandewalle JCP and Teugels G. (2006). Studies on the Biology of two species of catfish Synodontis schall and Synodontis nigrita (Ostariphysi: Mochokidae) from the Ouémé River, Bénin. Belg J Zool. 136(2):193-201.

Midhat, A.E.K.; Mohammed, M.N.A and Seham, A.I. (2012). Environmental studies on Synodontis schall (Bloch and Schneider, 1801), (Pisces: Mochokidae) in The River Nile at Gizza Sector, Egypt: Biological aspects of Population Dynamics.Journal of Fisheries and Aquatic. 7:104-133.

Pauly, D. (1998). Tropical fishes: patterns and propensities. Journal of Fish Biology 53: 1-17.

COMPARISON OF MONOFILAMENT AND MULTIFILAMENT GILLNETS IN ASA RIVER, ILORIN, KWARA NORTH CENTRAL, NIGERIA

[1]Abdulsalami, S. A., [2]T. T. Ogundare, [1]H. O. Sadiq, [3]M. A. Belewu, [2]W. A. Jimoh, [2]M. I. Idiogede, [4]O. M. Ruben., [2]O. Y. Yusuf and [1]A. O. Afolabi
[1]Department of Fisheries, Aquaculture and Wildlife, University of Abuja, Abuja
[2]Department of Aquaculture and Fisheries, University of Ilorin, Ilorin
[3]Department of Dairy Science, University of Abuja, Abuja
[4]Department of Animal Science, Landmark University, Omu-Aran,
Corresponding author: somrat.abdulsalami@uniabuja.edu.ng, +2348037436389, 0000-0002-4025-1563

ABSTRACT
This study presents comparative analyses of monofilament and multifilament gillnets through field survey conducted in Asa River, Ilorin, Kwara State. Data were collected through the use of personal field observations and direct interview guides. A three-stage sampling technique was adopted; stages one and two involved purposive sampling procedures to select Asa local government area among others, whereas, waterfall, Apaata, Dam and Aliara fishing villages were considered for the study among others due to their prevalence in fishing activities. Simple random sampling technique was used in stage-three to select 5 each of monofilaments and multifilaments which formed the frame work that were studied per location with equivalent settling and retrieving procedures observed by the respondents. Descriptive statistics was used to analyse the data. Results indicated 5 species belonged to 5 different families caught by both gillnets. Among a relative total gramme of 32,050 species caught on daily basis, there were 29,688g of Oreochromis niloticus, 1,422g of Clarias gariepinus, 638g of Clupea harengus, 157g of Mormyrus rume and 150g of Synodontis clarias in the respective landing sites of Aliara, Dam, Apata and Waterfall. The total number of fish caught were 386, of which 302 (78.0%) and 84 (22.0%) were respectively caught by mono and multifilament across the studied locations. Monofilament, despite being cost effective still have better performances but most likely with dwindling catches sustainability for proper economic growth than multifilament, which is attributed to the invisibility in water, elasticity, high tensile strength, lighter weight and sensitivity nature of the former.

Keywords:
Fishing activities, Artisanal, Passive gears

INTRODUCTION

Over the years, studied have shown that a greater percentage of 0.7 million metric tons produced locally is from the capture fisheries (coastal and inland) (Obasi and Adeoye, 2022). Gill net fish farming has been a significant practice in Ilorin, Kwara State, Nigeria. According to Adeyemo (2019), the use of gillnets for fishing is quite popular in the region, and it is one of the traditional methods used by local fish farmers for commercial purposes. Gillnets are made up of long, vertical panels or curtains of mesh netting that the use of gillnets in fish farming has been a common practice in the region because it is an inexpensive method and requires minimal equipment. The primary objective of fish farming using gillnets is to cultivate various fish species, including tilapia, catfish, and tilapia hybrid species. As noted by Adesanya et al. (2020), this method is advantageous as it eliminates the need for constant monitoring; making it ideal for small-scale farmers who cannot afford sophisticated equipment. In

Kwara State, most of the fish farmers use gillnets to maximize the yield of their fish farming operations. Gillnets are tied to bamboo poles and staked into the water, forming a rectangle or circle, depending on the shape of the pond.

According to Fasakin et al. (2015), gillnets are allowed to hang vertically into the water, and the fish swim into the nets and get caught in the meshes. The Asa River, a significant river in Kwara State, Nigeria, passes through the city of Ilorin. The Asa River is vital to Ilorin's economy since it supports a variety of industries like agriculture, fishing, and transportation. Farmers in the region use the river as irrigation to grow crops such yams, maize, and rice. Local fishermen can catch fish from the river. A monofilament net is one where the net is made of single strands of a synthetic material that replicates a stand of modern fishing line, as opposed to a multifilament net, which itself is one where the net is made of thin braided or twisted twine (like very thin rope) on every "string" or filament making up the net mesh. Unlike braided fishing line, which is formed of many fibers of material, monofilament fishing line is made of a single plastic fiber (Tobor et al., 2012).

Transparency is important in monofilament lines as it affects how noticeable they are to fish in the water. Multifilament gillnets are subject to regulations that limit mesh sizes, restrict fishing in certain areas, and impose quotas on catches (FAO, 2020). In Kwara State, most of the fish farmers use gillnets to maximize the yield of their fish farming operations. According to (Omowumi et al. 2020), the use of gillnets in Asa River has increased in recent years due to high demand for fish as a source of protein by the rapidly growing population in the area. This has led to overfishing and depletion of fish stocks, resulting in reduced catch per unit effort (CPUE) for fishermen (Agbon et al., 2019). The commonly used artisanal fishing gear in Asa River include gillnets, traps, hook and line, cast nets and fish pots (Otitoloju and Ojo, 2019).

Statement of the Problem

Understanding how monofilament and multifilament nets differ in their selectivity can help identify the net type that minimizes bycatch and promotes sustainable fishing practices (Ajiboye et al., 2018). By comparing the composition of catch between the two net types, we can determine their respective impacts on fish populations and ecosystem health. Efforts to regulate the use of gillnets in Asa River have been made by the government and non-governmental organizations. For instance, the Kwara State Government has established fishing regulations that prohibit the use of certain types of fishing gear, including gillnets, during certain times of the year to allow for fish populations to recover (Olawoyin et al., 2021).

In addition, some NGOs have provided alternative means of livelihoods to local fishermen to reduce their reliance on gill net fishing (Ogundiran et al., 2020). Gillnets due to its construction pattern; can unintentionally capture non-target species, including juvenile fish and non-commercial species.

MATERIALS AND METHODS

Study Area

Asa river is the major water body in Ilorin, its course enters the Southern end of industrial estate from Asa dam and it runs northwards through residential and commercial areas of Ilorin city (Omoleye et al., 2023). Asa-dam River is in Asa Local government area of Kwara State in North Central of Nigeria. Asa River, being the major water body in Ilorin, enters the southern end of the industrial estate and runs northwards through residential and commercial areas (Kolawole et al., 2017). It thus serves as a recipient of domestic, agricultural, and industrial wastes. According to a study conducted by Odeyemi-Bello et al., (2015), Asa River in Ilorin has a total length of about 100 km and a catchment area of 1,270 km^2.

It is a highly dynamic river system that experiences seasonal fluctuations in water flow, as the river swells during the rainy season (May to October) and recedes during the dry season (November to

April). Asa r.iver serves as a source of water for fishing, irrigation, and other agricultural activities in Kwara State, and flows through several states, including Osun, Oyo and Ogun before ultimately emptying into the Atlantic Ocean. Four (Waterfall, Apaata, Asa dam and Aliara fish landing sites) out of the existing fishing locations in Asa river were purposefully selected for sampling, others were Laduba, Apaata iya Ganiya, Balogun Fulani, Aba Yawu and Oke oyi (

Fig. 1).

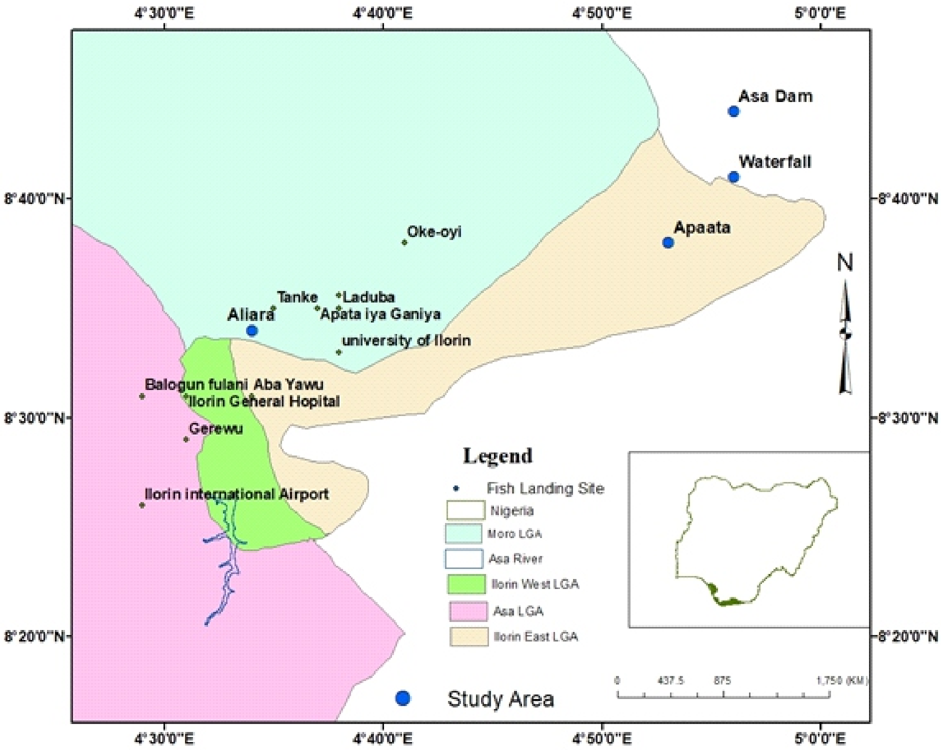


Fig. 1: Map of Asa River showing the study locations
Source: Field Survey, 2024

Data Collection Instruments

Data for this study were collected between January and April, 2023 from the active gillnets users in Waterfall, Apaata, Dam and Aliara fishing villages of Asa River, Ilorin Kwara States. Qualitative method was used for collection of primary data; personal field survey/ observation and direct interview guides) and secondary; available literatures such as journals, books maps, articles, magazines, annual reports from ADPs, NIOMR, FISON, NIFFR, FDF, NAERLS, Universities, internet and other publications) sources (Abdulsalami et al., 2017).

Sampling Procedure and Sample Size

A three stage sampling technique was used to select 5 each of mono and multi filament gillnets per location through 40 respondents from Waterfall, Apaata, Dam and Aliara fishing villages in Asa River. In stage one; purposive sampling procedure in accordance with Abdulsalami (2017), was used to select Asa local government area from the sixteen local government areas in the state due to its closeness to Asa River and the prevalence of artisanal fishing activities in the area. Meanwhile, utmost cooperation of the village leaders and active respondents were attained through native approach and incentives initiative, after which Waterfall, Apaata, Dam and Aliara fishing villages were considered for the study among others because of their activeness in fishing activities, thus, this formed the stage two of purposive sampling technique (Abdulsalami, 2017). Moreover, stage three involved simple random sampling technique with the following elucidations. There were about 40 fishermen per location, out of which 30 were active, and of the active ones were 20 that fished with gillnets, and thus, 10 (50%) of

them were communicated at each landing site. Five (5) each of monofilaments and multifilaments gillnets formed the frame work that were studied per location per three (3) weeks duration with equivalent settling and retrieving procedures observed by the respondents across the locations (Adjarho et al., 2012).
The sizes of the 40 nets ranged between 15-25mettres in length, 3-4m depth and with mesh sizes ranged between 25.5 and 102mm mounted on 50% or 75% hanging ratio (E= 0.5 of 0.7%). Individual net was usually set between 5.00pm and 6.30pm in the evening with or without bait (earthworm), and mostly tied to grasses around the river bank and pulled until it finished and the terminal end was again tied to a stone to allow for sinking. The retrieving or hauling period of the net was usually between 9am and 11am the following day, thereby maintaining net-setting time of 17 hours (Adjarho et al., 2012). The catches were carefully removed as the net were been hauled into planked canoes, and were simultaneously separated according to the type of gillnet, sorted, measured with electronic scale and counted into their respective species using fish identification keys (Olaosebikan and Raji, 2021).

Statistical Analysis
Tools like descriptive statistics such as mean, median, mode, standard deviation were used for the analyses (Johnson et al., 2019).

RESULTS
Abundant average rate of fish species caught with monofilament and multifilament gillnets in Asa River is shown in Table 1. Five different fish species belonged to five different families were caught by both mono and multi fillaments gillnets in Asa River. Among an average total gramme of 32, 050 fish species caught on daily basis for three months duration in Asa river, Oreochromis niloticus amounted to a lager gramm of 29,688 followed by Clarias gariepinus of 1422g, Clupea harengus of 638g, Mormyrus rume of 157g and with the least gramm of 150 of Synodontis clarias. Aliara landing site had the highest quantity of 10,538g Oreochromis niloticus, 8720g of this same specie was caught in Dam landing site, 7325g of it was caught in Apaata landing site and with the least of 3100g caught in Waterfall landing site. The respective gramms of 492, 380, 325 and 225 of Clarias gariepinus were caught in Apaata, Waterfall, Dam and Aliara landing sites. 335g and 303g of Clupea harengus were caught in Aliara and Waterfall respectively, with none of this specie caught in Apaata and Dam. Just 150g of Synodontis clarias was caught only in Waterfall landing site among other three experimented landing sites in Asa River. Highest gramme of 11,098 fish was caught in Aliara landing site, followed by 9,113g, 7,817g and 4022g in Dam, Apata and Waterfall landing sites (Table 1). The prevalent level of these respective species of fish; Oreochromis niloticus, Clarias gariepinus, Clupea harengus, Mormyrus rume and Synodontis clarias caught by gillnetting could probably be tagged to their abundant rate in Asa river, with highest cathability obtained in Aliara followed by Dam, Apata and Waterfall landing sites (Table 1).

Table 1: Average weight (g) of fish species caught with monofilament and multifilament gillnets in Asa river

Average weight of species caught per day	FISHING Waterfall	Apaata	LOCATIONS Dam	Aliara	Gramm Total of each specie
1. *Oreochromis niloticus* (Cichlidae)	3100	7325	8720	10538	**29,693**
2. *Clarias gariepinus* (Clariidae*)*	380	492	325	225	**1,422**
3. *Clupea harengus* (Clupeidae)	303	0	0	335	**638**
4. *Mormyrus rume rume* (Mormyridae)	89	0	68	0	**157**
5. *Synodontis clarias* (Mochokidae)	150	0	0	0	**150**
Total along locations	**4022**	**7817**	**9113**	**11098**	**32,050**

Table 2 presents the average daily number and percentage of various fish species caught in Asa River. The average total number of fish caught was 386, of which 302 (78.0%) and 84 (22.0%) were respectively caught by mono and multi filament gillnets across the study areas. Out of 386 (100%) fish species caught, Oreochromis niloticus amounted to a larger number of 335 (90%), followed by 18 (4.8%) Clarias gariepinus, 11 (2.9%) Mormyrus rume, 5 (1.5%) Clupea harengus and with the least of 3 (0.8%) Synodontis clarias caught in landing sites of Asa River. The order of dominancy of species caught by monofilament net was 257 Oreochromis niloticus, 13 Clarias gariepinus, 11 Mormyrusrume, 4 Clupea harengus and with just 3 pieces of Synodontis clarias. Whereas, a lesser quantity of 78 Oreochromis niloticus which had the highest proportion among others fish species caught by multifilament gill net was recorded. The dominant rate of other species caught by multifilament net were 5 Clarias gariepinus, 1 Clupea harengus and with no catches of Mormyrusrume and Synodontis clarias (Table 2).

Table 2: Average number and percentage of fish caught by monofilament and multifilament gillnets in Asa river

SPECIES	WATERFALL				APAATA				DAM SITE				ALIARA				TOTAL	
	M1		M2		M1		M2		M1		M2		M1		M2		M1 & M2	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No	%	No.	%	No.	%
Oreochromis niloticus	25	73.6	15	83.33	59	95.16	29	90.62	78	92.86	17	100	95	92.24	17	100	335	90
Clarias gariepinus	2	5.9	2	11.11	3	4.84	3	9.38	5	5.95	0	0	3	2.91	0	0	18	4.8
Synodontis clarias	3	8.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0.8
Clupea harengus	3	8.8	1	5.56	0	0	0	0	1	1.19	0	0	0	0	0	0	5	1.5
Mormyrus rume rume	1	2.9	0	0	0	0	0	0	5	4.85	0	0	5	4.85	0	0	11	2.9
TOTAL	**34**	**100**	**18**	**100**	**62**	**100**	**32**	**100**	**103**	**100**	**17**	**100**	**103**	**100**	**17**	**100**	**386**	**100**
RELATIVE TOTAL BY NET	**MI 302**	**78 %**									**M2 84**	**22 %**						

KEY: M1 Monofilament gillnet , M2: Multifilament gillnet, No: Number and %: Percentage

DISCUSSION

A total of 5 fish species belonged to 5 different families were caught by gillnets in Asa River with respective dominant species of Oreochromis niloticus, Clarias gariepinus, Clupea harengus, Mormyrus rume and Synodontis clarias. This concurs with the findings of Awotunde et al. (2018), that they found a total of 21 fish species from 14 families in Asa River, with the dominant families being Cichlidae, Bagridae, and Mormyridae. The most abundant species were Clarias gariepinus, Oreochromis niloticus, and Sarotherodon melanotheron.

Monofilament gill net had higher performance in terms fish catch per unit effort (CPUE) as compared to multifilament gill net in Asa River. The catch effectiveness of monofilament over multifilament gillnets despite its cheaper rate was probably due to its invisibility, elasticity, high strength, lighter weight and its sensitivity nature. This finding agrees with the work of Adjarho et al. (2012), that monofilament gillnet is more efficient that multifilament gillnet because of transparent nature of the net in water. The findings of Jawad and Hadi (2017), also conforms with this study, that transparent lines are less visible to fish, making them more effective and increasing the chances of catching them.

CONCLUSION

Gillnets are walls of rectangular netting that hangs horizontally in water column, typically made of monofilament or multifilament nylon with varying hanging ratios (E) of 0.5 to 0.7% and mesh sizes of 25.5 to 102mm which are relative to to their rate of performances. Gillnets, especially the mono type are the most adopted gear among others by the fishermen in most Nigerian's inland waters, such as Asa River due to its cost effectiveness, better performances and higher catchability rate. This is factored to its invisibility in water, high strength-to-diameter ratios, elasticity, flexibility, lighter weight and moderately dense fibre, though with poor resistance to rot, abrasion, sensitivity nature and also its entanglement nature that makes retention of fish easier within the mesh is comparable to multifilament gillnets.

Asa River is dominant with these respective species of Oreochromis niloticus, Clarias gariepinus, Mormyrus rume, Clupea harengus and Synodontis clarias caught mainly by monofilament than multi filament gill net with or without bait (earthworms) in Aliara, Dam, Apata and Waterfall landing sites. Despite multifilament gillnets being a recent innovation that has the potential to address some of the recruitment and growth overfishing that are associated with monofilament gillnets in inland environments, majority of the fishermen still keen to putting pressure on fishing with the latter for their benefits of maximum exploitation and with no consideration for future sustainability.

RECOMMENDATIONS

Asa River is believed to be richly blessed with quality fish species through assessment with gillnetting techniques, yet, there is strong need by the national and local authorities to enforce any promulgated laws in order to ensure sustainability of these inland fishery resources for present and future benefits through proper maintenance, monitoring and regulations of measures such as mesh sizes, prioritization of multi to mono filament usage, closed season observance and other intrinsic factors be emphasized. Sustainable fishing practices need to be conducted to target awareness campaigns and workshops that specifically aimed at educating the fishermen in Asa river and Ilorin metropolis. These initiatives should focus on educating fishermen about the potential negative impacts of using mostly monofilament gillnets with small mesh sizes and emphasis be frequently made on importance of sustainable fishing practices for self and economic growth.

Abundant rate of these respective species of Oreochromis niloticus, Clarias gariepinus, Mormyrus rume, Clupea harengus and Synodontis clarias in Asa river could serve as good documentary for managerial and experimental purposes. Also that Aliara landing site with higher biomass of fish species could be a training landing centre for fishing practices among other fishing sites like Dam, Apaata and Waterfall in Asa River.

REFERENCES

Abdulsalami, S. A. (2017). Isolation of fungi organisms from the operating fishing gears and crafts in Oyan Lake, SouthWest, Nigeria. Book of Proceedings of the Maiden Bioscience Annual Conference ' Harnessing Bioscience for Economic Development' held on 15th-17th, August, 2017 at Postgraduate Auditorium, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria, pp 40-45.

Abdulsalami, S. A., Ezeri, G. N. O., Odulate, D. O., Udolisa, R. E. K., Olaoye, O. J., Jimoh, W. A., Ayeloja, A.

A. and Abubakar, M. I. (2017). Bacterial associated with artisanal fishing gears and crafts in Oyan Lake, SouthWest, Nigeria. Book of Proceedings of the Maiden Bioscience Annual Conference 'Harnessing Bioscience for Economic Development' held on 15th-17th, August, 2017 at Postgraduate Auditorium, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria, pp 8-13.

Adesanya, A.S., Henderson, B. A., and Wong.J. L. (2020). A method for estimating gillnet selectivity of walleye (Stizostedion vitreum) in multi mesh multifilament gill nets in Lake Erie, and its application. Canadian Journal of Fisheries and Aquatic Sciences, 48(12), 2420-2428. doi: 10.1139/F91-283.

Adeyemo, E.A, Baranov, F.I., (2019). Theory of Gillnet Fishing, Selected Work on Fishing Gear: Commercial Fishing Gear Techniques. Israel Program. Science. Transl. Keter Publishers, Jerusalem, 1(1), 251- 289.

Adjarho, A., Omotoyosi, O. and Odulate, D. O., (2012). Comparative study of monofilament and multifilament Gillnets in Lake Kainji. Book of Proceedings of the 27th Annual Conference and Biennal General Meeting of the Fisheries Society of Nigeria (FISON), held on 25th -30th, November 2012 at Banquet Hall, Government House, Yenagoa, Bayelsa, Nigeria, pp115-117.

Agbon, B. J., T. J. Treska, L. G. Rudstam, P. J. Sullivan, J. R. Jackson, A. J. VanDeValk, and J. L. Forney., (2019). Estimating density, gear catchability, and mortality using three fishery-independent data sets for Oneida Lake, New York. Canadian Journal of Fisheries and Aquatic Sciences, 65(6), 1366–1378.doi:10.1139/F08-062

Ajiboye, R.O., Nakashima, T.,and Matsuoka, T., (2018). Ghost-fishing ability decreases over time for lost bottom-gillnet and estimation of the total number of mortality. Nippon Suisan Gakk, 70(5), 728–737.Food and Agriculture Organization (FAO), (2020). Fisherman's Workbook. Oxford: Food and Agriculture Organization of the United Nations., 189pp.

Fasakin A.A., Oladiji, A.T., Adeyemi, O. and Abiola, O.O., (2020). Toxicological evaluation of the surface water of Amilegbe River using rats. Niger. Soc. Exper. Biogyl. Biochem, 16(2), 94-101.

Ibrahim, B. U., Dadi-Mamud, J. N., Isa, M. C. and Dogara, A. Y. (2019). Fish Fauna of Tagwai Reservoir in Relation to Gear Selectivity in Minna, Niger State, Nigeria. Lapai Journal of Science and Technology, 5 (1) 2682-4965. ISSN: 2346-7371 (PRINT) 2682-4965(Available online).

Jawad, R.T., Hadi, S.O., (2017). Efficiency of capture of tench, Tinca tinca by trammel nets of monofilament and multifilament net twine combinations. Fisheries Management and Ecology, 7(4), 515-521.

Johnson, C. S., Kocovsky, P. M., Brenden, T. O. and Liu, W. (2019). Selectivity evaluation for two experimental gill-net configurations used to sample Lake Erie walleyes. North American Journal of Fisheries Management 31(3), 832–842.

Joseph, J. J., (2018). Relative efficiency of multifilament and monofilament nylon gillnets towards Lake white fish (Coregonus clupea formis) in Lake Huron. Journal of the Fisheries Research Board of Canada, 36 (3), 1180- 1185.

Kolawole, K., Colton, M.A.,and Swearer, S. E., (2017). A comparison of two survey methods: differences between underwater visual census and baited remote underwater video. Mar. Ecol. Prog. Ser. 400(3), 19–36. https://doi.org/10.3354/meps08377.

Obasi, E. U. and Adeoye, R. l., (2022). Empirical Study of Capture and Aquaculture Fish Production in Nigeria. International Journal of Fisheries and Aquatic Studies (IJFAS), 10(4), 61-65.

Odeyemi-Bello, M.L., Hoey, A.S., Bass, W. H., Bouwmeester, J., Catania, D., Cochran, J.E.M., Khalil, M.T., Miyake, S., Mughal, M.R., Spaet, J.L.Y., Saenz-Agudelo, P., (2015). The status of coral reef ecology research in the Red Sea. Coral Reefs, 32(3), 737–748. https://doi.org/10.1007/s00338-013-1055-8.

Ogundiran, T., Tweddle, D., Bowa, A., (2020): Gillnetting experiments in Lake Malawi, Africa (1) Multicoloured gillnet trials, with a review of previous coloured net trials. Collected Reports on Fisheries Research in Malawi, Occasional papers, pp37-46.

Olawoyin T., Grati F, Bolognini L., Fabi G, Santelli A, Scarcella G and Spagnolo A., (2021). The effect of monofilament thickness on the catches of gillnets for common sole in the Mediterranean small-scale fishery. Fisheries Research, 164(7), 170–177.

Olaosebikan, B. D. and Raji, A. (2021). Field guide to Nigerian freshwater fishes, Revised Edition, p144. ISBN 978-34 760-0-9

Otitoloju, A. A., and Ojo, O. A. (2019). Assessment of artisanal fish gear used in Asa river, Nigeria. Sky Journal of Agricultural Research, 8(4), 256-263.

Tobor, B. J., T. J. Treska, L. G. Rudstam, P. J. Sullivan, J. R. Jackson, A. J., and Forney. J. L. (2012). Estimating walleye (Sander vitreus) density, gear catchability, and mortality using three fishery-independent data sets for Oneida Lake, New York. Canadian Journal of Fisheries and Aquatic Sciences 65(3), 1366–1378.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR OF AFRICAN CATFISH HYBRID JUVENILES REARED UNDER LABORATORY CONDITION IN JOS, PLATEAU STATE. NIGERIA

[1]Mopho, F., [2]S.O. Musa, [3]I. K. ALABI, [1]O. O. Alabi-shauntell, [4M].Y. Mohammed

[1]Department of Fisheries Technology, Federal College of Land Resource Technology, P.M.B 2035 Kuru-Jos. Nigeria.

[2]Department of Zoology, Applied Hydrobiology and Fisheries Research Unit, Faculty of Natural Sciences, University of Jos, Jos. Nigeria.

[3]Department of Agricultural Extension and Management, Federal College of Forestry, P.M.B 2019, Jos. Nigeria.

[4]Department of Animal production, Faculty of Agriculture, University of Jos, Jos. Nigeria.

[1]Corresponding authors email: fynefacemopho@gmail.com, +2348061333949, 0009-0009-3166-2457

ABSTRACT

This study evaluated the length-weight relationships and condition factor of African Catfish hybrid juveniles for 24 weeks. Artificial induced breeding of reciprocal crosses of Clarias gariepinus and Heterobranchus longifilis were carried out using synthetic hormone. 60 juveniles (30 each) of Hetero-clarias and Claro-branchus hybrids of 34.06g and 42.66g mean weight were randomly selected and evaluated for the length-weight relationships. An experimental design of 2x3 was used, each of the treatment was replicated. Data collected on the body weight (g) and total length (cm) were evaluated for length-weight relationships. Correlation and regression were estimated by the values of the intercepts (a) and slope (b). Variation observed in the monthly mean values on weight (g) and total length (cm), slope (b) and condition factor (K) for each treatment were tested to determine the significant difference ($P<0.05$) level . The results revealed negative allometric growth with Claro-branchus (T2) having the highest (5.050). The "r" values obtained showed that Hetero-clarias (T1) and Claro-branchus (T2), had 0.985 and 0.982 respectively. The values of "a" and exponent "b" for the two groups of fish in this study were within the recommended limits. The K values indicated significant difference ($p< 0.05$) among the treatments examined. Water quality parameters were observed to be within the acceptable limit for optimum performance of studied fish species. This study has affirmed that Hetero-clarias and Claro-branchus hybrid juveniles exhibited good growth ratio. However, there were variabilities between the condition factors measured that may have resulted by several environmental and technical differences.

Keywords: Length-weight, condition factor, Clarias gariepinus, Heterobranchus longifilis, hybrid, Allometric

INTRODUCTION

The culture of the African Catfish is advancing in most West African countries including Nigeria. Meanwhile, field experiences have revealed the general need for proper management of the diverse catfish resources in the culture environments for sustainable fish production and conservation of fish species in African countries. Growth is an important trait in fish production. Hence, there is always the need to establish growth pattern in economically important fish species such as C. gariepinus and H. longifilis and their hybrids. The length-weight relationship (LWR) is an important tool used in fishery assessment for predicting weight from length required in yield assessment and in calculation of Biomas

(Okomoda et. al., 2018). Knowledge on relationship between weight and length is important for establishing production and biomass estimations of a species (Ogunola et. al., 2018;Okomoda et. al., (2018) reported that Length–Weight Relationship of fishes are important in fisheries biology because they allow the estimation of the average weight of fish of a given length group by establishing a mathematical relation between the two. The study of LWR of fish species allows the inter-conversion of length and weight parameters. It also enhances morphometric comparisons between species and populations. Furthermore, LWR allows the health status or condition of fish to be estimated. The relationship between the length (L) and weight (W) is usually expressed as W=aLb. where a is the intercept and b is the allometry coefficient. Values of the exponent b provide information on the fish growth. When b = 3, increase in weight is isometric, and when the value of b is other than 3, weigh increase is allometric (negative if b < 3, positive if b >3). Important information on the structure and function of fish population are provided by Length weight relationships. One of the benefits of estimating LWR is the ability to apply the length and weight data for prediction of well-being of studied population through the estimation of condition factor (K). The condition factor often referred to as "K" provides information on the wellbeing of a fish and is usually influenced by the fish, sex, season, maturity stage (Anyanwu, et. al., 2007). K= 100w/L3 was proposed by Fulton (1902) as the mathematical formula for quantifying or estimating the condition of fish. The relationship of length-weight can be used to estimate condition factor of fish species (Fishbase, 2013). Knowledge of growth pattern and well-being of fish species is of importance in fish production as it affords the opportunity of precision in utilization of the fish population. Such knowledge would assist in proper management of the fish progenies in either capture or culture environment. However, the dynamics of growth and condition factor could vary across strains of fish species. The length-weight relationship, size at first maturity and condition factor of African Catfish have been reported from several water bodies of Nigeria (Okomoda et. al., (2018). However, there is no compiled information on the length-weight relationship from juvenile stage to first maturity and the condition factor of African Catfish Hybrids in Aquaculture. Therefore, this study aim to evaluate the Length-weight relationship and condition factor of Hetero-clarias and Claro-branchus hybrid juveniles under Laboratory condition in Jos, Plateau State. Nigeria

MATERIALS AND METHODS

Study Area

The study was conducted at the Hydrobiology and Aquaculture laboratory of the Department of Zoology, University of Jos Nigeria and the Federal College of Land Resources Technology, Kuru, Jos. Plateau State.

Procedures

First phase: Artificial induced breeding of African Catfish (C. gariepinus) crossed with Bighead catfish (Heterobranchus longifilis) using Ovulin (0.5ml/kg b/wgt) synthetic hormone was carriedout, the hatchlings obtained were fed Alltech Coppens (45%cp) starter feed for 9 weeks.

Second phase: 60 juveniles (30 each) of Hetero-clarias and Claro-branchus hybrids of 34.06g and 42.66g mean weight were randomly selected from juveniles obtained from the first phase. The fish were stocked and designated as Treatment 1 and Treatment 2 respectively. The fish were reared in 50L circular plastic bowls at 10 fish/bowl. The bowls were filled with water and maintained at 40L. Each of the Treatments were replicated, while the fishes were fed Alltech Coppens (45%cp) feed at 4% body weight. Feed was adjusted and administered weekly for 24 weeks. Samples of 10 individuals from each treatment were used to determine the lengths and weights of the progenies. Fish samples were weighed weekly to the nearest grams (g) using electronic weighing balance and total length (distance from the tip of the snout to the tip end of the caudal fin) was measured using a measuring rule. The length increases and weight gain, growth rate, specific growth rates and condition factors were determined as reported in Okomoda et al. (2018).

Breeding/crosses and experimental design

Crossing of Clarias gariepinus and Heterobranchus longifilis were carried out as presented below. The experimental trial consisted of 2 treatments, and each of the treatment was in triplicate.

Treatment	Crosses
$T_1(R_1)$, R_2, R_3	♂ Hl X ♀Cg (*Hetero-Clarias*)
T_2 (R_1), R_2, R_3	♂CgX♀Hl (*Claro-branchus*)

Keys: Hl: (*Heterobranchus longifilis*), Cg: (*Clarias gariepinus*), ♂(Male), ♀(Female)

Determination of length-weight relationship and condition factor

Length-weight Relationship: this was determined using the equation

$$W = aL^b$$

where: W = weight of fish in (g), L = total length (TL) of fish in (cm), a = constant, b = the length exponent.

Condition Factor (K): This shows the degree of wellbeing of the fish in their habitat, and this was determined using (Le Cren, 1951).

$$K = \frac{100 \times W}{L^b}$$

Water quality parameter test

The physicochemical parameters were determined based on the procedures outlined in AOAC (2012). The determination of physicochemical water quality parameters was carried-out weekly for a period of 24 weeks. The water samples were collected in test bottles and taken to the Laboratory for analysis. The temperature of the water sample was taken immediately using the clinical mercury-in-glass thermometer. Other water quality parameters; pH, Ammonia and Dissolved oxygen were analyzed using a TestLab water quality test kit (JBL, GmbH and Co. KG, 67141,Neuhofen, Dieseletrabe 3, Germany) immediately after collection

Plate1: Experimental set-up showing the rearing units

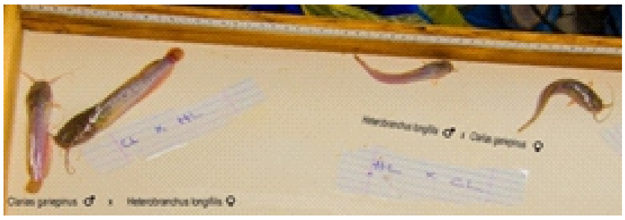


Plate 2: Hybrid Juveniles of African Catfish (used for the study

DATA ANALYSIS

Data collected on the body weight (g) and total length (cm) for relationships between body weight and total length were subjected to T-test. Correlation and regression were used to estimate the values of the intercepts (a) and slope (b) for weight and length relationship. Variation observed in the monthly mean values on weight (g) and total length (cm), slope (b) and condition factor (K) for each progeny was tested to determine the significant difference (P>0.05) level.

RESULTS AND DISCUSSION

Length-weight relationships and condition factor

The total length-weight relationships of all individual and groups were separately evaluated (figure 1 and figure 2). The Length weight relationship parameters, a and b, the coefficient of determination, r2 and the condition factor (k) are presented in Table 2. Information on the pattern of growth (allometric or isometric) was fully furnished. From the results as presented in table 2, hybrid juveniles in treatment 1 and treatment 2 recorded negative allometric growth, while T2 having the highest (5.050) value is incredibly above the reference value of "3". Value obtained for T1 was below (2.855) the reference value. The "r" values obtained showed that T1 and T2, had 0.985 and 0.982 respectively. The length-weight data obtained showed different values for each of the treatments. The values of "a" and exponent "b" for the two groups of fish in this study were within the recommended limits reported by Okomoda et. al.,(2018). From the result of the present study, most of the fishes had a negative allometric growth which came incredibly close to the reference value of "3" (b = 2.855, 5.050). According to Riedel et. al., (2007), when fish becomes tinnier as it increases in weight; it implies a negative allometric growth. An isometric length-weight relationship on the other hand implies that the weight of these fishes increases at approximately the same rate as the length (Olufeagba et. al., 2016). However, variations in the value of "b" between the treatments could be linked to so many factors. Some of which include differences in the physiology of different fishes and feeding rate, degree of stomach fullness (Hossain et. al., 2012), sexes, sensitivity to water quality parameters, differences in the observed length ranges of the specimens sampled or behaviour (Khallaf et. al., 2003). It could be rightly said that one or more of these factors must have interplayed to cause the current observation made on the length-weight relationship in this study. There was no consistency in the condition factor obtained for treatments in this study, even though values recorded were desirable. However, T2 exhibited the highest mean K value of 1.872 than values observed in T1. The K values obtained in this study were generally close to or above the recommended value of "1" for healthy fishes. The results also showed that, there is significant difference ($p< 0.05$) in K among the treatments examined which could be associated to the different behavioural response. According to Khallaf, et al., (2003) condition factor of fish are affected by many factors resulting to the variations in the values of "b" in this study (i.e. strain, species, stress, sexes, availability of feeds, water quality etc.). Hence, this could justify the differences between the observation of the present study and those of previous studies on different fishes under different experimental conditions (Solomon et. al., 2017; Rodriguez et. al., 2017). The water quality parameters results revealed that pH ranged between 6.55 and 6.80, temperature, 22.25^0c and 24.25^0c, Dissolve Oxygen, 6.25 and 7.20mg/l and Ammonium, 0.17 to 0.21. The values obtained for were all within the acceptable limit recommended for catfish.

Table 2: Length – weight relationships and condition factors of Hetero-clarias and Claro-branchus hybrid juveniles reared under laboratory condition for 24 weeks

Parameter	T1 (*Hetero-clarias*)	T2 (*Claro-branchus*)	p-value
A	-1.861	-5.002	-
B	2.855	5.050	-
r^2	0.985	0.982	-
K	0.789 ± 0.01^b	1.872 ± 0.02^a	0.001

Table 3: Mean weekly water quality parameters evaluated during the 24 weeks experimental trial

Parameters	Initial	12 weeks	16 weeks	20 weeks	24 weeks
pH	7.60± 0.06[b]	6.55±0 .06 [b]	6.70±0 .09 [b]	6.80±0 .05 [b]	6.80±0 .06 [b]
Temperature(°/c)	25.50 ±0.09 [a]	24.25± 0.05 [a]	24.13± 0.05 [a]	22.25± 0.04 [b]	22.88± 0.06 [b]
Dissolved Oxygen (mg/l)	8.20± 0.15 [a]	6.25±0 .18 [b]	6.88±0 .20 [bc]	7.70±0 .15 [b]	7.13±0 .25 [b]
Ammonium (mg/l)	0.20± 0.05[a]	0.20±0 .05[a]	0.21±0 .7[a]	0.17±0 .06[b]	0.17±0 .05[b]

Mean with different superscripts (a, b) along the rows are statistically significant (P<0.05)

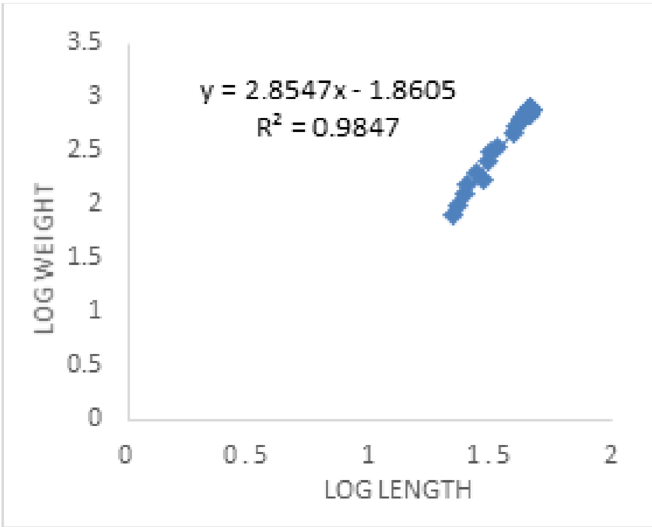


Figure 1: Length-weight relationship of Hetero-clarias

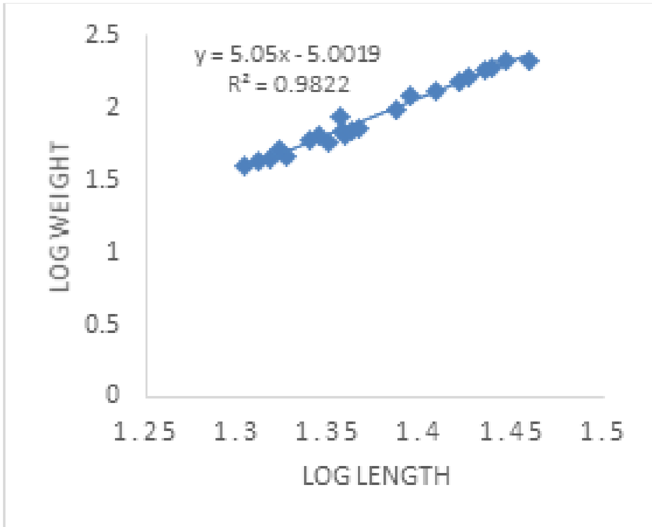


Figure 2: Length-weight relationship of Claro-branchus

CONCLUSION AND RECOMMENDATION

The length-weight relationship revealed a strong positive correlation as expected, that as the fish grow in length, the weight also increases i.e. the fish became heavier with increase in length. The regression analysis showed that the fish exhibited isometric growth. The value of the exponent b indicated that all treatments showed a negative allometric growth which implies that the fish is becoming tinnier as it increases in weight; hence, the fishes become slender. Water quality parameters were observed to be within the acceptable limit for optimum performance of studied fish species. This study has affirmed that the hybrid juveniles exhibited good growth ratio. However, there were variabilities between the condition factors measured that may have resulted by several environmental and technical differences .

REFERENCE

Anyanwu, P.E., Okoro, B.C., Anyanwu, A.O., Matanmi,M.A., Ebonwu, B.I., and Ayabu-Cookey, I.K. (2007). Length-weight relationship, condition factor and sex of Africa mud catfish (Clarias gariepinus) reared in the indoor water recirculation system tanks, Research Journal of Biological Sciences. 2(7):780-783.

AOAC, (2012). Official methods of Analysis. 19th ed. Maryland USA: Association of Official and Analytical Chemists (AOAC), 1263p.

Fishbase (2013). Online fish identification sheet. Available at http://www.fishbase.org/

Fulton,T.W.(1902).The rate of growth of fishes.20th Annual Report of the Fishery Board of Scotland 3:326-446.

Hossain, M.Y., Jasmine, S., Ibrahim, A.H.M., Ahmed, Z.F., Rahman, M.M. and Ohtomi, J. (2009). Length-weight and length-length relationships of 10 small fish species from the Ganges, Bangladesh. Journal of Applied Ichthyology 25:117-119.

Khallaf, E.A., Galal, M. and Authmam, M. (2003). The biology of Oreochromis niloticus in a polluted canal. Ecotoxicology 12:405-4016.

Ogunola,O.O., Onada,O.A. and Falaye,A.E. (2018). Preliminary evaluation of some aspects of the ecology(growth pattern, condition factor and reproductive biology) of African Pike, H. odoe (Bloch 1794) in Lake Eleiyele, Ibadan, Nigeria. Fisheries and Aquatic Sciences, 21,12-27.

Okomoda, V.T., Koh, I.C.C., Hassan, A., Amornsakun, T. and Shahreza, S.M. (2018). Length-weight relationship and condition factor of progenies of pure and reciprocal crosses of Pangasionodon hypophthalmus and Clarias gariepinus. Aquaculture, Aquarium, Conservation and Legislation, 11(4): 980-987.

Olufeagba, S.O., Okomoda, V.T. and Shaibu, G. (2016). Embryogenesis and early growth of pure strains and hybrids between Clarias gariepinus (Burchell, 1822) and Heterobranchus longifilis (Valenciennes, 1840). North American Journal of Aquaculture 78 (4):346-355.

Riedel, R., Caskey, L.M. and Hurlbert, S.H. (2007). Length weight relations and growth rates of dominant fishes of the Salton sea : implication for predation by fish eating birds. Lake and Reservoir management 23:528-535.

Rodriguez, C., Galli, O., Olsson, D., Tellechea, J.S.and Norbis, W. (2017). Length-weight relationships and condition factor of eight fish Specie inhabiting the Roca Lagoon, Uruguay. Brazillian Journal of Oceanography, 65(1): 97-100.

Solomon, S.G., Okomoda, V.T. and Achodo, S. (2017). Biometric relationship, food and feeding habit of Heterotis niloticus (Cuvier, 1829) and Labeo coubie (Ruppell, 1832) from lower River Benue. Journal of Aquaculture Engineering and Fisheries Research 3:19-27.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR OF Clarias gariepinus (BURCHELL, 1822) FROM LAKE GERIYO, ADAMAWA STATE, NIGERIA

[1]Jidauna, S. B., [2]Y. Ibrahim, [2]B.Y Hamidat and [2]S. Kabir

[1]Department of Fisheries, Modibbo Adama University, Yola
[2]Department of Fisheries Technology, Federal Polytechnic, Bauchi
[1]Corresponding Author Email: samueljidaunabuba@gmail.com, +2348140512221, 0000-0002-0406-4832

ABSTRACT
A study was conducted to determine the length-weight relationship and condition factor of Clarias gariepinus from Lake Geriyo for 8 weeks (July to August 2023). Sixty (60) fish samples were collected from the landing site and were sorted into male and female; twenty-four (24) males and thirty-six (36) females were weighed and measured. Length-weight relationships of males, females and combine sexes were calculated using linear regression on log transformed data. The regression coefficient, 'b' values for males, females and combined sexes indicated negative allometric growth patterns of 1.6, 1.9 and 1.8 respectively. The research revealed moderate to strong correlations (0.48, 0.62 and 0.56) with significant differences ($p < 0.05$) between length and weight of the males, females and combine sexes, respectively, while the values of 1.1 for condition factors for males, females and combined sexes were good.

Keywords:
Biology, Isometric and Species

INTRODUCTION

One of the most important aspects of fish biology is the study of the length-weight relationships (LWR) and condition factors (k) (Ashley-Dejo et al., 2022). The relationship between length and weight is very essential for proper fish exploitation and management schemes and it is possible to estimate the average weight of fishes at a given length (Ahmed et al., 2017). A change in weight or length of fish over a period of time is term growth (Ashley-Dejo et al., 2022). Fish can attain either isometric or allometric growth (Sakar et al., 2013). Isometric growth indicates that both length and weight are increasing at the same rate. Allometric growth can be either positive or negative. Positive allometric growth implies an increase in weight with increase in length. Negative allometric growth implies a decrease in weight with an increase in length

Condition factor (CF) is an estimation of general well-being of fish (Oribhabor et al., 2011) and is based on the hypothesis that heavier fish (at a given length) are in better condition than the lighter ones. The condition factor of ≥ 1 indicates good condition of fish while < 1 indicates bad condition (Fagbuaro et al., 2015).

Clarias gariepinus (Burchell, 1822) is an excellent aquaculture species with high commercial value and is one of the most enjoyed aquaculture species by Nigerians, in addition to its wide distribution in African freshwater ecosystems. However, the length-weight relationship data for this species along with other freshwater fish resources of Nigeria are limited (Fafioye and Ayodele, 2018). There are few works on the length-weight relationship and condition factor of Clarias gariepinus, particularly in Lake Geriyo (Abubakar, 2006). This study therefore aimed at determining the length-weight relationship and condition factor of Clarias gariepinus.

MATERIAL AND METHODS

The research was conducted in Lake Geriyo, Yola-North Local Government Area of Adamawa State, Nigeria. It lies between longitude 12° and 12° 28 East of Greenwich and Latitude 9°16 and 9°19 North of the Equator. Fish sample was identified using identification key (Holden and Reed 1972). The specimens were sexed, weighed, and measured. Sex was examined via hand held microscope and the external genital features was used as described by Offem et al. (2013).

Analysis of Length–Weight Relationship

Data were analyzed using regression analysis. The relationship between length (L) and weight (W) of fish was expressed by equation:

$$W = {}_aL^b \qquad \text{(Le-Cren, 1951)}$$

The above equation and data were transformed into logarithms before the calculations were made. Therefore,

$$\text{Log } W = \log a + b \text{ Log } L$$

Where:

W = weight of fish in (g)
L = Total length (TL) of fish (cm)
a= Constant (intercept)
b = The Length exponent (slope)

The "a" and "b" values were obtained from a linear regression of the length and weight of fish. The correlation ®, that is, the degree of association between the length and weight was computed from the linear regression analysis:

$$R = r2$$

Analysis of Condition Factor

The condition factor (k) of the individual experimental fish species was estimated from the relationship and calculated for each month using the formulae described by Worthington and Richardo (1930) as:

$$K = (W\,100/L^3)$$

Where:

K = condition factor
W = Weight of the fish in (g)
L = Total length of fish in (cm)

Linear Regression analysis was used to determine the length-weight relationship (LWR). Correlation matrix was used to evaluate the association between morphometric and meristic characteristics of the species. All analyses were done at an alpha level of $\infty = 0.05$.

RESULTS AND DISCUSSION

The length-weight relationships and condition factor (K) obtained for C. gariepinus is illustrated in Table 1. The log weights of all the samples, on the Y–axis was plotted against the log values of standard length, body weight on the X and Y–axis respectively. These relationships gave straight line graphs with their b (growth exponent) values were less than 3 ($P<3$), which indicates negative allometric growth of C. gariepinus from the Lake Geriyo within the study period.

The b-value for this study indicates negative allometric growth pattern. This implies that the rate at which body length increases is not proportional to the rate of increase in body weight. That is, the fish grow faster in length than in weight. The value obtained for b was 1.8 for the whole population, 1.6 for males, and 1.9 for females. This result shows that C. gariepinus exhibits a negative allometric growth ($b < 3.0$) thus, the length increases at higher rate than the body weight. This finding is in line with reports by Solomon et al. (2016). No near isometric growth was recorded for C. gariepinus in this study. When b > 3.0 positive allometric growth pattern occur (Adeyemi et al., 2009). The b values recorded in this study is similar to the ranged of 1.4 – 1.6 recorded for some fish species from lower Usuma Reservoir Bwari, Abuja by Dan-Kisaya (2013).

The condition factor (k) value obtained in this study shows no significant difference ($P < 0.05$) but was greater than 1. This suggest that the fish were in good physiological and stable condition in the lake throughout the period of the study. This finding was similar to the results reported by Kefas et al. (2012) for C. gariepinus from Rivers Ilagil and Ngurore both in Yola South, Adamawa State. However, the "k" value recorded in this study varied slightly from the result of Famoofo and Abdul (2020), for some fish species from Iwopin freshwater, Ogun State.

CONCLUSION

The study revealed negative allometric growth in the length- weight relationship and good condition factor of Clarias gariepinus in Lake Geriyo. Further study into water quality parameters of the Lake is recommended.

REFERENCE

Abubakar, K. A. (2006). A Study of Aspects of Productivity and Stock Status of Oreochromis niloticus and Clarias gariepinus in Lake Geriyo, Yola Adamawa State, Nigeria. PH.D Thesis Federal University of Technology, Yola, Nigeria. 212

Ahmed. O., Mohammed, E., Afra, A., and Esam, M. K. (2017). Length-weight relationships and condition factor of five fresh water fish species in Roseires Reservoir, Sudan European Journal of Physical and Agricultural Science. 5 (2): 3-7.

Adeyemi, S. O., Bankole, N. O., Adikwu, I. A., Akombo, P. M. (2009). Age, growth and mortality of some commercially important fish species in gbadikere lake, kogi state, Nigeria. International Journal of Lakes and Rivers Research India Publication. 2 (1), 63–69

Ashley-Dejo, S. S., Ogah, I. S. Usman Y. (2022). Length-weight relationship and condition factor of Tillapia zilli in River Yobe, Northeast, Nigeria. Jurnal Perikanan Universitas Gadjah Mada, 24 (1): 55-61.

Dan-Kishiya,, A. S. (2013). Length-weight relationship and condition factor of five fish species from a tropical water supply reservoir in Abuja, Nigeria. America Journal of Research Communication 1 (9), 175–178.

Fafioye, O. O. and Ayodele, O. P. (2018). Length-weight relationship and condition factor of four commercial fish species of Oyan Lake, Nigeria. Examines in Marine Biology and Oceanography 2(4), 1- 4

Famoofo, O. O. and Abdul, W. O. (2020). Biometry, condition factors and length-weight relationships of sixteen fish species in Iwopin fresh-water ecotype of Lekki Lagoon, Ogun State, Southwest Nigeria Helyon Science direct https://doi.org/10.1016/j.heliyon.2019.e02957

Fagbuaro, O., Oso, J. A., Olurotimi, M. B., Akinyemi, O. (2015). Morphometric and meristic characteristics of Clarias gariepinus from controlled and uncontrolled population from South Western Nigeria. Journal of Agriculture and Ecology Research International. 2(1): 39- 45

Holden, M. and Reed, W. (1972). West African Freshwater Fish. Longman Group Ltd London.pp31

Kefas, M., Abubakar, K. A and Ndonya, A. E. (2012). Some aspects of biological status of Clarias gariepinus in River Ilagil, Ngurore, Yola-South Local Government Area, Adamawa State, Nigeria. Adamawa State University, Journal of Scientific Research Vol.2, No.1.

Le Cren, E. D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in perch (perca fluviatilis) Journal of Animal Ecology 3: 201-219.

Offem, B. O., Ayotunde, E. O. and Ada, F. B. (2013). Trophic Ecology, Growth and Population Dynamics of Synodontis Clarias (Pisces: Siluriformes: Mochokidae) (Lin: 1758) in Cross Rivers, Nigeria. Journal of fisheries and Aquaculture, 4 (1): 67–74.

Oribhabor, B. J., Ogbeigbu, A. E., Udo, M. T. (2011). The length-weight relationship of brackish water/ marine fish species assemblage in Niger Delta mangrove creek, Nigeria. Current Research Journal of Biological Science. 3(6): 13-21

Sakar, U. K., Khan, G. E., Dabas, A., Palhak, A. K., Mir, J. I., Rebello, J. C., Pal, A. and Singh, S. P. (2013). Length-weight relationship and condition factor of selected freshwater fish species found in River Ganga, Gomti and Rapti. India Journal of Environmental Biology.23 (7): 123-32

Solomon, S. G., Okomoda, V. T. and Ogbenyikwu, A. I. (2016). Intraspecific morphological variation between cultured and wild Clarias gariepinus (Burchell) (Clariidae, Siluriformes) – Archives of Polish Fisheries, 23: 53-61

Worthington, B. E. and Richard, C. K (1930). Scientific result of the Cambridge expedition to the East Africa Lakes No. 15; the fishes of Lake Rudolf and Lake Baringo. Journal Limnology Society of Zoology, 267: 353-389

Table 1: Length-Weight Relationship and Condition factor of *Clarias gariepinus* from Lake Geriyo from July – August 2023.

Sex	N	Weight (g)		SL (cm)		TL (cm)		a	b	R^2	K
		Range	Mn±Sd	Range	Mn±Sd	Range	Mn±Sd				
Male	24	15.20 – 173.23	63.09±32.03	5.1 – 25.5	14.9.0±4.1	12.00 – 29.70	18.10±3.83	-0.23	1.6	0.48	1.1
Female	36	26.91 – 145.29	69.39±26.00	10.0 – 22.3	15.6±3.1	13.00 – 25.70	18.35±2.69	-0.60	1.9	0.62	1.5
Combine	60	15.20 – 173.23	66.91±28.69	5.1 – 25.5	15.3±5.6	12.00 – 29.70	18.25±3.19	-0.43	1.8	0.56	1.1

n = number of observations

Mn = mean

Sd = standard deviation

AN APPRAISAL OF THE CURRENT FISHERIES OF EGBE RESERVOIR, EKITI STATE, NIGERIA

[1]Ago, N. D., [1]I.Y. Yem., [1]R.Y. Atiribom., [1]B. M. Gwari., [1]D. C. Nwangwu., [1] E. A. Robert and [2] T.E. Binyotubo [6]

[1]National Institute for Freshwater Fisheries Research, P.M.B. 6006, New Bussa, Niger state.
[2]Nigeria Maritime University, Okerenkoko, Delta State.

Corresponding author:
henusgo2010@gmail.com, +234 8057325358

ABSTRACT

A frame and catch assessment survey of the fisheries resources of Egbe reservoir was undertaken for a period of five months (August – December, 2023). Two communities were found to be closely attached to the reservoir. A total of 57 fishers were recorded to be using gillnets, castnets, longlines, malian pot traps, wire traps and spears for their fishing activities. Five fish families, Cichlidae, Channidae, Clariidae, Hepsetidae and Mormyridae, consisting of seven species were recorded. Cichlidae dominated the fish population (75.91% by number and 71.66 by weight) and Coptodon zillii was the most abundant species. Estimated annual potential fish yield was 181.45 metric tons per annum while the actual fish yield was 20.41 tons per annum with 11.25% of the fishery resources exploited. The few species of fish and their abundance encountered in the reservoir indicated that the reservoir is under-exploited and it can support increased fish production if proper measures are taken to enhance sustainable use of its aquatic resources.

Keywords:
Egbe reservoir,
fish abundance,
potential fish yield,
actual fish yield

INTRODUCTION

Lakes and reservoirs are invaluable ecological resource that serve many human needs and enhance our lives by providing a lot of opportunities. According to Akachukwu et al. (2019), a large proportion of the Nigerian population live and rely heavily on the resources of water bodies such as lakes, reservoirs, rivers, swamps and coastal lagoons as their source of animal protein and income. The Egbe water reservoir is one such water body. Located in Ekiti State, South-West Nigeria, the Reservoir, with a water surface area of 272.5 hectares, takes its source from Kwara State and empty into the Osse River in Ondo-State (Edward and Ugwumba, 2013). It lies between latitudes 7036'N and 7039' North and longitude 5032' E and 5035' East. Built for domestic use and irrigation to the people of Gbonyin Local Government Area of the State but also serves as a source of fish protein for a number of members of the riparian communities. This potential can be improved upon through the generation and analysis of frame-and-catch data of the reservoir to meet the national goal of increase inland fish production and food security for better livelihoods of the people. Though some fisheries studies were carried out on the reservoir by Edward and Ogwumba (2013), this current study was done to up-scale such studies in view of the importance of the fisheries aspect of the reservoir to the riparian communities. A 5-month frame and catch assessment survey were undertaken between in 2023 to provide data required for the reservoir's optimum exploitation, management and development.

MATERIALS AND METHODS

Data for the frame survey were generated from communities around the reservoir using structured questionnaires and interviews with the head of fishers. Total count and listing of all the fishing villages, landing sites, fishers and fishing equipment operating on the reservoir were made following the methods of du Feu and Abiodun (1998), Abiodun and Ayanda (2007), FAO (2024) and Ago et al. (2020). During the catch assessment, fishers' catches at various landing sites were assessed. Whenever a fisher landed with a canoe, fish caught were identified using identification manuals of Idodo-Umeh (2003) and Olaosebikan and Raji (2021), and sorted according to species and the gear type used.

Potential fish yield

In order to predict a value as the potential fish yield of the reservoir in kg/ha/annum, the Morpho-Edaphic Index (MEI) method as described by Henderson and Welcome (1974 cited in Edward, 2013, p. 260) was adopted. Water quality parameters such as temperature, pH, electrical conductivity and the average depth of the reservoir were taken into cognisance. The depth at each sampling station was measured using the method of Idowu and Ayoola (2008). The pH and conductivity were measured in-situ using a digital pH meter Suntex® (model TS-2) and a conductivity meter model DA-I code 1908 respectively. MEI was computed by dividing the conductivity in micro-siemens per centimeter (μS/cm) by the average depth in meters (m) of the reservoirs as follows:

$$\text{MEI} \frac{conductivity}{mean\ depth}$$

While the Potential Fish Yield (PFY) in kilogram per hectare (kg ha1) was predicted using the formula: PFY=23.281x $\text{MEI}^{0.447}$ (Edward, 2013).

Current/Actual fish yield

To estimate the current/actual fish yield in kilograms per annum, the method of Abiodun et al. (2014) was adopted. Thus, the current fish yield was computed as follows:

Total catch = Total fishing effort * Catch per unit effort 1

Fishing effort = Fcap * BAC * A 2

Where Fcap = Fishing capacity (the total number of fishing boats that are potentially operating at all fishing sites)

BAC = Boat Activity Coefficient (the probability that any boat will be active on any day during the month)

A = A raising time factor expressing total number of days that fishing activities take place during the month.

RESULTS

Frame Survey

Two fishing communities (Egbe and Ode-Ekiti) were found around the reservoir. A total of three landing sites were identified. One at Egbe and two at Ode-Ekiti. Table 1 shows the distribution of the fishers, their fishing crafts and gears at the existing communities. A total of 57 fishers were enumerated.

Table 1: Frame data of Egbe reservoir

Fishing community	No. of landing sites	No. Fishers	Canoe	GN	CN	LL	MT	WT	S
Ode-Ekiti	2	37	45	280	12	57	708	2879	9
Egbe	1	20	15	100	7	20	300	1000	4
Total	3	57	60	380	19	77	1008	3879	13

GN= Gill nets, CN=Cast nets, LL=Longlines, MT=Malian traps, WT=Wire traps, S=spare

Sixty (60) wooden canoes were counted. Fishing gears recorded include: 380 gillnets, 19 castnets, 77 longlines, 1008 Malian traps, 3879 wire traps and 13 spares.

Catch Assessment

Table 2 shows a total of 7 fish species from 5 families were recorded at the reservoir. The family Cichlidae was the most abundant family contributing 75.91% by number and 71.66% by weight of the total fish caught on the reservoir; while Mormyridae was the lowest abundant family accounting for 0.58% and 0.15% in terms of number and weight respectively.

Table 2: Fish composition, abundance and weight (Wt) on Egbe reservoir Current Fish Yield of Egbe Reservoir

Family/Species	No	% No	Wt(kg)	%Wt	Mean Weight (kg)
Cichlidae					
Oreochromis niloticus	540	19.65	23.12	14.78	0.043
Coptodon zilli	1 072	39.01	57.91	37.01	0.054
Sarotherodon galilaeus	474	17.25	31.1	19.87	0.066
Channidae					
Parachana obscura	56	2.04	6.71	4.29	0.120
Clariidae					
Clarias buthupogon	379	13.79	14.5	9.27	0.038
Hepsetidae					
Hepsetus odoe	211	7.68	22.91	14.64	0.109
Mormyridae					
Mormyrops anguilloides	16	0.58	0.23	0.15	0.014
Total	2 748	100.00	156.48	100.00	

In the course of this study, interactions with fishers on the reservoir revealed that an average of 10 fishing units operate per day on the reservoir. Fishing activities are said to take place for an average of 27 days in a month. Catch per unit effort (CPUE) is found to be 6.3kg per fisher per fishing day. Production per annum can therefore be estimated from the catches of the average of ten fishers operating daily on the reservoir.

This is thus calculated:

Daily Total Catch (kg) = [Daily average no. of fishers x CPUE]

Annual Catch = Daily Total Catch (kg) x 27days x 12months

= 6.3 x 10 x 27 x 12 = 20 412kg

Current Fish Yield per annum of the reservoir = 20 412kg per annum. This is equivalent to 20.41 metric tons per annum.

Potential Fish Yield of Egbe Reservoir

The potential fish yield per annum of Egbe reservoir is estimated using the Morpho Edaphic Index (MEI) prediction technique of Henderson and Welcomme (1974). The technique has gained recognition as a tool for predicting fish yield in lakes and reservoirs in all regions and for providing a quick evaluation of potential yield. It was used by Ovie et al. (2011 and 2015) and Ago (2019). The MEI is calculated by dividing the total dissolved solids or conductivity (μS/cm) by the average depth (m) of the water body as follows:

$$MEI = \frac{conductivity}{Mean\ Depth}$$

$$= \frac{45.6}{6.53} = 6.98$$

Potential Fish Yield (PFY) = 23.281 x MEI $^{0.447}$ = 23.281 X 6.98$^{0.447}$ = 55.49 $^{kg\ ha\text{-}1}$

$$\text{Potential Fish Yield Per Annum} = \frac{\text{PFY IN Kgha}^{-1} \times \text{surface area of Egbe Reservoir(ha)} \times 12}{1000}$$

$$\frac{55.49 \times 27.5 \times 12}{1000} = \frac{181452.3}{1000}$$

$$= 181.45 \text{ metric tonnes per annum}$$

$$\text{Percentage exploitation of Egb reservoir} = \frac{20.41 \text{ Mt}}{181.45 \text{ Mt}} \times 100 = 11.25\%$$

$$\% \text{ Unexpected} = 100 - 11.5 = 88.75\%$$

DISCUSSION

Egbe water reservoir can justly be classified as a small waterbody having a small-sized fishery. With a total surface area of 272.5 hectares (<3km2) (Edward, 2013), only two permanent fishing communities were found to be closely attached to it and a total of 57 fisherfolks were also found to be operating on the reservoir. However, with the recommendation of a density of two (2) full-time fishers per square kilometre, not more than 6 full-time fishers would be permitted on the reservoir. Based on this hypothesis therefore, the reservoir can be regarded as been over-flocked with 57 fisherfolks majority of whom used below the recommended mesh-sized nets (<76.2mm) on the reservoir. This is enough reason to cause the generally small sizes of fish that were observed to predominate the fishery of the reservoir. Parachana obscura (0.120kg) and Hepsetus odoe (0.102kg) formed the mean size of the fishes recorded in the course of this study (Ago et al., 2020).

With regard to species diversity, the family Cichlidae had the highest diversity with three species namely: O*reochromis niloticus*, Coptidon zillii, and Sarotherodon galilaeues. They also formed the most abundant species in terms of number and weight. This success of the cichlids in the reservoir is not surprising as the family Cichildae is said to dominate many tropical freshwater bodies under uncontrolled conditions (Edward, 2013) also attributed the preponderance of cichlids to their ability to thrive on a wide range of food items and their prolific breeding nature. The families Channidae, Clariidae, Hepsetidae and Mormyridae had one variant each namely Parachana obscura, Clarias buthupogon, Hepsetus akawo and Mormyrops anguilloides, respectively. The fish species diversity in this study can well be compared with the findings of Edward (2013) that revealed five families and eight different fish species from the same reservoir. This diversity index is however low compared to the findings of Yem et al. (2016) from a similar water body.

There seemed to be a decline in the water conductivity of the reservoir when compared to the findings of Edward (2013) who revealed a conductivity as high as 231 S/cm while only 45.6 S/cm was recorded in the present study. This is not impracticable as water quality conditions are subject to alteration with the slightest change in atmospheric weather and edaphic conditions. The differences in conductivity figures from the two studies conversely led to the different potential fish yields predicted for the same reservoir. No significant difference was noticed in the actual fish yield.

CONCLUSION

Egbe reservoir is one of many water resources that can be branded “under-utilised”. A resource with such magnitude and quality of water can be improved upon for better fisheries production in addition to provision of portable water which is the primary purpose for its creation. A fish species diversity of seven species is considered low when compared with similarly active reservoirs. From the present study, an actual fish yield of 20.41 metric tons was estimated per annum and potential fish yield of 181.45 metric tons per annum was predicted for the reservoir. This implies that only 11.25% of the reservoir is exploited for its fisheries resource. Although this figure is higher when compared to the 4.8% obtained by Edward (2013), a lot can be done to improve the fisheries of Egbe reservoir for the benefit of the riparian communities and the country at large.

REFERENCES

Abiodun, J. A. and Ayanda J. O. (2007). Operational and Management Problems of FisheryEntrepreneurs of the Kainji Lake Basin, Nigeria. Nigerian Journal of Fisheries. 4(1), 66 - 74.

Ago, N. D. (2019). Assessment of The Fisheries of Gurara Reservoir, Kaduna State, Nigeria. A PhD Thesis Submitted to The Department of Biology, A.B.U. Zaria. 188pp.

Ago, N. D., Abiodun, J.A., Auta, J. and Balogun J.K. (2020). Composition and Production of Ichthyofauna in Gurara Water Reservoir, Kaduna State, Nigeria. Nigerian Journal of Fisheries 17(2), 2095 – 2100

Akachukwu, E, N., Arimoro, F.O. and Keke, U.N. (2019). Spatio-temporal variation in some environmental variables of Bosso Dam, Nigeria. Tropical Freshwater Biology, 28 (2), 1-12.

Bankole, N.O. and Mbagwu, I.G. (2000). Aspects of the Fisheries of Lake Alau in North Eastern Nigeria. African Journal of Tropical Hydrobiology and Fisheries. 9 (1), 49-62

du Feu, T. A. and Abiodun J. A. (1998). Fisheries Statistics, Kainji Lake, Nigeria, 1994 – 1998. GTZ Livestock and Fisheries. Eschborn .pp 261 – 275.

Edward, J.B. (2013). Evaluation of the Fisheries Potentials of Egbe Reservoir, Ekiti State, Nigeria. Greener Journal of Biological Sciences. 3(7), 260-267 ISSN: 2276-7762

Edward, J.B. and Ugwumba A.A.A. (2013). Fish Fauna of a Tropical Southern Reservoir in Nigeria. International Journal of Innovative Research & Development. 2 (2), 434 – 444. ISSN: 2278 – 0211. Available at http://interantionaljournalcorner.com/index.php/ijird_ojs/issue/view/8144 [Accessed 6 August 2024].

Food and Agriculture Organisation of the United Nations (FAO) (2024). Fishery and Aquaculture Profiles. Nigeria. Country Profile Fact Sheets. In: Fisheries and Aquaculture. Updated Aug 5, 2024. Retrieved from https://www.fao.org/fishery/en/facp/nga

Henderson H. F. and Welcome R. I. (1974). The relationship of yield to MEI and number of fishermen in Africa Inland Fisheries. CIFA Occasional Paper 1, 19pp.

Idodo-Umeh, G. (2003). Freshwater Fishes of Nigeria (Taxonomy, Ecological notes, Diet and Utilization). Idodo-Umeh Publishers Limited, Benin City, Nigeria 232pp.

Idowu, A. A. and Ayoola, S. O. (2008). Fish Resources and Physicochemical Parameters of Lagoon in Ogun Waterside Local Government Area, Ogun State, Nigeria. Journal of Environmental Extension. 7, 56 – 60.

Ko, H., Choo, H. and Ji, K. (2023). Effect of temperature on electrical conductivity of soils – Role of surface conduction, Engineering Geology 321 August 2023 https://doi.org/10.1016/j.enggeo.2023.107147

Offem B. O., Samson, Y. A. and Omoniyi, I. T. (2009). Fish composition and abundance in the wetlands of Cross River, Nigeria. Aquatic Ecology DOI: 101007/S10452-009-9240-0.

Ovie, S. I., Bwala, R. L. and Ajayi, O. (2011). A preliminary study on limnological stock assessment, productivity and potential fish yield of Omi Dam, Nigeria. African Journal of Environmental Science and Technology. 5(11), 956 – 963. Available online at http://www.academicjournals.org/AJEST

Ovie, S. I., Mbagwu, I. G., Adukwu G. and Ajayi, O. (2015). Preliminary Study on the Limnology and Zooplankton Abundance in Relation to Fish Production in Kontagora Resevoir. NIFFR Annual Report. pp. 49 – 42.

Olaosebikan, B.D. and Raji, A. (2021). Field Guide to Nigerian Freshwater Fishes (4th Edition). Remi Thomas Press.

Yem, I.Y., Bankole, N.O., Ibrahim A. and Kwen, K. (2016). Ichthyofauna Survey of Goronyo Reservoir, Sokoto State, Nigeria. Proceedings of the 31st Annual Fisheries Society of Nigeria (FISON) Conference, held in Katsina, Katsina State, Nigeria. pp. 255- 258.

MORPHOMETRIC CORRELATION, LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR OF *Lates niloticus* FROM CHALLAWA-GORGE RESERVOIR AND RIVER HADEJIA, NIGERIA

[1]SANI, A.A., [2]S.A. ABDULLAHI, [2]A. YUSUF, AND [3]A.K. HABIBU
[1]Department of Wildlife and Ecotourism Management Binyaminu Usman Polytechnic Hadejia, Jigawa State
[2]Department of Biology, Ahmadu Bello University Zaria, Kaduna State
[3]Department of Fisheries and Aquaculture, Federal University Dutsin-Ma, Katsina State
Corresponding author: aminasaniaminu777@gmail.com

ABSTRACT
Morphometric Correlation, Length-Weight relationship and condition factor of Lates niloticus from Challawa-Gorge reservoir and River Hadejia, Nigeria were evaluated from July 2022-March 2023. Fish samples were collected and identified from two water bodies, then morphometric characters were measured, and the length-weight relationship and condition factor were evaluated. The relationship between the total weight and all measured characters indicated a strong positive relationship in both water bodies, however, the coefficient of correlation (r) was higher in River Hadejia than in the Challawa-Gorge reservoir. An isometric growth pattern of Lates niloticus was observed in both the water bodies (b = 3.0337 and 3.0029) Challawa-Gorge and River Hadejia respectively and a mean condition factor of 1.13 (Challawa-Gorge Reservoir) and 1.24 (River Hadejia). Conclusively, a strong positive correlation exists amongst all measured characters of Lates niloticus in Challawa-Gorge reservoir and River Hadejia, River Hadejia with stronger r than Challawa-Gorge reservoir. Moreover, Lates in both water bodies has isomeric growth patterns, and higher condition factors exist in River Hadejia than in the Challawa-Gorge reservoir. Fisheries management interventions It is therefore recommended to prevent over-exploitation of Lates niloticus for future catch in Challawa-Gorge reservoir and River Hadejia because the majority of the fish population was small-sized.

Keywords:
wellbeing; Morphometrics; Lates niloticus; Challawa-Gorge Reservoir; River Hadejia

INTRODUCTION

Nile Perch (Lates niloticus) is native to Africa particularly East and West African water bodies (Asnake, 2018). It is a member of the Latidae formerly Centropomidae. L. niloticus is a carnivore unique to Northern Nigeria (Kahwa, 2013). This fish species has excellent bone-free white flesh/meat that is rich in protein and vitamins including omega-3 which is vital for human consumption, nutrition, wellbeing and development due to these the flesh is widely accepted by many people and distributed global. Its weight and length so far reported were 200 kg and two meters respectively, good fish for aquaculture development (Asnake 2018).

The Challawa-Gorge Reservoir and River Hadejia are considered to be rich with L. niloticus and other fisheries resources. For fish in their natural habitats to evolve and be available for future generations, morphometric variety is essential (Xia et al., 2015). Morphometric measurements are widely used to identify differences between fish populations and have received increased attention in stock identification (Specziar *et al.*, 2009). Various studies have been conducted on the population characteristics (length-weight relationship, condition factor, biology and abundance) of different fish species from different water bodies in Nigeria (Kabir *et al.*, 2021; Kosai *et al.*, 2014; Nazeef and Abubakar, 2013; Haruna 2006; Omoniyi and Agbon, 2004). However, the scarcity of information that exists on the L. niloticus, hinders the development of selective breeding programs. The present study will be useful in decision-making in the management and conservation of fisheries resources. This study therefore aims in provide a broader diversity of knowledge on the morphometric correlation, length-weight relationship and condition factor (phenotypic characteristics) of the two different populations of L. niloticus in both reservoir and river systems that could be used when designing conservation measures.

MATERIALS AND METHODS

Study Area

The Gorge Reservoir is located at 8006'58.04"E latitude 11041'21.95"N longitude in Karaye Local Government of Kano State in the Northwest of Nigeria, about 90 km southwest of Kano city. It is a major Reservoir on the Challawa River, a tributary of the Kano River, while Kano River is the main tributary of the Hadejia River (Etiosa, 2009). River Hadejia is located (longitude 12.65N and latitude 10.64E) in Jigawa state, Northwest of Nigeria. The river forms along with Nguru Lake and is now 80% controlled by the Tiga and Challawa-Gorge Reservoirs in Kano state (Kabir *et al.*, 2021).

Sample Collection

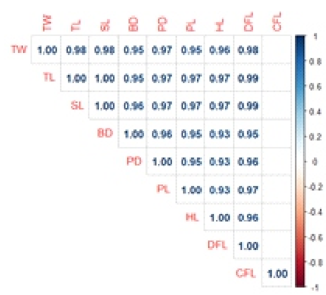
A total of one hundred and twenty-three Nile Perch were purchased from fisherfolks at the landing sites of the water bodies for nine (9) months. The Fish samples were immediately identified using field guide of Olaosebikan and Raji (2013), and morphometric characters (Total Length (TL), Standard Length (SL), Body Depth (BD), Caudal fin Length (CFL), Head Length (HL), Dorsal Fin Length (DFL), Peduncle Length (PL), and Peduncle depth (PD)) were measured to the nearest 0.1cm using centimeter ruler with the exception Total weight (TW) which was measured to the nearest 0.01 g using a digital balance.

Data Analyses

The data were logarithmically transformed to stabilize the variance that could result from size-dependent weight measurements. Fish morphometrics was subjected to correlation. The exponents (b) of LWR were tested for departure from isometry b=3) using W=**a L**^{b} (Pauly, 1983) where W = weight of fish samples, L=total length of fish samples a= intercept= b= regression coefficient. Condition factor (K) was determined using K = ***100W/L3*** where K= condition factor, W= total weight (g), L = total length (cm) and 3 = the cubic relationship between length and weight R-studio and Microsoft Excel packages were used to run all analyses.

RESULTS AND DISCUSSIONS

The morphometric relationship of Lates niloticus population was evaluated, indicating a strong positive relationship in total weight TW to TL, SL, HL, PL, and PD, in both water bodies (Figure 1), however, fish morphometric relationship values (coefficient of correlation (r)) in River Hadejia was higher than the Challawa-Gorge Reservoir, this finding corroborates Kosai et al. (2014), it might be due to the least growth changes in those parameters over the fish size, and River Hadejia has no embankment while Challawa-Gorge Reservoir has embankment.



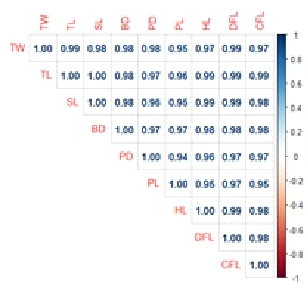


Figure 1: Correlation matrix of the measured morphometric characters of Lates niloticus population in (a) Challawa-Gorge Reservoir (b) River Hadejia

The length-weight relationship and condition factor for both Challawa-Gorge Reservoir and River Hadejia were determined. The L. niloticus populations from both the water bodies showed an isometric growth pattern with values of regression slope b = 3.0337 and 3.0029 for Challawa-Gorge Reservoir and River Hadejia respectively, (b = 3) (Figure 1 and 2). This result obeys the cube law $W=L^3$ that is, the weight of the fish increases in proportion to the cube root of its length and corroborates Kabir et al. (2021); but the present study is in contrast with the records Dambatta *et al.* (2017) in Wudil River, Kano, which may be due anthropogenic and environmental factors prevailing in the aforementioned water body.

The Condition Factor (K) for the L. niloticus population differed significantly ($p<0.05$) among the populations, with 1.13 (Challawa-Gorge Reservoir) and 1.24 (River Hadejia) while the lowest value was obtained in Challawa-Gorge Reservoir (Figure 3). This finding agrees with the ranges recommended by Ujjania *et al.* (2012), stating that a condition factor ≥ 1 is good, indicating a good level of feeding and proper environmental conditions

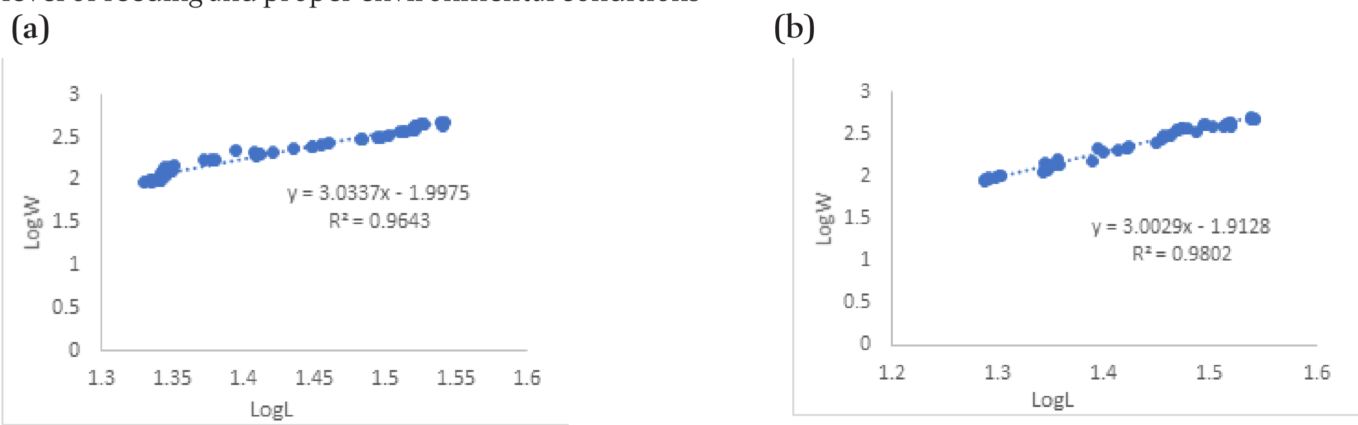
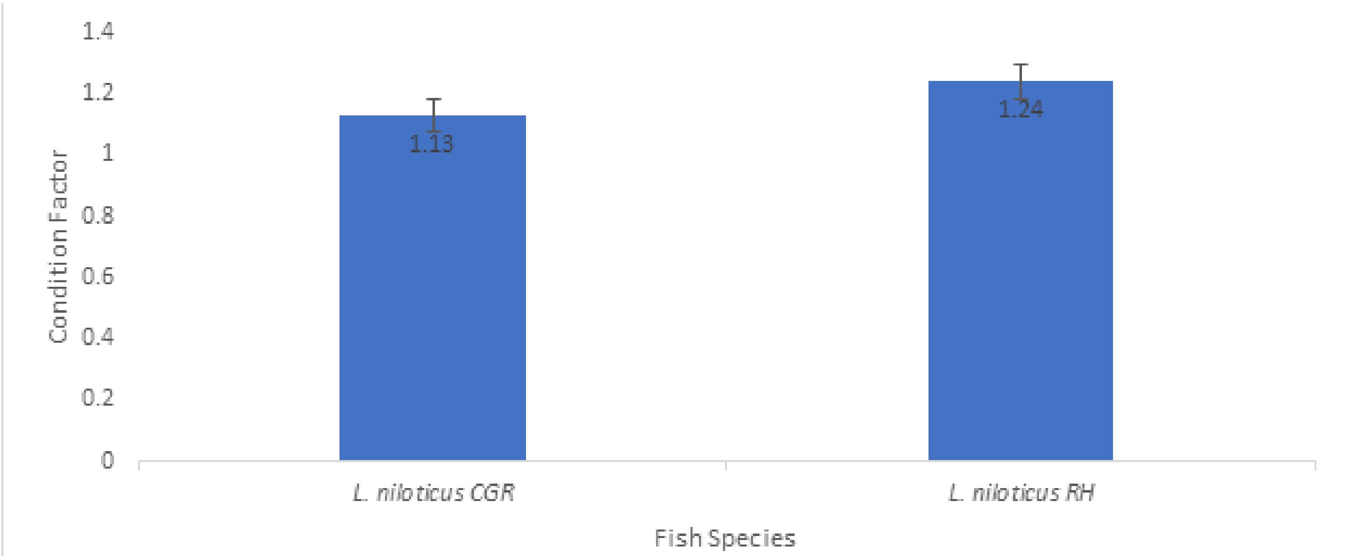


Figure 2: Length-Weight relationship of Lates niloticus in (a) Challawa-Gorge Reservoir (b) River Hadejia



Key: CGR- Challawa-Gorge Reservoir, RH- River Hadejia

Figure 3: Condition Factor of Lates niloticus from Challawa-Gorge Reservoir and River Hadejia

CONCLUSION

In conclusion, a strong positive correlation exists among all measured characters of Lates niloticus in Challawa-Gorge Reservoir and River Hadejia, as River Hadejia has a stronger r than Challawa-Gorge reservoir. Furthermore, L. niloticus in both water bodies had isomeric growth patterns and, a higher condition factors were observed in River Hadejia than in the Challawa-Gorge Reservoir. It is therefore recommended to prevent over-exploitation of L. niloticus for future catch in Challawa-Gorge reservoir and River Hadejia because the majority of the fish population was small-sized.

REFERENCE

Asnake, W. (2018). Nile Perch (Lates niloticus): The Promising White Meat of the World. Journal of Nutrition and Food Sciences, 8(2):680-683

Dambatta, M. A, Bilyaminu, H., Zakari, H., Umar, A. F., Abdulrashed, I. and Sogbesan, O. A. (2017). Length – Weight Relationship and Condition Factor of (Oreochromis niloticus) in Wudil River Kano State, Nigeria. 7th International Conference on Biological, Chemical and Environmental Science (BCES-2017) Sept 6-7, 2017 Budapest (Hungary), 32-37.

Etiosa, U. (2009). The Efficiency and Impacts of Ams: A Case Study of Challawa-Gorge Reservoir. 2003:84064.

Haruna, M.A. (2006). Length -weight relationship of four fish species chichlidae from magagalake, keno, Nigeria. Best Journal, 3:109-111.

Kabir, M, Nasir, M, Tahir, A.T, Ashiru, R.M, Umar, A.M and Ibrahim, U, (2021). Stock Assessment of Oreochromis niloticus and Clarias gariepinus from River Hadejia, Jigawa State. American Journal of Biological and Environmental Statistics, 7(4): 88-93.

Kahwa, D. (2013). Gametogenesis, Gonadal Recrudescence, Restraint and Spawning Patterns in Nile perch, Lates niloticus (Linnaeus, 1758). PhD Thesis. Graham s town, Rhodes University, South Africa. 18-25.

Kosai, P., Sathavorasmith, P., Jiraungkoorskul, K. and Jiraungkoorskul, W. (2014). Morphometric Characters of Nile Tilapia (Oreochromis niloticus) in Thailand. Agriculture Technology and Biological Sciences, 11(10): 857-863.

Nazeef, S and Abubakar, U. M. (2013). Diversity and Condition Factor of Fish Species of DadinKowa Dam, Gombe State, Nigeria. Greener Journal of Biological Sciences, 3(10): 350- 356.

Olaosebikan, B. D. and Raji, A., (2013). Field guide to Nigerian Freshwater fishes. Printed by Remi Thomas Press 1998. ISBN 978-34 760-0-9 Revised edition 2013.

Omoniyi, I. T. and Agbon, A. O. (2004). Morphometric Variation in Sarotherodon melanotheron (Pisces: CICHLIDAE) from Brackish and Freshwater Habitats in South West Nigeria. Proc. of t he 29th Annual Conference of the Genetics Society of Nigeria, Oct. 11- 14, 2004, Abeokuta, Nigeria, University of Agriculture, 20-22

Specziar, A., Bercsenyi, M. and Muller, T. (2009). Morphological Characteristics of Hybrid Pikeperch (Sander lucioperca x Sander volgensis) (Osteichthyes, Percidae). Acta Zoology Hungary, 55:39-54.

Ujjania, N.C., Kohli, M.P.S. and Sharma, L.L. (2012). Length-weight relationship and condition factors of Indian major carps (C. catla, L. rohita and C. mrigala) in Mahi Bajaj Sagar, India. Research Journal of Biology, 2 (1), 30-36

Xia, J. H., Bai, Z., Meng, Z., Zhang, Y., Wang, L., Liu, F., Jing, W., Wan, Z. Y., Li, J., Lin, H. and Yue, G.H., (2015). Signatures of selection in tilapia revealed by whole genome resequencing. Scientific Report. 5:14168.

SPECIES ASSEMBLAGE AND LENGTH-WEIGHT RELATIONSHIP OF *Chrysichthys nigrodigitatus* FROM CROSS RIVER SYSTEM, ITU, NIGERIA

OKON, I. E., U. S. JACOB, A. I. ISANGEDIGHI, AND J. P. UDOH,

Department of Fisheries and Aquatic Environmental Management, Faculty of Agriculture, University of Uyo, Uyo, Akwa Ibom State, Nigeria.

Corresponding Author: udujacob@yahoo.com, +234 7031139056, 0009-0000-4730-2995

ABSTRACT

Species assemblage and length-weight relationship evaluation provide ecological and management information for fisheries sustainability. Species assemblages and the length-weight relationship of Chrysichthys nigrodigitatus were evaluated from the Cross River system Itu, Nigeria. 162 fish Samples were collected from January - May 2024 from artisanal fishermen's landings and analyzed for species assemblage and length-weight relationship. The highest species assemblage was Chrysichthys nigrodigitatus consisting of 72 individuals, while the lowest was Chrysichthys walkeri and parachanna obscura with 3 individuals each. The mean total length and body weight recorded were Oreochromis niloticus (18.52±0.67cm and 135.30±16.37g); Chrysichthys nigrodigitatus (28.29±0.98cm and 210.16±19.66g); Clarias gariepinus (20.77±1.67cm and 40.39±3.12g); Cynoglossus senegalensis (31.31±1.23cm; and 102.33±11.78g). Length-weight relationship results revealed that Chrysichthys walker, Oreochromis niloticus, Chrysichthys nigrodigitatus, Pomadasys peroteti, and Ethmalosa fimbriata had negative allometric growth ($b<3$) while parachanna obscura has positive allometric growth ($b>3$). However, Cynoglossus senegalensis had the lowest condition factor k (0.32) while Oreochomis niloticus had the highest condition factor k (2.03). Family Clarotidae had two species while others had one each. This study provides baseline information on species assemblage and length-weight relationship of Chrysichthys nigrodigitatus from the cross-river system which is critical for establishing monitoring and management programmes for freshwater fisheries in Nigeria.

Keywords:
Fish ecology, Ichthyofaunal assemblage, Chrysichthys nigrodigitatus, Condition factor, Cross-river system,

INTRODUCTION

The dietary component, nutritional value, and socioeconomic relevance of fish worldwide makes it one of the most sought-after natural food resources. However, fisheries stock decline in different parts of the world due to overexploitation, environmental degradation, and pollution threaten their sustainability (Coll *et al.*, 2010). Fisheries resources constitute a vital economic value for nations around the world, especially maritime. On the other hand, efforts to sustain a healthy marine environment and preserve fisheries resources yielded unfruitful results thereby making fisheries stock collapse inevitable (Tsikliras *et al.*, 2015).

Determining species assemblage and length-weight relationship is critical for fisheries ecological studies and biometric assessment. It provides information about the biological and ecological conditions influencing the well-being of the fish species (Udoh and Okon, 2017; Jacob *et al.*, 2023). Species assemblage and length-weight relationship have been reported in different parts of the world

(Özvarol 2014; Rimel *et al.*, 2015). In the cross-river system, fisheries research has focused mainly on the toxicity profile of the river sediment and fish muscle (Isangedighi *et al.*, 2024; Odoemelam, et al., 2020). Furthermore, a further scientific databases searches revealed scarce information on species assemblage and length-weight relationship of Chrysichthys nigrodigitatus inhabiting cross-river systems. This study is aims to provide and update existing scientific information on species assemblage and length-weight relationship of Chrysichthys nigrodigitatus inhabiting the cross-river system, Itu, Nigeria.

MATERIALS AND METHODS

Cross River system is located in South-South Nigeria between longitude 7o 30' and 9°30' North and latitude 4°30' to 7°15' East (Fig. 1). The area is marked by North-South movement of maritime (Atlantic) and dry continental (Sahara) air masses which creates distinct dry and wet seasons in the area (Jacob et al., 2023; Isangedighi *et al.*, 2024). The predominant human activity in this area includes farming, fishing, and commercial activities. This area's maximum temperature and annual rainfall are between 26-28°C and 362.5mm, respectively (Opeh and Udo, 2017).

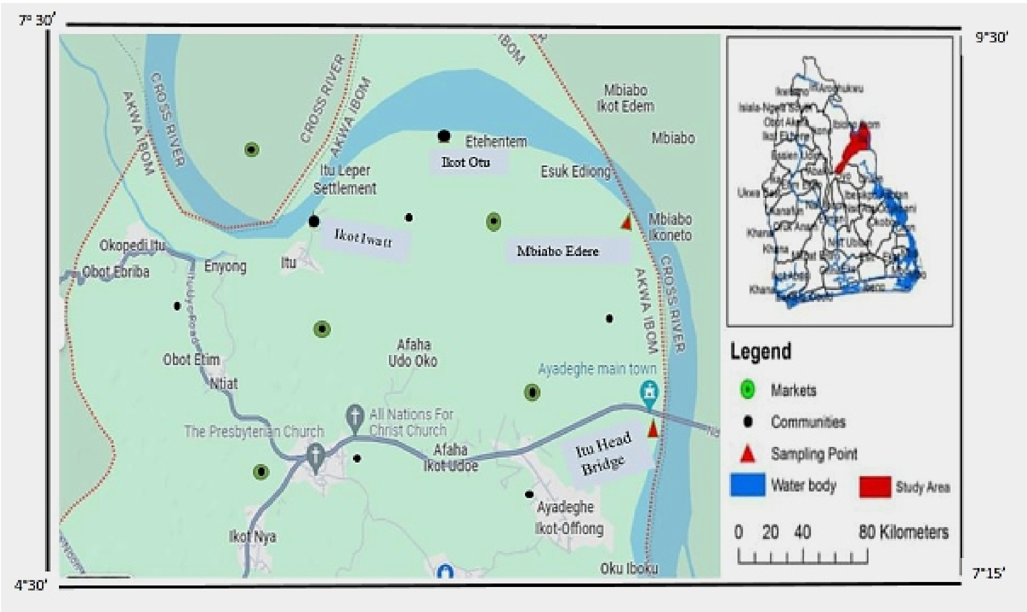


Figure 1: Map of the Study area

A total of 162 fish samples belonging to eight families and nine species were collected from commercial catches of artisanal fishermen from January - May 2024. Fishing gear used by the fishermen includes gill nets, seine nets, cast nets, hooks, fish, and bamboo traps. Each sampling was carried out between 08:30 am and 4.30 pm Nigerian time. Thereafter, the Fish were transported in an ice chest to the Department of Fisheries and Aquatic Environmental Management University of Uyo, Uyo, Nigeria for sorting, identification, and morphometric measurement. The total body weight (BW) and the total length (TL) of each fish were measured to the nearest 1g and 1cm respectively. Fish identification was carried out using the identification key guide of Nigerian freshwater fishes (Olaosebikan and Raji, 2013).

Length-weight relationships

The log transformation formula (Le Cren, 1951) was used to establish the LWRs equation W = a Lb. This was used to estimate the relationship between the total body weight (g) of the fish and its total length (cm). Using the linear regression of the log-transformed equation: log (W) = log (a) + b log (L), the parameters a and b were calculated with 'a' representing the intercept and 'b' the slope of the relationship.

Statistical analysis

Data were analyzed using IBM SPSS statistics version 25. To investigate the LWRs data, ANOVA was used to evaluate the statistical significance of the regression model detected when $P < 0.05$ (Gökçe *et al.*, 2010). The b-value was assessed according to the established convention $b < 3$ (negative allometric growth), $b = 3$ (isometric growth), and $b > 3$ (positive isometric growth) (Yilmaz et al., 2012).

RESULTS

Table 1. Showed results of the species assemblage and length-weight relationship, and growth of Chrysichthys nigrodigitatus. The total length of Oreochromis niloticus varied between 15.5 - 23.5cm (18.52±0.67cm) and the weight also varied between 76.30 - 247.55g (135.30±16.37g). The condition factor, k, was 2.03, and the b value was 2.85.

Table 1: Length-Weight Relationship Parameters, Body Condition Factors values and growth pattern

Family	Species	No	Length (cm)	Weight (g)	a	b	r^2	K	Growth
Ciclidae	*Oreochromis niloticus*	14	18.52±0.67 (15.5 - 23.5)	135.30±16.37 (76.30 - 247.55)	3.12	2.85	0.8873	2.03	-A
Claroteidae	*Chrysichthys nigrodigitatus*	72	28.29±0.98 (16.1 - 49.2)	210.16±19.66 (15.00 – 900.00)	2.74	0.83	0.6036	0.83	-A
	Chrysichthys walkeri	3	22.73± 2.18 (20.5 - 27.1)	106.03±37.71 (58.88 - 180.6)	2.83	2.82	0.981	0.83	-A
Clariidae	*Clarias gariepinus*	8	20.77±1.67 (14.1 - 25.4)	101.60±13.66 (143.02 - 81.82)	0.85	3.28	0.0827	1.51	+A
Cynoglossidae	*Cynoglossus senegalensis*	12	31.31±1.23 (23.0 - 37.0)	102.33±11.78 (35.98 - 163.25)	2.23	1.90	0.9616	0.32	-A
Sciaenidae	*Pseudotholithus senegalensis*	24	17.38±0.40 (14.2 - 22.8)	45.77±5.91 (19.35 - 152.98)	2.42	2.85	0.6095	0.81	-A
Haemulidae	*Pomadasys peroteti*	15	15.99±0.43 (13.7 - 20.3)	59.42±7.30 (23.98 - 137.31)	2.80	2.04	0.9502	1.37	-A
Dorosomatidae	*Ethmalosa fimbriata*	11	16.59±1.25 (12.4 - 27.8)	60.94±20.19 (20.93 - 256.50)	2.75	1.99	0.9515	1.08	-A
Channidae	*parachanna obscura*	3	28.33± 2.26 (24.9 - 32.6)	247.46±91.45 (141.49-429.56)	3.66	3.64	0.941	0.99	+A

I: Isometric; -A: Negative Allometric; +A: Positive Allometric; b= exponent; a=intercept

The total length and the body weight of *Chrysichthys nigrodigitatus* ranged between 16.1 - 49.2cm (28.29±0.98cm) and 15.00 – 900.00g (210.16±19.66g), and the k and b value was 0.83 and 0.83 respectively. *Chrysichthys walkeri* has a total length and body weight range from 20.5 - 27.1cm (22.73± 2.18cm) and 143.02 - 81.82g (106.03±37.71g), the condition factor, k, was 0.83 and b value was 2.82. In *Clarias gariepinus* the total length ranged between 14.1 - 25.4cm (20.77±1.67cm) and the body weight ranged between 12.0 - 121.1g (40.39±3.12g) and the respective k and b value were 1.51 and 3.28.

DISCUSSION

Species assemblage and length-weight relationship evaluation provide valuable scientific information on the biology, physiology, ecology, population dynamics, and stock assessment which is imperative for life histories of the same species in different regions (Epler *et al.*, 2009). Information derived from species assemblage and the length-weight relationship of *Chrysichthys nigrodigitatus* can be applied to

the sustainable management of ichthyofaunal species in tropical and subtropical freshwater systems.
The estimated length-weight relationship parameters (a and b), the coefficient of variation (r2), and the growth pattern are shown in Table 1. Based on the b-value and its statistically significant difference ($P < 0.05$), the growth type is identified as isometric growth (I) for b = 3, positive allometric growth for b > 3, and negative allometric growth for b < 3. C*hrysichthys walkeri* and *Pseudotholithus* senegalensis had b = 3 indicating isometric growth pattern. C*hrysichthys nigrodigitatus*, C*larias gariepinus*, *Cynoglossus senegalensis*, *Pomadasys peroteti*, and *Ethmalosa fimbriata* had a b < 3, which indicates a negative growth pattern. Oreochromis niloticus and Parachanna obscura exhibited b > 3 indicating a positive allometric growth pattern. These results did not agree with the report of Abowei (2009) on Hepsetis odoe from the Nkoro River, Niger Delta, Nigeria. This may be due to the variations in the sampling period, sampling location, and study season. Froese (2006) reported a b-value of 2.5235 for Diplodus puntazzo which indicated a negative allometric pattern that was similar to the value recorded for C*hrysichthys nigrodigitatus*, C*larias gariepinus*, Cynoglossus senegalensis, Pomadasys peroteti and Ethmalosa fimbriata in this study. However, variation in the growth pattern of a species usually occurs among individuals of the same population over a short or long period due to the availability of food (Ricker, 1975); water quality, biological, temporal, and sampling factors (Mehanna and Farouk, 2021). It is important to note that sampling factors of the catchment area, fish community, fish weights as measured in each work, and time of collection, as well as the laboratory personnel and instrument errors, can contribute to the result of the study (Evelyn, 2023).
Increased food availability and favourable environmental conditions usually result in increased tissue growth, and energy storage in the muscle tissue and liver with an attendant increase in the length and weight of the fish. This favourable condition always resulted in an increased relative condition factor, k (Busacker *et al.*, 1990). Condition factor remains an integral fisheries analysis tool roughly used to assess fish condition, state of nutrition, fitness, and body physiological, starved or fed, spawned or spent, healthy or unhealthy (Busacker et al., 1990). Condition factor, k ≥ 0.5 indicates the fish is in good condition (or high nutritional state). Therefore, in our study, only Cynoglossus senegalensis had a k-value less than 0.5 indicating poor habitat conditions. Other fish species had a k-value greater than 0.5 indicating favourable habitat conditions. Environmental factors, food supply, and parasitism may have a strong influence on fish health (Le Cren, 1951). Low feeding intensity and degeneration of ovaries may lead to low k value in fish in some seasons, while high k values could be attributed to high deposition of fats as preparation for the spawning season. A population and a species cannot express constant condition factors over a long time. Variations usually occur due to both biotic and abiotic factors such as feeding regime and stage of gonadal development. Transfer of energy to gonads development during reproduction in certain stage of fish life history might lead to decreased condition factor, k (Lizama *et al.*, 2002). Other factors such as season of the year, availability of prey organisms, growth, maturity, and stomach fullness have a profound influence on fish condition factor, k, value.

CONCLUSION

A study on LWR and condition factors is important to understand the health status of commercially important and recreational fishes. In this study, the three growth patterns namely isometric growth, positive and negative allometric growth pattern, were recorded. The present study revealed a mixed response to ecological conditions by the different fishes. The results also had some variations from previous studies related to length-weight relationship in fish from Nigeria and other part of the world, in response to change in biological, physiological, and environmental factors. The results of this study are critical in understanding the effects of environmental and human-induced effects on fish. Furthermore, this study provides significant information for fish stock assessment in the Cross River system, Itu, Nigeria.

REFERENCES

Abowei, J. F. N. (2009). The Condition Factor, Length-Weight Relationship and Abundance of Elops seneganensis (Regan, 1909) from Nkoro River, Niger Delta, Nigeria. Advance Journal of Food Science and Technology, 2(1): 16–21.

Busacker, G. P., Adelman, I. R. and Goolish, E. M. (1990). Growth.Methods for fish biology (Eds. Schreck, C.B., and Moyle, P.B.). American Fisheries Society, Bethesda, Maryland, USA-PCWA- L 446, pp: 363.

Coll, M., Piroddi, C., Steenbeek, J., Kaschner, K., Ben Rais Lasram, F., Aguzzi, J., Ballesteros, E., Bianchi, C. N., Corbera, J., Dailianis, T. and Danovaro, R. (2010). The biodiversity of the Mediterranean Sea: estimates, patterns, and threats. PloS one, 5(8), 11842.

Epler, P., Nowak, M., and Popek, W. (2009). Growth rate of the chub (Squalius cephalus) and the nase (Chondrostoma nasus) from Raba, Dunajec, and Poprad River. Aquaculture, Aquarium, Conservation & Legislation. 2(1), 1–8.

Evelyn, R. (2023). Length-weight relationship and well-being factors of 33 fish species caught by gillnets from the Egyptian Mediterranean waters off Alexandria. Egyptian Journal of Aquatic Research, 49: 361–367.

Froese, R. (2006). Cube law, condition factor, and weight–length relationships: history, meta-analysis, and recommendations. Journal of applied ichthyology, 22(4), 241–253.

Gökçe, G., Cekic, M., and Filiz, H. (2010). Length-weight relationships of marine fishes off Yumurtalık coast (İskenderun Bay), Turkey. Turkish Journal of Zoology, 34(1), 101–104.

Isangedighi A. I., Imaobong E. O., Jacob U. S., and Andikan E. U. (2024). Assessment of Heavy Metal Concentration in Commercially Important Fishes from Cross River System Itu, Nigeria. Bima Journal of Science and Technology, 8(2): 2536–6041.

Jacob, U. S., Okoboshi, A. C., Jonah, E. U., Ejemole, K. I., Oji, A. E., Isangedighi, I. A., Asifia, N. S., and Inyang, U. A. (2023). Physicochemical Parameters and Ichthyofaunal Composition of Streams in Ikono and Ibiono Ibom Local Government Area, Akwa Ibom State, Nigeria. Journal Applied Science Environmental Management, 27 (10) 2257–2263.

Le Cren, E. D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (Perca fluviatilis). The Journal of Animal Ecology, 201–219.

Lizama, M. D. L. A. P., and Ambrosio, A. M. (2002). Condition factor in nine species of fish of the Characidae family in the upper Paraná River floodplain, Brazil. Brazilian Journal of Biology, 62, 113-124.

Mehanna, S. F., and Farouk, A. E. (2021). Length-Weight Relationship of 60 Fish Species From the Eastern Mediterranean Sea, Egypt (GFCM-GSA 26). Frontiers in Marine Science, 8. https://doi.org/10.3389/fmars.2021.625422 625422.

Odoemelam, S. A., and Udongwo, A. M. (2010). Heavy Metals Pollution in Surface Water and Sediment of Lower Cross River System in Akwa Ibom State, igeria. Communication in Physical Sciences, 5(1, 2, 3).

Olaosebikan B. D., and Raji, A. 1998. The field guide to Nigeria's freshwater fishes. FCFFT P.M.B.1500, New-Bussa Niger State, Nigeria Decency Enterprise and Stationary Ltd.

Opeh, B. P. and Udo, P. J. (2017). Biodiversity of Fishery Resources of the Cross River System: Implication for Conservation and Management. Journal of Aquaculture and Marine Biology, 6(3): 00154. DOI: 10.15406/jamb.2017.06.00154.

Özvarol, Y. (2014). Length-weight relationships of 14 fish species from the Gulf of Antalya (northeastern Mediterranean Sea, Turkey). Turkish Journal of Zoology, 38, 342–346.

Ricker, W. E. (1975). Computation and interpretation of biological statistics of fish populations. Fisheries Resources Board Bulletin. 191, 1–382.

Rimel, B., Mourad, C. and Koched, W. (2015). Length-Weight Relationships of 15 Ground Fish

Species Caught In Tunisian Deep Water (Sw Mediterranean Sea). International Journal Recent Science Resources. 6(9), 6386–6388.

Tsikliras, A. C., Dinouli, A., Tsiros, V. Z., and Tsalkou, E. (2015). The Mediterranean and Black Sea fisheries at risk from overexploitation. PloS one, 10(3), 0121–188.

Udoh, J. P., and Okon, I. E. (2017). Environmental factors forcing patterns of in-stream fish assemblages of the Lower Cross River Estuary at Oron, Southeast Nigeria. Tropical Freshwater Biology, 26(1), 11–28.

Yılmaz, S., Yazıcıoğlu, O., Erbaşaran, M., Esen, S., Zengin, M., and Polat, N. (2012). Length-weight relationship and relative condition factor of white bream, Blicca bjoerkna (L., 1758), from Lake Ladik, Turkey. Journal of Black Sea/Mediterranean Environment, 18(3), 308–387.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

FRAME AND CATCH ASSESSMENT SURVEY OF LAKE FEFERUWA, LAFIA NASARAWA STATE, NIGERIA

[1]**Kwala, G. J. and [2]A. A. Kigbu**
[1]Department of Fisheries and Aquaculture, Federal University of Lafia, PMB 146 Lafia, Nasarawa State Nigeria
[2]Department of Fisheries and Aquaculture, Nasarawa State University Keffi, PMB 1022 Keffi, Nasarawa State, Nigeria
Correspondence author: alexkigbu@nsuk.edu.ng. +2348039534309

ABSTRACT
Lake fisheries play a vital role in the provision of fish protein to the people of Feferuw Nasarawa State. However, for several years, dwindling catches from these resources have become common knowledge. The study was conducted in the Feferuwa Lake, Lafia East of Nasarawa State, Nigeria to mainly assess fish communities, fish catches, fishers and gears and crafts used in the Lake. Six (6) landing sites or fishing villages, 192 fishers, 9 motor canoes and 145 canoes without engine were recorded. The fishing villages identified are Gidan Atla, Chan Kusu, Gidan Jidan, Tunga Nupawa, Tunga Daudu and Gidan Dogo. The fishing gears identified with fishermen are gillnets, cast nets, trawl nets, fyke nets, Malian traps and hooks and lines. The study revealed seventeen (17) fish species belonging to eight (8) families in the lake. Catches were dominated by the family Cichlidae 6938 (85.80%) with Oreochromis niloticus being the predominant species (42.68%), followed by Claridae 551(4.03%), Schilbiade 531 (5.97%) while the family with lowest abundance was Gymnarchidae 23 (0.17%). Fish catches were generally poor as a result of increasing number of fishers, therefore, closed season of fishing should be considered to promote spawning and growth of fish.

Keywords:
Frame Survey, Catch assessment Survey, Lake Feferuwa, Lafia, Nasarawa State

INTRODUCTION
Freshwater fisheries provide benefits such as food to the people in developing countries. They provided a livelihood and income for millions of the world's poorest people, and also contribute to the overall economic wellbeing of many developing countries by means of export commodity trade, tourism and recreation (World-Fish Centre, 2002). Nigerians are high fish consumers with total consumption figures of about 1.5 million metric tones, out of which about 700,000 metric tonnes is imported (FAO, 2013).
Lakes are invaluable ecological resources that serve many human needs and, therefore, enhance our lives by providing a lot of opportunities. This explains why a large proportion of the Nigeria population lives near water bodies such as lakes, reservoirs, rivers, swamps, and coastal lagoons. Many depend heavily on the resources of such water bodies as their main source of animal protein and family income (Haruna *et al.*, 2006)
Catch Assessment Surveys (CAS) are conducted to obtain reliable current estimates of the total quantity of the fish harvested by fishers. Species composition and fishing efforts involved in the catch are considered as secondary objectives while frame surveys among other things provide reliable estimates of changes in the size and structure in the fishing industry over time.
According to the FAO (2013), out of 1.9 million people engaged in fishing and about 98% belongs to the artisanal sector. However, this sector is characterized by low technology, lack of modern equipment

and low fund, resulting in labour intensiveness with little or no opportunities to expand. Fish is the cheapest source of animal protein to humans, therefore, there is need to protect and manage the fisheries industry. In order to do this effectively, detailed knowledge of artisanal fisheries is of great importance. Due to the varied habits and habitat of the fish species peculiar to water bodies, assorted arrays of fishing gears are equally employed to catch them (Abdul, 2005).

Feferuwa Lake is the largest natural lake in Nasarawa state and has highest fish species composition and abundance based on survey carried out by Ita *et al.* (1979). But most of the species are threatened and catches by fishermen are decreasing justly as reported by fishermen fishing in the Lake. This study, therefore, aims at investigating the status of fishery resources of the lake in order to proffer fishing management practices that will reduce overexploitation of the lake fisheries.

MATERIALS AND METHODS

Description of Study Area

Lake Feferuwa is located between longitude 8°50, East and latitude 8°40, North. It is 40km east of Lafia Local government in Nasarawa state, Nigeria. The lake is approximately 7.5km long and 1.25km wide at its widest point during wet season. Feferuwa Lake originated from springs both outside and within Lafia Local government Area. The water flows through a flood plain area before emptying into Lake Feferuwa through a thickly vegetated inlet channel. The inlet channel of the lake (a continuation of River Feferuwa), flows into River Gwanyaka, which is a tributary of the River Dep. The River Dep flows into the Benue River at the southern eastern corner of the Awe grazing reserve in southern Nasarawa State.

Method of Data Collection

Data for the study were collected through catch composition assessment surveys from the month of January to July, 2023. The frame assessment survey was carried out by going round the entire lake to identify the fishing community, number of fishers, and the fishing crafts and gears employed by fishers in the lake.

The catch assessment survey was conducted twice a week from January to July 2023, at the landing sides. All fish species landed were sorted according to species, counted; weighed, using weighing scale. Genus and species identification of all fishes caught was carried out using the revised edition of Olaosebikan and Raji (2013) and Idodo-Umeh (2003).

Statistical Analysis

Descriptive statistics were used to analyze data collected from the study. The descriptive statistical tools include percentage and bar charts.

RESULTS AND DISCUSSION

The result of frame survey carried out in the Feferuwa Lake is presented in Table 1, while the fishing villages identified is shown in Figure 1. Six fishing villages namely, Tunga, Nupawa, Tunga Daudu, Gidan Dogo, Gidan Jidan, Gidan Atla and Chansu Kusu were identified around the lake. A total of 9 motorboats and 105 canoes without engines were recorded in the six villages, with Tunga Nupawa having the highest number of boats (43 boats), while Gidan Atla has the least number (8 boats). A total number of 192 fishers were recorded, with Gidan Dogo having the highest number of 60 fishers, followed by Tunga Nupawa with 40 fishers, while Gidan Jidan has the lowest number of 15 fishers. The fishing gears used in the fishing villages included gill nets, cast nets, trawl nets, fyke nets, trammel net, wire traps, malian traps, hooks and lines.

Table 1: Result of frame survey showing the distribution of fishing activities on Lake Feferuwa

S/No	Fishing villages	Fishers	Motor Canoes (MC)	Canoe without engines (CE)	Types of gears used
1	Tunga Nupawa	40	3	40	Trammel nets, hook and line, Malian net, gillnet and drag net
2	Tunga Daudu	32	5	30	Cast nets and gill net
3	Gidan Atla	25	1	7	Malian tracks, trammel net and gillnet
4	Gidan Dogo	60	-	33	Gillnets, dragnets, hooks and line
5	Gidan Jidan	15	-	7	Fyke nets, gillnet, cast net and Malian trap
6	Chan Kusu	20	-	58	Malian traps /wire trap/hook and line
	Total	**192**	**9**	**145**	

Table 2 shows the result of catch assessment indicating fish families/species caught, number caught, weight and percentage composition. A total number of 8065 fish belonging to 8 families and 17 Species were caught by fishermen, identified and recorded during the study period. The result revealed that the family Cichlidae has the highest number of four (4) species followed by the families Clariidae, Mormyridae and Schilbide which had three (3) species each while the families Citharinidae, Gymnarchidae, Centropomidae and Polypteridae had one (1) Species each. The table shows that the species Oreochromis niloticus of the family Cichlidae had the highest composition (42.68%) followed by Tilapia zilli with 23.20% and Sarotherodon galillaeus with 18.51% species composition. Gymnarchus niloticus of the family Gymnarchidae had the lowest composition of 0.17%. The result further shows that Cichlidae had the highest percentage weight of 96.86%, followed by Clariidae with 2.62%, while the least were Centropomidae and Gymnarchidae with 0.01% respectively.

Table 2: Result of catch assessment survey from Lake Feferuwa showing fish families/species, number, weight and percentage composition.

Fish family species	Number	Weight (Kg)	% Composition	% Weight
Cichlidae				
Sarotherodon galillaeus	2574	199.8	18.51	6.17
Oreochromis niloticus	5934	474.6	42.68	14.64
Tilapia Zilli	3226	2462.4	23.20	75.98
Tilapia marie	204	2.24	1.47	0.07
Sub total	**6938**	**3139.04**	**85.80**	**96.86**

Claridae				
Clarias gariepinus	234	81	0.53	2.50
Heterobranchus longifilis	208	2.50	2.25	0.08
Clarias anguliaris	109	1.30	1.25	0.04
Subtotal	**551**	**84.8**	**4.03**	**2.62**
Mormyridae				
Mormyrus anguilloides	90	1.12	0.65	0.03
Hyperopisus bebe	85	1.00	0.61	0.03
Mormyrus rume	175	2.14	1.26	0.07
Sub Total	**350**	**4.26**	**2.52**	**0.13**
Schilbidae				
Schillbe mystus	304	2.54	2.19	0.11
Schillbein termedius	326	3.83	2.34	0.12
Eutropius niloticus	201	2.36	1.45	0.07
Sub Total	**531**	**8.73**	**5.97**	**0.30**
Citharinidae				
Citharinus citharus	107	2.27	0.77	0.07
Centropormidae				
Lates niloticus	25	0.30	0.18	0.01
Gymnarchidae				
Gymnarchus niloticus	23	0.25	0.17	0.01
Polypteridae				

Figure 1 gives the abundance of the eight fish families identified; Cichlidae (6938), Clariidae (551), Mormyridae (350) Schilbidae (531), Citharinidae (107) and Polypteridae (80) has the higher fish abundance, respectively, while the remaining families Centropomidae (25) and Gymnarchidae (23) has the lowest fish abundance.

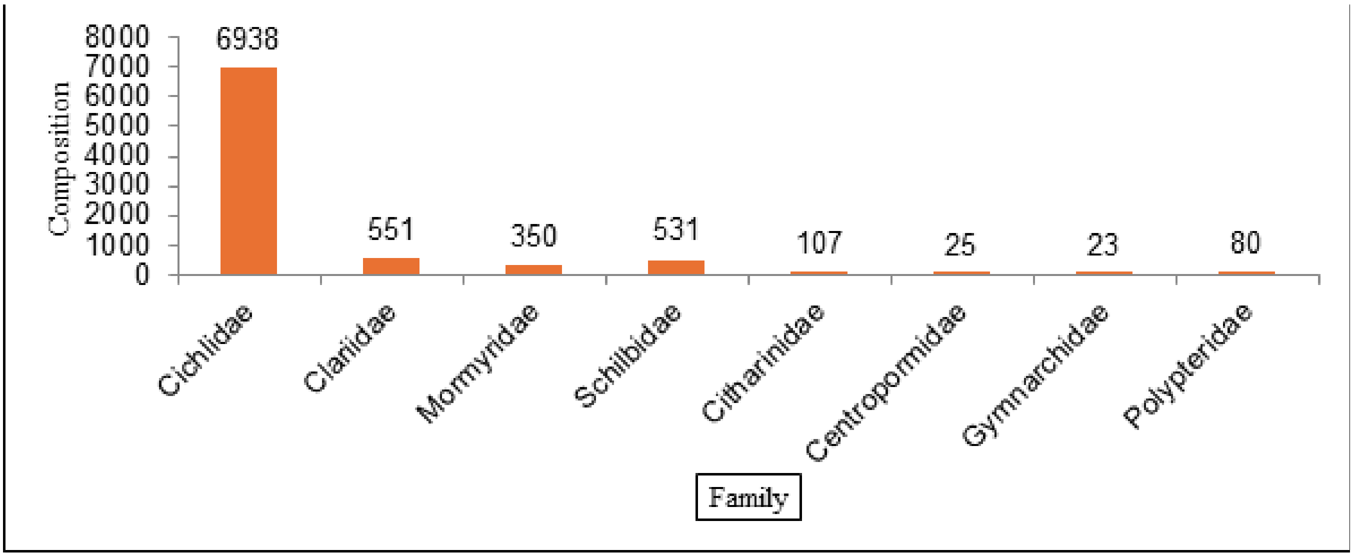


Figure 1: Abundance of fish by families in Feferuwa Lake

The results of this study showed a decline in trend, both in frame and catch survey compared to the records of Ita et al., (1979) in the same Lake feferuwa. A total of six active fishing villages were identified in this study, which is in contrast to the 13, recorded also there was reduction in numbers of Boats and fishers in the lake as compared to report by Ita *et al.,* (1979). This is likely due to the reduction in catches that could have arisen from over-exploitation by the fishers over the years, it could also be the reason some villages abandon the occupation to crop farming. Even in the active fishing villages, most of the fishers engage in fishing on a part-time basis due to low catch in recent years. The alternation in the habitat of the lake ecosystem is another factor that may have led to low catches by the fishers as most of the breeding ground for the fish species has been cleared for arable crops like rice and sugar cane.

Ita *et al.,* (1979) recorded 19 families, and 42 species, but only eight families and 17 species were recorded in this study. The current study showed a declined trend both quantitatively and qualitatively. The result is also in line with the work of Balogun (2005), who reported a decreasing number and weight of fish caught by fishers on Kangimi reservoir. In Lake Feferuwa, majority of the fishers used gill net for catching fish and this corresponds to the work by Ita *et al.* (1979). The gill net method is widely used in artisanal fisheries in developing countries because they are efficient, relatively inexpensive and capable of catching higher amount of commercially valuable species (Valdez-pizzini et al., 1992). The total number of 17 species, belonging to eight different families recorded in the present study is similar to 19 different fish species belonging to nine different families caught by artisanal fishers in Lake Kangimi, Kaduna State (Balogun and Auta, 2001). Abdul (2005) reported 26 species in River Benue around Boronji Area; Balogun, (2005) recorded 18 species in Kangimi Reservoir; 31 species were identified by Gregory et al. (2009) in Anambra River Basin; Nazeef and Abubakar (2013) reported 15 species in Dadin Kowa Dam, Gombe State; Solomon et al. (2017) recorded 27 species belonging to 16 families in Lake Klagwai, Jigawa State; while Hassan (2017) also recorded 11 species in Doma Dam, Nasarawa State. The Cichilidae family dominated the catches in the Lake Feferuwa during the period of the current study, particularly Saratherodon gallileaus, Oreochromis niloticus and Tilapia zilli. This might be attributed to their prolific breeding habit, voracious feeding, herbivores nature and less predation.

CONCLUSION

The gradual decline in fish species, families, number and weight of fishes in Lake Feferuwa are probably due to alternation of habitat and overfishing as compared with the report of earlier studies from the lake. This declining trend may be a factor responsible for reduced number of fishers when compared to previous work, which has led to many fishers abandoning fishing as occupation to other sources of livelihood, as the income from fishing can no longer sustain their family needs. There is, therefore, the need to apply the code of conduct for responsible fishery/fisheries laws by the relevant authorities in order to sustain the already threatened fisheries resources of Lake Feferuwa.

REFERENCES

Abdul, W.O (2005). Fishing Gear Design and Production lectures. In fishing methods in Nigeria. Federal University of Agriculture, Abeokuta, Nigeria. 20pp.

Balogun, J.K. (2005). Fish distribution in a small domestic water supply reservoir: A case study of Kangimi reservoir, Nigeria Journal of Biological Science 61(4):61-73.

Balogun, J.K. and Auta, J.A. (2001). Fisheries Resources and Development Potentials of Lake Kangimi, Kaduna State. Nigerian Journal of Science, Vol (1):50-56pp

Food and Agriculture Organization (FAO) (2013). Nations for a World without Hunger. Department of Fisheries and Aquaculture, FAO, Rome, Italy.

Gregory, E.O., Nwani, C.D. and Joseph, E.E. (2009). The fish fauna of Anambra River basin, Nigeria: Species abundance and morphometry, International Journal of Tropical Biology, 57 (1-2):177-186.

Haruna, A.B., Abubakar, K.A, and Ladu, B.M.B. (2006). An assessment of Physic-Chemical Parameters and Productivity Status of Lake Geriyo, Yola, Adamawa State, Nigeria. Biological and Environmental Sciences Journal for the Tropics 3(1): 1823.

Hassan, A.B. (2007). Study on physic-chemical and fish species diversity in Doma Dam, Nasarawa State, Nigeria. A P.hD thesis submitted to the Department of Biological Science ABU Zaria. Unpublished thesis.

Idodo-Umeh, G. (2003). Freshwater Fishes of Nigeria (Taxonomy, Ecological notes, diet and utilization). Idodo Umeh publishers Limited, Benin City, Nigeria. p.232.

Ita, E.O., Otunbusin, S.O., Yaro, L., Mohammed, A. and Ibitoye, B. (1979): Fisheries investigation in the Lafia Agricultural development project Area of Plateau State, Nigeria. 82pp.

Nazeef, S. and Abubakar, U.M. (2013). Diversity and condition factor of fish species of Dadin Kowa Dam, Gombe State. Nigeria. Greener Journal of Biological Sciences. 3(10):350-356.

Olaosebikan, B.D. and Raji, A. (2013). Field Guide to Nigerian Freshwater Fishes. 2nd edition, Federal College of freshwater fisheries Technology, New Bussa, Nigeria. p.111.

Solomon, S.G., Ayuba V.O., Tahir M.A and Okomoda, V.T. (2017). Abundance Composition of fish in lake Kalgwai Jigawa State Nigeria. Jordan Journal of Agricultural Sciences 13:401, pp 45.

Valdez-Pizzini, M., Acosta, A. Griffith, D.C. and Ruiz-Peres M. (1992). Assessment of the Socio-Economic Impact of Fishery Management Options upon Gillnets and Trammel Nets Fishermen in Puerto Rico: An Interdisciplinary Approach (Anthropology and fisheries biology) for the Evaluation of Management Alternatives. Final Report NOAA/NMFS, p. 96

World-Fish Center (2002). Fish: An Issue for Everyone. A Concept Paper for Fish for all.

FISH SPECIES DIVERSITY OF TATABU LAKE, NIGER STATE

Olowosegun O. M., I. Y. Yem, N. D. Ago and T. Olowosegun
National Institute for Freshwater Fisheries Research, P.M.B. 6006, New Bussa, Niger State
Email: omolowosegun@gmail.com +2348054500971

ABSTRACT
A study was conducted to assess the diversity of fish species in Tatabu Lake, Niger State. Fish species obtained from fishermen's catches and experimental gill nets were examined for identification. A total of thirty – eight (38) species of fish belonging to eighteen (18) families were identified. In terms of species diversity, the family Bagridae had the highest number of species (6), followed by the family Cichlidae and Mochokidae with five different species in each family and then the family Alestidae and Mormyridae with four different species in the family. This study shows that there is still a high diversity of fish species in Tatabu Lake.

Keywords:
Fish species, Diversity, Tatabu Lake, Niger State

INTRODUCTION

Tatabu Lake (also known as Lake Ndakolowu (Ita, 1993)) is a floodplain lake of the River Niger downstream of Jebba dam. It is located between 9o 12' 14'N and 4o 52' 4o 58; E, about 24km from Jebba along the Ilorin – Mokwa road. The damming of the Niger at Kainji in 1968 and at Jebba in 1963, and the subsequent water control from these dams resulted in drastic reduction of the floodplains downstream of Jebba dam up to Lokoja and beyond. One of the most badly affected floodplain lakes was Tatabu Lake. Investigations into the fisheries of this lake were conducted by the Kainji Lake Research Institute between 1977 and 1979. In 1971, the surface area of the Lake was estimated at 9km2 and by 1977 it was reduced to 6km2. By 1979 the area was much less than 6km2 and after the completion of Jebba Dam in 1983 the open water area of the lake was completely obliterated and the lake was reduced to pockets of overgrown swamps (Ita, 1993). The lake represents a major inland - water fisheries in Nigeria. It draws its water source from Lake Jebba, where a hydro dam is situated (DFID/FAO, 2004). According to Lundberg *et al.*, (2000), over 10,000 species of fish live in freshwater, which is approximately 40 percent of global fish diversity. The diversity of fish species in any water body is attributed to favourable conditions. Fish populations can also respond to factors such as over-fishing, pollution and eutrophication in the aquatic environment (Welcomme, 1999). Presently, numerous fish stocks and species have declined in abundance and composition since their historical peaks, and some have gone extinct while others are threatened, leading to urgent calls for more stringent management and establishment of protected areas (Roberts, 2003). This study therefore aims to assess the current state of the fish species of Tatabu Lake.

MATERIALS AND METHODS

Morphological Characterization of the fish species

Fish samples were obtained from local fishermen and also experimental gill nets. Detailed examination and identification using identification keys developed by Idodo-Umeh (2003) and Olaosebikan and Raji (2013) were used to enable the identification of the fish species.

Morphometric measurements taken.

Measurements were taken to compare the body shape in different species. Morphometric characters were measured and recorded in centimeters to the nearest 0.01cm, and this was done using dial calipers, a pair of dividers, measuring board, meter rule and a rope. Point to point measurements were taken on each fish and these included:

1. Standard length (SL): The distance from the anterior part of the snout (with the jaw closed) to the base of the caudal fin.
2. Body girth (BG): Vertical depth of the fish body taken from the anterior base of the pelvic fin to the dorsal fin.
3. Head length (HL): This was measured, with the mouth closed, from the tip of the snout to the posterior edge of the opercula bone.
4. Head depth (HD): Vertical height measured at the anterior end of gill - opening
5. Inter-orbital space (IOSp). Space between the orbits of the eyes
6. Pre-dorsal distance (pDD): Point to point distance from anterior tip of the snout to the anterior base of the dorsal fin.
7. Pre-pelvic distance (pPvD): Point to point distance from anterior tip of the snout to the anterior base of the pelvic fin.
8. Eye diameter (ED) - This was taken, (using a dial caliper) as the length of the orbit
9. Length of the caudal peduncle
10. Weight measurements (w) were taken in gramme (g) using a sensitive weighing scale.

Meristic counts

In addition to the morphometric measurements, eleven meristic characteristics were observed.

1. Pectoral fin rays (PFR)
2. Pelvic fin rays (PvFR)
3. Dorsal fin rays, (DFR)
4. Anal fin rays (AFR)
5. Caudal fin rays (CFR)
6. Spines in the dorsal fins
7. Spines in the anal fins
8. Spines in the pelvic fins
9. Scales along the lateral line
10. Scales above the lateral line
11. Scales below the lateral line

Qualitative observations were also made on the shape and colour of the fish, position and shape of the mouth, nostrils, scale type, snout profile, types and position of teeth.

RESULTS AND DISCUSSION

A total of thirty – eight (38) species of fish belonging to eighteen (18) families were identified.

Table 1: Summary of the fish species identified and their families

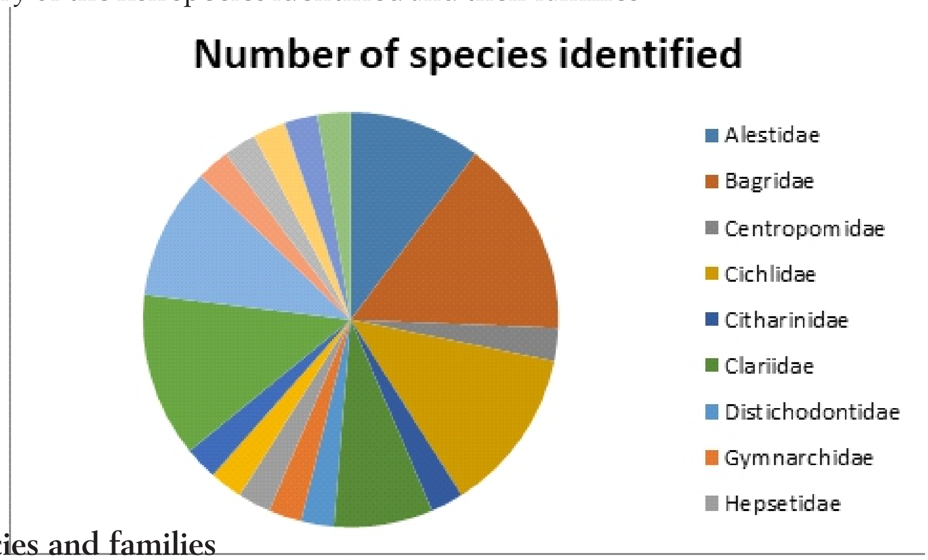


Fig.1. Fish species and families

A total of thirty – eight (38) species of fish belonging to eighteen (18) families were identified in this study and this attests to the fact that Lake Tatabu still has a high variety of fish species when compared with the fish species diversity of Lake Kainji where recent studies recorded a total of fifteen families (Yem et al., 2005).

In terms of species diversity, the family Bagridae had the highest number of species (6) within a family, followed by the family Cichlidae and Mochokidae with five different species in each family and then the family Alestidae and Mormyridae with four different species in the family (Fig 1), this may be as a result of the ability of these fish families to survive in almost all niches. Ajayi (1972) reported that members of the family Bagridae were found to frequent both onshore and offshore shallow waters apart from shore and bottom of deep waters. Although the species richness of the family Bagridae identified in Tatabu Lake was not as high as that of Lake Kainji where about eight species of the family Bagridae were identified (Yem *et al.*, 2005) other families identified had similar number of species as seen in Lake Kainji. The reduction in surface area of Lake Tatabu may be the reason for the dwindling species diversity observed in some of the families identified during the study. Nautiyal and Rizvi (2005) reported that as per species richness – area relationship, the number of species increased with corresponding increase in surface area.

Studies of changes in species composition and distribution over the years by Turner (1972) Lelek (1972), Ita (1978) and Lewis (1974), assessed the status of fishery based on the composition of individual species and families.

According to Ita, (1993), the fish species composition of floodplain waters generally depends on the flood regime. Consequently, fish are concentrated in permanent water bodies at low water levels, but disperse further afield over the floodplains during the flood phase. Migration of fish within tropical river systems has been well documented (Motwani, 1970, Welcomme, 1969 and 1975). The major controlling factor is dissolved oxygen concentration. A lower level of dissolved oxygen is observed in floodplain waters than in the main river channels (Ita, 1993). Consequently, species found in floodplain waters are adapted for survival in low dissolved oxygen conditions. According to Otobo (1977), the dominant fish family by weight in Tatabu Lake in 1977 was the Osteoglossidae, closely followed by the Cichlidae, Hepsetidae, Gymnarchidae, Clariidae and Mochokidae. The current study shows that these fish families are still present in the lake.

Ita (1985) reported that there was a recovery of species diversity from 9 species to 25 species after refilling Lake Tatabu. In this study, 38 fish species were identified, which shows that in spite of the intensive exploitation of the wetland fisheries, a comparatively high diversity has been sustained, though many of the fish species identified are of little economic importance on account of their small sizes.

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CONCLUSION

The differences observed in species diversity could be attributed to the continual changes in the environment whereby a particular family could adapt better than other families within a span of time. The results further confirm that the diversity of species in Lake Tatabu is still high. Further study on the fish species diversity of Tatabu Lake for a longer duration is therefore recommended as it may reveal the presence of more fish species than were observed in this study.

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The authors acknowledge the contributions of the Internal Management Committee of the National Institute for Freshwater Fisheries Research, New Bussa, Niger State for the support to carry out the research. All the members of the Artisanal Fisheries Division are also acknowledged in addition to the community leader and other members of council of Tatabu village.

REFERENCES

Ajayi, O. (1972). Biological studies on the family Bagridae (Pisces: Siluroidae) in Lake Kainji, Nigeria. M.Phil. Dissertation, University of Ife, Nigeria.

DFID/FAO (2004). Community report for Tatabu Fishing village: Outcome of PRA Study. 17pp

Idodo-Umeh, G. (2003). Freshwater Fishes of Nigeria (Taxonomy, Ecological notes, Diet and Utilization. 243pp.

Ita, E. O. (1978) Analysis of fish distribution in Kainji Lake, Nigeria. Hydrobiologia, 8 (3), 233 - 244

Ita, E. O. (1993). Inland Fishery resources of Nigeria. CIFA Occasional Paper No. 20 120pp

Lelek, A. (1972). Fish population of Kainji Lake: Trends in their development and utilization. FAO Technical Report 2 FI: SF/NIR 24

Lewis, D. S. C. (1974). The effects of the formation of Lake Kainji, Nigeria upon the indigenous fish population. Hydrobiologia, 45 (2-3), 281 - 301

Lundberg, J. G., Maurice, K., Gerald, R. S., Melanie, L. J. S. and Anthony, C. G. (2000). So many fishes, so little time: An overview of recent Ichthyological discovery in continental waters. Annals of the Missouri Botanical Garden, 87 (1), 26 – 62.

Motwani, M. P. (1970) Fishery investigations on the Niger and Benue Rivers in the Northern Region and the development of a programme of riverine fishery management and training. FAO Report, TA 2271., 196p., FAO Rome

Nautiyal, P. and Rizvi, A. F. (2005). Species richness and peculiarities in the fish fauna of Himalaya and Central Highlands. In: Fisheries and Fish Toxicology, Pandey, B.N. and G.K. Kulkami (Eds). APH Publishing Cooperation, New Delhi, India, pp 34 - 71

Olaosebikan, D. O. and Raji, A. (2013). Field Guide to Nigerian Freshwater Fishes. 144pp

Otobo, F. O. (1977). The commercial fishery of the middle River Niger, Nigeria.CIFA Tech. Pap., (5), 185-208

Roberts, C. M. (2003). Application of ecological criteria in selecting marine reserves and developing reserve networks. Ecological Applications, 13, S215 - S228

Turner, J. I. (1972). The fish population of the newly impounded Kainji Lake in Nigeria. J.West Afr.Sci.Assoc. 16 (1), 44 -58.

Welcomme, R. L. (1969). The Biology and ecology of the fishes of a small tropical stream. J.Zool.Lond. 158, 485 – 529.

Welcomme, R. L. (1975). The fisheries ecology of African floodplains. CIFA (FAO) Tech.Pap. (3): 51p.

Welcomme, R. L. (1999). A review of a model for qualitative evaluation of Exploitation levels in multi-species fisheries. Fisheries Mgt and Ecology, 6, 1 – 19

Yem, I. Y., Bankole, N. O., Olowosegun, O. M., Mshelia, M. B., and Dantoro, B. F. (2005) Current diversities of fish species in a sampling site on Lake Kainji. African Scientist 6(3), 85 – 90.

COMPOSITION, DIVERSITY AND DISTRIBUTION OF ICHTHYOFAUNA IN ZOBE LAKE, KATSINA STATE

[1] Usman, I. M., [2] D. O. Odulate, [3]T. S. Gbaior
[1]Department of Fisheries and Aquaculture, Federal University Dutsin-Ma, PMB 5001, Katsina State, Nigeria
[2]Department of Aquaculture and Fisheries Management, Federal University of agriculture, Abeokuta
[3]Joseph Sarwuan Tarka University, Makurdi
Correspondence: umuhammad2@fudutsinma.edu.ng, +234 806 286 8790

ABSTRACT
Composition, distribution and diversity of ichthyofauna in Zobe Lake Katsina State, Nigeria were studied from March to October, 2022. The study area was divided into four strata along the lake. Purposive sampling was used to select one landing site from each stratum based on the level of fishing activities. Fish samples were collected monthly from landing sites, sorted, identified into species and counted. Diversity indices were computed using [PAST, version 4.] This study identified 6125 fish species belonging to 8 families. The families Cichlidae and Bagridae were the most represented with 32 % and 31 % of the total composition respectively, while Mochokidae was the least family (0%) in the Lake. Site 1 had the highest fish abundance (1846) followed by Site 4 (1543), While Site 2 (1265) recorded the least number of fish abundance. Diversity indices of fish species from the lake revealed that species richness varied from Site 2 (17) to Site 1 (20). Shanon index varied between Site 1 (2.40) and Site 3 (2.27). The study showed that Zobe Lake was rich in fish abundance and diversity. External variables that are known to have an impact on the population of freshwater fish species should be addressed.

Keywords:
Composition, diversity, distribution, ichthyofauna

INTRODUCTION

One-fourth of all vertebrates are freshwater fish, which offer priceless products and services but are increasingly impacted by human activities (Guohuan *et al.*, 2021). According to estimations by Allen *et al.*, (2018) less than 1% of the earth's surface is made up of rivers and lakes, which are home to a high degree of biodiversity. This accounts for a quarter of all vertebrates worldwide Akegbejo (2022). It was also estimated that fish are the most numerous vertebrates, with approximately 34,700 described species and a great deal more yet to be described and classified (Froese and Pauly, 2021).

Akegbejo (2022) reported that the freshwater environment is an aquatic environment where the salinity of the water is zero. These include inland waters like rivers, lake, streams etc. A brackish water environment is an aquatic environment where the salinity of the water changes depending on the season of the year e.g., lagoons, creeks, estuaries etc. With a variety of fish species found in its many fishery resources, the marine environment has a salinity of around 35ppt, which is 10,000 times saltier than freshwater found in rivers and lakes (Gupta and Verma 2015). Freshwater is however considered as unique ecosystem due to its ability to form a habitat for diverse species of fish and plant material. This is also a result of its ability to support the aquatic resources with balanced physical, chemical and biological parameter required for an interrelationship between the fauna and flora cohabiting the fisheries resources (Gurjar *et al.*, 2020). Pallavi and Ajay (2013) stated that the abiotic and biotic factors that coexist in an ecosystem are related to the diversity of ichthyofauna, however, while other factors that significantly influence the level of biodiversity include the age of the water body, mean depth, fluctuations in water level, and the morphometric features of the water. The ichthyofauna will also be affected if the level of the primary productivity in the aquatic resources is only able to satisfy a particular species, (affecting the food web) thus leading to loss of certain species in the aquatic resources. This study aims to investigate ichthyofauna composition, and distribution in the lake.

MATERIALS AND METHODS

The study was conducted in Zobe Lake, which is situated in Katsina State, Nigeria's Dutsin-Ma Local Government Area. It lies on latitude between 12°20 0 N - 12°25 0 N and longitude 7°27 230 - 7°35 0E (Figure 1). The study area was divided into four strata (Sites 1, 2, 3 and 4) along the lake for easy assessment. Purposive sampling was used to select one landing site from each stratum based on the level of fishing activities

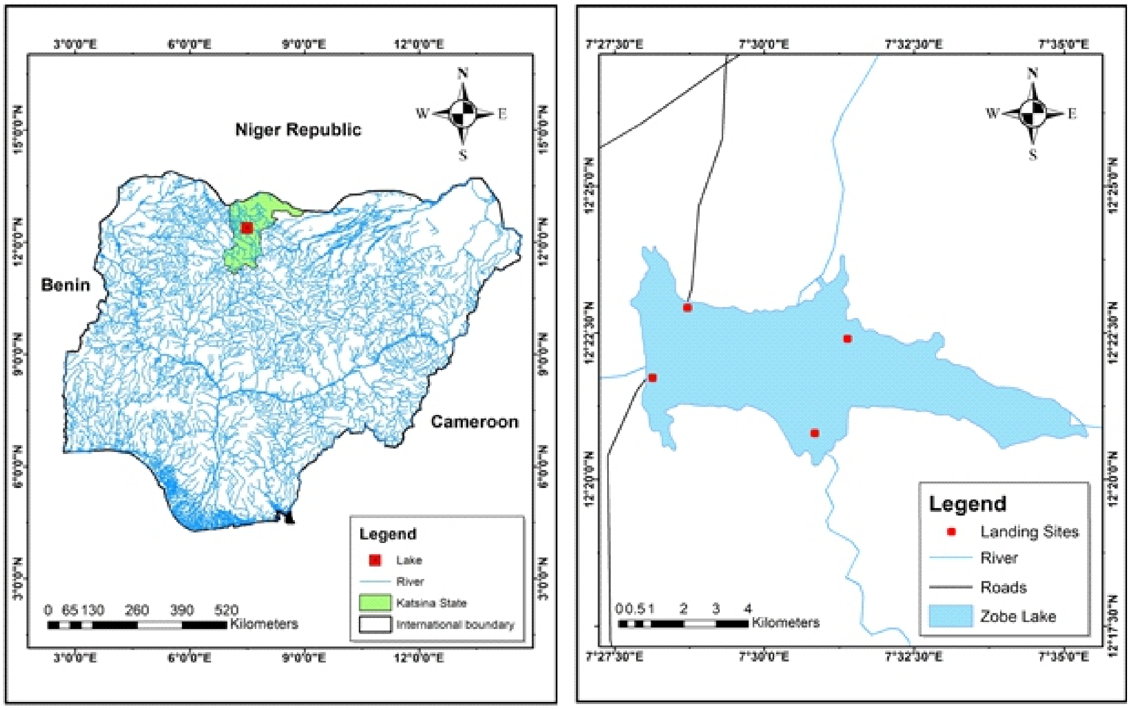


Fig 1: Map of Nigeria showing Zobe Lake and landing sites.

Assessment of commercial catches

Ichthyofauna present in the reservoir was sorted and identified based on the classification of Babatunde and Raji (1998) and Idodo-Umeh (2003). Weight of the catch from the reservoir was recorded, and photographs of the fish species identified were taken. The catches were identified and sorted into species. Each species was counted and weighted in batches using a digital weighing scale (MH-999). The fish species were identified to lowest taxonomic level possible based on Olaosebikan and Raji, (2018).

Statistical analysis

Data obtained from analysis of species composition, distribution and diversity of ichthyofauna in the lake were subjected to paleontological statistics software (PAST 4) which was used to check diversity Indices (Simpson Diversity index, Shannon-Weiner index and Evenness index).

RESULTS

Figure 2 revealed that families Cichlidae and Bagridae were the most represented with 32 % and 31 % of the total composition respectively, while family Mochokidae recorded the least family (0%) in the

Lake. Table 1 shows the results of diversity indices of the sampled freshwater fish species from the landing sites. A total number of (6125) individual fish species was recorded across the four sampling Sites. Highest number of fish taxa 20 highest individual fish species1846 was reported in Site 1 while Site 3 and 4 recorded the highest dominance 0.14 each. Site 3 recorded lowest Shannon index (2.27) which is moderate according to Fernando et al., 1998). Evenness 0.54 in Site 3 which signifies unstable community and equitability is moderately high degree of heterogeneity (0.79). Site 2 recorded the lowest taxa (17), individuals (1265) and dominance (0.12).

Table 2 shows spatial distribution of fish catch from Zobe Lake between March and October 2022. The result showed that Site 1 had the highest fish abundance (1846) followed by Site 4 (1543), while Site 2 recorded the least number of fish abundance (1265). The most abundant fish species in Site 1 was O*reochromis* niloticus (369), followed by Bagrus bayad (362) and C*larias gariepinus* (252). The most predominant species in Site 2 were B. bayad, O. *niloticus* and C. *gariepinus* with 280, 220 and 155 fishes respectively. The predominant species in Site 3 were B. bayad (328), O. niloticus (177), B. docmac and C. *gariepinus* (184). The most abundant fish species in Site 4 were B. bayad (368), followed by O. *niloticus* (325) and C. *gariepinus* (233). The least abundant fish species in Site 1 was *Heterobranchus longifilis* with only 2 fish captured throughout the study period. In Site 2 *Hemichromis fasciatus* was the least abundant fish having only 3 individuals captured throughout the study period. In Site 3, Petrocephalus bovei was the least abundant fish having only 3 individuals captured. In Site 4, the least number of fish individuals recorded was for Alestes baremoze (4) individuals. With regards to the weight of fish sampled, Site 1 recorded the highest weight (936.6 kg) followed by Site 4 (729.53 kg) while Site 3 recorded the least weight (609.7 kg). Bagrus. bayad had the highest weight among the individual fish samples at all the sample sites with a weight of 259.4 kg, 198.6 kg, 202.1 kg and 203.7 kg at site 1, 2, 3 and 4 respectively. The least weights recorded were for Synodontis membranaceous (0.3kg) at site 1 with least weight was recorded for synodontis membranaceous (0.3 kg) at site 1 with Hoplarcus psittacus (0.8 kg) at site 2 with Petrocephalus bovei at site 3; and Alestes baremoze (2.1 kg) at site 4.

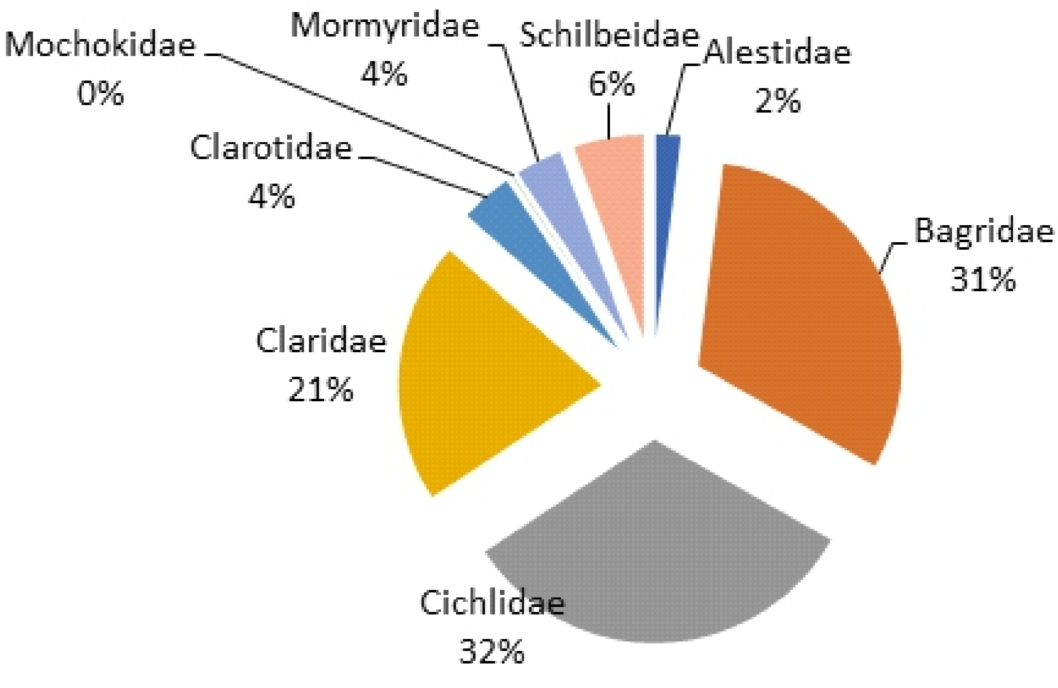


Fig 2: Fish families' composition by abundance from Zobe Lake.

Table 1: Diversity indices of fish species from Zobe Lake, Katsina State, Nigeria

Indices	Site 1	Site 2	Site 3	Site 4	Pooled
Taxa_S	20	17	18	18	20
Individuals	1846	1265	1268	1543	6125
Dominance_D	0.12	0.13	0.14	0.14	0.13
Simpson_1-D	0.88	0.87	0.86	0.86	0.87
Shannon_H	2.40	2.30	2.27	2.31	2.36
Evenness_e^H/S	0.55	0.59	0.54	0.56	0.53

Table 2: Spatial distribution of fish catch from Zobe Lake between March and Oct 2022.

	SITE 1		SITE 2		SITE 3		SITE 4	
Fish species	Abundance	Wt (kg)	Abundance	Wt (kg)	Abundance	Wt (kg)	Abundance	Wt (kg)
Alestes dentex	23	4.6	11	2.3	8	7.2	25	10.1
Alestes nurse	5	2.2	10	12	11	5.7	13	4.4
Alestes baremoce	7	3	0	0	4	2.1	4	2.1
Bagrus docmac	111	63.9	155	113.7	184	78.4	120	91.4
Bagrus bayad	362	259.4	280	198.6	328	202.1	368	203.7
Brienomyrus brachyistius	16	3.1	0	0	0	0	22	11.8
Chrysichthys nigrodigitatus	117	56.2	46	19.8	45	20.2	46	27.4
Clarias anguliaris	114	67.7	82	40.4	48	29.2	74	38.8
Clarias gariepinus	252	122.2	172	105	184	95.2	233	103.73
Coptodon zilli	81	48.8	82	39.3	67	22.6	76	25.7
Hemichromis fasciatus	35	8.4	3	0.8	5	1.3	27	6.8
Heterobranchus longifilis	2	0.5	18	12.1	19	6	29	11.4
Hoplarchus Psittacus	80	32.4	26	7.5	15	5.4	22	6.3
Mormyrus rume	40	17.1	15	4.9	21	7.3	20	4.5
Oreochromis niloticus	369	153.6	220	92.5	177	69.2	325	122.6
Petrocephalus bovei	6	1.5	7	1.8	3	0.9	27	10
Petrocephalus bane	13	9.6	6	4.7	33	13.8	0	0
Sarotherodon galilaeus	125	44.9	69	29.8	75	32.7	48	24.4
Synodontis membrenaceous	4	0.3	0	0	0	0	0	0
Schilbe mystus	84	37.2	63	19.1	41	10.4	64	24.4
TOTAL	**1846**	**936.6**	**1265**	**704.3**	**1268**	**609.7**	**1543**	**729.53**

DISCUSSION

A total of 6125 fish from eight families belonging to 20 species were captured "between" March 2022 and October 2022. There are 20 species (species richness) in the ecosystem of Zobe Lake. This is less than the 41 species that Ajagbe et al., (2021) reported in Ikere-George Reservoir Oyo State Southwest Nigeria, 28 species reported by Iber *et al.*, (2018) from River Fete in Benue State, and the 27 species that Solomom (2017) reported from Lake Kalgwai in Jigawa State, Nigeria. This was also higher than the observation of Nababa *et al.*, (2021) on same reservoir where he reported 13 fish species belonging to 7 families. The variation observed in species composition from earlier work is likely to be the difference in time, gear used and space. Higher value of Simpson index 0.88 recorded in Site 1signifies lower diversity while Sites 3 and 4 recoreded the least value 0.86 respectively but higher diversity. Highest evenness value in Site 2 and lowest in Site3 reveals that all fish species have similar distribution due to lower disparity between the Sites. This study reveals that Bagridae dominated the catch as against S. galilaeus reported by Ajagbe et al., (2021).

CONCLUSION

This study identified 6125 fish belonging to 8 families; Cichlidae contributed the highest in terms of abundance (32 %) while bagridae contributed the highest in weight (39 %). The volume of the fish harvested was higher in Site 1 as compared to the other study Sites. More so, Site 1 was the major contributor to the total fish production among the four selected Sites. Zobe Lake is low in fish with lower diversity as indicated by high value of Simpson index.

REFERENCES

Ajagbe, S. O., Odulate, D. O., Akegbejo-Samsons, Y., Kehinde, A. S., Ajagbe, R. O., and Ojubolamo, M. T., (2021). Species composition, abundance and diversity of Ichthyofauna of Ikere-Gorge, Oyo State, Nigeria. Acta Ecologica Sinica, 41(6), 575-583.

Akegbejo-Samsons, Y. (2022). Aquaculture and fisheries production in Africa: highlighting potentials and benefits for food security. In Food Security for African Smallholder Farmers (pp. 171-190). Singapore: Springer Nature Singapore.

Allen et al., (2018). Global extent of rivers and streams. Science 361, 585-588 147

Babatunde, D.O. and Raji, A. (1998). Field Guide to Nigerian Freshwater fishes. Federal College of Freshwater Fisheries Technology, New Bussa. Pp1-2, 84-92.

Guohan, Su., Logez, M., Xu, J., Tao, S., Villéger, S., and Brosse, S. (2021). Human impacts on global freshwater fish biodiversity. Science, 371(6531), 835-838.

Froese, R.and D. Pauly. (202)1. Editors FishBase, World Wide Web electronic publication. www.fishbase.org, version (08/2021).

Gurjar, P., Lakhera, K., Vyas, V, Raina, R.K. and Vishwakarma, K. (2020). Studies on Ichthyofaunal diversity from River Sip, a Tributary of River Narmada. Journal of Environmental Biological-Science.34, 59-63.

Gupta,V.K. and Verma, K., (2015). Animal Diversity, Natural History and Conservation, Published by: Daya Publishing House, New Delhi. 5: 165–176

Idodo-Umeh G., (2003). Freshwater fishes of Nigeria (Taxonomy, Ecological Notes, Diets and Utilization. Idodo-Umeh Publishers Limited, Benin City, Nigeria 232pp.

Nababa, A. S., Bichi, H. A. Y., and Olukayode, S. A. (2022). Itchthyofaunal Composition, Abundance, and Diversity Indices in Zobe Reservoir of Katsina State, Nigeria. Ummaru Musa Yar'adua University Scientifica, 1(1), 42-48.

Olaosebikan, B. D., and Raji, A. (2018). Field guide to Nigerian freshwater fishes. Federal College of Fisheries and Marine Technology.

Pallavi, S., and Ajay, S., (2013). Distribution and diversity of freshwater fishes in Aami River, Gorakhpur, India. Advances in Biological Research, 7(2), 26-31.

THE FOOD AND FEEDING HABITS OF *Mormyrus rume* (VALENCIENNES, 1846) OF SEBORE RESERVOIR, MAYO - BELWA, ADAMAWA STATE

[1]Nababa, A. S, [2]Kela, E. and [3]Ali, M. E.
[1]Department of Fisheries and Aquaculture, Federal University Dutsin-Ma, Katsina State, Nigeria.
[2]Department of Biological Sciences, Gombe State University, Gombe, Nigeria.
[3]National Biotechnology Development Agency, Billiri, Gombe state, Nigeria.
[4]Department of Fisheries, Modibbo Adama University, Yola, Adamawa State, Nigeria.
Corresponding Author's email: naababa77@gmail.com

ABSTRACT

Food and feeding habits of Mormyrus rume of Sebore reservoir was investigated monthly for a period of one year. Total of 120 samples were collected, washed with clean water and preserved in ice crest to minimize any post - mortem changes. The stomach contents of each of the Mormyrus rume sample were identified and analysis was done using the numerical and frequency of occurrence methods. The results obtained from the 120 samples of Mormyrus rume indicated that 60 (50.00%) have their stomach full with food, 54 (45.00%) were having a half - filled stomach, while 6 (5.00%) were having an empty stomach. The high number of Mormyrus rume samples recorded with full stomach than the Mormyrus rume samples with half - filled and empty stomach in the study area indicated that there was constant availability of food for the fish. Findings from this study indicated that the Mormyrus rume of Sebore reservoir, is an omnivore. Although, it feeds mostly on animal materials (detritus, insects, insect's larvae and pupae also on unidentified worms) than on plant materials. The different varieties of food items observed in the gut make it a potential suitable candidate for aquaculture.

Keywords:
Feeding Habits, Mormyrus rume. Stomach, Omnivore, Sebore Reservoir.

INTRODUCTION

Mormyrus rume (Valenciennes, 1846) commonly known as the Elephant snout fish belongs to the order Osteoglossiformes; family *Mormyridae* and *genus Mormyrus* (Olaosebikan and Raji, 2013; Jibrin and Shu'aibu 2023a). Four species of the genus Mormyrus, were reported in Nigeria, these are: *Mormyrus rume, Mormyrus tapirus, Mormyrus macrophthalmus and Mormyrus hasselquistii* (Olaosebikan and Raji, 2013). Some of the major distinctive features of M. rume from other species of the genus *Mormyrus* includes: its trunk - like snout, terminal and small mouths and greyish - yellow and silvery ventrally colour (Idodo-Umeh, 2003). Mormyrus rume are bottom dwellers with a widespread distribution except in the Cross River (Olaosebikan and Raji, 2013). The fish specienhabits the freshwater lakes, reservoirs, rivers, streams and swamps, and is capable of discharging electric current (25 - 30 hz) that can shock its prey or enemies (Idodo-Umeh, 2003). It contributes significantly to the animal protein sources within many freshwater bodies and also make up of a portion of the inland fisheries in Nigeria as its flesh is delicious and is widely consumed by many people (Idodo-Umeh, 2003). Various researches have been carried out on the food and feeding habits of fish. This has been in order to assess the dietary composition and food habits of fish aimed at a sound fisheries management programme on fish rearing in captivity (Abdulkarim *et al.,* 2018). The food and feeding habitat of fish may be an important characteristic of the life - history strategy of a species to know the foremost necessary functional role of the fish inside their living ecosystems (Kuebutornye *et al.*, 2019). The objective of this study was therefore, to determine the food and feeding habits of Mormyrus rume of Sebore reservoir, Mayo-Belwa, Adamawa State.

MATERIALS AND METHODS

Study Area

Sebore reservoir is located at Mayo-Belwa local government area (LGA), Adamawa State Nigeria. Mayo–Belwa LGA lies within latitude 9° 3' 0' north and longitude 12° 3' 0' east. It covers an area of 1768km^2 (682.63 sq. m) and is 75 km away from Yola, the state capital.

Sample Collection

A total of 120 samples of *M. rume* were sampled monthly for a period of one year, from December 2021 to November 2022. Fishing was done using gill nets as the fishing gear and canoe was used as fishing craft. The fish specimens were washed with clean water and preserved in ice crest to minimize any post-mortem changes and taken to the laboratory at the Department of Fisheries Modibbo Adama University, Yola for analysis of the food contents.

Laboratory Analysis of Sample

The total length of the *M. rume* samples were measured using a measuring board in centimetres (cm) and weighted using an accurate digital scale in grams (g). The body cavity was opened using a pair of scissors, beginning ventrally from the anus to the mouth, the entire visceral and intestinal organs such as the liver, fat and other organs attached to the intestine and stomach were gently removed and emptied into a plastic petri dish, the length and weight of the stomach were measured and recorded. Thereafter, the *Mormyrus rume* were kept in formalin solution of about four percent (4%) to avoid any form of deterioration and contamination of the stomach contents. The stomach contents were opened using a pair of scissors and the complete stomach contents were emptied into petri dish for examination and identification based on the work of Yusuf *et al.* (2024). The random samples of the stomach contents were taken and dropped on a slide (counting chamber) with the aid of a dropping pipette and viewed under a light microscope. The general views were made with a binocular dissecting microscope (SE306) stereo zoom total magnification of 100x; the stomach contents were studied and recorded. The stomach contents of each of the *M. rume* samples were analysed using the numerical and frequency of occurrence methods as described by Balogun (2006).

In the numerical method (NM), the number of individuals in each food category was expressed as a percentage of the total individuals in all food categories:

$$NM\ (\%) = \frac{\text{Total no. of a particular food item}}{\text{Total no. of all the food items}} \times 100$$

In the frequency of occurrence method (FO), all stomach containing food were recorded and expressed as the percentage of the total number of stomachs examined:

$$FO\ (\%) = \frac{\text{No of stomach with a particular food item}}{\text{Total no. of fish examine and food in the stomatch}} \times 100$$

Statistical Analysis

Data obtained were analysed using descriptive statistics (Frequency and percentages) using SPSS (20, version).

RESULTS

The results recorded from the 120 samples of Mormyrus rume collected from Sebore reservoir are given as follows: 60 samples of *M. rume* representing 50.00% had their stomach full with food, while 54 individuals representing 45.00% were observed to have a half-filled stomach and 6 individuals representing 5.00% were observed to have an empty stomach (Table 1). The high numbers of *Mormyrus rume* samples recorded with full stomach than the *M. rume* samples with half-filled and empty stomach in the study area indicated that there was constant availability of food for the fish year-round. Table 2 shows the summary of the stomach contents of *M. rume* from Sebore reservoir.

Table 1: Stomach Fullness of *Mormyrus rume* from Sebore Reservoir

No. of Full Stomach	Percentage of Full Stomach	No. of Half Stomach	Percentage of Half Stomach	No. of Empty Stomach	Percentage of Empty Stomach
60	50.00%	54	45.00%	6	5.00%

Table 2: Stomach Contents of *Mormyrus rume* from Sebore Reservoir

Food items	Numerical method		Frequency of occurrence method	
	Number of Items	Percentage (%)	Number of stomachs	Percentage (%)
Bottom organism:				
Detritus	1,179	13.70	92	80.70
Fish materials:				
Fish eggs	32	0.37	9	7.89
Fish bones/scales	23	0.27	6	5.27
Insects:				
Anax spp. nymph	163	1.90	14	12.28
Chaoburus spp. larvae	1,384	16.08	65	57.01
Chaoburus spp. pupae	436	5.07	54	47.36
Chironomus spp. larvae	724	8.41	53	46.49
Chironomus spp. pupae	321	3.72	48	42.10
Cullicoides spp. larvae	933	10.83	60	52.63
Cullicoides spp. pupae	255	2.97	39	34.21
Remains of insects	1,019	11.83	89	78.07
Other materials:				
Sand particles	-	-	38	33.33
Unidentified worms	618	7.18	41	35.97
Plant Materials:				
Remains of plants	1,011	11.74	69	60.52
Phytoplankton:				
Chlorella spp.	15	0.18	6	5.26
Diatomella spp.	19	0.22	8	7.01
Oscillatoria spp.	21	0.24	9	7.89
Phacus spp.	24	0.28	7	6.14
Zooplankton:				
Arcella spp.	45	0.52	23	20.17
Centropyxis spp.	49	0.57	27	27.17
Daphnia spp.	43	0.50	17	23.68
Diaptomus spp.	59	0.69	33	28.94
Moina spp.	55	0.63	24	21.05
Nauplius spp.	67	0.78	35	25.43
Rotaria spp.	61	0.70	23	30.70

DISCUSSION

Findings from the food and feeding habits of *Mormyrus rume* of Sebore reservoir indicated that the fish species had a broad spectrum of food ranging from bottom organism mainly detritus, fish materials, insects, other materials such as sand particles and unidentified worms, plant materials, phytoplankton's and zooplanktons. This was in support with the findings of Igejongbo (2019) who reported similar results for this fish species in River Owena, Osun State, Nigeria. and Jibrin and Shu'aibu (2023b) for this species from lake Geriyo, Adamawa, Nigeria. The broad food spectrum of this fish indicated that they feed both in surface water column and even near the substratum. However, *M. rume* appears to be basically a bottom feeder as evident from the significant contributions of the bottom-dwelling food items such as insect's larvae and pupae, detritus and insect remains in its total diet. The sand grains, which contributed substantially to the stomach content, might have been accidentally ingested along with food, but their contribution to the nutrition of the species is not clear. The discovery of sand in the gut of *M. rume* was also reported by Igejongbo (2019). *Mormyrus rume* feeds on both plant and animal materials with detritus, insects, insect's larvae and pupae also with plant materials dominating its food. A similar result was reported by Idodo-Umeh (2003). Food items of animal origin contributed significantly to the diet, which was dominated principally by bottom dwelling immature insects (Chaoburus spp. larvae and Cullicoides spp. larvae) and the remains of other insects. In addition, plant materials contributed significantly to the stomach content of the fish. It may therefore be justifiable to classify M. rume as an omnivore, which is consistent with the findings of Jibrin and Shu'aibu (2023b) for *M. rume* from Lake Geriyo, Adamawa, Nigeria.

CONCLUSION

Findings from this study indicated that the *Mormyrus rume* from Sebore reservoir of Adamawa State is an omnivore that feeds on both plant and animal materials. Although the results showed that it fed mostly on animal materials (detritus, insects, insect's larvae and pupae, and also unidentified worms) than on plant materials.

REFERENCES

Abdulkarim, M., Yusuf, Z. A., Misau, A. B., Garba, A. M. and Mahmood, S. (2018). Realistic interpretation of condition factor with stomach content analysis of Clarias gariepinus in Gwallaga River, Bauchi–Nigeria. Nigerian Journal of Fisheries, 15(2):1440-1443.

Balogun, J. K. (2006). Basic fisheries biology and management for tertiary institutions. Published by Ayo - Sule (Nig.) printers and publishers, Zaria. Pp. 88.

Idodo - Umeh, G. (2003). Freshwater fishes of Nigeria, taxonomy, ecological notes, diets and utilization. Idodo-Umeh Publishers, Benin. Pp. 232.

Igejongbo, T. F. (2019). Food and feeding habit of Mormyrus rume in river Owena, Osun State, Nigeria. Proceedings of the 34th Annual Conference of the Fisheries Society of Nigeria (FISON). Pp. 494–498.

Jibrin, B. and Shu'aibu, N. (2023a). Assessments of some morphometric parameters of Mormyrus rume (Valenciennes, 1846) from Lake Geriyo, Adamawa, Nigeria. International Journal of Fisheries and Aquatic Studies, 11(5): 99-105.

Jibrin, B. and Shu'aibu, N. (2023b). Food and feeding habit of Mormyrus rume (Valenciennes, 1846) in Lake Geriyo, Adamawa, Nigeria. International Journal of Fisheries and Aquatic Studies, 11(6): 102–109.

Kuebutornye, F. K. A., Akongyuure, D. N. and Alhassan, E. H. (2019). Morphometric Characteristics and feeding habits of five commercial fish species of the Libga reservoir in the northern region of Ghana. International Journal of Oceanography and Aquaculture, 3(2): 000164

Olaosebikan B. D. and Raji, A. (2013). Field guide to Nigerian freshwater fishes (Revised Edition). Remi Thomas Press, Nigeria. Pp. 144.

Yusuf, Z. A., Bara'atu, A., Hassan, S. K., Nababa, A. S, Ali, M. E. and Abdulkarim, M. (2024). THE Food and feeding habits of Aucheonoglanis occidentalis (Valenciennes, 1840) inhabiting Sebore reservoir, Mayo-Belwa, Adamawa state. Proceedings of the 49th Conference of the Nigerian Society for Animal Production (NSAP). Pp. 1999-2002.

AN APPRAISAL OF CURRENT FISHERY COMPOSITION OF EGBE RESERVOIR, EKITI STATE, SOUTH- WESTERN NIGERIA

Yem, I. Y., N. D., Ago, I. Adamu, M. O. Olowosegun, R. Y. Atiribom, H. Kabiru, M. K. Haruna, K. Kwen and J. Hussaini
National Institute for Freshwater Fisheries Research, P.M.B. 6006, New Bussa, Niger State
Corresponding Author: yeminnocent@gmail.com, +234 8054504176

ABSTRACT
The current fishery composition of Egbe Reservoir, Ekiti state, Nigeria was assessed using fleets of experimental gillnets. Seven (7) species from 5 families were recorded. An edible species of frog was also recorded. Highest diversity (3) was recorded in the family Cichlidae; *Oreochromis niloticus*, *Coptodon zillii* and *Sarotherodon galilaeus*. Cichlidae was most abundant in both number and weight while *Mormyridae* was least. *Coptodon zillii* was the dominant species in terms of number and weight with *Brienomyrus* sp. as lowest. Highest catch was recorded on 1" followed by 4" and 3" as lowest in terms of number. 4" recorded highest weight followed by 1" while the lowest was 3". Bulk (71.52%) of fish caught were from meshes below the recommended size for inland water bodies. The use of small mesh sizes should be discouraged in order to prevent the exploitation of small-sized fishes. There may be need to stock the reservoir with echo-friendly fish species. Further investigation on the actual presence of other non - fin fish aquatic animals need to be conducted.

Keywords:
Appraisal, composition, fishery, Egbe, reservoir, Ekiti State

INTRODUCTION

Egbe Reservoir was created primarily to serve as a source of water for domestic use and irrigation. The water supply scheme was commissioned on 25th January 1989 but as expected, it provided other important opportunities in particular, small - scale fisheries for the immediate and surrounding communities, which need to be developed and managed sustainably. Therefore, management of a fishery depends on regular assessment of the stock. This provides information on the population of fish structure, stock size and exploitation level amongst others (Edward, 2013). Such information, reveals catch composition - abundance and diversity, which describe the productivity of the water body being crucial for formulation of appropriate management plans or decision enabling sustainable usage and conservation of the resource. Investigation of the fishery of water bodies have been carried out over the years. This included the recent works of Ukaonu and Ugwumba (2021) and Yem *et al.* (2024). However, there is dearth of such information on Egbe reservoir. This study assessed the fishery composition of the reservoir for sustainable management.

MATERIALS AND METHOD

Ekiti State is blessed with water resources, notably Egbe Reservoir. It is located between Latitudes 7o36' and 7o39' N and Longitudes 5o32' and 5°35' E constructed in 1975 across Ose River at Egbe - Ekiti. It has average depth of 6.5 metres and total surface area of 272.5 ha (Edward, 2013). The area around the reservoir is rocky and hilly with thick vegetation.

Three (3) fleets of experimental gillnets each measuring 50 meters long and 3 meters deep with mesh sizes of 1", 1½", 2", 2½", 3", 3½", 4", 5" and 7". The nets were set to cover shoreline, surface and bottom of the water body; checked early in the morning between 6:00 am to 8:00 am and between 4:00 pm to 6:00 pm in the evening. Fishes caught were collected according to mesh sizes, sorted into species and identified using manual and checklist of fish (Paugy et al., 2003; Olaosebikan and Raji, 2021). Fishes were counted and weighed using weighing balance to the nearest 0.0g. Percentages (%) of number and weight of each species of fish were calculated using the following formula:

$$\text{Percentage number/weight (\%)} = \frac{\textit{Total no. of /wt of fish species}}{\textit{Total no. of /wt of entire fish caught}} \times 100$$

Fishers' catches at various landing sites on the reservoir were also assessed and compared with experimental gillnet catches. This was carried out between August 2022 and December 2022.

RESULTS AND DISCUSSION

Experimental gillnetting and catch assessment: Table 1 and plates 1-7 shows seven (7) fish species from five (5) families at Egbe reservoir. Earlier work of Edwards (2013) revealed eight (8) species from five (5) families and 8 species from the same reservoir, but low compared with the result of Yem et al. (2016) from a similar water body. This is an indication that the reservoir is still low in species diversity. The family Cichlidae was the most relatively abundant contributing 73.75% by number and 69.84% by weight of the total catch on the reservoir while *Mormyridae* family was the lowest accounting for 1.96% and 0.85% in terms of number and weight respectively. C*optodon zillii* (formerly Tilapia zillii) which is a Cichlid, dominated the catch in terms of number (38.09%) and weight (36.16%) whereas Brienomyrus spp. was the least in both number (1.96%) and weight (0.85%). The highly prolific nature and feeding habit of the Cichlids have contributed immensely to their dominance in most water bodies. The family Cichlidae had the highest number of species (3): O*reochromis niloticus*, C*optodon zillii*, and *Sarotherodon galilaeus;* while C*hannidae*, C*lariidae*, *Hepsetidae and Mormyridae* had one variant each; *Parachana obscura*, C*larias buthupogon*, *Hepsetus odoe* and *Brienomyrus spp*. respectively. The low mean weights recorded was because fishes caught were mostly small to moderate in sizes. The composition also shows that there are two carnivores and five forage species, which is an indication that the population may not be balanced even though the reservoir has the capacity to support viable small-scale fishery.

Table 1: Fish composition of Egbe Reservoir, Ekiti State, South-western Nigeria

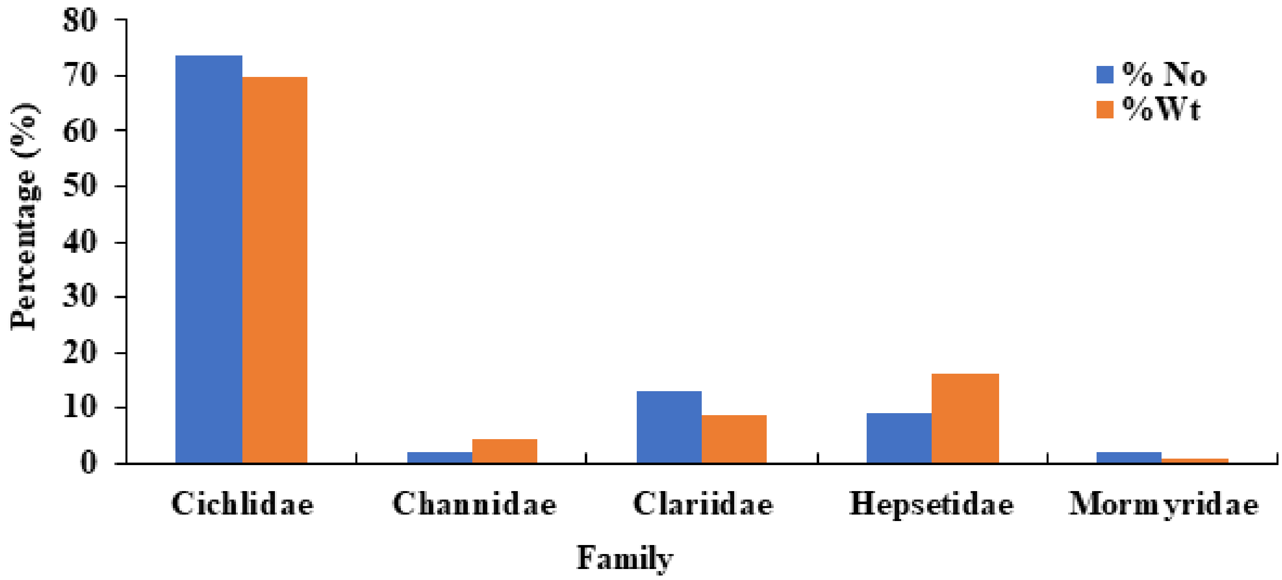
Family/Species	No	% No	Wt (kg)	%Wt	Mean Weight
Cichlidae					
Oreochromis niloticus	540	18.57	23.12	14.03	0.043
Coptodon zillii	1107	38.09	59.61	36.16	0.054
Sarotherodon galilaeus	496	17.09	32.39	19.65	0.065
Channidae					
Parachana obscura	62	2.13	7.46	4.53	0.120
Clariidae					
Clarias buthupogon	379	13.04	14.5	8.80	0.038
Hepsetidae					
Hepsetus odoe	265	9.12	26.34	15.98	0.099
Mormyridae					
Brienomyrus spp	57	1.96	1.4	0.85	0.025
Total	**2906**	**100**	**164.82**	**100**	

Gillnet Selectivity

The fish caught in the various meshes of experimental gillnet is shown in table 2. Mesh size 1" recorded the highest catch in terms of number (29.11%) followed by 4" (21.52%) while 3" mesh size had the least catch (6.96%). This is an indication that most of the fish caught were small to medium in sizes, which could be the reflection of the stock. Mesh size of 4" had the highest weight (28.23%) and the least weight was recorded in mesh size 3" (2.65%), which is the recommended mesh size of inland water body of the country. Meshes 3" and 4" only contributed 28.28% and 30.88% in number and weight respectively of the catches. This shows that fishery production of the reservoir is poor. This is supported by the fact that most catches (71.52%) were below 3"recommended for inland water bodies of Nigeria

Table 2: Fish caught, and Weight in Experimental gillnet catches from Egbe Reservoir, Ekiti State, South-western Nigeria

Mesh size	1"	1½"	2"	2½"	3"	4"	Total
No. of fish caught	46	23	30	14	11	34	158
Percentage (%)	29.11	14.56	18.99	8.86	6.96	21.52	100
Weight (Kg)	2.95	1.77	2.27	0.85	0.30	3.20	11.34
Percentage (%)	26.03	15.61	19.98	7.50	2.65	28.23	100



The figure above shows that Cichlidae recorded the highest number (73.75%) as well as weight (69.84%). This is evident because the family had the highest number of species in the reservoir as well as high reproductive capabilities. This is then followed by *Clariidae* (13.04%). The higher weight recorded by Hepsetidae could be due to the sizes caught during the period of study. The *Mormyridae* recorded least both in number (1.96%) and weight (0.85%) as the species was scanty in both experimental gillnet and fishers catches at landing sites. Most of the catches were small herbivorous species and moderate carnivores.
Non-fin fish of the reservoir: A species of edible frog (Plate 8), which is common on the reservoir was caught fishers. It serves as a popular delicacy for the locals.

CONCLUSION

Egbe Reservoir is poor in species composition in terms of abundance and diversity. Nevertheless, the reservoir has potential to support small-scale fishery if fully developed and managed in a sustainable manner. The use of small mesh sizes should be discouraged in order to prevent the continual exploitation of small-sized fishes form the reservoir. There may be need to stock the reservoir with forage species and for further investigation on the actual presence of other non - fin fish aquatic animals.

REFERENCES

Edward J. B. (2013). Evaluation of the Fisheries Potentials of Egbe Reservoir, Ekiti State, Nigeria. Greener Journal of Biological Sciences, 3 (7), pp. 260-267

Olaosebikan, B.D. and Raji, A. (2021). Field Guide to Nigerian Freshwater Fishes. 4th Edition. University of Ilorin Press.

Pauly, D., Leveque, C. and Teugels, G. G. (2003). The Freshwater and Brackish water Fishes of West Africa. Institute of Research and Development Editions. Collection Faune et Flore tropicales,40 (1):457

Ukaonu, S.U. and Ugwumba, A.A.A (2021). Species composition, abundance and diversity of fish f auna of Yewa Lagoon, South-West Nigeria. Proceedings of the 36th Annual National Conference of Fisheries Society of Nigeria (FISON) held at University of Port Harcourt, Choba, Rivers State, pp.25-29

Yem, I.Y., Bankole, N.O., Ibrahim A. and Kwen, K. (2016). Ichthyofauna survey of Goronyo Reservoir, Sokoto State, Nigeria. FISON Conference Proceedings, pp. 255- 258.

Yem, I.Y., Ewutanure, S. J., Ibrahim A., Husaini, J., Haruna, M. K. and Ogunfowora, O. O. (2024). Ichthyofauna composition of Malale and Kaya in the Southern portion of Kainji Lake, Nigeria. Proceedings of 1st International Conference of OAUSTECH Leadership Academy, pp. 193-199


Plate 1: *Oreochromis niloticus*


Plate 2: *Sarotherodon galilaeus*


Plate 3: *Coptodon zillii*


Plate 4: *Hepsetus odoe*


Plate 5: *Parachana obscura*

Plate 6: *Clarias buthupogon*


Plate 7: *Brienomyrus spp*


Plate 8: Edible frog

LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR OF *Pseudotolithus elongatus* (BOWDICH, 1825) FROM THREE TROPICAL ESTUARIES

[1]Ekelemu, J. K and [2]O. J. Eriegha.
[1]Department of Fisheries and Aquaculture, Delta State University, Abraka, Nigeria
[2]Department of Fisheries and Aquaculture, Nigeria Maritime University, Okerenkoko, Nigeria
*Corresponding Author: ekelemujerimoth@gmail.com; +2348036792753; 0000-0002-6204-8961

ABSTRACT
This study examined the length-weight relationship (LWR) and condition factor (K) of Pseudotolithus elongatus across three estuaries: Escravos Estuary, Qua Iboe Estuary, and Lagos Lagoon. The objective was to evaluate the growth patterns and overall health of fish populations in these estuarine systems, which are currently subjected to varying degrees of environmental pressure. A total of 150 specimens were collected from artisanal fishers using gill nets. Total length and body weight of each specimen were recorded. The growth pattern was evaluated using the power equation: W= a.Lb, while the condition factor was computed using Fulton's formula: K = 100W/L3. The results indicated that the fish populations from the three estuaries exhibited varying growth patterns, with the values of the exponent b ranging from 2.81 (Escravos) to 5.51 (Lagos Lagoon). The K values also varied significantly, with mean values of 0.76 in Escravos Estuary, 0.83 in Qua Iboe Estuary, and 0.85 in Lagos Lagoon. These values which were all below 1, suggest that the fish populations in these estuaries are not in optimal condition. The relatively lower K value in Escravos Estuary is particularly worrisome, as it points to suboptimal environmental conditions potentially caused by oil pollution. Fish from Lagos Lagoon and Qua Iboe Estuary, while still exhibiting condition factors below 1, showed comparatively better health, likely due to relatively more favourable environmental conditions. The study underscores the role of environmental conditions in shaping the growth and well-being of P. elongatus, aiding sustainable fisheries management in Nigeria.

Key words:
Growth pattern, Bob Croaker, Condition factor, Escravos Estuary, Qua Iboe Estuary, Lagos Lagoon.

1.0 INTRODUCTION

The Gulf of Guinea is one of the most important marine ecosystems in West Africa, supporting a rich biodiversity and a wide range of fisheries that are critical to the livelihoods of millions of people in coastal communities (Pabis *et al.*, 2020). Among the species targeted by artisanal and commercial fisheries is *Pseudotolithus elongatus* (Bobo Croaker), a demersal fish that plays a key role in local diets and economic activities. However, the sustainability of these fisheries is increasingly under threat due to overfishing, habitat degradation, and environmental pollution. Effective management of P. elongatus populations requires a detailed understanding of its biology, including growth patterns and overall health in response to environmental conditions. The length-weight relationship (LWR) and condition factor (K) are vital metrics that can provide insights into the growth performance and condition of fish populations (Ekelemu and Zelibe, 2014). These parameters help in assessing whether fish are thriving in their environments or experiencing stress due to factors such as pollution, habitat destruction, or changes in water quality (Chandran *et al.*, 2023; Eriegha and Eyo, 2023). For P. elongatus, whose populations are subjected to varying degrees of environmental pressure in different estuaries, understanding these metrics is essential for determining the health of the population and identifying areas that may require intervention.

In recent years, the estuarine environments that support P. elongatus and other species have been under growing pressure from anthropogenic influences (Mitchell et al., 2015). In Nigeria, as in many parts of the world, estuaries are increasingly impacted by human activities such as industrial pollution, oil exploration, agricultural runoff, habitat destruction, and urbanization (Zabbey *et al.*, 2019). These activities contribute to the degradation of water quality, leading to altered ecological conditions that can profoundly affect aquatic organisms (Nubi *et al.*, 2022). For instance, the Escravos Estuary, located in the Niger Delta, is heavily influenced by oil exploration and related activities, which often result in pollution events that degrade water quality (Eriegha and Sam, 2020; Eriegha *et al.*, 2024a). Similarly, the Qua Iboe Estuary is affected by industrial, oil exploration and agricultural runoff (Benson et al., 2017), while the Lagos Lagoon faces significant pollution challenges due to proximity to Nigeria's most populous city, Lagos, and its associated urban sprawl (Nkwoji *et al.*, 2020). Despite the economic importance of P. elongatus and the growing environmental pressures on its habitat, there is a paucity of data on its length-weight relationship and condition factor in Nigeria's estuarine ecosystems. This study fills a critical knowledge gap by providing data on the growth patterns and health status of P. elongatus across three distinct estuaries. The information generated will be crucial for informing fisheries management policies and developing conservation strategies aimed at ensuring the sustainability of this valuable species.

2.0 MATERIALS AND METHODS

2.1 Description of the study area

This study was carried out in three water bodies that have connections to the Gulf of Guinea, Atlantic Ocean. These were the Escravos estuary, Qua Iboe estuary and Lagos lagoon (Figure 1). The sites were also characterized by landing sites, with high species richness and availability of economically important fish species. The Escravos estuary is located in Delta State and lies within the tropical region in South Southern Nigeria. Located in latitude 5° 34' 56" N and longitude 5° 10' 49" E, the Escravos estuary is noted for shipping and inland water transportation and is the preferred route for ocean-going vessels engaged in the oil and gas industry (Nwaogbe *et al.*, 2023). The Qua Iboe estuary which is located in Akwa Ibom State lies within the tropical region in South Eastern Nigeria. It is located at latitudes 4°391 and 27°611 N and longitudes 7°521 and 42°181E. It drains it catchment area of about 7.092 km2 and the river course covers a distance of 151 km from its source at Umunike in Imo State to where it discharges into the Atlantic Ocean at the Bight of Bonny close to Ibeno (Essien-Ibok and Isemin 2020). The Lagos Lagoon is the largest of the four lagoon systems of the Gulf of Guinea and lies in latitude 6° 26' 59.99" N and longitude 3° 22' 59.99" E. Fresh water from the upland is fed into the lagoon from the northern part of the system by Ogun River, with a host of other smaller rivers as well as tidal creeks. It discharges in the south into the South Atlantic Ocean through the Lagos harbour (Alademomi *et al.*, 2020). The three water bodies provide ample fishing opportunities, waterways transportation, and offshore oil exploration (Eriegha *et al.*, 2024b)

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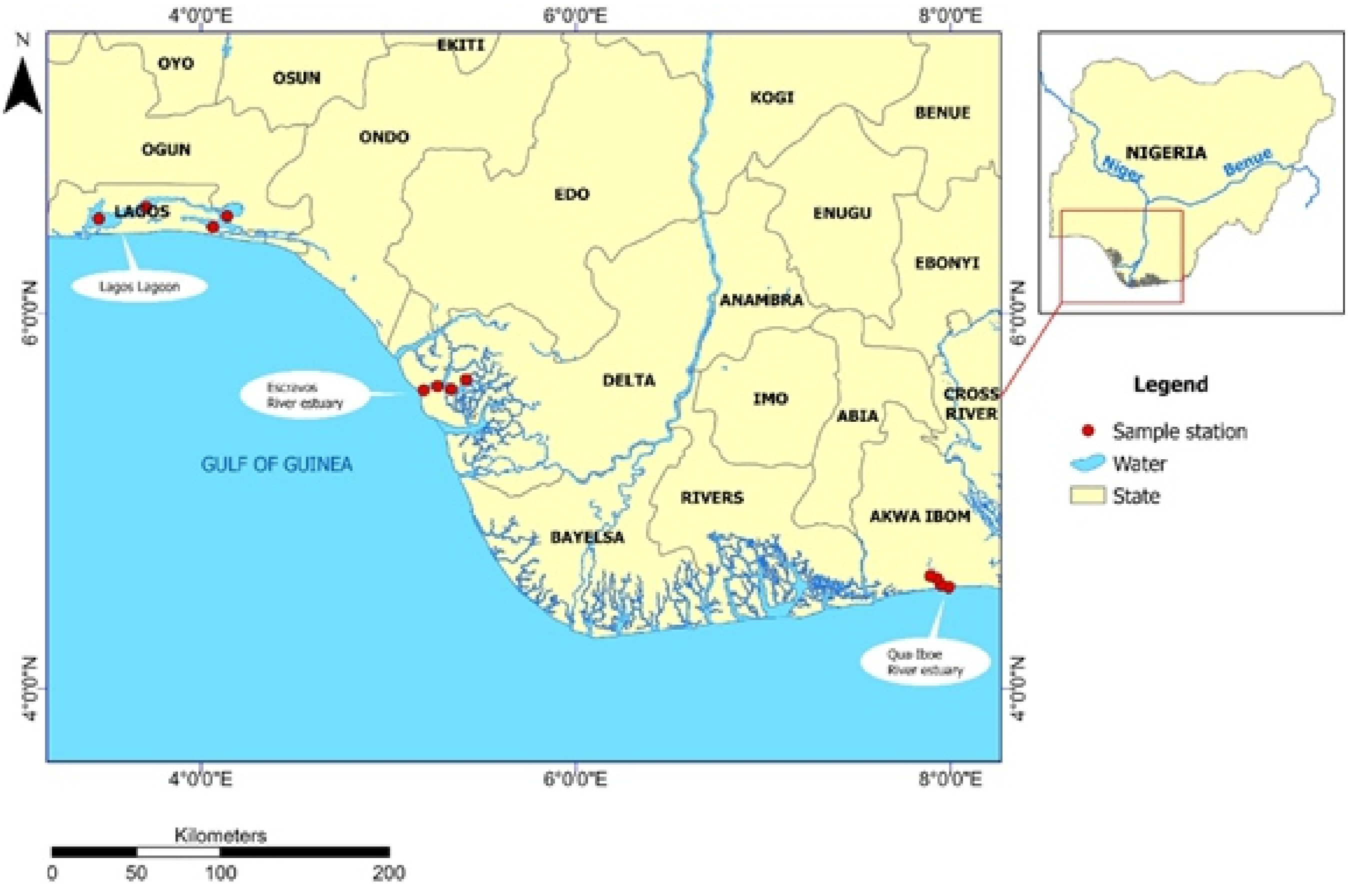

Figure 1: Map showing Escravos Estuary, Qua Iboe Estuary, and Lagos Lagoon adjoining the Gulf of Guinea in Nigeria.

2.2 Sample Collection and Measurement

A total of 450 fish samples, comprising 150 random samples of P. elongatus were collected each from Qua Iboe estuary, Escravos estuary and Lagos lagoon. These samples were collected from local fishers using gill nets in each of the water bodies. Length and weight were determined on fresh samples after a thorough species identification using Idodo-Umeh (2003). Measurement for length (cm) and weight (g) were determined using a meter rule and an electronic weighing balance, respectively.

2.3 Determination of length-weight Relationship and Condition Factor

The relationship between fish length and weight was expressed using Ricker's equation (1973) after data were log-transformed to address non-normality.

$W = a.L^b$

Where,

L = total length (cm)

W = body weight (g)

a = constant and,

b = slope (fish growth rate).

Using least squares linear regression, the constants (a and b) were derived from the log-transformed length and weight values (log W = log a + b log L). The condition factor (K values) was calculated, using Fulton's condition factor formula (Pauly, 1984); $K = 100W/L^{3}$.

3.0 RESULTS AND DISCUSSION

The length - weight regression equations of P. elongatus from the Escravos estuary, Qua Iboe estuary, and Lagos lagoon are presented in Table 1. The relationship can be expressed by the following equation:

$W = 0.1759TL^{2.8093}$, $R^2 = 0.9083$ (for Escravos estuary), $W = 0.1236TL^{5.333,}$ R2 = 0.9057 (for Qua Iboe estuary) and $W = 0.1179TL^{5.514,}$ $R^2 = 0.8538$ (for Lagos lagoon). The results indicated that the modeling efficiency or fit index was high, with the coefficient of determination ranging from 0.85 to 0.91 for fish from the three water bodies. The slope of the regression line of length and weight (b) computed for P. elongatus from the studied populations ranged between 2.81 (Escravos estuary) and 5.51 (Lagos lagoon).

The slope of length-weight relationship of the studied populations indicated that the species experience both positive and negative growth patterns. According to Sangun et al. (2007), fish growth rate is classified as positive allometric if $b > 3$ and negative allometric if $b < 3$. These variations in growth patterns are likely influenced by differences in the environmental conditions of the three estuaries. Escravos Estuary, being highly impacted by oil exploration and pollution, may have adverse conditions that limit the growth of P. elongatus. The negative allometric growth observed in this estuary could reflect stress from degraded water quality or reduced food availability. On the other hand, the positive allometric growth in Qua Iboe Estuary and Lagos Lagoon may be attributed to more favourable environmental conditions, though both of these estuaries are also subjected to anthropogenic influences, such as industrial pollution and urban runoff. The value obtained at the Lagos lagoon was in agreement with the b value obtained at the Mokoko River (2.657) by Lekan and Itunuola (2022). The regression exponent values obtained from this study were also in agreement with the values of 2.93 reported in Jaja Creek (Abiaobo *et al.*, 2023) and 3.145 reported in Cross River estuary (Ajah and Udoh, 2012). The regression exponent values obtained in this study were however higher than those documented by García-Isarch et al. (2023) in Guinea-Bissau (2.62), Wala et al. (2023) in Imo River (1.352) and by Ekpo (2020) in Qua Iboe River estuary (2.39).
The computed mean value and range of the condition factor of P. elongatus (Table 1) revealed that P. elongatus from the Escravos estuary and Lagos lagoon had a similar condition factor, having a condition of 0.83 and 0.85 respectively while fish from Escravos estuary had the least condition (0.76). Fulton's condition factor (k) values of 0.76, 0.83 and 0.85 for Escravos estuary, Qua Iboe estuary and Lagos lagoon, respectively, suggest that P. elongatus populations in all three estuaries are not in optimal condition ($K < 1$). The low condition factor in Escravos Estuary is particularly concerning and may be linked to the high levels of pollution associated with oil exploration activities. Comparatively, the slightly higher K values in Qua Iboe Estuary and Lagos Lagoon suggest that the fish in these estuaries are in better condition, but still below optimal health standards. The values obtained from this study compared favourably with the value of 0.83 reported in Jaja Creek (Abiaobo et al., 2023). These values were lower than those documented by García-Isarch et al. (2023) in Guinea-Bissau Estuary (1.09), Wala et al. (2023) in Imo River (1.09), Ibeno by Ekpo (2020) in Qua Iboe River estuary (0.98), Ajah and Udoh (2012) in Cross River estuary (1.01) and Lekan and Itunuola (2022) in Mokoko River (0.97 to 1.26).

Table 1: Length-Weight relationship and Condition Factor (K) of P. elongatus from Escravos estuary, Qua Iboe estuary and Lagos lagoon

Water Body	Equation (R^2)	$K \pm$ S.E	Range of K
Escravos	$W = 0.1759TL^{2.8093}$ (0.9083)	0.76 ± 0.11	0.62 – 1.00
Qua Iboe	$W = 0.1236TL^{5.333}$ (0.9057)	0.83 ± 0.04	0.59 – 1.33
Lagos Lagoon	$W = 0.1179TL^{5.514}$ (0.8538)	0.85 ± 0.09	0.69 – 1.03

4.0 CONCLUSION

This study has revealed significant variations in the length-weight relationship and condition factor of P. elongatus across three estuaries adjoining the Gulf of Guinea in Nigeria. The fish populations in Escravos Estuary exhibited negative allometric growth, while those in Qua Iboe Estuary and Lagos

Lagoon showed positive allometric growth. The condition factor values across all three estuaries were below 1, indicating suboptimal fish health, with the lowest values recorded in Escravos Estuary. These findings underscore the need for targeted fisheries management interventions aimed at improving the environmental conditions in these estuaries, particularly in Escravos, where the fish population appears to be under considerable stress. Regular monitoring of the length-weight relationship and condition factor of commercially important fish species is, therefore, crucial for sustainable fisheries management and the long-term conservation of fish stocks in Nigeria's estuarine ecosystems. Future studies should explore the specific environmental factors contributing to the observed growth and health patterns, including water quality assessments and the impacts of pollution from oil exploration and industrial activities. This will provide a more comprehensive understanding of the challenges facing P. elongatus populations and inform strategies to mitigate the adverse effects of human activities on these critical habitats.

REFERENCES

Abiaobo, N. O, Asuquo, I. E., Akpan I. I. and Augustine, A. L. (2023). Aspects of the Biology of (Pseudotolithus elongatus) Bobo Croaker Fish from Jaja Creek, Ikot Abasi Local Government Area, Akwa Ibom State, South Eastern Nigeria. Int J Zoo Animal Biol. 6(6), 1 -11. 000538.

Ajah, P. O. and Udoh, S. A. (2012). Food and feeding habits, condition factor and length-weight relationships of Mugil cephalus and Pseudotolithus elongatus in Cross River estuary, Cross River State, Nigeria. Tropical Freshwater Biology. 21(2), 59-70.

Alademomi, A. S., Okolie, C. J., Daramola, O. E., Agboola, R. O. and Salami, T. J. (2020). Assessing the relationship of LST, NDVI and EVI with land cover changes in the Lagos Lagoon environment. Quaestiones Geographicae, 39(3), 87-109.

Benson, N. U., Anake, W. U., Essien, J. P., Enyong, P. and Olajire, A. A. (2017). Distribution and risk assessment of trace metals in Leptodius exarata, surface water and sediments from Douglas Creek in the Qua Iboe Estuary. Journal of Taibah University for Science, 11(3), 434-449.

Chandran, R., Singh, R. K., Singh, A., Ganesan, K., Thangappan, A. K. T., Lal, K. K. and Mohindra, V. (2023). Evaluating the influence of environmental variables on the length-weight relationship and prediction modelling in flathead grey mullet, Mugil cephalus Linnaeus, 1758. PeerJ, 11, e14884.

Ekelemu, J. K. and Zelibe, A. A. (2014). Growth patterns and condition of four dominant fish species in Lake Ona, Southern Nigeria. Journal of Agriculture and Food Environment. 1(2), 148 – 155.

Ekpo, I. E. (2020) Condition factor and length weight relationship of bycatch of artisanal fisheries in Qua Iboe River estuary landed at Ibeno, Niger Delta, Nigeria. African Journal of Agriculture, Technology and Environment. 9(1), 196-207.

Eriegha, O. J. and Sam, K. (2020). Characterization of crude oil impacts and loss of livelihood in the Niger Delta, Nigeria: A fisheries perspective. International Journal of Maritime and Interdisciplinary Research. 1(1), 255-273.

Eriegha, O. J. and Eyo, V. O. (2023). Length-Weight Relationship and Condition Factor of the Bonga Shad Ethmalosa Fimbriata (Bowdich, 1825) From the Escravos Estuary, Delta State, Nigeria. Journal of Aquaculture and Fisheries. 7, 1 – 5.

Eriegha, O. J., Ekelemu, J. K., Nwachi, O. F. and Eyo, V. O. (2024a). Histopathology of Selected Economically Important Fish Species from the Escravos Estuary, Nigeria: A Baseline Study for Environmental Monitoring. International Journal of Innovative Studies in Aquatic Biology and Fisheries. 9(1), 1 – 8.

Eriegha, O. J., Ekelemu, J. K., Nwachi, O. F. (2024b). Comparative Morphology of Ethmalosa fimbriata (Bowdich, 1825) From Three Estuaries Adjoining the Gulf of Guinea, Nigeria. ILMU KELAUTAN: Indonesian Journal of Marine Sciences 29(2), 211-221.

Essien-Ibok, M. A. and Isemin, N. L. (2020). Fish species diversity, abundance and distribution in the major water bodies in Akwa Ibom state, Nigeria. MedCrave, 4(1), 42-48.

García-Isarch, E., Pérez, M., Partida, B., Landa, J., Czerwinski, I., Acosta, C. and Guitton, J. (2023). Stock identification: advancing in the knowledge of stock structure as a requirement for stock assessment. Proceedings of the 3rd 3 Regional Meeting on Improved Regional Fisheries Governance in Western Africa. 3-5 April 2023, Abuja, Nigeria.

Idodo-Umeh, G. (2003). Freshwater fishes of Nigeria (taxonomy, ecological notes, diet and utilization). Idodo-Umeh Publishers Limited. 232p.

Lekan, J. T. and Itunuola, O. S. 2022. Studies on Morphometrics, length-weight relationship, condition factor and food and feeding habit of Pseudotolithus elongatus from Makoko River, Lagos State. International Journal of Clinical Biology and Biochemistry. 4(1), 37-47

Mitchell, S. B., Jennerjahn, T. C., Vizzini, S. and Zhang, W. (2015). Changes to processes in estuaries and coastal waters due to intense multiple pressures–An introduction and synthesis. Estuarine, Coastal and Shelf Science, 156, 1-6.

Nkwoji, J. A., Ugbana, S. I., and Ina-Salwany, M. Y. (2020). Impacts of land-based pollutants on water chemistry and benthic macroinvertebrates community in a coastal lagoon, Lagos, Nigeria. Scientific African, 7, e00220.

Nubi, A. O., Popoola, S. O., Dada, O. A., Oyatola, O. O., Unyimadu, J. P., Adekunbi, O. F.and Salami, A. M. (2022). Spatial distributions and risk assessment of heavy metals and PAH in the southwestern Nigeria coastal water and estuaries, Gulf of Guinea. Journal of African Earth Sciences, 188, 104472

Nwaogbe, O. R., Eyo, V. O., Olisameka, A. and Nwaogbe, G. O. (2023). Emperical solutions to fish logistics and supply value chain to Warri markets from Escravos route fishing camps, Delta State, Nigeria. Proccedings of the 37/38 Annual Conference, Association for Aquatic Science. River State University, Port Harcourt. 26th – 29th June, 2023.

Pabis, K., Sobczyk, R., Sici ski, J., Ensrud, T. and Serigstadt, B. (2020). Natural and anthropogenic factors influencing abundance of the benthic macrofauna along the shelf and slope of the Gulf of Guinea, a large marine ecosystem off West Africa. Oceanologia, 62(1), 83-100.

Pauly, D. 1984. Fish population dynamics in tropical waters: A manual for use with programmable calculators. ICLARM Studies and Reviews 8. International Center for Living Aquatic Resources Management Manila 325.

Ricker, W. E. 1973. Two mechanisms that make it impossible to maintain peak-period yields from stocks of Pacific salmon and other fishes. Journal of the Fisheries Board of Canada. 30(9), 1275-1286.

Sangun, L., Akamca, E. and Akar, M. 2007. Weight-length relationships for 39 fish species from the north-eastern Mediterranean coast of Turkey. Turkish Journal of Fisheries and Aquatic Sciences. 7(1), 37 – 40.

Wala, C., Ugbomeh, A. P., Onwuteaka, J., Bob-Manuel, K.N.O. and Lazarus, O. T. (2023). Length-weight Relationship and Condition Factor of Fish species in Imo River, Rivers State, Nigeria. Journal of Research in Agriculture and Animal Science. 10(2), 29-39.

Zabbey, N., Giadom, F. D. and Babatunde, B. B. (2019). Nigerian coastal environments. In World seas: An environmental evaluation (pp. 835-854). Academic Press.

RELATIONSHIP BETWEEN RAINFALL, WATER LEVELS AND FISH CATCH IN SOME FISHING VILLAGES IN THE SOUTHERN BASIN OF KAINJI LAKE, NIGERIA

Gwari, B.M., M. Sabo, Z. Musa, Y. A. Birnin YaurI and E A. Robert
Research operation department,
National Institute for Freshwater Fisheries Research, P.M.B. 6006,
New Bussa, Niger State, Nigeria.
E-mail: bitrusgwari54@gmail.com

ABSTRACT
In order to ascertain the effect of rainfall, water levels, and floods on fish catch in the Kainji lake Basin, Niger State, Nigeria, studies on the relationship between these parameters were conducted for a full year between March 2022 and February 2023. It rained the most (325.5mm) in August. During this study, the rainfall levels ranged from 0 mm in November/February to 325.5mm in August. April saw the lowest water level (11m), while August saw the greatest level (25.6m). Between May (10.2 m) to August (25.8 m), the water level rose. When the dam spillway started to overflow in August, the dam started to flood. An examination of fish capture from 10 fisherman around the lake indicated substantial increase during the dry season when water levels were low (175kg, 178kg and 176kg for March, April and May respectively) than rainy season when water level were high (126kg, 128kg and 130kg for August, September and October respectively. Some fish species captured throughout the research period are Alesteidae, Characidae, Bagredae, Mochaidda, Momyridae, Cypridae, Claroteidae Chyprinidae and Hepsetidae (Dry season) and Claridae, Schibedae, claroteldae,Osteoglossidae, characidae, Osteaglossidae, Gymnorchidae,Chichlidae,Cluipeidae, Distichodontidae (rainy season). Significant correlations existed between rainfall and lake level but there is no statistical significance correlation between fish catch and rainfall.

KEYWORDS:
Rainfall, Water levels,
Fish catch, Flood, Kainji Lake

INTRODUCTION

The artisan farmers in the West African Subregion require a basic level of technical skill in order to determine the optimum fish production from the lake fishery. The ability to fish must be extended beyond just using equipment and include an understanding of the environmental aspects of the habitat in which they live. Due to their inability to advance the artisan fishery, the majority of our studies on the lake fisheries in Nigeria and other African nations have had little effect on enhancing sustainable fish output (Araoye, 1999). To name a few, the failure of the lake fisheries in New Bussa, Nigeria,Kivu, in Rwanda, Lake Malawi cannot be justified from this simple fact. These bodies of water were subjected to indiscriminate fishing, which over time eliminated the viable stock. To increase these artisan fishermen's understanding of the environmental elements that can impact fish productivity, an intervention programme for capacity building is required (Araoye, 2002).

In Asa Lake (Araoye, 1999) and Lake Asejire, Oyo State (Ipinmoroti and Iyiola, 2023) food availability has been found to be a significant factor influencing the seasonal and spatial distribution of fish (Weyl et al, 2013), Ngor et al, 2023): however, the seasonal abundance of these food sources is determined by environmental factors such as rainfall, water levels, and floods. Most of the artisan fishermen that fish on local bodies of water are probably used to these natural conditions, particularly during the rainy season. Because they are aware of the frequency of rainy days, the water level, and the severity of floods during each season, these fishermen are able to predict the amount of fish that can be obtained from the lake. Fishing activities in Kainji Lake was enhanced with the construction of the Dam in 1978 by the Federal Government for the purpose of electric generation.

The aim of this work therefore is to examine the relationship between rainfall, water levels, and floods on fish catch in some fishing communities of Kainji lake Basin, Nigeria. This work will be used to educate the fishermen in Kainji lake on the use of some environmental factors to predict fish catch around the lake as well as focused on fruitful fishing exercise in general.

MATERIALS AND METHODS

The environmental factors including rainfall, water levels, rainy days and flooding around the dam were determine in March 2022 and February, 2023 in the presence of 12 fishermen representing the fishermen group around the dam. Fish species caught by these fishermen twice a week were identified and classified according to families, counted weighted and recorded. They used traps, gill nets of different mesh sizes, ranging 7.2cm to 10cm and cast nets to catch fishes from the surface, shore and bottom habitats. The fishermen who were fairly educated (primary and secondary school levels were made to assist in the record keeping. Three sample sites were used in this study; one each from fishing villages of Yuna, Anfani and Malale (Figure 1). The period of floods around the lake was taken from the day the dam spillway began to overflow (September) to the last day the it stopped overflowing (March) (FAO),1973, Adegbehin et al, 2016)). The number of rainy days were obtained from the records of hydrological unit of National Institute of freshwater fisheries research New Bussa, Niger State. The water levels around the dam were also recorded using water level gauge installed at the Dam

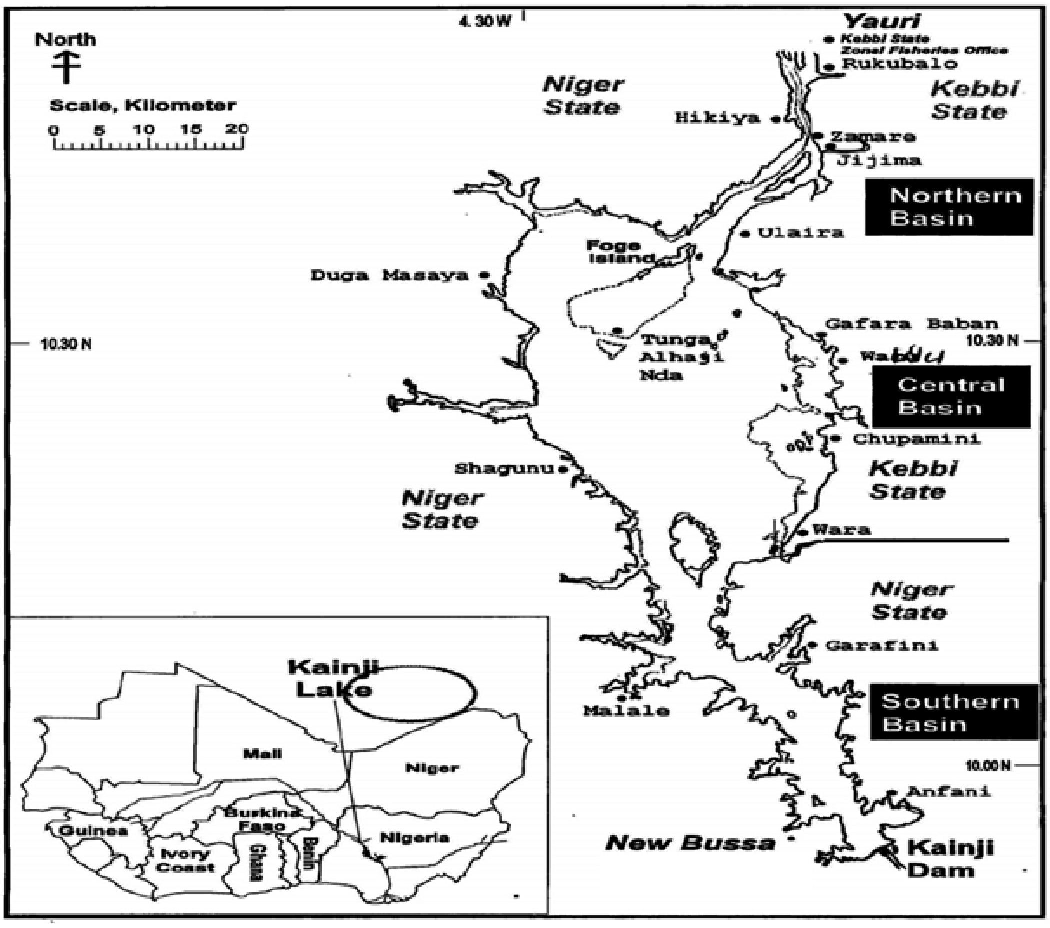

Figure 1. Map of Lake Kainji, Nigeria showing some of the Fishing Villages

RESULTS AND DISCUSSION

Rainfall and Number of rainy days

The monthly variation in the mean rainfall is presented in Table 1. Rainfall commenced in April and continued untill the maximum value of (325.5mm) was attained in August after which a continuous decrease occurred untill April. The range recorded was Zero to 325.5mm (Table 1). The number of rainy days also increased from April (3days) to August (21days) during the period of this research. The number of rainy days decreased from October(4 days) to March (Zero). The rainfall and water levels were negetively correlated. Negetive rainfall-water level correlations have been documented for Kainji Lake (Imevbore, 1975), Lake Heide, Jebba Lake (Adeniji, 1993), and Asa Lake (Araoye, 1997). These findings are typical of tropical lakes. The expertise gained by the few chosen fisherman will be passed on to the others for more lucrative fishing operations around the Dam because the fishermen also participated in the data collecting throughout this research.

Table 1: Shows relationship of fish catch and environmental elements

Months	Fish Catch (No)	Fish Catch (Wt)	Rainfall (mm)	Water levels (mm)	Rainy days (No)
Mar	167	176kg	0	11.3	0
Apr	169	178kg	0	11	2
May	155	175kg	53	12.5	3
Jun	154	172kg	182	14.3	6
Jul	100	136kg	205	15.7	15
Aug	65	126kg	325	24.3	21

Water levels

When the level of the water changes, fish react differently. Fish are more prone to congregate in deeper pockets and hide beneath objects like rocks and roots while the water level is dropping. Fishermen should look for deep, isolated pockets with lots of shade and cover when the water level is very low. The majority of fish will become even more spread during times of rising water levels, gathering in shallower places close to grass and other structural cover. Fish constantly migrate closer to the ocean's edge as water levels increase. Table 1 presents the outcome of the water levels as well. The dam's water level started to rise in May (12.5 m) and continued to do so until August (24.1 m), when it reached its maximum and remained there until September. From October, when the water level was 13.2 m, it gradually decreased until February, when it was at its lowest, 10.3 m.

The correlation analysis's result (Fig. 1) indicates that there is a negative Pearson's r value (-.798, -.809, and -.798) between fish catch and rainfall, water level, and rainy days. Thus, in the Kainji Lake Basin, a rise in rainfall causes the water level to rise, which in turn causes a decrease in fish catches, and vice versa. There is no statistical correlation between fish catch and rainfall ,water level and rainy days. Additionally, the two-tailed values of.002,.001, and.003 between fish catch and rainfall, water level, and rainy days indicate that there is no significant correlation between an increase in rainfall, water level, and rainy days and a decrease in fish capture. This result was in agreement with Samuel and Bernadette, (2024).

F ig. 1 shows relationship between hydroclimatic variables and fish catch

		Fish Catch (no)	Fish Catch (Wt)	Rainfall	Water L	Rainy days
Fish catch (No)	Pearson Correlation	1	.984	-.798"	-.809"	-.798"
	Sig (2-tailed)		.000	.002	.001	.002
	No	12	12	12	12	12
Fish catch (wt)	Pearson correlation	.984	1		-.784"	
	Sig (2-tailed)	.000		-.770"	.003	-.789
	No	12	12	.003	12	0.002
				12		12
Rainfall	Pearson Correlation	-.798	-.770		.885	
	Sig (2-tailed)	.002	.003		.000	
	No	12	12	1	12	.961
Water level	Pearson correlation	-.809	-.784		1	.000
	Sig (2-tailed)	.001	.003			
	No	12	12	12	12	12
Rainy days	Pearson correlation	-.798	-.789		.905	
	Sig (2-tailed)	.002	.002		.000	
	No	12	12	.885	12	.905
				0.000		.000
				12		12
				.961		1
				.000		
				12		12

** correlation is significant at 0.01 level

Fish catch

The monthly value of total of total fish catch is presented in Table 1. The months of March (167 specimens, 176kg) and April (169 specimens,178kg) recorded the highest number of total fish caught corresponding with the period of lowest water levels while the months of August (65 specimens,126kg), and September (67 specimens,128kg) corresponding with the periods of high water levels. The results have show that fish cought was higher during low water levels around the dam. Fish species captured throughout the resaerch period include Alesteidae, Characidae, Bagredae (Dry season) and Claridae, Schibedae, claroteldae, among others (Rainy season) (Table 2). This is useful information for the fishermen operating around the water body to reduce wasted effort of fishing activities especially during the rainy season for these species. The seasonal abundance of fish species was shown to be influenced by a combination of physiochemical parameters and the presence of food items (Lawal *et al.*, 2023). Ataguba (2014) reported the abundance of Synodontis species in a shallow river and a dam respectively during the period of low water levels explaing that during the high water levels and floods this catfish may show restricted movement due to reproductive activities, hence making them less vulnerable to fishing gear catchability. However, this work has also shown that the high catch during the dry season does not apply to Synodontis species alone, but also to other fish species around the dam. Also there is the tendency for high concentration of fish at low water levels to increase catchability.

Table 2. Fish species captured throughout the research period

Dry season	Rainy season
Alesteidae	*Claridae*
Characidae	*Schibedae*
Bagredae	*Claroteldae*
Mochaidda	*Osteoglossidae*
Momyridae	*Characidae*
Cypridae	*Osteaglossidae*
Claroteidae	*Gymnorchidae*
Chyprinidae	*Chichlidae*
Hepsetidae	*Cluipeidae*
	Distichodontidae

CONCLUSION

Findings indicate that there are significant correlations betweeen rainfall , water level and fish catch. Given the fluctuating water level conditions, effective control of fishing effort in Lake Kainji is likely to have positive influence on its annual fish yield. Sustainable management of the lake's fishery resource should include measures aimed at mitigating both human and climate-induced impacts on the lake level.

REFERENCES

Araoye, P.A. (1997). Bio-ecology of a Mochokid, Synodontis schall (Bloch and Schneider 1801) in Asa lake ilorin, Nigeria. Ph.D. Thesis, University of ibadan, Nigeria

Araoye, P.A. (1999).Physical factors and their influence on fish species composition in Asa Lake, Ilorin, Nigeria

Araoye, P.A. (2002)."Man-made lakes, ecological studies and conservation needs in Nigeria." Revista de Biología Tropical, vol. 50, no. 3-4, Dec. 2002, pp. 857.

Adegbehin , A. B., Y. O. Yusuf ., E. O. Iguisi and Zubairu I. (2016). Reservoir inflow pattern and its effects on hydroelectric power generation at the Kainji Dam, Niger State, Nigeria. Proceedings of the 3 International Conference on Environmental and Economic Impact on Sustainable Development. WIT Transactions on Ecology and The Environment, Vol 203, © 2016 WIT Press.

Ataguba, G A., Tachia, M.U and Aminu G. (2014). Fish species diversity and abundance of Gubi Dam,Bauchi State of Nigeria . Biological Diversity and Conservation. 7/2:1-

Lawal L, N., Abdullahi, S. A and Abolude, D. S. (2023). Physicochemical Characteristics and Fish Abundance and Diversity of Mairua Reservoir Water, Funtua, Katsina State, North-Western Nigeria. J Appl. Sci. Environ. Manage. 27 (1) 125-132

Hanek G., Leenderste, K and Farhani. B. (1991). Socio Economic investigations of Lake Kivu Fisheries. UNDP/FAO Regional Project for Inland Fisheries Planning (IFIP), RAF/87/099 – TD/23/91 (En): 55p

Heider,V.J. (1982). Lake Brokopondo filling phase limnology of a man-made lake in the humid tropics.Alblesserdem off Sedrukkerjji Kanters book V pp.427

Imovbore, H. (1975). The Ecology of Lake Kainji: The Transition from River to Lake. University of Ife Press. Pp.209.

Ipinmoroti, M. O. and Iyiola, A. O. (2023). Diversity, distribution and abundance of fish species in Lake Asejire,OyoState, Nigeria. The Zoologist, 21: 49-56.Zoological Society of Nigeria (ZSN)

Kombo, P.M ., Akange, E.T and Adeyemi, S.O. (2016). Diversity and abundance of Synodontis (Cuvier,1816) species in the lower river Benue, Makurdi, Benue state, Nigeria . International Journal of Fisheries and Aquatic Studies; 4(1): 238-242

Ngor, P.B., Uy, S., Sor, R., Chan, B., Holway, J., Null, S.E., So, N., Grenouillet, G., Chandra, S.,Hogan, Z.S and Lek, S.(2023) Predicting fish species richness and abundance in the Lower Mekong Basin. Front. Ecol. Evol. 11:1131142. doi: 10.3389/fevo.2023.1131142

Samuel, A and Bernadette, T.F. (2024). Temporal Variability and Predictors of Fish Catch (2009-2011) in the Niger and Benue Rivers: Implications for Contemporary Natural Resources Management in Kogi StateNigeria Communication in Physical Sciences, 2024, 11(4): 897-903

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TECNOLOGICAL INNOVATION IN FISHERIES AND AQUACULTURE (TIFA)

CURRENT TECHNOLOGIES USED BY FISH FARMERS IN ASSESSING INFORMATION IN ENUGU-EZIKE AGRICULTURAL ZONE OF ENUGU STATE

Obetta, N. C., M. O. Adadu And M. M. Paul
Department of Fisheries Technology, Federal College of Freshwater Fisheries Technology Baga, Borno State.
Correspondence Author; Obetta N.C., email – nathobettac@gmail.com, 07032557374 0000-0001-8554-7790

ABSTRACT
The study assessed the current technologies used by farmer in Enugu-Ezike Agricultural Zone for the purpose of receiving and disseminating information in fish farming enterprise. A multistage sampling procedure was used to select 116 respondents. Data for the study was collected using interview schedule and analyzed with descriptive statistics. Factor analysis was used to analyze the constraints. Results showed that (72%) are males, about (81%) are within the age bracket of 21 – 50 years. 100% of the fish farmers are literate and about (27%) earn above N 2,000,000 per year. Mobile phones had a high level (100%) of use, followed by Facebook (34.48%) and e-mail (16.38%). The fish farmers' preference in use of ICTs showed that mobile phone (47.41%) was preferred followed by Facebook (20.69%) and Television (14.66%). The constraints faced by the fish farmer in the use of ICT's include; high cost of the device, low income of the farmers, erratic power supply and low scale fish production among others. It was recommended that adequate training be given to the fish farmers by the extension officers in the use of multiple ICTs to increase their production and income. Supply of power and network services should be improved by the various bodies responsible for the services and a good government policy that will favour fish farming be put in place.

Keywords:
Current Technologies, fish farmers, Enugu-Ezike Agricultural Zone,

INTRODUCTION

Sulaiman, *et al.* (2022) states that Information and communication technology (ICT) is a general phrase used to describe a range of technologies for gathering, storing, retrieving, processing, analyzing, and transmitting information. As such, advances in ICT have progressively reduced the cost of managing information, enabling individuals and organizations to undertake information-related tasks much more efficiently.

Information and communication technologies (ICTs) play inevitable roles in every aspect of human activities today, including agriculture. The key players in agriculture are the farmers, and their ability to use improved technologies defines the role of ICT in agriculture generally (Nwagwu and Opeyemi, 2015). The use of ICTs seems to be on the increase now globally as it increases access to and exchanging of information, ICT offers the potential to increase efficiency, productivity, competitiveness and growth in various aspects of agricultural sector. Those that engage in agriculture in small scale utilize various forms of ICT such as mobile phones, computers, the internet, and so forth (Yekinni et al. 2019). ICTs have been a great companion in sustainable development issues in remote areas as it enhances production capacity of the rural dwellers. Similarly, they can be used to breakdown both national and international barriers and have turned the world into a universal village, making

information available to everyone, everywhere and at the needed time (Ogbonna and Agwu, 2013). The rapid growth in the demand for fish and fish products in Nigeria call for provision of efficient flow of information and knowledge to the fish farmers, without gender prejudice, for better decision making. Fish farming has become a common practice to increase income of practitioners and in the process reduce the wage bill expended on fish importation (FAO, 2022). Fish farmers thus need information to optimize production (Zeinab et al. 2014). Chhiato (2018) asserted that information dissemination is the activity of conveying and spreading one's ideas and knowledge through the exchange of thoughts, messages, as by symbols, signs, speeches, visuals, signals, writing, or behavior; and also, it is the meaningful exchange of information between two or among a group of people. Bello and Aghadiuno (2019) summarized information dissemination as the channel through which facts are linked to the rightful individual seekers and organizations. All these may not be achieved without the necessary information and communication technology (ICT) in place.
Information technology in Nigeria has gone a long way, but despite its existence, there seems to be limited access and utilization of these technologies. Consequently, there is the need to examine the utilization of ICTs by fish farmers in Enugu-Ezike agricultural zone. Zango (2019) stressed that without constant power supply, the ICT facilities and equipment cannot be fully used for global purposes. There is dearth of information and data in this important area of agriculture in the study area
Objective of the study: The major objective of the study was to assess the level of use of ICTs among fish farmers in Enugu-Ezike Agricultural zones of Enugu State.

MATERIALS AND METHOD

This study was carried out in Enugu-Ezike agricultural zones of Enugu State, comprising of Igbo Eze North, Igbo Eze South and Udenu Local Government Areas. A multistage sampling technique was used in the study. Four communities from each of Local Government Areas were purposely selected because of their fish farming activities. Twenty percent of fish farmers were selected through random sampling procedure from each of the twelve communities to give a total of 116 respondents.

Data were collected with the use of interview schedule from the selected respondents. The interview schedules were personally administered by the researcher.

Descriptive statistics was used to show the frequency, percentages and means. Factor analysis was used to determine the constraints of the fish farmers in the use of ICTs.

Table 1: Sample size selection.

Enugu-Ezike Agricultural Zone	LGA	Communities	Sample Frame	Sample Size
	Igbo Eze North	Ogrute	45	9
		Imufu	36	7
		Arji	48	10
		Umuida	41	
	Igbo Eze South	Ovoko	51	10
		Iheaka	49	10
		Ibagwa-Aka	66	13
		Itchi	50	10
	Udenu	Obollo-Afor	44	9
		Orba	58	12
		Immilike	45	9
		Ugbeleajima	46	9
		Total	579	116

Source; Adapted from Enugu State Ministry of Agriculture Fisheries Sector 2021.

RESULTS AND DISCUSSION

Socio-economic Characteristics of Fish Farmers

Table 2 revealed that majority (72%) of the respondents were males, while 28% were females. The high number of males shows their dominant position in the farm family decision making and as heads of families. The result agrees with works of Akinpelu et al. (2013) who reported 27 females out of 110 fish farmers in Oyo State, Nigeria. Also, Adelakun et al. (2015) reported 85% and 15% of male and female involvement in catfish farming. Women generally are burdened with family responsibilities and hardly have enough time for businesses like this. They may also not have access to capital for investment. These could have been some of the reasons only a few women were involved in the catfish production in the locality. The dominance of men in fish production was also reported by Umaru, et al., (2016). About (81%) of the farmers are between 21 - 50 years. This shows that they might be healthy and strong to perform the task of fish farming. This result agrees with Udo and Nyienakuna (2008) who reported that age of fish farmers which lies between 20 and 40 years positively influenced adoption of fishing technologies. Also, age of fish farmers 50 and above was found to have positively influenced activities of fish farmers at Jos (Solomon and Isaac, 2018).

It was found that (100%) of the respondents were literates as shown on Table 1. Education helps in socialization, exposure of people, and in the adoption of recommended farm practices and technologies. High literacy level of the respondents is an added advantage since improved educational level tends to facilitate more curiosity and interest in proven aquaculture technology. This result agrees with Jiriko et al. (2015) who found that majority (57.5%) had tertiary education with many graduates and postgraduate degree holders. This result is similar to the findings of (Sule et al., 2009) that 62% of fish farmers had tertiary education. Education reduces the amount of complexity perceived in a technology thereby increasing adoption. The respondents have put in many years in fish growing. The table also revealed that 63% had put in ≤10 years. The mean fish farming experience was 11.40 years. The implication is that the respondents are experienced and has higher likelihood of risk in their occupation. It shows that the respondents have a good knowledge of fish farming. This result disagrees with the result of Aphunu and Atoma (2011) who reported that 18.3% of fish farmers in Isoko Delta state had 6 – 10 years' experience in fish farming.

Table 2 revealed that about 27% earn above N2, 000,000 per year. Income is one of the major factors that impinge adoption of information and communication technologies. Income inequality will result in fish farmers with better income to adopt information technology positively in their farming routine while comparatively those with low income will do the different way (Gine and Klonner, 2005).

Table 2; Socio-economic Characteristics of the Respondents

Variables	Frequency	Percentage
Sex		
Male	84	72
Female	32	28
Age		
21 – 30	18	16
31 – 40	36	31
41 – 50	40	34
51 - 60	21	18
Above 60	1	0.9
Level of education		
Primary	5	4
Secondary	55	47
Tertiary	56	48
Farming experience		
<10	73	63
11 – 20	32	28
21 - 30	10	9
31 – 40	1	0.9
Annual income		
<# 500,000	22	19
#500,000 – #1,000,000	30	26
#1,000,000 - #1,500,000	20	17
#1,500,000 - #2,000,000	13	11
Above #2,000,000	31	27

Source; field survey 2022

Levels of ICTs Usage·

Table 3 below shows that new technological applications are being used across the fisheries value chains (inland and aquaculture). Mobile phones as well as traditional media such as the radio are used in promotion of agricultural development. ICTs are known to enhance or expand human networks (Yun et al. 2016). Mobile technology has a particularly positive impact in this area, fosters networks of farmers and agribusiness, so that they can support each other. Specialized applications are developed to further extend this impact, mobile phones for trading and emergencies, radio programming targeted at and in many cases compiled by fishing communities and Web-based serves fisheries specific information and networking resources (Ejiogu-Okeke, *et al.*, 2016). Nwobodo and Nwabugwu (2016) reported a high usage of ICTs by farmers in Anambra State, Nigeria. Wole-Alo and Oluwagbemi (2020) reported a high level of usage of ICTs by farmers in Ondo State, Nigeria. The video CDs are used by the fish farmers in watching documentaries on fish farming and programmes, Satellite television helps deliver signals in areas where customers may not be served by cable television or "terrestrial" broadcasting. The fish farmers use the television in watching the State broadcast on agricultural programmes example fish productions in the State. This result agrees with the assertion that among

modern ICTs, mobile phones serve as a means for effective transfer of knowledge and information about agricultural market and technology to farmers that enable them to apply the knowledge directly to improve their farming output and make easy access to market (Chhachhar *et al.*, 2014).
Digital and electronic technologies are transforming our economies, societies and lives. Technology has had a profound impact on the information and communication technologies.

Table 3; Level of ICTs usage in the study area

ICT	High F(%)	Low F(%)	Moderate F(%)	Not used F(%)	Mean
Mobile phone	116(100)	-	-	-	4
WhatsApp	8(6.90)	5(4.31)	103(88.79)	-	2.98
Radio	9(7.76)	7(6.03)	99(85.34)	1(0.86)	2.95
Video CD	-	70(60.34)	7(6.03)	39(33.62)	1.67
E-mail	19(16.38)	44(37.93)	38(32.76)	15(12.93)	2.46
Facebook	40(34.48)	44(37.93)	15(12.93)	17(14.66)	2.59
Cable media	-	20(17.24)	20(17.24)	76(65.52)	1.50
Satellite television	-	1(0.80)	39(33.62)	76(65.52)	1.62
Webcasting video	-	26(22.41)	10(8.62)	80(68.97)	1.42
Home video	6(5.17)	29(25)	81(69.83)		

Source; Field survey 2022
Figures outside the parenthesis are frequencies and those inside parenthesis are percentages

Preferred ICTs by the Respondents

Table 4 revealed the preferred ICT among the farmers. A good number (47.41%) preferred Mobile phones. Mobile phones are used in various ways; used for making calls, sending short messages. Those with Android mobile phones could check their e-mails, browse the internet and send messages through Facebook, WhatsApp, telegram and instagram. They could listen to radio programmes and use it as television. It shows that the fish farmers are literate and can make use of electronic media. The result indicates that use of mobile phones are reliable for adoption. New information and communication technologies are used across the fisheries value chains (maritime, inland and aquaculture). In addition, motivating farmers in adoption of new agricultural technologies remained a focal point of the agricultural extension (Muddassir *et al.*, 2016). Several studies have been conducted and prove that fish farmers prefer mobile phone with different purposes and goals. It has been observed by different experiences that modern fish farmers require accurate and reliable information. Mobile phones are good source of communication to connect with customers' relatives and friends on market prices and availability of technologies. This aid adoption of improved fish production technologies.

Use of this technology improves fish farmers' basic livelihoods in indirect ways. In this case it has been observed that mobile phones empowered the life of the fish farmers for trading and exchanging the information about weather, danger and location among each other. By using mobile communication technologies their lives can be improved. Furthermore, mobile phones can provide opportunities to fish farmers and merchants to communicate with each other by calls, short message services (SMS) even farmers could sell their product while still harvesting (Zango, 2019). This study showed that mobile phone, Facebook, WhatsApp, e-mail and radio were the most commonly preferred ICTs.

Table 4: Preferred ICTs by the Respondents

ICT	Percentage
Mobile Phone	47.41
WhatsApp	14.66
Facebook	20.69
E-mail	7.76
Radio	6.90
Satellite television	0.86
Webcasting television	0.86

Source; Field survey 2022

Constraints Faced by the Fish Farmers in Accessing ICT Facilities in Enugu-Ezike Agricultural Zone.

Table 5 shows that there were four major categories of constraints faced by the fish farmers in accessing information in Enugu-Ezike Agricultural Zone, namely; Socio-economic constraints (Factor1), Administrative constraints (Factor 2), Environmental constraints (Factor 3) and Technological constraints (Factor 4). This is in line with the works of Yekinni et al. (2019) who indicated that fish farmers are facing many problems and hindrances in ICT usage.

These four major categories of constraints have several implications as far as use of ICTs is concerned. Firstly, socio-economic constraints can adversely affect fish farmer's access to ICTs facilities and this in turn, can affect its use. Take for instance, high cost of devices, low income of fish farmers, unavailability and cost of batteries can mar fish farmers' accessibility to ICT facilities.

Secondly, administrative constraints such as erratic electricity power supply, fluctuation of services, lack of maintenance can adversely affect accessibility of fish farmers to ICTs and this in turn, can slow down the rate of use in Enugu State.

Thirdly, Environmental constraints such as poor access to ICTs can affect both accessibility of fish farmers to ICTs. Fourthly, technological constraint such as complexity and poor connectivity of ICT can pose as a barrier to rural fish farmers' use of ICTs in their fish farming business. Take for instance, poor connectivity to internet due to remoteness of some rural areas to urban centers where ICT facilities are found may hinder fish farmers from having access to ICTs.

Besides, some ICT facilities are too complex for rural fish farmers to comprehend or understand and put into use. This result agrees with the works of Aphunu and Atoma (2011) who found that lack of government enabling policy is one of the main pressing constraints to effective usage of ICTs in Nigeria. Maintenance problems, low scale of fish production and rural poverty were also identified as serious constraints to ICTs use by fish farmers. Suleiman *et al.,* (2022) stated that government's low level of assistance to ICTs infrastructural provision and absence of any policy to encourage farmers gain ICT education pose as threats to agricultural development. Ejiogu-Okeke et al. (2016) in their work in Rivers State found that; high cost of device, low income of farmers, low level of education, poor access to ICT device and erratic power supply are major constraints in the use of ICTs by the fish farmers.

Table 5: Factor Analysis of Constraints to Accessing Information by Fish Farmers.

Variables	Factor 1	Factor 2	Factor 3	Factor 4
1. High cost of devises (HCD)	0.5496*	-0.353	0.1474	0.1800
2. Low income (LI)	0.6209*	-0.1213	0.0451	0.1064
3. Poor access to ICTs (PAI)	-0.2258	0.2317	0.6888***	0.0886
4. Erratic power supply (EPS)	-0.4453	0.6964**	0.2103	0.1119
5. Poor connectivity (PC)	-0.3626	0.3214	0.0616	0.7084****
6. Inadequate policy framework (IPF)	-0.0929	0.5378**	.2562	-0.1451
7. Low scale of fish production (LSFP	-0.2868	0.4554**	0.2356	-0.2894
8. Low skills (LS)	0.3669	0.3261	0.1387	-0.3388
9. Low awareness/knowledge (LAK)	0.4265*	0.3020	-0.0024	-0.2840
10. Language barrier (LB)	0.3616*	0.4149	-0.1599	-0.1605
11. Lack of interest (LI)	0.6796*	0.1601	-0.2567	0.0460
12. Time of transmission (TT)	0.1499	0.5763**	-0.1329	0.3018
13. High call tariff (HCT)	-0.1126	0.5548**	0.1598	0.0720
14. Rural poverty (RP)	0. 5321	0.1473	-0.1533	0.0562
15. Poor maintenance of tools (PMT)	-0.5015	0.4644 **	0.1846	0.1664
16. Unavailab. and cost of batt. (UCB)	0.3749*	0.2725	-0.0527	0.0989

Complexity of ICTs (CI)
Source; Field survey 2022
Method: Varimax with Kaisar normalization
*- Socio-economic cum cultural constraints (Factor 1)
**- Administrative constraints (Factor 2)
*** - Environmental constraints (Factor 3)
**** technological constraints (Factor 4)

CONCLUSION

ICT plays important roles in fish farming. ICT devices such as mobile phones are highly used, also Facebook, email, radio, WhatsApp and home video are used at a certain high level in the study area. The results showed various other levels of use of the ICTs. The fish farmers preferred mobile phones in their fish farming activities followed by Facebook and radio. This implied that ICT increases production and accessibility of fish among the farmers and customers.

Adequate training should be given to the youth fish farmers by the extension officers in the use of multiple ICTs to increase their productivity and income. Supply of power and network services should be improved by the various bodies responsible for the services and a good government policy that will favours youths in farming be put in place.

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REFERENCES

Adelakun, K.M., Amali, R.P., Ogundiwin, D.I. and Bakare, K. (2015). Assessment of catfish farming in Osogbo(Nigeria) and its environs. Peer Journal Pre- Prints, 3, 17-27

Akinpelu, O.M., Ayeloja, A.A., George, F.O.A., Adebisi, G. L., Jimoh, W.A. and Idowu, S.D. (2013).Gender Analysis of Processing Activities among Commercial Catfish Processors within Ibadan Metropolis, Oyo State South-Western Nigeria. Journal of Aquaculture Research and Development, 4, 176-181

Aphunu, A. and Atoma, C. N. (2011). Extent of Use of ICTs by Fish Farmers in Isoko Agricultural Zone of Delta State, Nigeria. Journal of Agricultural Extension, 15 (1) 10 – 21

Bello, S. A., and Aghadiuno, P. C. (2019). Information needs, repackaging and dissemination: sustainable library services for national development. International Journal of Arts, Languages and Business Studies (IJALBS), 2(1), 176-186. http://www.ijalbs.com/index.php/ijalbs/article/view/56/55

Chhiato, L. (2018). Use of social networks for dissemination of information by media professionals in Mizoram. [Master's dissertation, Mizoram University].

Chhachhar, A.R., Querestic, B., Khushk, G.M. and Ahmed, S., (2014). Impact of ICTs in agriculture development. Journal of Basic Applied Science Resources. 4, 281–288.

Ejiogu-Okereke, N.E., Ubochioma, C. J., Ifeanyi, O.E. and Chikezie, P. N. (2016). "Roles of Information and Communications Technologies in Improving Fish Farming and Production in Rivers State, Nigeria."Library Philosophy and Practice (e-journal). 1445.

Food and Agriculture Organization of the United Nations (FAO) (2022). Aquaculture Growth Potentials in Nigeria. Aquaculture production Pp 17 – 24

Gine, X. and Klonner, S. (2005). Credit constraints as a barrier to technology adoption by the Poor lessons from South- Indian small-scale fishery. World Bank Policy Research Working Paper 3665.

Jiriko, R. K., Obianuko, J. C. and Jiriko, K. G. (2015). Socio-economic Factors Affecting ICT Utilization by Youths in, Fish Farming in Kaduna State, Nigeria. Global Journal of Agricultural Research. 3(4), 12-22

Muddassir, M., Jalip, M.W., Noor, M.A., Zia, M.A., Aldosri, F.O., Zuhaibe, Au H., Fiaz, S., Mubushar, M. and Zafar, M.M. (2016). Farmers' perception of factors hampering maize yield in rain-fed region of PindDadan Khan, Pakistan Journal of Agricultural Extension. 20, 1– 17.

Nwagwu, W.E. and Opeyemi, S. (2015) ICT Use in Livestock Innovation Chain in Ibadan City in Nigeria. Advances in Life Science and Technology Vol 32,

Nwobodo, C. E. and Nwabugwu, T. S. (2016). Challenges to adoption of ICT tools by agricultural extension workers in Anambra State, Nigeria. Asian Journal of Agricultural Extension, Economics and Sociology, 10(4), 1 – 6

Ogbonna, O.I. and Agwu, A.E. (2013). Access and use of Information CommunicationTechnologies by Rural Farmers in Enugu North Senatorial Zone, Enugu State.Journal ofAgricultural Science, 3 (7): 264-270

Solomon, Z. W. and Isaac, T. R. (2018). Urban Fish Farming in Jos, Nigeria: Contributions towards Employment Opportunities, Income Generation, and Poverty Alleviation for Improved Livelihoods.www.mdpi.com/Journal/Agriculture.

Sulaiman, K. G. and Bankole, Q. A. (2022) "Information and Communication Technology (ICT) Tools for Dissemination of Covid19 Information: A Usage Analysis among Information Professionals in Kwara State". Library Philosophy and Practice (e-journal). 7348. https://digitalcommons.unl.edu/libphilprac/7348

Sule, A.M, Sanni, A.O, Olowosegun, T, Agbelege, O.O, and Olabanji,, M. (2009). Socio-economic factors influencing the adoption of “Gura” fish trap technology in Nigeria. Continental Journal of Fisheries and Aquatic Science, 3, 12-19.

Udoh, A.J. and Nyienakuna, M. J. (2008). Examining the Socio-economic Characteristics and Adoption Trend of Artisanal Fishers of Akwa Ibom State in West Africa. Journal of Agriculture and Social Sciences, 4, 141-146

Umaru, I. L., Okoh, T. C., and Ishiwu, R. C. (2021). Profitability of Catfish Production in Enugu Metropolis, Enugu State, Nigeria. Open Journal of Agricultural Science 2(2) 01 - 11

Wole-Alo, F. I. and Oluwagbemi, I. O. (2020). Adoption and Utilization of ICT through farmers. NG technology in Ondo State, Nigeria. International Journal of Applied Agricultural Sciences, 6(1), 7 – 15

Yekinni, O.T., Ladigbolu, T.A., Adeniyi, R.T. and Adebisi, G.L. (2019). Benefits Derived from use of Information and Communication Technologies among Rural Farmers in Northeast Nigeria. Journal of Agricultural Extension. 23(3) 117 125.

Yun, Z., Lei, W. and Yanqing, D. (2016). Agricultural information and dissemination usingICTs: A review and analysis of information dissemination model in China. InformationProcessing in Agriculture, 3 17– 29, Available at www.sciencedirect.co

Zango, A.U. (2019). New technologies in business education in Nigeria: Issues and trends. Association of Business Educators of Nigeria Conference Proceedings. 6(1), 573-578.

Zeinab, Z., Bahaman, A. S., Siti, Z. O., Jusang, B. and HayrolA. M. S. (2014).Fisherman'sAcceptance of Information andCommunication Technology Integration in Malaysia:Exploring the Moderating Effect ofAge and Experience.Journal of Applied Sciences, 14: 873-882.

FOOD SECURITY ANALYSIS OF PARTICIPATING AND NON-PARTICIPATING FARMERS IN THE INTEGRATED RICE-FISH TECHNOLOGY IN NIGERIA

[13*]Fasakin I. J, [2]Fonsah, O. A, [3]Oni, B. T, [3]Omonona, F. A., [3]Sowunmi, E. K., [4]Ajani, B. O. [4]Omitoyin, [1]Okomoda, V. T. and [5]Rodrigue, Y.

[1]WorldFish, International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.
[2]Department of Agricultural Resource Economics, University of Georgia, Tifton Campus. USA.
[3]Deoartment of Agricultural Economics, University of Ibadan, Ibadan, Nigeria
[4]Department of Aquaculture and Fisheries, University of Ibadan, Ibadan, Nigeria
[5]WorldFish, Penang, Malaysia
*Corresponding author: idowujamesfasakin@gmail.com, +2348066513923, ORCD: 0000-0002-9122-7176

ABSTRACT
Rural farming households in Nigeria are facing food insecurity due to poverty, lack of infrastructure, and declining agricultural productivity. Participating in agriculture programs can go a long way in reducing these problems. Thus, this study examined the food security among participating and non-participating farmers in the integrated rice-fish system. Using a multistage sampling technique, primary data was collected from 458 farmers, including 178 participating and 280 non-participating farmers in Kebbi and Ebonyi States. The study used descriptive statistics and Foster Greer and Thorbecke (FGT) to determine the food security level of the farmers. Findings show that the mean ages were 45 years ±10.04 and 47 years ±11.44 for participating and non-participating farmers. The distribution of the farmers by gender revealed that 82.02% of the participating farmers in the integrated rice-fish technology were male, while 17.98%were female. The distribution for the non-participating farmers shows that 73.93%were male while 26.07% were female. The mean household sizes for the participating and non-participating farmers were 7 and 8 members, with the maximum household size members being 15 and 17, respectively. The FGT analysis shows that the food insecurity incidence was 0.416 and 0.441, the coefficient of food security depth was 0.139 and 0.163, and the food security severity was 0.070 and 0.079, respectively for the participating and non-participating farmers. The study concluded that food insecurity was higher among the non-participating farmers than the participating farmers and recommended improving rural households' food expenditure through modern farming practices, infrastructure improvement, market access, and continuous education.

Keywords:
Food security, Integrated rice-fish farming, Rural households, Nigeria

INTRODUCTION

The world's evolving landscape of agricultural production systems is influenced by urban expansion, technological advancements, population growth, and shifting consumption patterns (Pawlak and Kołodziejczak, 2020; Tokula, 2018). One notable development significantly impacting food security and livelihoods is the integration of fish farming into rice production systems. This response to increased fish demand and advancements in aquaculture technologies is a game-changer. Rice, a fundamental food source for many and a significant contributor to global caloric intake, is now being enhanced by adding fish (Mohidem et al., 2022; Fukagawa and Ziska, 2019). This integration is significant and urgent in Nigeria, where rice consumption has risen at an unprecedented rate due to urbanization, improved incomes, and a preference for rice over other grains. As a critical protein source, fish is vital to Nigeria's food security. The issue of food security, encompassing food availability, access, and utilisation, is of utmost importance. Nigeria faces acute food insecurity due to various factors such as climate change, poverty, corruption, violence, and conflict. This has led to stunting, wasting, underweight children, and inadequate food access (Peng and Berry, 2018; Berry et al.,2015). Over the years, the demand-supply gap in rice production has been persistent. Rice consumption has increased to 7.8MT, with milled rice production still at 5.2MT, leading to a deficit of 2.6MT in 2023 (Statista, 2022). According to the Aquaculture in Nigeria Fact Sheet (2019), to meet the dietary needs of its 200 million inhabitants, the nation still needs about 2.66 million metric tons of fish annually. Sadly, despite fish making up approximately 41% of the average Nigerian's animal protein intake, the country's total annual domestic fish supply from all sources (capture and culture fisheries) is less than 0.7 million metric tons; as a result, fish's high demand in Nigeria is unavoidable (WorldFish, 2024; FAO, 2022). Furthermore, the poverty situation in Nigeria is a concern, with a substantial percentage of the population experiencing multidimensional poverty (National Bureau of Statistics [NBS], 2022). The integration of fish farming into rice production offers economic, environmental, and social benefits and holds the potential to combat hunger and malnutrition. This system enhances water, land, and resource productivity while broadening the aquaculture value chain with minimal environmental impact. It supplies nutrients for both rice and fish, reducing manual labour as fish serve as natural weeds, pest controllers, and fertilisers. The dietary advantages of the rice-fish culture system are crucial in our fight against hunger and malnutrition, offering a significant potential to improve food security (Berg et al., 2023; Wambugu, 2020; Feifan et al., 2021). This study analyses the food security status of farmers involved in integrated rice-fish systems. By determining the impact on their livelihoods, we can gain valuable insights into the potential of these systems to alleviate poverty and improve food security. Examining the food insecurity of rural households from a consumption expenditure perspective is crucial for policy. The FGT poverty measure is a valuable tool for understanding and addressing poverty. Its flexibility, clarity, policy relevance, and theoretical foundation make it a powerful instrument for measuring and monitoring poverty reduction efforts.

MATERIALS AND METHOD

The research was conducted in Nigeria, specifically focusing on Ebonyi in the Southeast and Kebbi in the Northwest, both prominent regions for rice production and part of the intervention zone for the Feed the Future Innovation Lab project. Ebonyi state is known for its Ebonyi or Abakaliki rice, making it an ideal environment for rice production, while Kebbi State's savannah environment is conducive to rice farming. The study collected data from participating and non-participating farmers in the rice-fish farming system under the USAID/FAO Feed the Future project. A multi-stage sampling technique was employed, selecting 458 farmers, including 178 participating and 280 non-participating farmers.

The study modified the Foster Greer and Thorbecke (FGT) poverty measure to determine the food security measurement. The FGT index was used to determine the threshold that was used to categorise the participating and non-participating farming households into food security classes.

Following Foster Greer and Thorbecke (1984), the FGT index is given by

$$P_\alpha = \frac{1}{N}\sum_{j=1}^{N}\left(\frac{1-y_i}{z}\right)^\alpha \mathrm{I}\,(y_i \geq z) \qquad (1)$$

y_t=The value of food security indicator index per capita. In this case, Per Capita food accumulation of the ith rice-fsh farmers
t= number of rice-fish farmers sampled
z - y_t= food security gap of the ith farmer
= food security ratio
œ= A positive parameter of food security could be 0, 1, or 2. They are reflections of the social valuation of food insecurity intensity.
œ= 0 gives the headcount of food insecurity. It measures the incidence of food security in households.
œ= 1, gives the depth of food insecurity. It denotes the proportion of food security line that the food insecure household will require to get out of food insecurity
œ=2, gives the severity of food insecurity. It measur
es how far away the food-secure households are from the food-security line

Note that

$$MPCFE = \frac{\text{Total food of Expenditure}}{\text{Household Size}} \quad (2)$$

RESULTS AND DISCUSSION

Descriptive statistics of the households.

In Table 1, we present the socioeconomic characteristics of the rice-fish farmers. The distribution of the farmers by sex showed that 82.02 % of the participating farmers in the integrated rice-fish technology were male, while 17.98 %were female. The distribution for the non-participating farmers shows that 73.93 %were male while 26.07 %were female. This agrees with the study of (Ogunkule et al., 2023 Omotesho et al., 2015), where male-headed households adopt rice technology more than female-headed households. The distribution by age shows that the participating farmers' minimum and maximum ages in the integrated rice-fish technology were 18 and 68 years, while the minimum and maximum age of non-participating farmers were 22 years and 77 years, respectively. The average ages were 45 years ±10.04 and 47 years ±11.44 for participating and non-participating farmers. This result implies that farmers are still at an active working age while engaging in agricultural activities in the study area. As such, the farmers would be more productive. The distribution of the farmers by household size shows that the mean household sizes for the participating and non-participating farmers were 7 and 8 members, with the maximum household size members being 15 and 17, respectively. These present findings are consistent with (Amoo and Fasakin, 2020), where many farming households suggest the availability of family labour for farm production. Findings also reveal that a significant percentage of participating farmers 94.38% and non-participating farmers, 95.00%, were married. This suggests the crucial role of the family in farming, as being married and having children or dependents can provide the necessary family labour required on the farm, a characteristic widespread in Nigeria's rural areas (Iyanda et al., 2014). The distribution of the rice-fish farmers by their education level showed that a more significant percentage of participating farmers 63.49% had formal education (primary, secondary and, tertiary), lower than the 66.86% of the non-participating farmers. Also, 26.40% and 28.57% of the participating and non-participating farmers had no education. This highlights the importance of education in technology adoption, as access to formal education has been identified as a veritable tool for technology adoption. This agrees with (Ogunkunle et al., 2023), in which most farmers adopting improved rice technology had primary, secondary, and tertiary education. The distribution of the Rice-Fish Farmers by access to credit indicates that 50% of the participating farmers had access to credit while 50% did not have access to credit. Results for non-participating farmers show that the majority, 61.07%, did not have access to credit, while 38.93 %had access to credit. The lack of credit access by the non-participants might be because of their inability to meet collateral and stringent demands by the credit providers; thus, this may inhibit their likelihood of adopting agricultural technology. This present finding of the non-participating farmers' poor credit access agrees with Babatunde et al.'s (2017) study, where farmers in rural areas had inadequate access to credit for their production.

Results further revealed that 69.66% of participating farmers were members of cooperatives, while 30.34% of the farmers were not. Of the participating farmers, 34.29% were cooperative association members, while 65.71% were not. This underscores the role of cooperatives in technology adoption, as membership in a cooperative enables farmers to interact with other farmers, share their experiences, and assist themselves. The cooperative association is an avenue through which farmers can interact, and it is a channel of technology or innovation (rice-fish technology) diffusion. Membership in a cooperative enables farmers to interact with other farmers, share their experiences, and assist themselves. The interaction of farmers with one another is an avenue through which innovation diffusion can occur. This aligns with the study of (Kolapo et al., 2022), where most farmers engaged in agriculture technology were members of cooperative associations. The distribution of rice-fish farmers by access to extension services. The finding indicates that the majority, 61.79% of the participating farmers, did not have access to extension services, while 38.20% had access to extension services. For the non-participating farmers, a more significant percentage, 65.71%, did not have access to extension services, while only 33.57 % had access to extension services. Also, the mean of farming experience for participating and non-participating farmers in the integrated rice-fish farming is 27.14years±11.32 and 25.15years±13.53. This result implies that farming experience was averagely high, indicating that most rice-fish farmers are likely to be more experienced in using innovative techniques to increase productivity in the study area. Lastly, the distribution of rice-fish farmers by phone usage reveals that the majority, 94.94 %of the participating farmers, had access to phone usage, while 5.06 %of the participating farmers did not have access to phone usage. For non-participating farmers, the result shows that the majority, 83.21%, had access to phone usage while a few, 16.79%, did not have access to phone usage. This implies that having access to phone usage might eventually lead to timely access to vital information on innovation for the farmers. It might also lead to the improvement of farmers' livelihoods.

Table 1: Socioeconomic Characteristics of the Rice-Fish Farming Households

Variable	Participants		Non- Participants	
Sex	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Male	146	82.02	207	73.93
Female	32	17.98	73	26.07
Age				
≥20	03	1.69	00	0.00
21-40	50	28.09	89	31.79
41-60	114	64.04	152	54.29
61-80	11	6.18	39	13.93
Mean	45		47	
Min	18		22	
Max	68		77	
Household Size				
≥5	0	00.00	76	27.14
6-10	36	20.22	143	78.21
11-15	120	67.42	43	93.57
16-20	15	8.43	11	97.50
21-25	07	3.93	06	2.142
>26	0.00	0.00	01	0.36
Mean	7.46	8.25		
Min.	1	1		
Max.	15	17		
Marital Status				
Married	168	94.38	266	95.00
Single	08	4.49	02	0.71
Divorced	00	0.00	01	0.36
Separated	01	0.56	06	2.14
Not married	01	0.56	05	1.79
Primary Occupation				
Farming	74	41.57	33	11.79
Rice-farming	66	37.08	159	56.79
Artisan	20	11.24	38	13.57
Fish farming	00	0.00	15	5.36
Civil servant	18	10.11	35	12.5
Education Level				
Formal Education	113	63.49	190	66.86
Adult Education	06	3.37	02	0.71
Religious	12	6.74	08	2.86
No education	47	26.40	80	28.57
Access to Credit				
Yes	89	50	109	38.93
No	89	50	171	61.07
Cooperative Association				
Yes	124	69.66	96	34.29
No	54	30.34	184	65.71
Access to Extension Services				
Yes	68	38.20	94	33.57
No	110	61.79	186	65.71
Farming experience				
≥20	52	29.77	127	45.35
21-40	108	60.78	124	44.28
41-60	17	9.55	29	10.35
Mean	27.14		25.15	
Min.	01		02	
Max.	50		60	
Owned Telephone				
Yes	169	94.94	233	83.21
No	09	5.06	47	16.79
Total	**178**		**280**	

Source: Field Survey, 2023

Profiling Participating and Non-participating Rice-Fish Farming Households by Food Security Status

The participating and non-participating farmers in the integrated rice-fish system were further classified by their food security status to determine the level of food security in the study area. The food security indicators of the participating and non-participating farmers of the integrated rice-fish system in Northwest and Southeast Nigeria are shown in Table 2. The table shows that the food security line of the participating and non-participating farmers was 2102 and 1830, respectively. The food insecurity headcount was 0.416 for the participating farmers and 0.441 for non-participating farmers. This implies that 41.6 percent of the participants and 44.1 percent of non-participants were food insecure or affected by food insecurity. The participating farming households who spend below 2102 monthly are considered food insecure, while those who spend exactly 2102 are considered not food poor. The non-participating households who spend below 1836 monthly are regarded as food insecure, while those who spend precisely 1830 are regarded as not food poor. The coefficient of food security (gap), the income shortfall for the participating and non-participating in the integrated rice-fish culture technology, was 0.139 and 0.163, respectively. This implies that the participating farmers in the integrated rice-fish system required less food expenditure to get out of food insecurity when compared with non-participating farmers. The food security depth or gap explains the gap between the poor farmers and the food security line, which is 0.139, and it will take the poor rice fish farmers 29217.8 to cover up or make up for the food security gap. The food security depth or gap explains the gap between the poor farmers and the food security line, which is 0.163 and it will take the poor rice fish farmers 29,926.8 to cover up or make up for the food security gap. The food security severity was 0.070 and 0.079, suggesting that non-participating farming households are worse off than the participating households, i.e. 7 percent of the participating farming households and 7.9 percent of the non-participating households suffer severe food insecurity.

Table 2: Distribution of the Rice-Fish Farmers by Food Security Status of the Participants and Non-Participants in the Integrated Rice-Fish System

Food security indices	Participating	Non-Participating
Food security incidence (P_0)	0.416	0.441
Food security depth (P_1)	0.139	0.163
Food security Severity (P_2)	0.070	0.079
Relative food security line (₦)	2102	1836
Total	**178**	**280**

Source: Authors computation, 2023.

CONCLUSION

The study confirmed that the rice-fish farming households in Kebbi and Ebonyi state are grappling with food insecurity issues. Notably, food insecurity was higher among the non-participating farming households than the participating ones. Moreover, the study revealed a higher depth and severity of food insecurity in the study area. Notably, the analysis also identified a varied degree of food insecurity incidence, depth, and severity among the households, compared with some selected socioeconomic variables of the farmers. Therefore, the study recommends that increasing rural households' per capita food expenditure can significantly improve their food nutritional status and overall well-being. This can be achieved by introducing modern farming practices, such as improved seeds, fertilisers, and irrigation systems, to increase crop yields and improve rural infrastructure such as roads, electricity, and irrigation services.

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REFERENCES

Amoo I.O and Fasakin I. J (2020). Determinants of Food Security Among Pepper Farming Households in Oyo State, Nigeria. Conference: 2020 Horticultural Association of Nigeria, University of Nigeria, Nsukka (HORTSON): Nsukka, Enugu State, Nigeria.

Aquaculture in Nigeria Factsheet, 2019. Aquaculture factsheet Nigeria. Available at https://www.agroberichtenbuitenland.nl/binaries/agroberichtenbuitenland/documenten/publicaties/2019/01/23/factsheet-aquaculture-in-nigeria/Aquaculture+in+Nigeria.pdf

Babatunde, R. O., Adejobi, A. O., and Fakayode, S. B. (2010). Income and calorie intake among farming households in rural Nigeria: results of parametric and nonparametric analysis. Journal of Agricultural Science, 2(2), 135–146.

Berg, H., Lan, T. H. P., Tam, N. T., Trang, D. H., Van, P. H. T., Duc, H. N., and Da, C. T. (2023). An ecological economic comparison between integrated rice-fish farming and rice monocultures with low and high dikes in the Mekong Delta, Vietnam. AMBIO, 52(9), 1462–1474. https://doi.org/10.1007/s13280-023-01864-x

Berry EM, Dernini S, Burlingame B, Meybeck A, and Conforti P. (2015). Food security and sustainability: Can one exist without the other? Public Health Nutr. 2015 Sep;18(13):2293-302. doi: 10.1017/S136898001500021X. Epub 2015 Feb 16. PMID: 25684016; PMCID: PMC10271846.

FAO, (2022). The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome, FAO. https://doi.org/10.4060/cc0461en.

Fasakin I. J; Popoola O. O (2019). Agriculture Co-operative Associations, Livelihood Income and Rural Households Welfare in Osun State, Nigeria. Greener Journal of Agricultural Sciences 9(2): 180-188, http://doi.org/10.15580/GJAS.2019.2.030419043.

Feifan Li, Jiancao Gao, Yue Xu, Zhijuan Nie, Jinghui Fang, Qunlan Zhou, Gangchun Xu, Nailin Shao, Dongpo Xu, Pao Xu, Mingyu Wang (2021). Biodiversity and sustainability of the integrated rice-fish system in Hani terraces, Yunnan province, China, Aquaculture Reports. Volume 20. https://doi.org/10.1016/j.aqrep.2021.100763

Foster, J., Greer, J. and Thorbecke, E.: A class of decomposable poverty measures. Econometrica 52, 761-776 (1984)

Fukagawa NK and Ziska LH. (2019). Rice: Importance for Global Nutrition. J Nutr Sci Vitaminol (Tokyo). 2019;65(Supplement): S2-S3. doi: 10.3177/jnsv.65. S2. PMID: 31619630.

Iyanda, J.O, Afolami, C.A, Obayelu, A.E and Ladebo, O.J (2014). Social Capital and Access to Credit among Cassava Farming Households in Ogun State, Nigeria. Journal of Agriculture and Environmental Sciences, 3(2): 175-196.

Kolapo A., Adekunle I., Ogunyemi O. and Ologundudu, O (2022). Impact Assessment of Fadama III Group Participation on Food Security Status. International Journal of Agricultural Sustainability. 13. 12.

Mohidem, N. A., Hashim, N., Shamsudin, R., and Che Man, H. (2022). Rice for Food Security: Revisiting Its Production, Diversity, Rice Milling Process and Nutrient Content. Agriculture, 12(6), 741. https://doi.org/10.3390/agriculture12060741

National Bureau of Statistics (NBS, 2022). Nigeria's Multidimensional Poverty Index (2022)

Ogunkunle, T., Olaniyi, O. A. and Puseletso, L. (2023). Determinants of youth farmers' utilisation of improved rice production practices in southwest Nigeria. Journal of Agricultural Extension 27 (1) 61-74.

Omotesho, K. F., Ogunlade, I., Lawal, M. A., and Kehinde, F. B. (2016). Determinants of level of participation of farmers in group activities in Kwara state, Nigeria. Gaziosmanpa a Üniversitesi Ziraat Fakültesi Dergisi, 33(3), 21–27.

Pawlak, K., and Kołodziejczak, M. (2020). The Role of Agriculture in Ensuring Food Security in Developing Countries: Considerations in the Context of the Problem of Sustainable Food Production. Sustainability, 12(13), 5488. https://doi.org/10.3390/su12135488.

Peng, W. and Berry, E.M., (2019). The Concept of Food Security. In: Ferranti, P., Berry, E.M., Anderson, J.R. (Eds.), Encyclopedia of Food Security and Sustainability. 2(1-7). Elsevier.

Statista (2022). Rice production in Nigeria

Tokula E. (2018). The Impact of Urban Expansion on Agricultural Land and Crop Output in Ankpa, Kogi State, Nigeria. Landscape Architecture. 1. 10.31058/j.la.2017.11001.

Wambugu M. M., Ndunda E. and Gathuru G. (2020). Integrating fish into rice farming as an economical substitute for chemical pesticides. IJRDO-Journal of Agriculture and Research. 6(3), 17-37. https://doi.org/10.53555/ar.v6i3.3545

WorldFish. (2024) WorldFish in Nigeria. Penang, Malaysia: WorldFish. Factsheet: 2024-44.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

ADOPTION AND BENEFITS OF MODERN FISH POND MANAGEMENT AND TECHNOLOGIES AMONG STUDENTS: A CASE STUDY OF KINGS COLLEGE, LAGOS

Eitokpah E.P., A.M. Adeyemo, S.N. Waniko and J.P. Archibong

Extension Research and Liaison Services Department, Nigerian Institute for Oceanography and Marine Research, 3, Wilmot point road, Victoria Island, Lagos, Nigeria.
Corresponding author: Eitokpah E.P
Email: priscillaeit@gmail.com

ABSTRACT
This study examined the level of adoption of aquaculture technology among students of Kings College, Lagos, Nigeria. Ten respondents were randomly selected from the school. Data were collected through use of well-structured questionnaires. Descriptive statistics such as percentage and frequency distribution were used to analyse the data. The results showed that the respondents were mostly aware about pond types (70%), while the least areas of awareness was in feeding management,(100%). The students mostly adopted pond type management (70.0%), while their least adoption was Safety measures in the farm (90.0%). The results further showed that the respondents' highest benefits were in the practical knowledge of fish pond (50.0%) and with both practical knowledge of brood stock management. (50.0%). While their least benefitted areas were both in practical knowledge of feeding management (60.0%) and in practical knowledge of water quality management (50.0%). The respondents were mostly constrained by their lack of interest in agricultural training (60.0%),) While the least constraints encountered were stealing from the school ponds (0.0%). The respondents mostly had a positive perception about their engagement and the impact of the programme, that their knowledge of fish farming has improved (x=4.40) and that they will like to specialize in fish farming as a result of the training (x=4.20).

Keywords:
Aquaculture, Adoption, Students, Benefits,

INTRODUCTION

Fish farming is expanding rapidly throughout the world and has a high potential for the provision of valuable protein in less developed countries. World aquaculture production attained an all-time high level in 2006, at 47.3 million tonnes excluding aquatic plants and non-food products (FAO 2015). According to National Information Centre (NIC) (2017), aquaculture plays an important role in many developing economies. In Nigeria, aquaculture is gaining increasing importance for employment creation and income generation, particularly in the socio-economic weak communities of fishermen, which represents the poorest section of the society in many developing countries (NIC, 2017). The average annual demand for fish in Nigeria by 2006 was estimated to be 2.66 million metric tonnes, (FDF, 2017). According to FAO (2020) aquaculture system is not operating in a sustainable and efficient manner, however, efforts are underway to develop new suitable techniques to grow the industry. The major problem has been the inadequacy of appropriate technologies (FAO, 2015). Aquaculture technologies have been developed and disseminated to fish farmers across the nation. Daniel et al, (2019), says, people do not just adopt technologies because of its availability but for its usefulness. In the case of student participation in aquaculture, "catching them young" is the phrase for adaptation and adoption of youth into programs so as to make them get interested early. Fish production being an important aspect of food security is seen as a means to an end to help boost food production. Involving school students in secondary schools to participate in aquaculture to spur their interest in fisheries as a subject hence, making them future contributors to fish production in Nigeria was one of the reasons for this project. It means that interest of students should be aroused starting from the secondary school levels. This study was carried out to assess the level of adoption in fish pond technologies among the students of Kings College, Lagos, Nigeria.

METHODOLOGY

Study Location

Kings College Lagos was chosen as an adopted school in 2018, for plastic pond technology for aquaculture and the team is now back there to evaluate, how the project and technology has impacted the students including adoption rate. Kings college Lagos is situated in south west Nigeria, at N0 3 Catholic mission street, Lagos island, Nigeria. It is a boy's school established by an act of British parliament. (Latitude 51.511448, and Longitude 0.116414 degrees).

Procedures for Data Collection

The team from the Extension Research and Liaison Services department (NIOMR), went on a field trip to Kings College, Lagos with the aim of evaluating the past activities and create more awareness and enlightenment in the area of fish farming which involved the agricultural students. On arrival at the school, three (3) staff including the agricultural science teacher were involved. The data collection method used was questionnaire which was filled by the students in addition to individual interactions. Ten questionnaires administered to the students were filled and also personal interview was carried out.

RESULTS AND DISCUSSION

The results from table 1 showed that the respondents were all within the age range of 14 - 17 years (100%). (100%) of them were male and all of them (100%) were in SS1 class, with 1 of them (10%) owning a pond at home. Only one of them (10%) stated that their school pond stocking density was 50 and above, while majority (80%) were not members of the school farmer's club with majority of them (90%) having their parent's educational background to be tertiary schools educational background. These findings agrees with the report of Sunberg and Hunt (2019) among some students in Eastern part of Africa and this could imply that majority of these students did not adopt the aquaculture technologies and this would have a positive outcome on their learning and behaviour as agricultural students, since many of them do not own fish pond at home and also don't belong to farmers membership club.

Table 2 revealed the types of fish technologies the respondents in the study area are aware of. It was shown that they were mostly aware about pond types (70%), while the least areas of awareness was in feeding management. (100%). These findings are in line with the observation of Akinwole et al. (2014) among some youths in Ibarapa area of Oyo State, Nigeria. This is very obvious that the respondents are not aware of fishing technologies in these areas.

As shown in Table 3, the students mostly adopted pond type management (70.0%), while their least adoption was safety measures in the farm (90.0%). These results agrees with the report of Azeez (2013) among some youths in Ido Local Government area of Oyo State, Nigeria This implies that they were rarely exposed to these areas in the fish farming technological field. Table 4 showed that the respondents' highest benefits were in the practical knowledge of fish pond (50.0%) and with both

practical knowledge of brood stock mgmt. (50.0%). While their least benefitted areas were both in practical knowledge of feeding management (60.0%) and in practical knowledge of water quality management (50.0%). These results agrees with the report of Azeez (2014) among some youths in Ido Local Government area of Oyo State, Nigeria. This implies that more efforts need to be applied in these areas of their least benefitted areas by their tutors and the programme in general in the future.
As reported in Table 5, the respondents were mostly constrained by their lack of interest in agricultural training (60.0%),). While their least constraints encountered were stealing from the school ponds (0.0%). These findings agrees with the report of Sunberg and Hunt (2019) among some students in Eastern part of Africa. This implies that more emphasis should be laid on educating these youths about the agricultural-business potential of fish farming as against the age-long wrong impression of its tediousness and poverty proneness as a career path. As shown in Table 6, the respondents mostly had a positive perception about their engagement and the impact of the programme, that their knowledge of fish farming have improved (x=4.40) and that they will like to specialize in fish farming as a result of the training (x=4.20). While they also mostly had negative perception that fish farming is too tedious to practice (x=1.80) and also feel they can never take up a career in agriculture because farming is meant for the rural poor (x=1.70) likewise they will feel inferior as a student of agriculture in the midst of friends studying other courses with a mean of (x=2.60) and I feel all agricultural related jobs are dirty jobs (x=1.90). This implies that the programme had a positive impact on the student's choice of fish farming as a future career though there are more emphasis which need to be employed in changing their mind-sets from the old negative perception of fish farming and agriculture in general as a tedious venture and have a positive mind-set in other to be proud of fish farming as a career in the society.

Table 1: Socio-economic characteristics of the respondents

S/n	Socio-economic Characteristics	F	%
1	Age		
	0-14	10	100
2	Sex		
	Male	10	100
3	Students class		
	SS1	10	100
4	Do you own a pond		
	Yes	1	10
	No	9	90
5	No. of fingerlings stocked		
	0-40	9	90
	50 and above	1	10
6	Membership of farmers club		
	Yes	2	20
	No	8	80
7	Educational background of student’s parents		
	No formal education	0	00
	Primary	0	00
	Secondary	10	100
	Tertiary	0	0

Source: field survey, 2022

Table 2: **Awareness of types of fish technologies**

S/N	Fish Technology	Awareness (%)	Not Aware (%)	Mean
1	Brood stock management	40	60	1.60
2	Hatchery management	20	80	1.80
3	Nursery management	20	80	1.80
4	Pond fertilization	10	90	1.90
5	Water quality mgmt.	30	70	1.70
6	Feed formulation	50	50	1.60
7	Feeding management	00	100	2.00
8	Processing technique	30	70	1.50
9	Pond type management	80	20	1.00
10	Processing management	20	80	1.40
11	Improved charcoal fish smoking kiln	40	60	1.40
12	Improved solar fish dryer	70	30	1.10
13	Fish disease prevention and control	50	50	1.30
14	Fish preservation and storage technique	10	90	1.70
15	Proper fish handling	10	90	1.70
16	Safety measures in the farm	10	90	1.70
17	Digital marketing	30	70	1.70

Source: field survey, 2022

Table 3: Adoption of the different types of fish technologies

S/N	Fish Technology	Adopted (%)	Not Adopted (%)	Mean
1	Brood stock management	50	50	1.50
2	Hatchery management	60	40	1.40
3	Nursery management	30	70	1.70
4	Pond fertilization	50	50	1.30
5	Water quality mgt.	60	40	1.20
6	Feed formulation	30	70	1.50
7	Feeding management	40	60	1.40
8	Processing technique	50	50	1.30
9	Pond type management	70	30	1.10
10	Processing management	40	60	1.20
11	Improved charcoal fish smoking kiln	60	40	1.00
12	Improved solar fish dryer	50	50	1.10
13	Fish disease prevention and control	60	40	1.00
14	Fish preservation and storage technique	20	80	1.40
15	Proper fish handling	40	60	1.20
16	Safety measures in the farm	10	90	1.50
17	Digital marketing	30	70	1.50

Source: field survey, 2022

Table 4: Benefits derived from the training by the respondents

S/n	Benefits Derived	Always (%)	Rarely (%)	Never (%)	Mean (%)
1	Practical knowledge of fish pond	50	40	10	1.70
2	Practical knowledge of brood stock mgt.	50	30	20	1.90
3	Practical knowledge of hatchery mgt.	40	40	20	1.80
4	Practical knowledge of water quality mgt.	20	20	60	1.40
5	Practical knowledge of feeding mgt.	20	20	60	2.10
6	Practical knowledge of processing techniques	40	30	30	1.70
7	Practical knowledge of fish marketing	30	30	40	2.10

Source: field survey, 2022

Table 5: Constraints encountered in the training by the respondents

S/no	Constraints	VS	S	NS	Mean
1	Stealing from school ponds	00	30	70	2.40
2	Inadequacy of funds to carry out the programme	30	40	30	1.90
3	Lack of continuity of established farm	20	50	30	1.80
4	Complexity of technologies	50	10	40	2.30
5	Lack of interest from students	60	10	30	2.20
6	Insufficient agric. Teachers	20	50	30	1.80

Source: field survey, 2022

Table 6: Student's perception of their engagement and impact of the NIOMR's adopted school programme

S/N	Perception statements	SA	A	U	D	SD	Mean
1	I will like to specialize in fish farming after school as a result of this training exposure	50	40	0	0	10	4.20
2	Fish farming is too tedious to practice	70	00	10	20	00	1.80
3	Fish farming has increased my interest in the choice of agricultural science as a subject	10	60	00	10	20	3.30
4	The programme is only a waste of time as its meant to while away the students time	20	60	10	00	10	2.20
5	I can now raise fingerlings to table size on my own as a result of this training	10	50	00	10	30	2.80
6	I will feel inferior as a student of agriculture in the midst of friends studying other courses	20	40	10	20	10	2.60
7	My knowledge of fish farming has improved	40	50	10	00	00	4.00
8	I feel all agricultural related jobs are dirty jobs	30	50	20	00	00	1.90
9	Fish smoking is a profitable business that I will like to venture into as a result of my involvement in this training	30	50	10	10	00	3.70
10	I can never take up a career in agriculture because farming is meant for the rural poor	50	40	00	10	00	1.70
11	I believe there is high return on investment in agriculture as it is a lucrative venture	30	20	30	10	10	3.20
12	I feel being a farmer is similar to being poor	20	70	10	00	00	1.90
13	I believe this programme will have impact if the school authority will be more committed to it	70	10	10	10	00	4.40

Source: field survey, 2022

CONCLUSION

The students have shown great enthusiasm in the field of aquaculture especially the adoption of plastic pond technology, which has made it easy and attractive to them. The school management needs to be more supportive in terms of finance and motivation to help the students improve in fisheries as a subject and spur their interests in that area to help improve their overall performance thereby driving the nation towards better food production and better economy in the area of food security. These observations were made to assist the school in the area of maintaining the fish farm in the school in order to encourage the students towards entrepreneurship, agriculture and food sustainability in addition to their academics as this will help them in the future with regards to generating more income outside their major career fields. Based on this study, it is recommended that agencies should embark on various enlightenment programs and motivation of students at secondary schools to encourage the study of aquaculture as a profession

REFERENCES

Afolabi, J. A. (2017): Evaluation of poultry Egg marketing in South –Western Nigeria. Agriculture and Extension Services. 8, Pp13.

Akinwole, A.O. , Bankole A.F., Dauda A. B. and Ayanlere, S. V. (2014): Fish farming facilities, and operation in ibarapa area of Oyo state. European International Journal of Applied Science and Technology 1(2): 85-94.

Azeez, R. O. (2013): Extension service needs of registered catfish farmers in Ido Local Government Area of Oyo State. A project submitted to the Department of Agricultural Extension and Management, Federal College of Forestry, Ibadan.

Daniel E., Wilson, H. and Myers, A. (2019): Innovation in small and medium scale enterprises: The case of e-commerce adoption in UK. Innovation management policy and practice. www.innovation-enterprise.com/4.1/4.1.12.htm.retrieved on January, 2016.

FAO (2015): Small scale aquaculture in sub – Sahara Africa: Revisiting the aquaculture target group paradigm. Rome, FAO Fisheries, Pp 34.

FAO (2019): The State of World Fisheries and Aquaculture (SOFIA): World Review of Fisheries and Aquaculture 1- 84pp

Food and Agriculture Organization (2020). Statistical Yearbook. World Food and Agriculture. Rome. pp.245.

FDF, (2017): Fishery statistics of Nigeria, 4th Edition (2005- 2007). Federal Department of Fisheries. 47pp.

National Information Centre (2017): Information on Agricultural Development. Reports on NLC Agriculture for the Nation. Pp22

Sunberg, J.and Hunt, J. (2019). Are African rural youth innovative? Claims, evidence and implications. J. Rural Stud. 69: 130-136. https://doi.org/10.1016/j.jrurstud.2019.05.004

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

MODELING THE NON-LINEARITY IN LENGTH-WEIGHT RELATIONSHIP OF *Pseudotolithus elongatus* IN THE CROSS RIVER ESTUARY, NIGERIA: RANDOM FOREST APPROACH

[1]Asuquo, P. E. and [2]H. T. Ifon

[1]Fisheries and Aquaculture Unit, Institute of Oceanography, University of Calabar, Nigeria
e-mail: philodear@yahoo.com; ORCID: 0000-0002-4203-3308
[2]Department of Fisheries and Aquaculture, Faculty of Agriculture, University of Calabar, Nigeria

Corresponding Author: honor.t.ifon@gmail.com, +234 706 732 0384, 0000-0003-1502-7284

ABSTRACT

Accurate prediction of the length-weight relationship of commercially important fish species is essential for effective fisheries management in the Cross River Estuary. Traditional linear regression often fails to capture the non-linear biological growth patterns of fish, which typically exhibit allometric growth. This study evaluates the efficacy of Random Forest in predicting the length-weight relationship of *Pseudotolithus elongatus*. A dataset of 1,000 fish samples was collected from artisanal fish landings from January to December 2023. The length (cm) and weight (g) of each fish specimen were measured and analyzed using Python (Ver. 3.12.6). Performance was evaluated using Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and the Coefficient of Determination (R^2). Linear Regression resulted in parameters $a-2.62$ and $a=1.33$, while Random Forest produced $a=-2.64$ and $a=1.34$. Both approaches indicated negative allometric growth ($a<3$). However, Random Forest significantly outperformed Linear Regression, achieving an RMSE of 51.2, MAE of 31.6, and R^2 of 0.98, compared to 121.5, 100.4, and 0.88 for Linear Regression, respectively. These findings demonstrate that Random Forest provides a more accurate and robust approach for modeling fish growth patterns. This can enhance fisheries management by generating reliable estimates for stock assessments and promoting sustainable harvest strategies.

Keywords:
Pseudotolithus elongatus, length-weight relationship, Random Forest, fisheries management, machine learning

INTRODUCTION

The West African Croaker *(Pseudotolithus elongatus)* is a species of significant ecological and economic importance in the Cross River Estuary, Nigeria. As a key target species for local fisheries, its population health directly impacts the livelihoods of fishers and the broader fishing industry in the region. Effective management of this species requires an understanding of its growth dynamics, which allows for more accurate management decisions, such as determining sustainable harvest limits and evaluating the potential impacts of environmental changes on fish populations (Abiaobo *et al.*, 2023; Asuquo and Ifon, 2019; Jisr *et al.*, 2018).

The length-weight relationship (LWR) has long been used as an essential measure to describe how a fish's weight increases in proportion to its length. This relationship typically reflects allometric growth, where different parts of an organism grow at different rates relative to each other. In fisheries, such relationships are vital for stock assessment, as they help estimate fish biomass, monitor species health, and predict growth rates over time (Olatunji, 2021). Accurate predictions of these growth patterns can lead to better conservation strategies and more efficient management of fish stocks, especially for species like the West African Croaker, which plays a critical role in local food security and economic activity. However, predicting growth patterns accurately is a challenging task, as factors such as environmental conditions and genetic variability can introduce complexities into these relationships (Jisr *et al.*, 2018).

Historically, traditional statistical models like Linear Regression have been widely used to estimate the LWR of fish. While Linear Regression offers simplicity and interpretability, it assumes a linear relationship between length and weight, which does not reflect the true, often nonlinear nature of fish growth dynamics. This assumption can lead to less accurate predictions unless the data is log-transformed to linearize the relationship (Asuquo and Ifon, 2022; Kuriakose, 2014). In contrast, advanced machine learning models like Random Forest offer greater flexibility in capturing the inherent nonlinearities of fish growth without the need for data transformations. Random Forest, a decision-tree-based ensemble model, can model complex relationships between length and weight directly, improving predictive performance by accounting for interactions between biological and environmental factors (Luan *et al.*, 2020). This capability makes it particularly useful for fisheries management, where growth dynamics are influenced by a variety of non-linear factors.

Despite the efficiency of advanced models like Random Forest (RF), there has been limited research comparing these approaches with traditional models, such as Linear Regression (LR), in predicting the LWR of economically significant species like *Pseudotolithus elongatus* in Nigeria. This study seeks to fill that gap by conducting a comparative evaluation of both models to determine which offers better predictive accuracy for fisheries management.

MATERIALS AND METHODS

Study Area

The study was conducted in the Cross River Estuary, located in southeastern Nigeria, a region renowned for its rich biodiversity and ecological importance (Asuquo and Enin, 2017). The estuary lies between longitudes 2°03'E and 10°00'E and latitudes 4°00'N and 8°00'N of the Greenwich meridian. Its drainage basin covers an area of approximately 54,000 km^2, with 74% situated in Nigeria and the remaining 26% extending into Cameroon (Zapfack *et al.*, 2001). The estuary is characterized by a mix of freshwater and marine environments, providing critical habitat for numerous aquatic species, including the West African Croaker *(Pseudotolithus elongatus)*. This species thrives in the estuarine ecosystem due to its rich nutrient content, which supports high levels of primary and secondary productivity (Ekpo et al., 2021). The site was selected based on the economic importance of the species to local fisheries and the availability of relevant fish populations for length-weight studies.

Data Collection

Sampling of *Pseudotolithus elongatus* was conducted over a 12-month period, from January to December 2023, using standard fishing techniques. Gill nets and traps with mesh sizes of 30-50 mm were deployed in different sections of the estuary to capture fish specimens (Ama-Abasi *et al.*, 2022). Sampling was carried out weekly, with each session lasting approximately 5 hours, covering both high and low tide conditions. The fish were selected based on their availability, ensuring a wide range of sizes to capture the variability in growth patterns. Specimens that appeared injured or had obvious deformities were excluded from the study to maintain data integrity.

After each sampling session, the total length and body weight of each fish were measured. The total length (TL) was recorded to the nearest millimeter using a digital caliper, and the body weight (BW) was measured to the nearest gram using a digital weighing scale with a precision of ±0.1 g (Opeh *et al.*, 2023). Care was taken to ensure consistent measurement conditions, with all measurements taken on-site immediately after fish capture to avoid weight loss due to dehydration.

Data Preparation

Before model implementation, the collected data underwent a thorough cleaning process. Outliers, such as extreme values that significantly deviated from the mean length and weight, were identified and removed based on a 1.5 interquartile range (IQR) rule to minimize their impact on model performance (Okamura *et al.*, 2023). Any missing data were also addressed, with records missing either length or weight excluded from the analysis. The cleaned data were log-transformed to stabilize variance and normalize the distribution of the variables, making them more suitable for linear regression and other predictive models (Asuquo and Ifon, 2023).

The dataset was randomly split into training and testing sets using an 80/20 ratio. The training set, comprising 80% of the data, was used to train both the LR and RF models, while the remaining 20% was reserved for testing their performance (Roy and Larocque, 2019). A five-fold cross-validation technique was employed to optimize the model parameters and prevent overfitting, ensuring results generalization beyond the training dataset.

The LR model was fitted to the dataset, assuming a linear relationship between the fish's length and weight, following the classic allometric growth equation:

$$W = aLb \quad (1)$$

where W represents the weight, L is the length, and a and b are parameters estimated by the model.

Given the non-linear nature of the relationship between length and weight, the data were log-transformed. This transformation helped stabilize variance and normalize the distribution of the variables, making them more suitable for linear regression and improving the performance of predictive models (Asuquo and Ifon, 2023).

$$\log(W) = \log(a) + b\log(L) \quad (2)$$

The cleaned dataset was then randomly split into training and testing sets, with 80% of the data allocated to the training set and 20% reserved for testing. The training set was used to train both the Linear Regression (LR) and Random Forest (RF) models, while the testing set allowed for the evaluation of model performance (Roy and Larocque, 2019). To further ensure robust model performance, a five-fold cross-validation technique was used. This technique helped optimize the model parameters and prevent overfitting, ensuring that the results would generalize well to new, unseen data.

For the LR model, a linear relationship between log-transformed length and log-transformed weight was assumed, and the model was fitted using these transformed data. The resulting model aimed to estimate the parameters log (a) and b that define the allometric growth equation. In parallel, the RF model was trained using the same length-weight data. The RF model comprised 100 trees, with hyperparameters such as the number of variables considered at each split being optimized using grid search. Cross-validation was again applied to prevent overfitting and enhance the generalizability of the model's predictions (Roy and Larocque, 2019). The RF model, unlike LR, does not require assumptions about the functional form of the relationship between length and weight, allowing it to capture non-linear patterns and interactions in the data.

Model Evaluation

The performance of both models was evaluated using Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and the Coefficient of Determination ®²).

RESULTS

A total of 1000 fish specimens were analyzed, with lengths ranging from 10.0 cm to 62.5 cm and an average length of 36.3 cm. The weights varied from 4.7 g to 1369.9 g, with an average weight of 362.5 g (Table 1). The Random Forest (RF) model significantly outperformed the Linear Regression (LR) model, as shown in Table 2. The RF model achieved a lower RMSE (51.2 vs. 121.5) and MAE (31.6 vs.

100.4), and its R^2 value of 0.98 indicated a higher explanatory power compared to the LR model, which had an R^2 value of 0.88. The higher R^2 for the RF model suggests a better fit in explaining the variance in the dataset. This was further supported by the residual analysis, where the RF model showed smaller, more randomly distributed residuals co he LR model, indicating a superior fit.

For both models, the growth coefficient b was calculated. The Linear Regression model yielded a growth coefficient (b) of 1.33, while the Random Forest model produced a similar coefficient of 1.34. These values are significantly different from 3, as indicated by statistical testing ($p < 0.05$), which suggests that the fish species exhibited negative allometric growth. The negative allometry is characterized by a lower weight gain relative to the increase in length, which is typical in many fish species, particularly as they mature. The similar values for b in both models reinforce the consistency of the allometric pattern detected by both the Linear Regression and Random Forest approaches. These findings highlight the improved performance of Random Forest in modeling the length-weight relationship in P. elongatus, while both models provide consistent evidence of negative allometric growth for this species.

TABLE 1: Descriptive Statistics for Length and Weight of *Pseudotolithus elongatus*

Length (cm)		Weight (g)	
Range	**Average**	**Range**	**Average**
10.0 - 62.5	36.3	4.7 - 1369.9	362.5

Table 2: Performance Evaluation of Linear Regression and Random Forest Models

Model	RMSE	MAE	R^2	a	b
Linear Regression (LR)	121.5	100.4	0.88	-2.62	1.33
Random Forest (RF)	51.2	31.6	0.98	-2.64	1.34

DISCUSSION

The results revealed that the Random Forest (RF) model significantly outperformed the Linear Regression (LR) model in modeling the length-weight (LW) relationship of *Pseudotolithus elongatus*. The LR model's lower performance can be attributed to its inherent assumption of a linear relationship between length and weight, which does not adequately capture the inherent non-linearity of biological growth. Fish growth typically follows an allometric pattern, where weight increases at a different rate than length, and this pattern is only partially addressed by the LR model, especially when no log transformations are applied (Kuriakose, 2014). The growth coefficient (b) for the LR model was 1.33, which indicates a negative allometric growth, consistent with the results from the RF model where b=1.34. Both coefficients are significantly different from the isometric value of 3 ($p < 0.05$), suggesting that the species exhibits negative allometric growth, where the weight does not increase proportionally with length. This finding is typical of many fish species, especially as they mature.

In contrast, the RF model proved more adept at capturing this non-linearity without requiring any prior assumptions about the relationship between the variables. As a non-parametric method, RF does not make assumptions about the functional form of the relationship between predictors (length) and response (weight). This flexibility is a key advantage of RF, as it can model the complex interactions governing fish growth, which are often influenced by environmental factors, genetics, and other biological processes. The RF model produced a growth coefficient that was identical to that of the LR model, indicating that RF can accurately capture the same biological pattern but with a better overall fit. This is reflected in the model's superior performance metrics, including a much lower RMSE, and a higher R^2, as well as a more favorable residual distribution.

Moreover, the non-parametric nature of the RF model justifies its application in this study. While LR models require transformations (such as log transformations) to approximate non-linear relationships, RF does not rely on such transformations and is capable of modeling complex, non-linear interactions directly from the data. This makes RF particularly suitable for ecological and biological data, where relationships between variables can be complex and difficult to capture with parametric models. These characteristics of RF align with findings from previous research. For instance, Luan et al. (2020) demonstrated that non-linear models consistently outperform linear models when dealing with ecological datasets that involve multiple interacting factors. Similarly, Asuquo and Ifon (2023) emphasized the value of machine learning algorithms like RF for predicting ecological phenomena, particularly in cases where traditional statistical models fail to capture such complexity.

The superior performance of the RF model underscores its potential utility in fisheries management. Reliable length-weight relationships are fundamental for accurate stock assessments, which in turn inform sustainable catch limits. Such assessments are crucial for the conservation of fish populations and the maintenance of ecosystem balance. The adoption of RF models in fisheries science can lead to more accurate predictions and improve fisheries management strategies, ultimately contributing to the long-term sustainability of fisheries.

REFERENCES

Abiaobo, N. O., Asuquo, I. E., Akpan, I. I., and Augustine, A. L. (2023). Aspects of the Biology of (Pseudotolithus elongatus) Bobo Croaker Fish from Jaja Creek, Ikot Abasi Local Government Area, Akwa Ibom State, South Eastern Nigeria. International Journal of Zoology and Animal Biology, 6(6), 1–11.

Ama-Abasi, D., Ibor, O. R., Uyoh, E. A., Job, B., and Uwalaka, S. (2022). Influence of physical environmental parameters on the abundance of Chrysichthys nigrodigitatus of the Cross River, Nigeria. Scientific African, 16 (e01247), 1–7.

Asuquo, P. E. and Ifon, H. T. (2019). Morphometric adaptation of bobo croaker, Pseudotolithus elongatus (Bowdich, 1825) (Sciaenidae) in the Cross-River estuary, Nigeria. International Journal of Natural and Applied Sciences (IJNAS) 12, 87 – 92.

Asuquo, P. E., and Ifon, H. T. (2022). Allometric Model for Assessing Ontogenetic Variation in Growth Pattern of the Bobo croaker (Pseudotolithus elongatus) in the Cross River Estuary. International Journal of Natural and Applied Sciences (IJNAS), 14, 18 – 22.

Asuquo, P. E., and Ifon, H. T. (2023). Machine Learning Algorithms for Assessing the Atlantic Blue Crab (Callinectes sapidus) Stock in the Qua Iboe River Estuary, Nigeria. Book of Proceedings for the 38th Annual national Conference of Fisheries Society of Nigeria (FISON), 117, 617 -.621.

Ekpo, P. B., Ekpo, I. P., Ifon, H. T., Edet, A. R. (2021). Ecological Indices of Zooplankton Communities in the Great Kwa River, Nigeria. International Journal of Natural and Applied Sciences (IJNAS), 14, 156 – 162.

Jisr, N., Younes, G., Sukhn, C., and El-Dakdouki, M. H. (2018). Length-weight relationships and relative condition factor of fish inhabiting the marine area of the Eastern Mediterranean city, Tripoli-Lebanon. The Egyptian Journal of Aquatic Research, 44(4), 299–305.

Kuriakose, S. (2014). Estimation of length weight relationship in fishes. In Summer School on Advanced Methods for Fish Stock Assessment and Fisheries Management (p. 150).

Luan, J., Zhang, C., Xu, B., Xue, Y., and Ren, Y. (2020). The predictive performances of random forest models with limited sample size and different species traits. Fisheries Research, 227, 1–10.

Okamura, H., Morita, S., and Kuroda, H. (2023). Forecasting fish recruitment using machine learning methods: A case study of arabesque greenling. bioRxiv, 1, 1–20.

Olatunji, A. M. (2021). Length –weight relationship and condition factor of long neck croaker –Pseudotolithus typus (Bleeker, 1863) from Lagos Lagoon, Nigeria. International Journal of Fisheries and Aquatic Studies, 9(2), 09–13.

Opeh, P. B., Ifon, H. T., Idung, J. U., Ojang, R. O., and P. J. Asinde (2023). Morphometric Assessment of the Prawn Species (Macrobrachium macrobrachion and M. vollenhovenii) in the Calabar River, Nigeria. Book of Proceedings for the 38th Annual national Conference of Fisheries Society of Nigeria (FISON), 140, 737 -.741.

Zapfack, L., Ayeni, J. S. O., Besong, S., and Mdaihli, M. (2001). Ethnobotanical survey of the Takamanda forest reserve. https://www.yumpu.com/en/document/view/ Accessed 22nd March, 2022

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

ASSESSMENT OF INFORMATION AND COMMUNICATION TECHNOLOGIES ON CATFISH MARKETING IN SAPELE LOCAL GOVERNMENT AREA OF DELTA STATE, NIGERIA

[1]Omonode, E. N. [2]S.A. Omitoyin and [3]Adebote, E. E.

[1&3] Nigeria Institute for Oceanography and Marine Research, P.O. Box 12729. 3 Wilmot Point Victoria Island, Lagos.
[2] Department of Fisheries and Aquaculture, University of Ibadan, Ibadan, Oyo State.

Correspondence Email:
stobule@yahoo.com, +234 8022200563, 0009-0003-5470-613X

ABSTRACT
Information plays a vital role in increasing agricultural production, improving marketing, and enhancing distribution strategies. Hence, this study assessed the impact of ICTs on fish marketing in Sapele Local Government Area of Delta State, Nigeria. Primary data were collected from 100 respondents using purposive and simple random sampling techniques. Results were analyzed using descriptive and inferential statistics. The study revealed that the majority 93% were youth, the majority 70% female, 50% married, 50% household less than 10 and 69% attended with formal education. 85% were members of co-operative society with 59% earning less than N20, 000. The research findings indicates ICT an important marketing tool in accessing customers (3.0), market information (2.9), advertisement of product (3.0), information on market days (2.55) and access to fish price (2.8) while the cut-off point of the mean was (2.5). This indicated that ICT has improved the knowledge of fish marketers on marketing information. T-test analysis shows that the mean (¯("x")) of income and volume of sales (6.01) was higher using ICT compare to (4.59) before the use of ICT facilities. This indicates that ICT is effective in fish marketing in the study area. Erratic power supply, cost of ICT facilities, and access to affordable services were the major constraints faced by the respondents. Hence, this study recommends efficient power supply in the study area, to optimize usage of ICT in fish marketing. Availability of loan facilities through co-operative/micro-finance institutions in acquiring ICT tools.

Keywords:
Fish, Consumers, Key management and Gadgets,

INTRODUCTION

Fish marketing majorly consists of all the activities involved in delivering fish from the producer to the consumer, through a veritable network of distribution (Bada and Rahji, 2010). Hence, fish marketing may be described as all those functions involved from the point of catching of fish, to the point of final consumption (Alam *et al.*, 2010). Fish marketing plays a vital role in the lives of people living in coastal areas, fishing communities and areas with large concentration of fish farmers and consumers in terms of employment and nutrition (Madugu and Edward, 2011). Despite this, Ali *et al.* (2008) indicated that fish marketing provides additional income to many Nigerians who engaged in distribution of fresh and processed fish in rural and urban areas across the country. However, lack of appropriate marketing strategies, skills and knowledge in marketing has further complicated the situation leaving many fish farmers and fishers struggling to grow market share. As Sustainability of fisheries production largely depends on the producers receiving sufficient income. (Aswathy et al., 2014). However, marketing channels is an identifiable pathway through which goods and services flow before reaching the final consumer. Pauly *et al.,* 2002 on the other hand described marketing institutions through which goods or services are moved from their producers to their consumers (Flood, 2006). Fish marketing is beyond advertising, selling, or making fish available to consumers. It is a key management that brings success to the business (Babalola *et al.,* 2015). Ladipo and Simwa (2022) asserted that an ICT machine is a small, transportable tool that may be used for numerous duties associated with records and conversation technology. These gadgets generally have a variety of features. They may be used for multiple purposes, which include staying linked with buddies and family, or getting access to records and entertainment. Common ICT devices encompass Smartphones; Tablets; Laptops; Desktop computers; Smartwatches; Fitness trackers; Virtual fact headsets; Augmented fact headsets; Wearable cameras; Smart TVs; Radio sets; USB flash drives; SD cards; Wireless headphones; Power banks; Portable audio system among others. To most people, their phone is the most essential gadget. They generally use it for forwarding texts, making calls, surfing the internet, checking email, and lots more. Fish marketing contributes significantly to the livelihoods and food security of the people in Sapele Local Government, Delta State, Nigeria and not much research has been carried out to verify the assessment of the impact of ICTs on fish marketing by fish marketers in this study area, hence, the need for this study. Due to this background, this study assesses the impact of ICTs on fish marketing in this area. The specific objectives are:

i. Describe the socio-economic characteristics of fish marketers in the study area.
ii. investigate the level of usage of ICT by fish marketers
iii. determine the impact of ICT on fish marketing in the study area.
iv. identify the constraints associated with using ICT in fish marketing in the study area.

MATERIALS AND METHODS

The Study Area, Sample Procedure, and Sample Size.

The area of study is the Sapele Local Government Area of Delta State. It is located in the South-South geo-political zone of Nigeria. It lies between longitude 50 541 and Latitude 50 401 with an elevation of 30 feet. Sapele Local Government Area has its headquarters in Sapele. It is bordered by Ughelli-North Local Government Area to the North, Warri- South Local Government Area to the East, Warri-North Local Government Area to the South, and Ethiope-West Local Government Area to the West. The study area has a total land area of 17,108 km2 and a population of over 238,000 people (NPC, 2006). Sapele has both wet and dry seasons. The study area has a tropical monsoon climate. The temperature of the study area is 290 C. It typically receives about 240.7 millimeters (9.46 inches) of precipitation at the time and 294.75 rainy days (80.75% of the time annually with a humidity of 78.85%). The economy of Sapele is based on agriculture, fishing, and timber. The catfish marketers in the study area constituted the population of this study. Purposive and simple random sampling techniques were used to select five (5) markets, they are Amukpe, Ghana, Ibada-Elume, Okirigwe, and Sapele markets. Twenty (20) respondents were randomly selected from each market to give a sample size of one hundred (100) respondents. The markets were purposively selected based on their prominence in catfish marketing.

Method of Data Collection

Data collected for the study was obtained from a digitalized well-structured questionnaire with Computer Aided Interview (CAPI), an open-source application installed on Android phones. CAPI allows for recording interview responses on handled devices such as tablets or smartphones, rather than Paper Aided Personal Interviews (PAPI).

Measurement of Variables

The dependent variable is the assessment of the Impact of Information and Communication Technologies (ICTs) on catfish marketing. This was measured by using a mean rating of high and low on the income received before and after the impact of ICTs. The independent variables were;

Age: was measured by indicating the respondent's chronological age in years.

Sex: was measured by the respondents indicating whether they were female or male.

Marital Status: was measured by the respondents indicating if respondents were married, single, separated, or divorced.

Household size: This is the number of people the respondent is housing at the time the data was collected.

Educational Qualification: This indicates the respondent's educational attainment at the time of data collection.

Income: This is the money that the respondents obtains from the catfish marketing in Naira.

Religion: This indicates the religious body the respondents belonged to at the time the survey was conducted

Ethnicity: This indicates the ethnic group the respondents belong to during the survey.

Cooperative Society: This indicates if the respondents were cooperators who belonged to one cooperative organization or not at the time the study was conducted.

Method of Data Analysis

Descriptive and Inferential statistics were used to analyze the collected data, Descriptive statistics such as simple percentages, frequency count, and mean ratings were used to achieve objectives 1, 2, and 4 while inferential statistics such as paired T-tests were used to analyze objective 3.

RESULTS AND DISCUSSION

The distribution of socioeconomic characteristics of respondents is shown in Table 1. The majority (93%) of the respondents were youths between the age range of 20-49 while 17% of the respondents fell in the range of 50 and above. This implies that the majority of the respondents were youths who were actively involved in the marketing of catfish. They also fall within the economically active age group as defined by the Food and Agricultural Organization (FAO,) (2009). This submission also agrees with Akinrotimi and Edun (2011), who reported a similar finding among Oyster marketers. The result also indicated that the majority (70%) of the respondents were females and (30%) were males. This reveals that females were more involved in Catfish marketing than males. This result agrees with Cliff et al., (2011) who reported that women are more involved in marketing than men, The result indicates that half (50%) of the respondents were married, a little above one-quarter (29%) of the respondents were singles, 14% were divorced and 7% were separated. This implies that the marketers have family responsibilities to attend to. This submission agrees with Etebu and Odiri (2023), who reported the same for market women's use of ICT gadgets in Nigeria. The result also depicts that (20%) have a household size of less than 5, half (50%) of the respondents have a household size of less than 10, one-quarter (25%) of the respondents have a household size greater than 10, and (5%) of the respondents have a household size of greater than 15. This reveals that the majority of the catfish marketers were using family members in their business operation and only a few hired labour due to the size of their family. This finding is in line with Otene *et al.,* (2018). The respondents (21%) had primary school leaving certificates, (27%) had secondary school certificates, (21%) of the respondents had tertiary education and (31%) of the respondents did not attend any form of education at all. This gave a general insight that the majority (69%) of the respondents were knowledgeable enough to operate their ICTs and could derive information from these ICTs and can derive information from ICT gadgets. This finding is similar to Otene *et al.*, (2017). The result from the table also shows that close to the total population (90%) were Christians, (5%) of the respondents were Islam and Traditional worshippers respectively. Half (50%) of the respondents were Okpe, (15%) of the respondents were Urhobos, one-quarter (25%) of the respondents were Itsekiris and (10%) were Ijaws. Over three-quarters (85%) of the respondents were cooperators while (15%) of the respondents did not belong to a cooperative society. Well over half (59%) of the respondents generated an income less than N20, 000:00k, one-fifth (20%) of the respondents generated income between N20, 000:00k-N40,000:00k, (11%) of the respondents generated income between N40,000:00k-N60,000:00k and (10%) of the respondents generated income greater than N60,000:00k. This implies that (90%) the respondents got below N60, 000:00k monthly.

Table1: Distribution of the Respondents according to their socio-economic characteristics.

Characteristics	Frequency	Percentages
Age (Years)		
20-29	25	25
30-39	28	28
40-49	30	30
50-59	10	10
60 and above	7	7
Total	100	100
Sex		
Female	70	70
Male	30	30
Total	100	10
Marital Status		
Married	50	50
Single	29	29
Divorced	14	14
Separated	7	7
Total	100	100
Household Size		
0-5	20	20
6-10	50	50
11-15	25	25
15 and above	5	5
Total	100	100
Educational Qualification		
Primary	21	21
Secondary	27	27
Tertiary	21	21
No Formal Education	31	31
Total	100	100
Religion		
Christianity	90	90
Islam	5	5
Traditional	5	5
Total	100	100
Ethnicity		
Okpe	50	50
Urhobo	15	15
Itsekiri	25	25
Ijaw	10	10
Total	100	100
Cooperative Society		
Yes	85	85
No	15	15
Total	100	100
Income Generated Monthly (Naira)		
<20,000	59	59
20,000-40,000	20	20
40,000-60,000	11	11
>60,000	10	10
Total	100	100

Source: Field Survey, 2024

The distribution of means rating the Catfish usage of ICTs by Catfish marketers is shown in Table 2. The mean (x)of (3.0) of the respondents indicates that they used ICT tools to have access to customers, the mean (x) of (2.9) of the respondents used ICT to access market information, the mean (x) of (3.0) of the respondents use ICT to advertise their fish products. The mean (x)of (2.55) used ICT to know information on market days and the mean (x) of (2.8) used ICT for the price of the fish. The cut-off mean (C.O.P.M) was obtained by dividing the total number of respondents by half (1/2) and later dividing the result by 20. That is (100÷1/2) =50. Fifty (50) divided by twenty (20) will give a cut-off point mean of 2.5. Since the means(x) obtained were greater than the cut-off point (x) this shows that ICT tools have improved the respondents' knowledge of Catfish marketing information in the study area. These findings confirm earlier study by Shiro (2008).

Table 2: Distribution of Respondents according to Mean Rating the level of usage of ICTs by Catfish marketers

	Names of market	Number of Respondents	Scores (frequency)	Total Score = (f)x Numbers of Respondents	Mean (Total Score÷ Total number of Respondent	Rating	Remarks
Variables							
Access to customers	Amukpe	20	15.00	15x20 =300	300÷100= 3.0	3.0	**S**
Access to market informarion	Ghana	20	14.50	14.5x20 =290	290÷100= 2.9	2.9	**S**
Advertisement of Product	Ibada-Elume	20	15.00	15x20 =300	300÷100= 3.0	3.0	**S**
Information on Market days	Okirigwe	20	12.75	12.75x20=255	255÷100= 2.55	2.55	**S**
Access to Price on fish	Sapele	20	14.00	14x20 =280	2880÷100= 2.8	2.8	**S**
Total		100	71.25	1425		14.25	

Source: Field Survey, 2024
N.B: S= Significant

The distribution of the Impact of ICTs on Catfish marketing on respondents is shown in Table 3. The t-test analysis shows that the mean (x) of income and volume of sales (6.01) is higher after the use of ICTs compared to the mean (x) of income and volume of sales (4.59) before the use of ICTs. This signifies that ICTs positively impact Catfish marketing in the study area. The finding agreed with Aker (2008), who found that ICTs positively impact agricultural income, reduce cost, and increase efficiency.

Table 3: The Paired T-test Analysis used to determine the Impact of ICTs on Cat fish marketing.

	N	Mean ($\overline{x}$)	Ste $\overline{x}$	T-cal	T-tab	df	Remark
Variables							
Income and Volume of Sales Before Use of ICTs	30	4.59	1.78	3.19	2.048	28	**S***
Income and Volume of Sales After Use of ICTs	30	6.01					

Source: Field Survey, 2024.
N.B: S* Significant

The constraints faced with the use of ICTs by Catfish marketers are depicted in Table 4. The majority (89%, 88%.and 80%) of the respondents had constraints of erratic power supply, cost of ICT facilities, and access to affordable services respectively. A little above two-thirds (70%) of the respondents had constraints of poor networks. A little above half (60%) and two-thirds (67%) of the respondents had constraints of lack of ICT skills and training and unavailability of ICT centers. Half (50%) and a little above half (52%) of the respondents had inadequate access to ICTs and a language barrier.

Table 4: Distribution of Respondents according to the constraints faced with the use of ICTs.

	Frequency (f)	Percentage (%)	Rating**
Variables			
Erratic power supply	89	89	1
Cost of ICT facilities	88	88	2
Access to affordable services	80	80	3
Poor Network Coverage	70	70	4
Lack of ICT skills and training	67	67	5
Unavailability of ICT centers	60	60	6
Inadequate access to ICTs	52	52	7
Language Barrier	50	50	8
Total	**556***	**556***	

Source: Field Survey, 2024
Note: ** Rank in descending order
Note: * Multiple Responses

CONCLUSION AND RECOMMENDATIONS

The study concluded that the catfish marketers in the study area utilize ICTs. The level of use was significant all through. The marketers also had high income and sales when they used ICTs. The constraints faced by the marketers were highest with the erratic power supply and the least being the language barrier. Based on the findings of this study, it was recommended that the Power Holdings Company of Nigeria (PHCN) ensure a steady power supply in the study area to facilitate more use of ICT tools for fish marketing. Loan facilities by cooperative societies should be made available to the marketers to obtain ICT facilities and the network providers should provide affordable services in the study area.

REFERENCES

Aker, J. C. (2008). Does Digital divide or provide? The impact of cell phones on grain markets in Nigeria. Center for Global Development, 154pp.

Akinrotimi, O. A., and Edun, O.M. (2011). Consumer disposition towards Oyster consumption in selected fishing communities of Rivers State, Nigeria. Continental Journal of Agricultural Economics, 5(1): 41-46.

Alam, J. M., Yasmin, R. A., Rahman, Nahar, N., Pinky, N. I., and Hasan, M. (2010). A study on fish marketing system in Swarighat, Dhaka, Bangladesh. Nature and Science, 8(12): 96-103.

Ali, E.A., H.I.M. Gaya and T.N. Jampada, (2008). Economic analysis of fresh fish marketing In Maiduguri Gamboru market and Kachumbari Alaudam landing site of North-Eastern, Nigeria. Journal of Agriculture and Social Sciences, 2(4): 23-34.

Aswathy, N., Narayanakumar, R., and Harshan, N. K. (2014). Marketing costs, margins, and efficiency of domestic marine fish marketing in Korala. India Journal Fish, 61(2): 97-102.

Babalola, D. A., Bamiji, O and Isitor, S.U. (2015). Economic potentials of fish marketing and women empowerment in Nigeria. Evidence from Ogun state. Africa Journal of Food, Agriculture, Nutrition and Development. 15(2): 21

Bada, T., and Rahji, M. A. (2010). Frozen Fish Markets and Marketing Problem in Ibadan, Nigeria. Journal of Agric Sci., 2(3): 34-40.

Cliffe, P. T., Akinrotimi, O. A., and Ibemere, I. F. (2011). Promoting women's participation in aquaculture as a viable tool for poverty alleviation in the rural areas of Nigeria. Global Approaches to Extension Practice, 7(1): 98-105.

Etebu, A. T. and Odiri, V. A. (2023). Market Women Use of Information and Communication Technology (ICT) Gadgets in Nigeria. Library Philosophy and PracticeI, 7: 6-19.

Food and Agricultural Organization (FAO) (2009). State of food insecurity in the world: Addressing food security in protracted crises. Rome: FAO

Flood, R. L. (2006). Entrepreneurship and innovativeness Entrepreneur. Innovative Change, 1:13-23.

Ladipo, F., and Simwa, A. (2022). ICT gadgets and their uses explained: Get the complete list. Available online: https://www.legit.ng/ask-legit/top/1129797-ict-gadgets-functions/

Madugu, A. J., and Edward, A. (2011). Marketing and Distribution channel of processed fish in Adamawa state, Nigeria. Global Journal of Management and Business Research; 11(4):21-26.

NPC (2006). Nigeria National Population Census Report.

Otene, V. A., Ezihe, J.A.C., and Torgenga, F.S. (2017). Assessment of mobile phone usage among farmers in Keana local government area of Nassarawa State, Nigeria. Journal of Agricultural & Food Information, 19(2): 141-148. DOI: 10.1080/10496505. 2017.1361829

Otene, V.A., Ijuh, R.H., Iheanaetu, A.C. and Chia, J.I. (2018). Assessment of use of Information and Communication Technologies (ICTs) by Farmers in Makurdi Local Government of Benue State: Implications for Accessing Market Information. Greener Journal of Agricultural Sciences, 8(9): 251-256

Pauly, D., Christensen, Walters. V., Guenette, S., Pitcher, T. J., Sumaila, U. R., Walters, C. J., Watson, R., and Zeller, D. (2002). A review article on "Towards Sustainability in World Fisheries". Fisheries Centre, University of British Columbia, Canada.

Shiro, J. (2008). A case study of DIV CT. Journal of information, 10 (4): 40-60. Spore, (1998). Marketing information. Case of KACE CTA Information for Agricultural Development in ACP Countries CTA, Wageningen 78: 16pp.

BOOK OF PROCEEDINGS FOR THE 39TH ANNUAL NATIONAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) ABUJA

AUTOMATION AND ROBOTICS IN FISHERIES

Okpo, U. E., O. E. Afia and T. M. Abasiubong

Department of Fisheries and Aquatic Environmental Management, University of Uyo, Uyo, Nigeria

Corresponding author:
ofonimeafia@uniuyo.edu.ng; +2348028381053, 0009-0004-6390-2383

ABSTRACT
Technological innovations in fisheries and aquaculture play an important role in boosting the productivity of fish farming. Numerous novel technologies have brought about a significant transformation in this field. On full show are technological advancements in robotics, autonomous systems, drones, electronic tracking and reporting, autonomous feeding devices, acoustic devices, remote sensing, satellite monitoring, integrated multitrophic aquaculture systems, aquapods, and fish biosensors. This review focuses on these technological innovations - how the new innovative technologies used in this sector have changed the scenario of fish production and the livelihood of the farmers paving way for a future in which sustainable fishing practices and healthy aquatic ecosystems coexist.

Keywords:
Technological innovations, Aquaculture, Reproduction

INTRODUCTION

Fisheries and aquaculture play critical roles in global fish production, both on land and in the water. The sector is currently suffering a number of challenges as a result of the employment of antiquated traditional processes, poor management, environmental contamination, and high labor expenses. As a result, this sector has embraced the deployment of novel technology to overcome these difficulties (Latief *et al.*, 2024). Technological innovation is critical to the future of fisheries and aquaculture.
The gap between innovation and technology is substantial. Innovation is the invention and implementation of new ideas, technologies, practices, and approaches that improve the industry's sustainability, efficiency, and overall performance (Lucchetti *et al.*, 2023). Innovation results in new ideas, methods, products, or restructuring, remodeling, creative concepts, and new imagination in a gadget or process. Technology, as an application of scientific knowledge, has helped humans create a brighter future (Ghosh and Soumili, 2019).

According to Latief *et al.* (2024), technological innovations are practices that contribute to the research, development, and design of new goods and procedures, as well as the improvement of existing results and the creation of new technical abilities. Technological advancements that are transforming fisheries and aquaculture operations have resulted in a substantial shift in the field in recent years. These developments, which vary from sophisticated monitoring systems to cutting-edge robotics, improve production, sustainability, and the overall health of our oceans (Balaji *et al.*, 2023). Innovative technologies have a significant influence since they contribute to a sustainable harvest of marine resources and fishing operations. In recent years, global aquaculture production has expanded with inventive and technological improvements within the fisheries sector and scaled up in world total fisheries production (Latief *et al.*, 2024).
Fisheries innovations date back thousands of years, and have traditionally been driven by maximizing catch efficiency, which has been aided by a better understanding of the habits and behaviors of the sold

species (Lucchetti *et al.*, 2023). In the modern era, the industrialization of fisheries in the nineteenth and twentieth centuries brought technological innovations such as steam-engine vessels, onboard refrigeration and freezing of catches, synthetic netting materials, and information technologies to aid communications, navigation, fish location, and gear performance monitoring while fishing (Squires and Vestergaard, 2013).

Rapid development has been observed for the last few decades in fisheries and aquaculture, thanks to innovation. Technologies used in fisheries and aquaculture have a huge role in increasing the productivity of fish farming. These innovations have sustained the productivity as well as strengthened the economy of the fish farmers. Some innovations have revolutionized the reproduction of fishes. It has increased production and helped better the farmers' welfare. Solving the problems that farmers face in fish cultivation; is the only target of all these technologies. Albeit, the great strides, the sector is facing numerous issues due to the use of age-old traditional techniques, improper management, environmental pollution and expensive labour costs (Latief *et al.*, 2024). It is important to discuss how these new innovative technologies used in fisheries and aquaculture help changed the o of fish production and the livelihood of the farmers. The aims of this review are to highlight technological breakthroughs in fisheries and aquaculture and to examine the innovative technical developments in fisheries management and how these revolutions impact the sector for a sustainable future

There are numerous revolutionary technologies, including GIS, GPS, remote sensing, radar, sonar, drones, automatic feeding devices, sensors, and robotic fish. Fisheries and aquaculture innovations include conservation technologies, aquaculture technology, harvesting technologies, new products, and institutional innovation. Great advancements are being made in automated fishing due to technological advances. Innovative technologies also allow for more comprehensive learning (Latief *et al.*, 2024).

TECHNOLOGICAL INNOVATIONS IN FISHERIES

Technological breakthroughs are ushering in a new era in fisheries management, one in which sustainability and efficiency are inextricably linked (Balaji *et al.*, 2023). Advances in remote sensing, artificial intelligence, robotics, electronic monitoring, and aquaculture are providing fisheries stakeholders with the knowledge and resources they need to make sound decisions, protect marine ecosystems, and ensure the fishing industry's long-term survival (Latief *et al.*, 2024). New horizons of technical innovation, such as the use of artificial intelligence, are being explored. The International Council for the Exploration of the Sea (ICES) defines innovation in fisheries as an improvement of the status quo, whether incremental, transformative, or disruptive (WKING; ICES, 2020).

Remote Sensing and Satellite Monitoring

Satellite-based technology provides global real-time monitoring of fishing activity. To efficiently detect illicit fishing, control overfishing, and enforce restrictions, vessel monitoring systems (VMS) and satellite imagery are employed to track fishing vessel movement and behavior (Balaji *et al.*, 2023).

Artificial Intelligence (AI) and Big Data Analytics

The combination of AI and big data analytics has altered the way we collect, examine, and use fishery data. Machine learning algorithms can handle massive amounts of data from a variety of sources, including catch reports, environmental sensors, and vessel monitoring (Balaji *et al.*, 2023). AI can detect patterns and correlations to provide exact stock evaluations, estimate fish population trends, and optimize fishing strategies for long-term yield (Pinsky *et al.*, 2018).

Robotics and Autonomous Systems

Robotic technologies are altering several aspects of fisheries management. Without human interaction, underwater vehicles (UUVs) equipped with sensors and cameras may scan marine ecosystems, monitor habitats, and assess fish stocks (Smith *et al.* 2010). With the ability to collect temperature, salinity, and water quality data autonomously, underwater gliders can provide valuable insights into the health of marine environments. In addition, aerial robotics and drones are used for airborne surveys, enabling for speedy evaluation of fish shoals, detecting illegal activity, and assisting with search and rescue missions (Balaji *et al.*, 2023).

Drones

One of the most common applications of new technology for sustainable fishing is the growing use of drones and completely or partially unmanned vehicles. Drones are classified into three types: unmanned aerial vehicles (UAVs), unmanned surface vehicles (USVs), and unmanned underwater vehicles. Fishing boats have also used drones to find illegal tuna aggregations in the Pacific Ocean. Drones can be used to inspect underwater cages for damage and monitor offshore fish farms. They are also used for tracking fish movements, detecting algae blooms, and monitoring water quality. Drones are one of the most commonly used applications for sustainable fisheries.

Acoustic Devices

Sonar, also known as sound navigation and ranging, is a way of communicating, navigating, and detecting objects on or beneath the water's surface via sound propagation (usually underwater). The Sonar is utilized for navigation, fish finding, wreck locating and recovery, detection, tracking, and destruction of hostile ships and submarines (Latief *et al.*, 2024).

Echosounder

Echo sounding is the process of detecting the depth of water using sound pulses. The echosounder aids in navigation by measuring the depth of the water and locating fish beneath the vessel for biomass estimation. Echosounder and Sonar vary in that they use (high-frequency) sound to detect and range underwater targets.

Aquaculture Technological Innovations

Technological improvements have fueled a revolution in the aquaculture business, allowing for more effective and sustainable practices (Kroodsma *et al.*, 2018). Automated feeders, remote sensing technology, and improved water quality monitoring systems improve fish farm operations while minimizing waste and environmental impact. Enhancing disease resistance and growth rates through genetic research and selective breeding programs contributes to sustainable aquaculture (Balaji *et al.*, 2023). Aquaculture technologies have a significant impact on fish farming productivity. Several innovative technologies have transformed aquaculture. Genetic tools and other reproductive technologies are widely employed and have eliminated numerous problems (Ghosh and Soumili, 2019).

Innovations related to reproduction

Biotechnological and genetic technologies have the potential to significantly increase productivity and improve ecosystem sustainability. These instruments have the potential to be the most effective weapon for improving reproductive success as well as the growth and survival of endangered species (Ghosh and Soumili, 2019).

Recent innovative aquaculture technologies are extremely beneficial for identifying and conserving aquatic biodiversity. Transgenic technology is a major component of these reproduction-related technical developments. These technologies make significant contributions to improving growth rates, market size, and feed conversion ratios, disease resistance, stress tolerance to extreme environmental conditions, and sterility difficulties (Ghosh and Soumili, 2019).

Technological Innovations in Cage Aquaculture

Technological advancements have begun to employ high-volume plastic cages that are resistant to tough offshore environments, reaching a diameter of 200 m, along with the necessity for systems to be used in open seas and bigger capacity systems (Diler *et al.*, 2017).

Robotic Fish Cages - Aquapod

This system, which began to be utilized in 2011, is a circular framework constructed by combining triangular net components. It is ideal for aquaculture in open sea circumstances because of its sinkable structure and completely surrounded by nets. Divers and electrical gadgets maintain constant control over the system (InnovaSea, 2017). The Aquapod is essentially a cage in which producers place their fish before leaving them adrift in the ocean. They are designed to accommodate a variety of aquatic species.

Smart Floating Farms

The intelligent floating farm model is a highly productive system that employs cutting-edge technology in aquaculture. Aquaponic production uses wastewater from fish ponds to produce vegetables, and the vegetables can be utilized in feed fish production (Diler *et al.*, 2017). Furthermore, the packaging modules in the middle area allow harvested products to be delivered directly. This approach is especially useful for cities with a large population (Anonymous, 2017).

Automatic Feeding System

Feed is the most expensive operating expense in aquaculture operations. When applying feed in an aquaculture system, the feeding schedule must be carefully considered (Latief *et al.*, 2024). Yeoh *et al.* (2010) developed an automated fish feeder that may be used in commercial aquaculture systems. This technology was developed to address the aquaculture industry's labor shortfall by introducing a semi-automated way.

Biosensors For the Assessment of Fish Health

Technological advancements allow for the measurement and identification of specific components even in complex situations (Windmiller and Wang, 2013). Over the last few decades, researchers have developed and applied biosensor technology to measure fish health and develop novel diagnostic tools with the potential to greatly enhance it. Many biosensors for fish health checks have been developed in an effort to improve the safety of farmed fish in the market (Latief et al., 2024).

Integrated Multi-Trophic Aquaculture Systems (IMTA)

IMTA is a method that produces live species to absorb nutrient waste from aquaculture (UMCCAR, 2017). In research, studies revealed that mussels cultivation integrated with trout farms developed 50% quicker and brown moss was 46% faster. Studies have also shown that integrating sea bream fish with crustaceans reduces environmental effect and organic deposition at cage bottom by 50% (Diler *et al.*, 2017)

Recirculating Aquaculture System

This strategy is based on leaving the plow and entering the farm with clean water (figure 9). This significantly increases the demand for water and causes the discharge of relatively unclean water into the reservoir as a result of its use (Ferreira *et al.* 2012). After using water in recirculating aquaculture systems, the particle filter, sand filter, biological filter, UV filter, and ventilation are remedied through physical, chemical, and biological methods. Recirculating aquaculture systems utilize 98% less water than conventional methods (Bregnballe, 2010). In this way, maximal output of aquatic products is obtained while minimizing environmental impact and water consumption.

CONCLUSION

Recent years have seen rapid progress in the fisheries and aquaculture sectors, ranging from simple procedures to high-tech systems. Many older techniques have been modified, and some new technologies have been invented. However, all of this progress has served the same purpose: to increase output and improve the farmers' economy. These technical advancements are making significant advances in fisheries and aquaculture. Innovative technologies allow for a more thorough learning process. New technologies have also raised public awareness of fisheries, particularly in remote fishing areas, thereby addressing the challenges that farmers face in the fish industry. The fisheries and aquaculture sectors will continue to play an essential role in offsetting the rapidly rising population's requirement for animal protein in the future through these technological innovations.

REFERENCES

Anonymus (2017). http://smartfloatingfarms.com/

Balaji, M., Sarka, S., Karunakaran, S., Kavithambika, S. and Shanmugam, S. A. (2023). Technological Innovations in Fisheries Sector. Trends in Agriculture Science, Vol.2, Issue 6, June, 411-414 414. https://doi.org/10.5281/zenodo.8037283

Bregnballe, J. (2010). A guide to recirculation aquaculture. An introduction to the new environmentally friendly and highly productive closed fish farming systems. Eurofish, Copenhagen, Denmark.

Diler, I., Bayrak, H., Kayhan, M. H and Kutlu, S. (2017). Recent Innovative and Technological Developments in Aquaculture 7 Published in 5th International Symposium on Innovative Technologies in Engineering and Science (ISITES2017 Baku - Azerbaijan)

Ferreira, J., Saurel, G. and Ferreira, J. M. (2012). Cultivation of gilthead bream in monoculture and integrated multi-trophic aquaculture. Analysis of production and environmental effects by means of the farm model. Aquaculture 358–359; 23–34.

Ghosh, S. and Soumili, D. (2019). New Innovative Technologies used in Aquaculture. International Journal of Inclusive Development, 5(1): 31-35,DOI: 10.30954/2454-4132.1.2019.6

InnovaSea (2017). Systems, Inc. https://www.innovasea.com/ portfolioitem /aquapod-a3600-in-puerto-rico/.

Latief, T., Bhat, F. A., Shah, T. H., Abubakr, A., Bhat, B. A. and Kumar, A. (2024). Innovative Technologies in Fisheries Sector. Chron Aquat Sci.;1(10):102-114

Lucchetti, A., Melli, V. and Brcˇ ic,´ J. (2023) Editorial: Innovations in fishing technology aimed at achieving sustainable fishing. Front. Mar. Sci. 10:1310318. doi: 10.3389/fmars.2023.1310318

Pinsky, M. L., Reygondeau, G., Caddell, R., Palacios-Abrantes, J., Spikers, J. and Cheung, W. W. L. (2018). Preparing ocean governance for species on the move. Science 360 (6394), 1189-1191. https://doi.org/10.1126/science.aat2360.

Smith, M. D., Roheim, C. A., Crowder, L. B., Halpern, B. S., Turnipseed, M., Anderson, J. L., Asche, F., Bourillón, L., Guttormsen, A. G., Khan, A., Liguori, L.A., McNevin, A., O'Connor, M.I., Squires, D., Tyedmers, P., Brownstein, C., Carden, K., Klinger, D.H., Sagarin, R. and Selkoe, K.A. (2010). Sustainability and global seafood. Science 327 (5967), 784-786. https://doi.org/10.1126/science.1185345.S.

Squires, D., and Vestergaard, N. (2013). Technical change in fisheries. Mar. Policy. 42, 286–292. doi: 10.1016/j.marpol.2013.03.019

UMCCAR (The University of Maine Center for Cooperative Aquaculture Research. Integrated MultiTrophic Aquaculture) (2017). https://umaine.edu/cooperativeaquaculture /integrated-multi-trophic-aquaculture/.

Windmiller, J. and Wang, J. (2013). Wearable electrochemical sensors and biosensors: a review. Electroanalysis 25, 29-46.

Yeoh, S. J., Taip, F. S., Endan, J., Talib, R. A. and Mazlina, M. K. S. (2010). Development of automatic feeding machine for aquaculture industry. Pertanika Journal of Science and Technology 18(1), 105- 110.

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EFFECT OF DIETARY β - GLUCAN LEVELS ON THE GROWTH PERFORMANCE AND SURVIVAL RATE OF *Clarias gariepinus (Burchell, 1822)* FRY

[1]Ali, M. E., [2]O. A. Sogbesan, [3]Z. A. Yusuf, [4]M. Newton, [1]S. K. Yusuf, [5]E. E. Omovwohwonie, [6]M. Abdulkarim and [3]G. J. Kwala

[1]National Biotechnology Development Agency, Billiri, Gombe State, Nigeria
[2]Department of Fisheries Modibbo Adama University Yola, Adamawa State, Nigeria
[3]Department of Fisheries and Aquaculture, Federal University of Lafia, Nasarawa State, Nigeria
[4]Department of Fisheries Technology, Federal College of Horticulture, Dadin - Kowa, Gombe State, Nigeria
[5]Department of Oceanography and Fisheries Science, Federal Polytechnic, Ekowe, Bayelsa State, Nigeria
[6]Department of Animal Production, Abubakar Tafawa Balewa University, Bauchi, Bauchi State, Nigeria

Corresponding Author:
mealikumbo@gmail.com, +234 8034935792, 0009 - 0002 - 0172 - 6121

ABSTRACT
This study was carried out at the Lay – Joy fish farm, Billiri, Gombe State to investigate the effect of dietary β - glucan levels on the growth performance and survival rate of C. *gariepinus* fry. β - glucan was incorporated in form of feed additive at 0.0g/100g (B0)), 0.5g/100g (B1), 1.0g/100g (B2,) 1.5g/100g (B3) and 2.0g/100g (B4) inclusion levels into Coppens fish feeds (0.2 – 0.5mm) with 49% crude protein, diet without β - glucan served as the control (B0), in triplicates. Diets were fed to fry (n = 1,500, 0.26±0.0g) for 28 days in 15 plastic hatchery tanks (n = 100). Fry were fed at a fixed feeding rate of 10% body weight 6 times daily between the hours of 07:00 and 23:00 at regular interval. Data obtained were analyzed using One - way ANOVA at P = 0.05. Body weight values in terms of MWG (1.87±0.93 g/fish), DWG (0.076±0.07 g/day) and SGR (3.27±0.16 %/day) significantly ($p < 0.05$) highest in fry fed diet B2, while diet B0 had the lowest MWG (1.56±0.04 g /fish), DWG (0.055±0.06 g/day) and SGR (3.01±0.15 %/day) values. FCR value was best (least) in B2 (0.390±0.07), while B0 had the poor (highest) value (0.467±0.01). In terms of the Survival rate, B2 had significantly ($p < 0.05$) the highest survival rate value (94.9±1.08), while B0 had the least value (87.8±1.09). This study indicated that incorporation of β – glucan at 1.0g/100g feed inclusion level into C. gariepinus fry feed improved growth and survival rate.

Keywords:
Growth Performance; Survival Rate; C. gariepinus; Fry; β - glucan.

INTRODUCTION

The larva and the fry stages are considered as the critical periods in the life cycles of many fish species (Ali, 2015). Success of fish larval culturing depends mainly on the availability of suitable feed or food that are readily eaten with efficiency of digestion and provision of the needed nutrients for growth, good health and survival of the fish larvae (Mehrabi *et al.,* 2018). However, the culturing of fish at the larvae and fry stages has been a great challenge for many fish breeders (Onyia *et al.,* 2016). The knowledge of the special nutritional requirements of fish fry can really promotes the functioning and standard of the cultured species. The choice of minute feed particles can result to nutrient leaching due to very high ratio surface to area volume (Onyia *et al.,* 2016). Live prey organisms, primarily zooplanktons, are mostly used as the starter food for the larvae and fry of many fish species that are not suitable to be reared on formulated feed (Ali, 2015). The increasing cost of Artemia is a constraint to fish breeders particularly in the tropical countries such as Nigeria. This has necessitated the need for alternative feeds like special fish diets incorporated with growth promoters as natural feed additives such as β – glucans which positively affect the body weight gain without any negative effect on public health and consumer (Ahmad *et al.*, 2015). Applications of β - glucans in aquaculture are emerging in Nigeria; β-glucans are long chain complex carbohydrates which can be found in cereals, seaweeds, mushrooms, yeast and some bacteria (Ali *et al.,* 2022). β-glucans as adjuvants, prebiotics or probiotics are the most popular immune enhancing nutrients used in aquaculture and are promising in the stimulation of non - specific immune response in fish while promoting growth (Ali, 2022). This study is aimed at evaluating the effect of dietary β - glucan levels on the growth performance and survival rate of *Clarias gariepinus* (Burchell, 1822) fry.

MATERIALS AND METHODS

Study Area

The study was carried out at the Lay – Joy fish farm Billiri., Billiri local government area (LGA), Gombe State. Billiri LGA lies within latitude 9°50' and 11°09'´N and longitude 9.833°and 11.150°E. It covers an area of 737km² and is 50 km away from Gombe the capital city. The fry for the experiment were bred at the hatchery room of the farm. The fry were 4 days old at the commencement of the feeding trial.

Experimental Diets

Coppens fish feed (0.2 – 0.5mm) was used as the basal diet for this study and was obtained from feed suppliers at Gombe while the β - glucan was purchased from Bon - Amour Pharmacy Limited Lagos, Nigeria, imported from Piping Rock Health Products, Ronkonkoma, New - York, USA. Experimental diets were prepared by incorporating β - glucan additive at four graded levels; 0.5g, 1.0g, 1.5g and 2.0g/100g feed, into Coppens fish feeds (0.2 – 0.5mm), while diet without β - glucan additive i.e. 0.0g/100g feed served as the control diet and were coded as B0 (0.0g), B1 (0.5g), B2 (1.0g), B3 (1.5g) and B4 (2.0g) respectively. The β - glucan additive was included at the measured quantity for each diet and were diluted into 5 ml of warm water (350C) to form a solution. The solution was sprayed onto the Coppens fish feed (0.2 – 0.5mm), fish oil was added to all the experimental diets with β – glucan to reserve the β – glucan additive. The Coppens fish feed (0.2 – 0.5mm) with β - glucan additive was prepared in 100g each time. The proximate composition of the Coppens fish feeds (0.2 – 0.5mm) fed to the C. gariepinus fry is presented in Table 1. All the diets contained 49% crude protein, 12% crude lipid, 6.0% crude fibre, 8.0% ash, 1.5% calcium, 8.0% moisture and 1.5% phosphorus.

Table 1: Proximate Composition of Coppens Fry Feeds (0.2 – 0.5 mm) Used for the Study

Nutrients	Percentage (%)
Crude protein	49
Crude lipid	12
Crude fibre	6.0
Ash	8.0
Calcium	1.5
Moisture	8.0
Phosphorus	1.5

Source: Field Survey (2023).

Experimental Design

Each of the treatment diets were fed to C. *gariepinus* fry (n = 1,500; 0.26±0.0g) in triplicate making a total of 15 plastic hatchery tanks (semi flow - through system) i.e. (n = 100 per tank). Water quality parameters such as; pH, dissolved oxygen (DO), temperature and ammonia were monitored weekly. Fry were fed 6 times daily between the hours of 07:00 and 23:00 at regular interval for a period of 28 days at a fixed feeding rate of 10% body weight as recommended by Ukwe *et al.* (2018). The initial body weight of each set of fry was measured using a digital weighing balance before stocking and subsequently bulk weighing of fry in each tank was done after every 7 days, the growth performance parameters were computed and analyzed according to the following equations as described by Stickey et al. (2006) as follows;

Mean weight gain, MWG = final weight(g) - initial weight (g)
Daily weight gain, DWG = (final weight (g) - initial weight (g) / experimental days
Specific Growth Rate, SGR = {(log final weight (g) - log initial weight (g)}/culture period} x 100
Feed Conversion Ratio, FCR (g/g) = Feed intake(g)/weight gain (g)
Survival rate = {(final no. of fish - initial no. fish)/initial no. of fish} x 100

Statistical Analysis

The data obtained was subjected to one - way analysis of variance (ANOVA) using the GraphPad instant package for windows 2010 of statistical analysis system (SAS, 2010). Mean separation was done (at P = 0.05) using Fisher's least significance difference (LSD) to separate the means in cases of significant difference.

RESULTS

Results of the growth performance parameters and survival rates of the C. gariepinus fry fed dietary - glucan at different levels of inclusion is shown in Table 2. The significantly ($p<0.05$) highest growth performance parameters' values in terms of MWG (2.13±0.38g/fish), DWG (0.076±0.07 g/day) and SGR (3.27±0.16 %/day) were recorded from the fry fed β – glucan incorporated diet at 1.0g/100g feed (B2). Similarly, the significantly ($p<0.05$) least (best) FCR value; (0.390±0.07) was recorded from the fry fed diet B2. The highest survival rate value; (94.9±1.08%) was recorded from the fry fed diet B2. There was also a significant difference ($p<0.05$) in terms of the survival rate values recorded from the diets. During the experimental period, the water quality parameters monitored such as the water temperature, pH, dissolved oxygen and ammonia were within the recommended ranges for C. gariepinus culture.

Table 2: Growth Performance and Survival Rate of C. *gariepinus* **Fry Fed Dietary β - glucan Levels**

Parameters	B_0	B_1	B_2	B_3	B_4
Initial mean weight (g/fry)	0.26±0.0^{a}	0.26±0.0^{a}	0.26±0.0^{a}	0.26±0.0^{a}	0.26±0.0^{a}
Final mean weight (g/fry)	1.82±0.13^{a}	1.84±0.17^{a}	2.13±0.38^{b}	1.85±0.15^{a}	1.87±0.16^{a}
Mean weight gain (g/fry)	1.56±0.04^{a}	1.58±0.07^{b}	1.87±0.93^{c}	1.59±0.80^{b}	1.61±0.08^{b}
Daily growth rate (g/day)	0.055±0.06^{a}	0.056±0.03^{a}	0.076±0.07^{b}	0.057±0.03^{a}	0.058±0.01^{a}
Specific growth rate (%/day)	3.01±0.15^{a}	3.03±0.13^{b}	3.27±0.16^{c}	3.05±0.09^{b}	3.06±0.07^{b}
Feed conversion ratio (g/fry)	0.467±0.01^{a}	0.462±0.04^{a}	0.390±0.07^{b}	0.459±0.05^{a}	0.453±0.03^{a}
Survival rate(%)	87.8±1.09^{a}	91.0±1.04^{b}	94.9±1.08^{c}	91.3±1.06^{b}	91.7±0.05^{a}

Mean values in each row with similar superscripts are not significantly different ($p>0.05$).
Keys: B0 - β - glucan (0.0g/100g), B1 - β - glucan (0.5g/100g), B2 - β - glucan (1.0g/100g), B3 - β - glucan (1.5g/100g), B4 - β - glucan (2.0g/100g).

DISCUSSION

Growth performance parameters values such as the MWG, DWG and SGR were highest in the fry fed diet B2 which corroborates the findings of Ramzani et al. (2014), who reported a similar result but for Oncorhynchus mykiss fry fed dietary β - glucan additive diets and the findings of Sogbesan (2023) for *C. gariepinus* fingerlings fed 1.0g/100g feed inclusion levels of dietary β - glucan additive diets. The FCR that was least (best) in the fry fed diet B2 containing β - glucan additive at 1.0g/100g level of inclusion in feed also was in agreement with the findings of Ahmad et al. (2015) that reported similar findings for Oreochromis niloticus fingerlings fed dietary β - glucan additive at 1.0g/kg feed and that of Abed Ali and Al - Faragi (2017), who reported a similar result for Cyprinus carpio fingerlings fed β - glucan additive diet at same 1.0g/100g feed inclusion level. The highest MWG, DWG, SGR and the least (best) FCR recorded from the fry fed diet B2 containing β - glucan additive at 1.0g/100g feed, indicated that the β - glucan additive has a beneficial effect when added to the diet at that optimal level but below or above that level may negatively affect the metabolism of the fish. The significantly ($p<0.05$) higher survival rate values recorded from all the fry fed diets with β - glucan additive used in this study indicated that the diets with β - glucan additive were well tolerated by the fry and also the water quality parameters were positively affected by the incorporation of β - glucan additive which also serves as a prebiotic into the diets thereby, improving the water qualities as well. These also corroborates the findings of Ekundayo, et al. (2014).

CONCLUSION

The present findings indicated that feeding C. *gariepinus* fry with diet incorporated with β - glucan at 1.0g/100g feed inclusion level significantly improved the growth performance, feed conversion ratio and survival rate of the fry which can greatly minimise the losses of the C. gariepinus fry through mortalities for fish breeders, thereby improving the seed production which is essential for the sustainability of the aquaculture industries.

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REFERENCES

Abed Ali, H. H. and Al - Faragi, J. K. A. (2017). Efficiency of betaine and β - glucan as feed additives on the growth performance and survival rate of common carp (Cyprinus carpio L.) fingerlings. Journal of Entomology and Zoology Studies, 5(4): 27 - 31.

Ahmad, M. H., El - Mousallamy A., Zein, N., Abd El - Naby, A. S. and Mohamed, S. Z. (2015). Evaluation of prebiotic as natural additives on growth performance and blood biochemistry for Nile tilapia (Oreochromis niloticus). Middle East Journal of Applied Sciences, 5(2): 526 - 533.

Ali, M. E. (2015). Comparative study on the performance of Clarias gariepinus (Burchell, 1822) fry fed shell - free Artemia, fermented cassava wastewater and sorghum broth. unpublished M. Tech. Thesis, Department of Zoology, Modibbo Adama University of Technology, Yola, Nigeria. Pp. 41.

Ali, M. E. (2022). Performance and cost benefit of African mud catfish Clarias gariepinus (Burchell, 1822) fed different levels of dietary betaine, β - glucan and co - mixed additives diets. Unpublished Ph.D. Thesis, Department of Fisheries, Modibbo Adama University, Yola, Nigeria. Pp. 183.

Ali, M. E., Abubakar, K. A. and Sogbesan, O. A. (2022). Efficacy of dietary β - glucan as natural additive on the growth performance and survival rate of Clarias gariepinus (Burchell, 1822) fingerlings. Proceedings of the 37th Annual Conference of the Fisheries Society of Nigeria (FISON). Pp. 129 - 133.

Ekundayo, T. M., Sogbesan, O. A. and Lauratu, T. H. (2014). A review on probiotics application in aquaculture. Fisheries and Aquaculture Journal, 5: 111. doi: 10.4172/2150-3508.1000111

Mehrabi, F., Khalesi, M. K. and Hazaie, K. (2018). Effects of pre - and probiotics on growth, survival, body composition, and hematology of common carp (Cyprinus carpio L.) fry from the Caspian Sea. Turkish Journal of Fisheries and Aquatic Sciences, 18: 597 - 602.

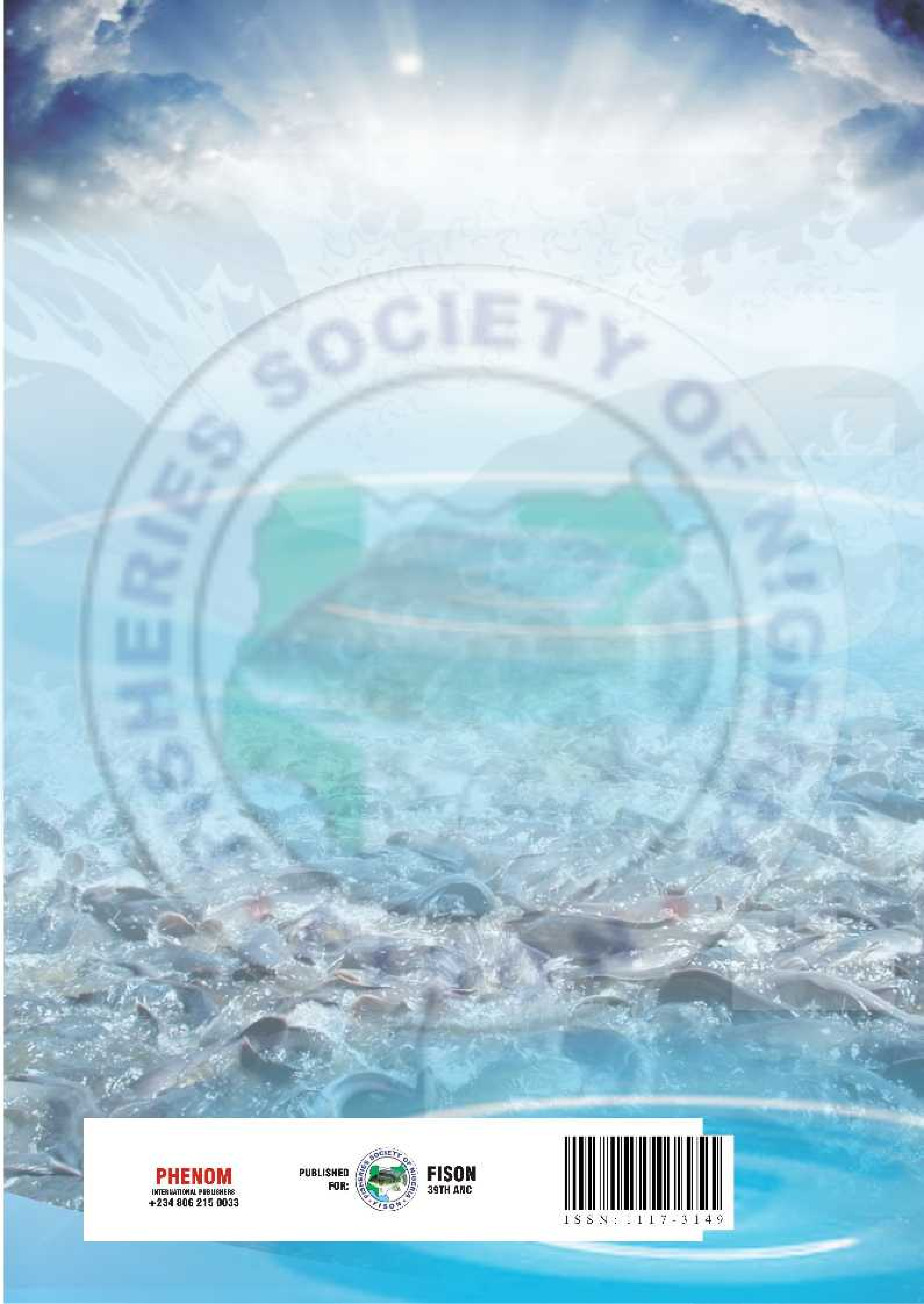
Onyia, L. U., Eramoh, O. F., Ochokwu, I. J. and Amadi, G. C. (2016). Growth performance of Clarias gariepinus fries fed live food, artemiaand fishmeal. Proceedings of the 31st Annual Conference of the Fisheries Society of Nigeria (FISON). Pp. 84 - 86.

Ramzani, S., Soltani, M. and Gholipourkanani, H. (2014). Influence of dietary dinamune® on growth performance and lysozyme activity in rainbow trout (Oncorhynchus mykiss) fry. Walailak Journal of Agriculture Technology and Biological Sciences, 11(10): 865- 869.

Sogbesan, O. A. (2023). Bio - recycling of some organic wastes in reducing fish production cost and attainment of food security. 26th Inaugural Lecture, Modibbo Adama University, Yola, Nigeria. Pp. 98.

Stickey, R. R., Hardy, R. W., Koch, K., Harold, R., Searight, D., Massee, K. C., Tacon, A. G. J., and Jackson, A. J. (2006). Utilization of conventional protein sources in practical fish feeds. Journal of Food Science, 2(4): 45 - 56.

Ukwe, O. I. K., Edun, O. M. and Akinrotimi, O. A. (2018). Comparative growth performance and survival of African catfish (Clarias gariepinus) fed with artemia and acartia live feeds. Journal of Aquatic Science and Marine Biology, 1(3):.24 – 28.



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