UNIVERSITY OF ILORIN

THE THREE HUNDRED AND SIXTH (306TH)
INAUGURAL LECTURE

"GREEN FEEDS, HEALTHY FISH: ENHANCING AQUACULTURE PRODUCTIVITY"

By

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My Lord Spiritual and Temporal,
Royal Fathers of the Day,
Members of my Family, Nuclear, Extended, and In-laws,
Distinguished Guests of Honour,
Gentlemen of the Print and Electronic Media,
Great Students of the University of Ilorin, in particular, Students of the Faculty of Agriculture and Department of Aquaculture and Fisheries,
Distinguished Ladies and Gentlemen.

Preamble

I am deeply grateful to Almighty Allah, the Knower of the unseen, the Lord of might, and the Hearer of all plights, for His boundless mercy in guiding me through the challenges of life. Despite financial constraints, He illuminated my path through the kindness of various people at different stages of my journey. Today, I stand before you as Professor Wasiu Jimoh, a scholar in Aquaculture Nutrition and Fish Product Development, reflecting on the journey that has shaped me. My academic pursuit began at Oro Muslim Community School, where I studied under the tutelage of my maternal grandmother. I then proceeded to Ansarul Islam Grammar School, Ijomu Oro,

graduating as the best student of the 1992 set. In the same year, I gained admission to the Federal University of Technology, Akure (FUTA) to study Fisheries and Wildlife. However, my initial dream was to study Medicine and Surgery at the University of Ilorin. My preliminary Quranic schooling began with Late Alh. AbdulRaheem Kuranga and was completed after gaining admission (100 L) at FUTA and the Islamic awareness by Ustaz Usman Abdulraheem (Bushrah, Oro) and the then Mallam but now Prof. Abdulganiy Okanla Ahmad (UNIABUJA) via Organisation of Muslim Unity Platform.

Mr. Vice-Chancellor, the milestones of my educational journey were not without trials. I aspired to study Medicine and made three attempts at admission to the University of Ilorin, but it was not to be. My mother, a pillar of strength and my sole breadwinner, advised me to continue with Fisheries and Wildlife, assuring me that Allah would bless it. Tragically, she passed away in 1995, the same year she gave me that counsel. At the time, I had little knowledge of the prospects in my chosen field until Allah guided me to seek advice from a 500-level student, Bro Shehu Akintola (now Professor Shehu Akintola of Lagos State University), who provided the much-needed guidance.

Financial difficulties almost derailed my studies in 400 level after the demise of my mother, but divine intervention came through the generosity of a sister, who offset my 400-level school fees. Little did I know that my mother's advice was preparing me for a path I had yet to understand. With the support of my uncles, cousins, and the Muslim Students' Society of Nigeria (MSSN) at FUTA, I completed my B. Agric. Tech in Fisheries and Wildlife. After the National Youth Service, my cousin promised to support my postgraduate studies abroad, but advised me to first pursue an M.Sc. in Nigeria. He asked me to choose among the University of Ilorin, University of Lagos, and FUTA, and I opted for FUTA. A major turning point in my career came when my undergraduate project, under the supervision of the then Dr. Eunice Adeparusi (now Professor Eunice Adeparusi), had to be converted into a research manuscript by me before she signed off on my thesis, which later resulted in my first publication in 2002 in Taylor & Francis' *Journal of Applied Aquaculture* (Adeparusi & **Jimoh**, 2002), an

achievement that seemed Herculean at the time laid the foundation for my research career. That same year, 2002, I met my beloved wife, Haolat Bint Idris Shekoni, and we got married, trusting in Allah's providence, even though there was no stable job, even as I was pursuing the M.Sc. programme. Prof. O.A. Fagbenro, my M.Sc. and Ph.D. supervisor, played a crucial role in my academic journey, providing both financial and moral support. He sponsored me for nine months after marriage, enabling me to complete my M.Sc., by employing me as a research assistant. I need to mention here that the M.Sc. Project was also published in a reputable conference proceeding (Fagbenro, Adeparusi & **Jimoh**, 2004) presented at the Sixth International Symposium on Tilapia in Aquaculture (ISTA 6), Manila. Philippines, and later published in Taylor & Francis' Journal of Applied Aquaculture ((Fagbenro, Adeparusi & **Jimoh**, 2007)

I began my Ph.D. in 2007. Whenever I expressed fear about completing my Ph.D. to my supervisor, Prof Fagbenro, he would always say: "***Do not nurture fear; when you get to the bridge, you will cross it***." Alas, during this period, I secured employment as a Lecturer II at Crescent University, Abeokuta where I worked from 2007 to 2011. The institution required a Ph.D. for career progression, which motivated me to push forward. In 2011, I was fortunate to secure a federal appointment at the Federal College of Animal Health and Production Technology, Ibadan, under the headship of Dr. Moshood Ademola Raji. That same year, my mentor, Prof. Fagbenro, gifted me a Volvo S90; a gesture that symbolised his unwavering support. However, 2011 also brought a painful loss, as my beloved wife, Haolat, passed away while giving birth to our son, Abdullahi. Mr. Vice-Chancellor, we had struggled together, hoping for a better future, but Allah in His wisdom called her home. She was a great woman; resilient, loving, and immensely supportive. Despite this heartbreaking loss, I remained committed to my academic pursuit. In 2012, I completed my Ph.D. in Aquaculture and Fisheries by Allah's grace, and in 2013, I remarried to Busari Kafayat Olanike, a Registered Nurse (now B.NSc.). She has been another divine gift, providing strength and unwavering support as we raised our children

together and built a strong family support system. In 2018, I joined the University of Ilorin as a Senior Lecturer through a transfer of service. I was promoted to a Reader in 2020 and, in 2023, further elevated to a Professor. Indeed, Allah has placed remarkable individuals in my life at every stage to help me attain this height, and to them all, I am deeply grateful.

The title of my inaugural lecture today, "**Green Feeds, Healthy Fish: Enhancing Aquaculture Productivity**," was carefully chosen to reflect my research journey, spanning from 1999 to the present day. Vice-Chancellor, Sir, it is with profound gratitude to Almighty God, deep humility, and an abiding sense of honour and privilege that I stand before this distinguished audience to deliver the 306th Inaugural Lecture of our great University. Today's lecture represents a defining moment in the history of the Department of Aquaculture and Fisheries and marks an important milestone in the academic journey of the Faculty of Agriculture. It is the 23rd delivered in the Faculty of Agriculture and the first to emanate from the Department of Aquaculture and Fisheries since its establishment in 2014. Furthermore, it is the first in the specialised fields of Aquaculture, Fish Nutrition, and Fish Product Development, and the first to be delivered by a serving Head of the Department of Aquaculture and Fisheries.

These historic milestones are not merely numerical achievements; they are enduring testimonies to the steady growth, resilience, and maturation of the Department. They reflect our unwavering commitment to excellence in teaching, cutting-edge research, innovation, and community service, while reaffirming the Department's strategic role in advancing sustainable aquaculture, food and nutritional security, environmental stewardship, and the blue economy in Nigeria and beyond. I am deeply grateful for the opportunity to contribute this modest chapter to the rich intellectual tradition of our great *Better-by-Far* University, and I consider it both a personal privilege and a collective achievement shared with my mentors, colleagues, students, and all those who have contributed to the growth and development of the Department over the years.

The title encapsulates my lifelong dedication to research. The need for eco-friendly, cost-effective, and nutritionally

balanced aquafeeds has never been greater. By integrating phytogenic substances and plant protein sources, we can revolutionise the sustainability of aquaculture, improve fish health, and enhance productivity. The Vice-Chancellor Sir, distinguished colleagues, esteemed guests, and beloved students, I welcome you all to this discourse on a future where aquafeeds are greener, healthier, and more sustainable.

Introduction

Fish have been a cornerstone of human civilisation for millennia, contributing profoundly to the survival, growth, and development of societies worldwide (Atlas *et* al., 2021). As one of the oldest and most reliable sources of nutrition, fish have supported humanity through times of abundance and scarcity, offering sustenance, economic stability, and a deep cultural connection to water bodies. Over time, its role has evolved, becoming increasingly integral to global food systems, economic frameworks, and cultural identities (Hara *et al*., 2021). Today, fish occupy a unique and irreplaceable position in the global landscape, influencing dietary patterns, shaping economic activities, and fostering traditions that are deeply rooted in historical and ecological contexts (Naya*k et* al., 2022; Oboh, 2022). Fish are not merely food sources but a lifeline that sustains billions of people worldwide. From the bustling fish markets of Asia to the artisanal fisheries of Africa, fish form the bedrock of diets, livelihoods, and communities (Cwiertka & Miho, 2020; Obier*o et al*., 2023). It is one of the most nutrient-dense and accessible protein sources, providing high-quality amino acids, omega-3 fatty acids, and essential vitamins and minerals.

For billions, fish are not just a meal but a necessity, especially in regions where alternative protein sources are scarce or economically unviable. In developing nations, where malnutrition and micronutrient deficiencies remain pressing issues, fish is a critical tool for combating these challenges and improving public health (Dongyu, 2024; Folorunso *et al*., 2021). Beyond its nutritional value, fish's economic contributions are monumental. The sector underpins rural and coastal economies, creating opportunities for income generation and community

development. For nations with abundant aquatic resources, fish contribute significantly to the Gross Domestic Product (GDP) and export earnings. In countries like Nigeria, the fisheries sector is both a critical food source and a driver of employment, particularly in rural areas, where fishing activities form the backbone of local economies (Folorunso *et al*., 2021).

The cultural significance of fish cannot be overstated. Across continents, fish have become symbols of tradition, identity and resilience. Coastal communities have long relied on fishing practices passed down through generations, not merely as a means of sustenance, but as a way of life (Santafe-Troncoso & Loring, 2021). In Japan, fish occupies a central position in the national culture, with dishes such as sushi and sashimi representing both culinary art and national pride. Similarly, Indigenous peoples of the Pacific Northwest Coast regard salmon as a cultural and spiritual emblem, intertwining its life cycle with traditions of sustainability and environmental respect (Cwiertka & Miho, 2020). In West Africa, fish is deeply woven into our cuisines, social interactions and cultural practices, embodying a rich history of shared meals, traditions and community relationships (Okech & Timothy, 2023).

Beyond its cultural significance, fish occupies a pivotal position in global food and nutrition security. With the world's population projected to reach 9.7 billion by 2050, ensuring access to sustainable and nutritious food sources will remain a pressing global challenge. Fish provides more than 3.4 billion people with at least 20% of their animal protein intake, making it an indispensable component of the global food system (Tacon *et al*., 2025). In my perspective, this places fisheries and aquaculture at the heart of the global conversation on how humanity will feed itself in the coming decades. The question, therefore, should no longer be simply whether we can produce more fish, but whether we can produce sufficient fish sustainably, make it accessible to those who need it most, and ensure that its benefits are equitably distributed across populations. This is particularly important in developing countries where fish contributes substantially to household food security and livelihoods. For Africa, and particularly for Nigeria, I believe that the development of fisheries and aquaculture

should be viewed not merely as an agricultural activity but as a strategic component of national development. Fish provides protein and essential nutrients, creates employment along an extensive value chain, generates income for millions of people and contributes to the livelihoods of fishing, farming, processing, transportation and marketing communities. The sector therefore possesses the capacity to address several challenges simultaneously: food insecurity, unemployment, poverty and rural economic stagnation.

However, our approach to fish production must evolve with the challenges of our time. Population growth, climate variability, environmental degradation, rising production costs and increasing competition for natural resources are placing unprecedented pressure on conventional fisheries and aquaculture systems. In my view, the response cannot be to pursue production at all costs. The future of fish production must be anchored in sustainability-producing more from available resources while protecting the ecological systems upon which aquatic production ultimately depends. This calls for greater integration of scientific knowledge, technological innovation, responsible resource management and the indigenous knowledge accumulated by fishing and farming communities over generations. The health benefits of fish further reinforce its importance in human diets. Scientific evidence highlights the role of fish consumption in reducing the risk of cardiovascular disease, supporting fetal and infant development and promoting brain health (Khalid *et al*., 2022). Omega-3 fatty acids, which are abundant in many fish species, are essential for cognitive function and possess anti-inflammatory properties that support overall well-being (Singh *et al*., 2025). For pregnant women and young children, fish is particularly important because of its contribution to brain development and maternal and child nutrition.

Economic Foundation and Livelihoods

Mr. Vice-Chancellor, Fisheries and Aquaculture are vital pillars of the global economy, providing employment and livelihoods for millions of people. Fisheries and Aquaculture industries directly employ over 60 million people, many of

whom reside in rural, coastal, and small-scale fishing communities (Nius *et al*., 2024). Beyond direct employment, the ripple effects extend through an intricate value chain encompassing harvesting, processing, distribution, marketing, and sales. Collectively, Fisheries and Aquaculture sustain the livelihoods of nearly 600 million people worldwide, reinforcing their indispensable role in local and global economies (Dongyu, 2024). For millions, particularly in low- and middle-income countries, fish is more than just a food source; it is a means of economic stability. In Nigeria, aquaculture has emerged as a transformative force, creating employment, reducing poverty, and stimulating local economies. The rapid expansion of fish farming has significantly reduced the country's dependence on fish imports while meeting the growing domestic demand for protein. This shift not only enhances food security, but also fosters economic resilience in fishing communities, where alternative livelihood opportunities are limited.

The economic significance of fisheries is further underscored by the diverse and dynamic value chain associated with fish production and trade (Ababouch *et al*., 2023). Beyond primary fishing activities, supporting industries such as feed production, transportation, processing, and retailing generate employment across multiple skill levels. Each link in this chain contributes to economic activity, strengthens local and international markets, and drives regional development. This interconnected network ensures that fisheries remain a vibrant and essential component of global commerce. However, these economic benefits are increasingly threatened by environmental and sustainability challenges. Overfishing, habitat destruction, pollution, and climate change have placed immense pressure on aquatic ecosystems, leading to declining fish stocks and biodiversity loss (Ogidi & Akpan, 2022). Economic incentives and growing global demand have further exacerbated unsustainable fishing practices, jeopardising both ecological balance and the livelihoods of those who depend on fish for survival (Gul *et al*., 2024). Small-scale fishers, in particular, remain vulnerable due to their reliance on natural fish stocks and limited capacity to adapt to changing environmental and economic conditions.

Aquaculture: My Research Pathway to its Sustainability

To address these challenges, aquaculture has emerged as a viable solution for meeting rising global fish demand while alleviating pressure on wild fish populations (Mohd & Mushtaq, 2025). By providing a controlled, predictable supply of fish, aquaculture reduces dependence on overexploited marine resources and ensures a stable source of protein for growing populations (Boyd *et al.,* 2022). Advances in feed development, water management, and disease control have significantly improved the aquaculture sector's efficiency and sustainability (Aly & Fathi, 2024). In Nigeria, aquaculture is playing a pivotal role in food security and economic diversification. The farming of species such as catfish and tilapia has gained traction due to their adaptability, fast growth, and high market demand (Akpalu & Nnaemeka, 2025). Sustainable fish farming practices are now at the forefront of ensuring long-term productivity while minimising ecological footprints. Fish farming is among the most resource-efficient forms of animal protein production. Compared to terrestrial livestock, fish require substantially less feed, water, and land, making aquaculture a resource-efficient alternative for protein production (Ali *et al*., 2022; Verdege*m et al*., 2023). Moreover, integrated systems such as polyculture and nutrient recycling further enhance sustainability by optimising resource use and minimising waste (Campanat*i et al*., 2022).

Moreover, by reducing reliance on wild fish-derived feed ingredients, these innovations align with eco-friendly practices that help preserve freshwater and marine ecosystems. Our team has also expanded research into the utilisation of agro-industrial by-products as supplementary feed ingredients **(Jimoh** *et al*., 2019a; **Jim**oh & Aroyehun, 2011; **Jimoh** *et al*., 2022a; **Jimoh** *et al*., 2021b; **Jimoh** *et al*., 2011b). These efforts contribute to a circular economy in aquaculture by minimising waste and maximising resource efficiency. Beyond nutrition, effective health management in aquaculture is crucial to reducing the industry's reliance on antibiotics and synthetic chemicals. My research has explored natural and sustainable health interventions, including medicinal plants with antimicrobial and immunostimulatory properties. Studies on exotic and indigenous plant-based additives have shown promising results in enhancing

fish immune response and disease resistance **(Jimoh** *et al*., 2023; **Jimoh** *et al*., 2022d; **Jimoh** *et al*., 2024, **Jimoh** *et al*., 2025, **Jimoh** *et al*., 2026a; **Jimoh** *et al*., 2026b; **Jimoh** *et al*., 2026c). This approach significantly reduces chemical runoff, mitigating environmental contamination while promoting healthier fish production systems.

By pioneering research-driven innovations, we contribute to the long-term viability of aquaculture as a solution to global food security challenges.

Thus, my research has progressively moved from asking "**What can fish eat**?" to a broader question:

"How can we produce healthy fish using feeds that are affordable, environmentally responsible, and sustainable?"

Our research points to a clear path forward: green feeds, functional nutrition, resource recycling, and science-driven health management.

This provides the foundation for the research journey I shall share with you in this inaugural lecture.

Exploration of Underutilised Legumes in Aquafeed

Mr. Vice-Chancellor, it is important to distinguish between feed intake and feed digestibility. While feed intake refers to the quantity of feed consumed by the fish, digestibility represents the proportion of ingested nutrients that are effectively broken down, absorbed through the intestinal villi into the bloodstream, and subsequently utilised for growth, maintenance, and other metabolic functions. Thus, a fish may consume large quantities of feed, but if the nutrients have poor digestibility coefficient, the nutritional benefits remain limited. Protein is an essential macronutrient in the fish diet, a source of nitrogen and essential amino acids, but the biological utilisation of dietary protein depends on its digestibility and the absorption of amino acids and peptides in the gastrointestinal tract. It is important to recognise that the digestibility of dietary proteins depends largely on their source. Animal-derived proteins, such as fish meal, meat meal, dairy products, and other animal protein sources, are generally highly digestible because they possess balanced amino acid profiles and are readily hydrolysed by

digestive enzymes and absorbed into the bloodstream for metabolism.

In contrast, plant-derived proteins often contain anti-nutritional factors such as tannins, phytates, trypsin inhibitors, lectins, and non-starch polysaccharides, as well as complex structural components that can limit nutrient availability and reduce digestibility (Ajomiwe *et al*., 2024). Consequently, the nutritional value of plant protein ingredients is greatly influenced by processing methods. Appropriate cooking, heating, fermentation, extrusion, autoclaving, or toasting can inactivate anti-nutritional factors, improve protein availability, and enhance nutrient digestibility, whereas excessive processing may denature proteins or trigger Maillard reactions that reduce amino acid availability (Qi *et al*., 2025).

In one of our pioneering studies, Adeparusi and **Jimoh** (2002) evaluated the apparent nutrient digestibility of Nile tilapia (*Oreochromis niloticus*) fed diets containing raw or processed lima bean (*Phaseolus lunatus* L.), a novel underutilised legume, subjected to heating at 204°C for 5, 10, or 15 minutes. The study employed acid-insoluble ash (AIA), a naturally occurring endogenous marker, to estimate the apparent digestibility coefficients of nutrients by comparing its concentration in the diets and faeces. The results demonstrated that diets containing lima beans heated for 10 minutes produced the highest apparent digestibility coefficients for crude protein, lipid, and gross energy, whereas heating for 15 minutes resulted in the greatest digestibility of crude fibre. What this means is that how long we heat lima beans matters. Ten minutes of heating made most of the important nutrients more available to the fish.

These findings demonstrated that the nutritional value of plant-based feed ingredients depended not only on their chemical composition but also on the processing method and duration employed. Appropriate thermal processing effectively reduced anti-nutritional factors, improved nutrient availability, and enhanced digestive efficiency, thereby enabling fish to extract more usable nutrients from the same quantity of feed. Conversely, over-processing may reduce nutrient quality through heat-induced damage, underscoring the need to optimise

processing conditions to maximise nutrient utilisation and sustainable aquaculture productivity.

Another underutilised legume investigated is jackbean (*Canavalia ensiformis*). In our studies, Fagbenro, Adeparusi and **Jimoh** (2004, 2007), detoxified jackbean seeds using eight distinct wet thermal methods, utilising either distilled water (5% w/v) or a trona solution ($Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$). Dried, detoxified jackbean seed meals were incorporated into practical diets to provide 20% or 30% of total protein and fed to Nile tilapia (*Oreochromis niloticus*) fingerlings. Mortality remained low, and no abnormal fish behaviour was observed, even at the 30% protein inclusion level. Growth and feed utilisation indices did not differ significantly ($p > 0.05$) between diets containing jackbean seeds cooked in water at 20% protein and those with cracked jackbean seeds cooked in trona solution at 20% or 30% protein.

Similarly, **Jimoh** *et al*. (2010) assessed the digestibility of nutrients in feeds containing cracked and cooked jackbean. There was no significant difference ($p > 0.05$) in lipid and organic matter digestibility between fish fed the control diet and those fed test diets. The absence of significant differences in growth performance, feed utilisation, and the digestibility of lipid and organic matter between fish fed processed jackbean-based diets and those fed the control diet demonstrated that appropriately processed jackbean could serve as an effective alternative plant protein ingredient in aquafeeds.

Mr. Vice-Chancellor, **Jimoh** *et al*. (2013a) investigated the use of another underutilised legume, *Luffa cylindrica* seed meal, as a partial replacement for soybean meal in the diets of African catfish (*Clarias gariepinus*) fingerlings. Diets were formulated with *Luffa cylindrica* replacing soybean meal at 15, 30, 45, and 60% inclusion levels. Results indicated that fish fed diets with up to 15% *Luffa cylindrica* achieved growth performance and nutrient utilisation comparable to the control group. Higher inclusion levels, however, resulted in reduced growth and feed efficiency, likely due to anti-nutritional factors and increased dietary fibre. The study concluded that a 15% inclusion level was optimal, providing a cost-effective and sustainable alternative to soybean meal without compromising

fish growth. This research highlighted the potential of underutilised plant resources in developing eco-friendly aquafeeds, supporting global sustainability objectives.

In a subsequent study **Jimoh** *et al*. (2019c), evaluated the growth and economic performance of *Clarias gariepinus* fed diets containing dry-heat-treated *Luffa cylindrica* seed meal as a partial replacer of soybean meal. The findings demonstrated that both processing time and inclusion level significantly ($p < 0.05$) influenced fish growth and feed utilisation. At a 15% inclusion level with 10 minutes of heat treatment (D1015T), growth performance was comparable to the control, indicating its cost-effectiveness. Economic analysis revealed reduced feed costs across test diets, with all treatments achieving a benefit-cost ratio above 1, confirming profitability. The D1015T diet was identified as the most favourable, balancing optimal growth and economic returns. **Jimoh** *et al*. (2019c) concluded that properly processed *Luffa cylindrica* seedmeal is a viable substitute for soybean meal in catfish diets, offering a sustainable solution to reduce feed costs. This study underscored the importance of exploring non-conventional feed resources to enhance economic and environmental sustainability in aquaculture.

Mr. Vice-Chancellor, research on the utilisation of watermelon seed meal (*Citrullus lanatus*) as a substitute for soybean meal in aquaculture has yielded promising results. **Jimoh** *et al*. (2018) and **Jimoh** *et al*. (2022c) evaluated its effects on the growth, feed utilisation, body composition, haematological profile, and economic viability in Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*) respectively. The findings demonstrate that watermelon seed meal can replace soybean meal up to 30% in fish diets without compromising growth or feed efficiency. Higher inclusion levels, however, showed diminished growth performance plausibly owing to anti-nutritional factors, which require processing optimisation.

Previous investigations by **Jimoh** *et al*. (2015b) assessed histological changes in the liver of *Oreochromis niloticus* fed diets containing watermelon seed meal. The study revealed that dietary inclusion up to 30% did not cause significant histopathological damage; however, higher replacement levels

resulted in noticeable hepatic vacuolation, indicating potential metabolic stress. Moreover, **Jimoh** *et al*. (2015a) reported that haematological analysis revealed no adverse effects on fish health, with some diets enhancing immunity-related parameters like white blood cell counts. Economic analysis underscored the cost-saving potential of watermelon seed meal, reducing feed production costs while maintaining profitability **(Jimoh** *et al*., 2015c) and digestibility **(Jimoh** *et al*., 2015e). This research affirmed that watermelon seed meal is a viable, sustainable alternative to conventional protein sources in aquaculture feeds. It contributed to reducing reliance on soybean meal, which faces high demand and cost, while promoting the use of underutilised agricultural by-products in enhancing food security and sustainable aquaculture practices.

Vice-Chancellor Sir, the potential of sunflower (*Helianthus annuus*) seed meal as a sustainable protein source in aquafeeds was also explored. Previous studies Fagbenro, Adeparusi and **Jimoh** (2010a) analysed raw, cooked, and toasted sunflower seed meals for their proximate, mineral, and anti-nutrient compositions. Findings indicated that raw sunflower seed meal contained the highest levels of anti-nutrients, including trypsin inhibitors (TIA), lectins, tannins, phytic acid, saponins, and oxalates. Cooking and toasting significantly reduced these anti-nutritional factors, improving nutrient availability. Building on this, Fagbenro, Adeparusi and **Jimoh (**2013a,b) evaluated the impact of processed sunflower seed meal on the growth performance, nutrient digestibility, and blood profile of *Clarias gariepinus*. The results demonstrated that fish fed sunflower meal-based diets exhibited superior haematological profiles compared to those fed soybean-based diets, although Fagbenro, Adeparusi and **Jimoh** (2010b) reported significant variations were observed in protein, energy, and lipid digestibility. Recent studies by **Jimoh** (2020a) further examined the effects of dietary replacement of soybean meal with toasted sunflower meal in African catfish. A 56-day feeding trial investigated growth performance, body composition, digestibility, haematology, and liver histology. Sunflower meal was toasted at 204°C for 5, 10, and 15 minutes, replacing soybean meal at levels of 15, 30, and 45%. The findings revealed

that up to a 30% replacement level yielded growth performance, nutrient digestibility, and haematological parameters that were not statistically different ($p > 0.05$) from those of fish fed soybean-based control diets. Similarly, research on cooked sunflower seed meal replacement by **Jimoh** (2020b) confirmed that cooking sunflower seeds for 10–20 minutes enabled up to 30% substitution for soybean meal without compromising fish growth, nutrient utilisation, or health indices. However, higher replacement levels (45%) resulted in reduced growth performance and hepatic abnormalities, including fatty infiltration and diffuse vacuolar degeneration of hepatocytes, indicating potential adverse effects at excessive inclusion levels probably owing to higher content of antinutrients in them.

Mr. Vice-Chancellor, the potential of sesame (*Sesamum indicum)* seed meal as a viable alternative protein source in aquafeeds was investigated by our team. **Jimoh** *et al*. (2014a) evaluated the response of African catfish (*Clarias gariepinus*) to differently timed wet-heat-treated sesame seed meal using growth performance, nutrient utilisation, and apparent digestibility coefficient as key indices. The results demonstrated good growth performance, nutrient utilisation, and digestibility, with no significant differences ($p > 0.05$) in those indices relative to the fish fed the control diet. Earlier studies by **Jimoh** *et al*. (2011a) examined the chemical profile of raw, cooked, and toasted sesame seed meals, assessing their proximate composition, mineral content, and anti-nutrient levels. A significant reduction ($p < 0.05$) in mineral composition was observed with increased processing time, while raw sesame seed meal contained the highest levels of anti-nutrients. Cooking and toasting effectively reduced anti-nutrient content, with complete removal of trypsin inhibitor activity (TIA) and lectins at higher processing times. Notably, lectin content was eliminated after 30 minutes of toasting. This indicated that proper heat treatment can enhance the nutritional quality of sesame seed meal for aquafeed applications.

Jimoh (2022) further examined the impact of toasted sesame seed meal as a partial replacement for soybean meal in African catfish diets. Over a 56-day feeding trial, growth performance, body composition, digestibility, haematology, and

liver histology were evaluated. The study found that replacing up to 30% of soybean meal with toasted sesame seed meal did not result in significant differences ($p > 0.05$) in growth parameters or feed conversion efficiency compared with fish fed a soybean-based control diet. Additionally, liver histology of fish fed sesame-toasted meal for 10 minutes showed no visible lesions, suggesting the safety and nutritional viability of sesame meal as an alternative protein source. Additional research by **Jimoh** *et al*. (2022e) evaluated the effects of cooked sesame meal on the haematology, liver, and kidney histology of African catfish fingerlings. The study used three batches of sesame seeds cooked for 10, 20, and 30 minutes and incorporated them into diets at inclusion levels of 15, 30, and 45%. The results indicated that replacing soybean meal with cooked sesame meal did not negatively affect haematological parameters at lower inclusion levels (15% and 30% for 10-minute cooked sesame, and 15% for 20- and 30-minute cooked sesame). However, higher inclusion levels led to reductions in haemoglobin content and red blood cell count.

Vice-Chancellor, Sir, the rising costs and limited availability of conventional protein sources, such as soybean meal, have necessitated the search for alternative plant-based protein ingredients for aquaculture. **Jimoh** *et al*. (2020a) and **(**2022b) explored the potential of *Jatropha curcas* seed meal as a viable protein source for fish diets, focusing on its digestibility, growth, economic performance, haematological impact, and histological implications. Incorporating *Jatropha curcas* seed meal into aquafeeds aligns with circular economy principles, reducing feed costs while minimising agricultural waste. By optimising its processing and inclusion levels, *Jatropha curcas* can contribute to a more sustainable and cost-effective aquaculture industry. **Jimoh** *et al*. (2020d) on *Jatropha curcas* seed meal in *Oreochromis niloticus* revealed that up to 40% of soybean meal could be replaced with 5-minute toasted *Jatropha curcas* without significant reductions in apparent protein digestibility and lipid digestibility. However, increasing the replacement level and processing time to 10 minutes led to reduced digestibility coefficients, suggesting that optimisation of

processing methods is essential for improving its utilisation in fish diets.

A 56-day feeding trial with *Oreochromis niloticus* by **Jimoh** *et al*. (2020e) showed that fish fed diets containing 5-minute toasted Jatropha curcas at 20% and 40% replacement levels exhibited comparable growth performance and economic returns to those on soybean-based control diets. However, diets with higher inclusion levels resulted in reduced growth rates and feed conversion efficiency, plausibly owing to the excessive amount of anti-metabolites in *Jatropha curcas* seed. Similar trends were observed by **Jimoh** *et al*. (2016a) in *Clarias gariepinus*, where cooked *Jatropha curcas* inclusion led to progressive reductions in growth parameters at higher inclusion levels. **Jimoh** *et al*. (2016b) also examined the impact of *Jatropha curcas* on fish blood parameters and organ health. Haematological analysis of *Clarias gariepinus* indicated no significant differences in most blood parameters between the control diet and diets containing up to 25% *Jatropha curcas* seed meal. However, higher inclusion levels led to slight variations in white blood cell counts, suggesting potential immune responses. Histological examinations of the liver and kidney of *Clarias gariepinus* fed *Jatropha curcas*-based diets revealed mild vacuolation in hepatocytes, but no significant tissue damage at lower inclusion levels. The presence of melanomacrophage centres as reported by **Jimoh** *et al*. (2020b) in the liver suggested that fish can tolerate moderate levels of *Jatropha curcas* without severe pathological effects. While *Jatropha curcas* has promising potential as an alternative protein source, its anti-nutritional factors, particularly phorbol esters, remain a challenge. Future research could focus on detoxification strategies such as fermentation and enzymatic treatments to enhance its safety and nutritional quality.

Mr. Vice-Chancellor, the collective findings from these studies demonstrated that the nutritional potential of underutilised feed ingredients depends not simply on their chemical composition, but on processing method, processing duration, inclusion level, nutrient digestibility, fish health and economic value. These studies provided a basis for reducing dependence on expensive fishmeal and soybean meal, lowering

feed production costs, improving resource utilisation and converting underutilised agricultural resources into valuable inputs for aquafeed production. In this way, the work contributed to the development of a more affordable, sustainable and circular aquaculture industry, particularly within the Nigerian context.

Gut Microflora and Aquaculture Health

Vice-Chancellor, Sir, the role of gut microflora in aquaculture nutrition and fish health is a growing area of research. Our investigations have, therefore, focused on the microbial load and diversity in the gastrointestinal tract of key aquaculture species, including Nile tilapia (*Oreochromis niloticus*) and hybrid catfish (*Clarias gariepinus* ♀ × *Heterobranchus bidorsalis* ♂) to understand the microbial interaction of fish digestion and health. Studies conducted by **Jimoh** *et al*. (2019d) in Ilorin and by **Jimoh** *et al*., 2013b; **Jimoh** *et al*., 2014b) in Ibadan revealed significant microbial diversity existed along different sections of the gastrointestinal tract, with the hindgut consistently harbouring the highest bacterial and fungal load. The gut microbiota play a crucial role in digestion, nutrient absorption, and immune function. Beneficial bacteria such as *Bacillus subtilis*, *Lactobacillus brevis*, and *Enterobacter aerogenes* play a crucial role in enzyme production, facilitating the breakdown of complex polysaccharides, proteins, and lipids, thereby enhancing digestion and nutrient absorption in fish (Ray *et al*., 2012; Ray *et al*., 2010). Additionally, *Saccharomyces cerevisiae*, a yeast species commonly found in the fish gut, has been identified as a natural probiotic that stimulates enzymatic activity (Waché *et* al., 2006), strengthens immune responses, and promotes overall gut health. **Jimoh** *et al*. (2019b) and **Jimoh** *et al*. (2019d) have further demonstrated that dietary modifications significantly influence gut microflora composition.

Harnessing the Prebiotic and Physiological Impacts of Leaf Meals in Aquafeeds

Vice-Chancellor, Sir, the inclusion of high-fibre leaf meals in fish diets is known to enhance gut microbiota activity, producing Short-Chain Fatty Acids (SCFAs) such as butyrate, acetate, and propionate, which serve as precursors for probiotic growth. These SCFAs contribute positively to intestinal health,

modulate immune response, and improve feed efficiency. **Jimoh** *et al*. (2019b) explored the use of high-dietary-fibre leaf meals; Napier grass, alfalfa, water spinach, and *Gliricidia sepium*; as natural prebiotics in the diets of hybrid lemon fin barb (*Barbonymus gonionotus* ♀ × *Hypsibarbus wetmorei* ♂) in a study conducted during my postdoctoral fellowship research at the Department of Aquaculture, Fakulti Pertanian, Universiti

Putra Malaysia, under an erudite scholar of Aquaculture Nutrition, Prof. Mohd Salleh Kamarudin.

Fig. 1. Prof. M.S. Kamarudin (right): My Host at Universiti Putra Malaysia

Fig. 2. Dr. M. O. Bello's visit to me at Universiti Putra Malaysia

The study assessed growth performance, body composition, nutrient utilisation, and intestinal amylase activity over a 56-day feeding trial. The results revealed significant improvements in growth and nutrient retention in fish fed diets containing 10% leaf meals compared to a control diet. Notably, the leaf meals enhanced protein and energy retention, with Gliricidia showing the highest intestinal amylase activity, indicating improved carbohydrate metabolism. Fish fed *Ipomea aquatica* and Napier grass-based diets exhibited the best growth

performance, reinforcing the role of these ingredients in enhancing nutrient digestibility **Jimoh** *et al*. (2019b) provided a pathway for enhancing fish health and growth while promoting resource efficiency in aquaculture systems. This innovation is a promising step toward sustainable fish production.

Further research by **Jimoh** *et al*. (2020h) assessed the impact of dietary fibre sources on the length-weight relationship of the hybrid lemon fin barb. A 10% inclusion level of these four different leaf meals revealed that significant length–weight regression models were obtained across all dietary treatments ($p < 0.01$), suggesting that the models developed could be used for prediction and/or estimation. However, the predictive models developed for the different diets did not differ significantly ($F_{4,84} = 1.296$, $p > 0.05$). This means that no particular dietary treatment produced a statistically superior model, and the models could therefore be used interchangeably to predict fish weight from length. **Jimoh** *et al*. (2022f) found out that the haematological, serum biochemical and histological responses improved in fish fed leaf meal-based diets. However, the liver tissues of fish fed leaf meal-based diets showed moderate vacuolation, suggesting some metabolic adjustments to high-fibre intake.

Phytogenic Additive for Enhancing Aquaculture Productivity

The Vice-Chancellor, Sir, in pursuit of sustainable aquaculture, my research has explored the integration of phytogenic additives in fish nutrition, with a focus on fenugreek (*Trigonella foenum-graecum*) as a dietary supplement for hybrid African catfish (*Clarias gariepinus* ♀ × *Heterobranchus bidorsalis* ♂) **(Jimoh** *et al*., 2024). The results of this study provided compelling evidence that dietary fenugreek supplementation significantly enhances the growth performance, physiological resilience, and antioxidant enzyme capacity of cultured fish. In the investigation, hybrid African catfish were fed diets supplemented with graded levels of fenugreek (0, 0.5, 1.0, 1.5, and 2%) for 60 days. The findings revealed that a 1.0% inclusion of fenugreek optimally enhanced weight gain, feed conversion efficiency, and protein retention, all of which are critical factors in improving fish health and productivity. More

importantly, the inclusion of fenugreek markedly reduced hepatic stress enzymes, improved metabolic enzyme functions, and strengthened antioxidant defence mechanisms.

Similarly, in another of our studies on coriander supplementation **(Jimoh** *et al*., 2022d), hybrid African catfish were fed diets containing graded levels of coriander powder (0, 0.5, 1.0, 1.5, and 2.0 %) for 56 days. The results demonstrated that a 0.5% inclusion of coriander significantly ($p < 0.05$) improved growth rate, protein and lipid retention, and flesh yield compared to the control group. Furthermore, coriander supplementation enhanced haematological parameters, including packed cell volume, haemoglobin content, and red blood cell counts, indicating improved immune response and physiological stability. Notably, the 0.5% dietary group exhibited optimal weight gain, with second order polynomial regression optimising a 0.55% inclusion level would yield the highest growth performance. Additionally, coriander-fed fish displayed lower levels of hepatic stress markers and improved kidney function, highlighting its hepatoprotective and nephroprotective properties.

Moreover, our research on cinnamon supplementation revealed its significant impact on fish growth, health, and physiological functions **(Jimoh** *et al*., 2023). Hybrid African catfish were fed diets containing varying levels of cinnamon powder (0%, 0.5%, 1.0%, 1.5%, and 2%) for 56 days. The study found that a 1.5% inclusion of cinnamon resulted in the highest growth performance, enhanced haematological indices, and improved antioxidant enzyme activities. Additionally, cinnamon supplementation reduced total cholesterol levels, lowered blood glucose levels, and improved kidney and liver function. The cinnamon-fed fish also showed a higher abundance of beneficial gut microbiota, which supported better digestion and nutrient absorption. The intestinal, liver, and kidney histomorphology of cinnamon-fed fish, remained intact, demonstrating its protective effects on vital organs.

Furthermore, **Jimoh** *et al.* (2026a) have explored the use of locally available herbal remedies, particularly Hunteria (*Hunteria umbellata*), as dietary additives for hybrid African catfish. The findings indicated that a 0.5% inclusion of Hunteria

optimally enhances growth performance, with significant improvements in feed conversion ratio, specific growth rate, and protein efficiency ratio. Fish fed Hunteria-based diets exhibited superior blood performance, with increased red blood cell counts, haemoglobin levels, and white blood cell activity. Notably, the Hunteria dietary groups demonstrated significant reductions in stress biomarkers, hepatic stress enzymes, and cholesterol levels, further confirming its hepatoprotective and renoprotective benefits. The histological analysis revealed well-preserved liver and kidney structures, emphasising the safety and efficacy of Hunteria supplementation in aquaculture.

Two complementary studies (**Jimoh** *et al.* 2026b; **Jimoh** *et al.* 2026c) investigated the effects of dietary supplementation with *Xylopia aethiopica* (0–2.0%) on hybrid catfish fingerlings, *Clarias gariepinus* ♀ × *Heterobranchus bidorsalis* ♂, over a 56-day feeding trial. The findings consistently indicated that moderate inclusion levels (0.5-1.0%) enhanced growth, fish health, and profitability, whereas excessive supplementation (2%) induced adverse effects, perhaps due to higher contents of phytochemicals in the feed. Growth performance peaked at lower inclusion levels, with 0.5% *Xylopia aethiopica* producing the highest weight gain, feed efficiency, and specific growth rate. Conversely, 1.0% *Xylopia aethiopica* led to greater increases in length. Polynomial contrast revealed a quadratic response of weight gain to the increasing dietary inclusion levels. Consequently, second-order polynomial regression was used to estimate the optimum inclusion level, and the analysis indicated that an inclusion level of approximately 0.7% would maximise weight gain. Supplementation at 2.0% significantly reduced growth, likely attributable to antinutritional compounds. Moderate *Xylopia aethiopica* supplementation improved haematological indices, reduced stress markers such as cortisol and glucose, and enhanced protein metabolism, indicating better health status and adaptability. Histological analysis revealed minimal tissue alterations at 0.5–1.0% supplementation, whereas higher levels caused hepatic and renal damage, oxidative stress, and electrolyte imbalance. Economically, 0.5% XE yielded the highest profitability, gross margin, and return on investment, making it the most cost-effective level, despite 1.0% *Xylopia*

aethiopica yielding only slightly greater length growth. In summary, dietary inclusion of *Xylopia aethiopica* between 0.5% and 1.0% benefits hybrid catfish production. About 0.7% is optimal for growth. Meanwhile, 0.5% offers the greatest economic benefit.

Earlier studies by **Jimoh** *et al*. (2025) examined the dietary effects of *Xylopia aethiopica* supplementation on gut health in hybrid African catfish (*Clarias gariepinus* ♀ × *Heterobranchus bidorsalis* ♂). Five isonitrogenous diets containing graded levels of *X. aethiopica* (0, 0.5, 1.0, 1.5, and 2.0%) were administered to assess changes in gut microbiota composition, digestive enzyme activities, and intestinal histology, to identify the optimal inclusion level for gut function. Supplementation with *X. aethiopica* significantly reduced the abundance of pathogenic bacteria, notably *Salmonella* spp., *Staphylococcus aureus*, and *Escherichia coli*, with the greatest reduction observed at a 1% inclusion rate. Microbial diversity increased at moderate supplementation (1.0%) but decreased at higher levels. Activities of digestive enzymes, including protease, amylase, and lipase, were significantly higher in fish receiving 1.0% and 1.5% supplementation, indicating improved digestive efficiency. Histological analysis revealed that supplementation with 1% preserved normal intestinal architecture, whereas higher inclusion levels (≥1.5%) induced mild mucosal erosion and inflammatory changes. These findings indicated that *X. aethiopica* supplementation, particularly at 1.0%, optimally supported a healthy gut microbiota, enhanced digestive enzyme activity, and maintained intestinal integrity in hybrid African catfish. These results highlight the potential of *X. aethiopica* as a natural feed additive in aquaculture nutrition, providing an alternative to synthetic growth promoters and antibiotics. Appropriate inclusion can improve feed utilisation, enhance growth performance, reduce disease risk, and promote more sustainable and productive aquaculture systems.

Microalgae as Fishmeal Replacer in Aquafeeds

Vice-Chancellor, Sir, Raji, **Jimoh**…Razak (2020**)** explored the potential of microalgae, particularly *Spirulina platensis* and *Chlorella vulgaris*, as alternative protein sources to

fishmeal in aquafeeds. In a 42-day feeding trial with African catfish, growth performance and apparent digestibility coefficients (ADCs) for fatty acids, amino acids, and macronutrients in fishmeal-based, Spirulina-, and Chlorella-based diets were assessed. The results revealed that Spirulina exhibited higher ADC of crude protein compared to Chlorella, while both diets showed superior ADC for all essential amino acids (EAA) compared to the control fishmeal diet. The Chlorella-based diet demonstrated significantly higher ADC values for histidine, arginine, valine, isoleucine, and tryptophan, making it a valuable alternative protein source. Additionally, Chlorella was found to have the highest digestibility of n-6 and n-3 polyunsaturated fatty acids (PUFAs), as well as lipids, contributing to better fatty acid profiles in fish. On the other hand, the Spirulina diet exhibited significantly higher digestibility of lysine, crude fibre, energy, dry matter, carbohydrate, and docosahexaenoic acid (DHA), reinforcing its role in enhancing nutrient absorption and metabolism **(**Raji, **Jimoh**…Razak, 2020**)**. Growth performance assessments revealed that fish fed Spirulina- and Chlorella-based diets exhibited similar or superior growth rates compared to those on fishmeal-based diets. Spirulina-fed fish demonstrated better feed conversion ratios, weight gain, and specific growth rates than the control group, while Chlorella-fed fish exhibited the highest protein efficiency ratio (PER), indicating effective nutrient utilisation (Raji, **Jimoh**… Razak, 2020). These findings highlighted the viability of Spirulina and Chlorella as sustainable alternatives to fishmeal, reducing the dependency on marine-derived protein sources while improving nutrient retention in fish.

Driving Sustainability in Aquaculture through Circular Economy Practices

Vice-Chancellor, Sir, in response to the increasing cost of fishmeal and the need to minimise waste in aquaculture, the concept of a circular economy, which seeks to minimise waste and maximise resource efficiency, provides a transformative pathway for aquaculture. **Jimoh** *et al*. (2021b, 2021c, 2022b) investigated the utilisation of catfish viscera/aquaculture by-

product (ABP) meal as a sustainable alternative to conventional fishmeal in the diets of African catfish (*Clarias gariepinus*). Over a 56-day trial, fishmeal was progressively replaced with viscera meal at inclusion levels of 15, 30, 45, and 60%. Across these studies, fishmeal replacement at 15–60% generally did not compromise survival, nutrient retention, whole-body composition, intestinal health, haematological and serum biochemical indices, or oxidative stress status, although higher replacement levels produced minor intestinal structural changes. Notably, 15% replacement enhanced intestinal microbial diversity, while economic evaluation demonstrated reduced feed costs and improved profitability, with performance remaining comparable to the control up to 30% replacement. These findings demonstrated that catfish viscera, which are often discarded and may contribute to environmental pollution, can be effectively converted into a valuable feed resource. The approach reduced dependence on conventional fishmeal and, consequently, pressure on wild fish stocks used for fishmeal production, while promoting nutrient recycling, waste valorisation and resource efficiency. This work therefore provided a practical circular-economy approach for reducing feed costs and improving the sustainability and profitability of aquaculture, particularly in Nigeria where the high cost of fishmeal remains a major constraint to fish production. This study exemplified how circular economy principles can mitigate these challenges by valorising waste streams.

Additionally, **Jimoh** *et al*. (2022a) evaluated *Musca domestica* (housefly maggot) meal as a protein-rich alternative in aquafeeds. A 56-day feeding trial with hybrid African catfish fingerlings demonstrated that maggot meal replacement up to 80% optimally supported weight gain (R^2 = 0.848), and feed efficiency. The study revealed that the inclusion of maggot meal enhanced haematological indices and nutrient utilisation, while maintaining gut, liver, and kidney integrity. Noteworthy to mention is that the 50% group showed the highest protein retention, the 100% group achieved comparable growth through lipid deposition, not protein accretion. Moreover, the 100% group showed glycogen accumulation in hepatocytes.

Mr. Vice-Chancellor, these studies collectively demonstrate a common theme in my research: the gut, the feed ingredient and the production environment are interconnected. By manipulating gut microbiota through dietary fibre and phytogenic additives, identifying safe levels of unconventional plant proteins, and converting aquaculture and/or agricultural wastes into valuable feed resources, the research contributed to a more healthy, affordable, antibiotic-conscious and environmentally sustainable aquaculture industry. In essence, the incorporation of viscera meal and maggot meal into aquafeeds represents a paradigm shift in how we view and utilise aquaculture or agriculture by-products. It is a step towards a more sustainable, resource-efficient aquaculture system that embodies the circular economy's very essence: turning waste into wealth.

Maize Replacers in Aquafeeds

The Vice-Chancellor, Sir, maize serves as a primary source of metabolisable energy in most compounded diets for catfish due to its high digestibility (Abu *et al*., 2010). However, maize, being primarily used for human consumption in Nigeria, is not produced in sufficient quantities to meet demand. The rising cost and scarcity of maize have made it imperative to explore alternative and underutilised energy sources for aquaculture (Munubi & Lamtane, 2021). *Chrysophyllum albidum* (African star apple) is widely consumed during its peak season, with the fruit pulp being eaten while the seeds are discarded as waste. Recognising this, our research sought to explore the potential of utilising the seed meal in aquafeed, reducing waste and contributing to sustainable feed development as a cost-effective substitute for maize in fish diets. **Jimoh** *et al*. (2014) investigated the impact of replacing maize with *Chrysophyllum albidum* seed meal on the growth performance, nutrient utilisation, and health of *Clarias gariepinus*. Experimental diets were formulated with graded levels of *Chrysophyllum albidum* replacing maize at 0%, 25%, 50%, 75%, and 100%. The results revealed a significant decline in growth performance and nutrient utilisation as the inclusion level of *Chrysophyllum albidum* increased. Fish fed diets with higher levels of *Chrysophyllum*

albidum exhibited reduced weight gain, specific growth rate, and feed conversion efficiency compared to those fed maize-based control diets.

Similarly, haematological analysis indicated significant changes in blood parameters, with a reduction in haemoglobin concentration and packed cell volume in fish fed higher inclusion levels of *Chrysophyllum albidum*. Further investigations by **Jimoh** *et al*. (2015d) examined histological changes in the liver and kidney of *Clarias gariepinus* fed *Chrysophyllum albidum*-based diets. The findings revealed structural alterations in hepatic and renal tissues at higher inclusion levels, with visible signs of vacuolisation and degenerative changes, suggesting potential metabolic stress induced by the anti-nutritional factors in *Chrysophyllum albidum*. Despite the observed challenges, *Chrysophyllum albidum* remains a promising alternative to maize in aquafeeds if properly processed to mitigate its anti-nutritional effects. Future research could focus on refining processing techniques such as fermentation and enzyme treatments to improve its digestibility and overall efficacy in fish diets. By addressing these limitations, *Chrysophyllum albidum* can serve as a sustainable and cost-effective ingredient, contributing to the diversification of energy sources in aquaculture feed formulation.

Other Maize Substitutes Explored

Mr. Vice-Chancellor, rice husk, often discarded as an agricultural by-product, and biscuit waste from food industries have been investigated as alternative energy source feed ingredients in line with circular economy principles. Studies on *Pleurotus tuber-regium*-degraded rice husk demonstrated that up to 10% of this agricultural by-product could replace maize without adverse effects on growth performance in *Oreochromis niloticus*. The biodegradation process improved its digestibility and reduced its fibre content, making it a viable feed ingredient (Aderolu, **Jimoh** … Aarode, 2015). The research findings indicated that biodegraded rice husk positively influenced nutrient retention, particularly protein and lipid digestibility, while maintaining optimal feed conversion ratios in cultured fish species. Similarly, biscuit waste was evaluated as an alternative

energy source in *Clarias gariepinus* diets. The findings revealed that up to 75% replacement of maize with biscuit waste significantly improved growth performance, nutrient utilisation, and carcass composition. Moreover, fish fed biscuit waste-based diets exhibited superior protein efficiency ratios, reduced feed conversion ratios, and enhanced profitability due to lower feed costs (Aderolu, Aarode … & **Jimoh**, 2011).

Fish Consumers' Preference: A Microeconomic Perspective

The Vice-Chancellor, Sir, the study by **Jimoh** *et al*. (2013c) offered critical insights into consumer behaviour through the lens of microeconomic consumer theory. The research, which evaluated factors influencing the preference for fresh and frozen fish in Ibadan, aligns with the principles of utility maximisation under budget constraints. Using data from 150 respondents, the study highlighted how socio-economic factors such as education, occupation, and expenditure shape consumer choices in fish consumption. Respondents with higher education and lower incomes showed a stronger preference for fresh fish, valuing taste and perceived health benefits, attributes linked to higher utility. Conversely, frozen fish was preferred for its affordability and availability, demonstrating how budget constraints influence choices. Determinants such as cost, packaging, and accessibility further revealed trade-offs consumers make to optimise satisfaction within their economic means. Additionally, the study aligns with the theory that consumer preferences are influenced by awareness and cultural habits. Nutritional awareness, a function of education, significantly impacted the preference for fresh fish, while socio-cultural factors played a lesser role. This research underscored the importance of understanding consumer demand curves to design policies and market strategies that align fish processing and marketing with the preferences and constraints of diverse consumer groups.

Building on this, our research on consumer behaviour in Ilorin **(Jimoh** *et al*., 2020f) further investigated consumer preferences for fresh and smoked catfish. Using a multi-stage sampling technique with 225 respondents, we found that a significant majority preferred smoked catfish, irrespective of

their socio-economic profile. The analysis revealed that only tribe had a significant effect ($p<0.05$) on the preference for whole or chunk fish, while family size, age, and religion significantly influenced the frequency of fish consumption. Key factors driving fish preference included price, ease of cooking, nutritional awareness, and sensory attributes such as taste and aroma. Notably, respondents who were more educated exhibited stronger nutritional consciousness, reinforcing the idea that consumer education plays a crucial role in shaping market demand. This study highlighted the need to align fish production, processing, and marketing strategies with consumer preferences to sustain demand and profitability in the aquaculture sector.

Further insights were provided **Jimoh** *et al*. (2021a) in a study on fish consumption behaviour and patterns in Oyo State. This study examined the determinants of fish consumption among 150 respondents using a multi-stage sampling technique. The results showed that the majority of respondents preferred smoked fish, with 88% favouring it when dining with family. Additionally, 51% of respondents preferred large fish, while 86% reported no complaints about fish consumption. Socio-economic factors such as education, income, and household size significantly influenced the preference for smoked over fresh fish, highlighting the role of consumer education in dietary choices. Interestingly, men with multiple wives were more inclined to eat fish with their children than those with only one wife, demonstrating a socio-cultural component in consumption patterns. The study further confirmed that taste, availability, and price were the primary factors influencing consumer choices, underscoring the need for strategic market positioning of fish products.

Our recent study on consumer acceptability of yellow croaker (*Larimichthys polyactis*) based on different processing methods provided additional insights (Ayeloja…**Jimoh** & Abdulsalami, 2019). The research investigated variations in consumer preferences for yellow croaker processed by sun drying, deep frying, solar drying, and smoking. Sensory evaluations revealed that smoked fish was significantly preferred for its odour and flavour, while solar-dried fish had the highest

crude protein content (71.45%). Smoked fish also contained the highest crude ash content (10.73%). These findings suggested that solar drying and smoking are the most effective processing methods for enhancing consumer appeal while maintaining the nutritional integrity of fish. The results further highlighted the importance of processing techniques in shaping consumer choices and optimising the market value of fish products.

Fish Product Development

Vice-Chancellor Sir, naturally occurring antimicrobial compounds present in plant parts could not only increase the shelf life of fish products by reducing the growth rate of harmful microorganisms (Beuchat & Golden, 1989), but also improve human health. In recent years, there has been considerable consumer demand for food products with natural organic preservatives (Kumar *et al*., 2015; Testa *et al*., 2019; Tiwari *et al*., 2009) because of their potential human health benefits. Natural products such as essential oils, spices, and herbal extracts are preferred preservatives because of their biodegradability, low cost and toxicity, and biocompatibility (Fatoki & Onifade, 2013; Tiwari *et al*., 2009). The antioxidant, flavouring, and antimicrobial properties of aromatic compounds derived from natural plants have been reported to enhance the nutritional quality and shelf life of food products (de Pinedo *et al*., 2007; Sarkar & Shetty, 2014). Our research **(Jimoh** *et al*., 2020g) investigated the antimicrobial and preservative effects of *Moringa oleifera* seedmeal marinade on smoked *Clarias gariepinus*. The study aimed to extend the shelf life of smoked fish by leveraging moringa's natural antimicrobial properties, reducing microbial spoilage, and ensuring food safety. The findings revealed that marinating *C. gariepinus* in *Moringa oleifera* seedmeal significantly reduced bacterial and fungal loads during storage. The study identified *Aspergillus flavus, Aspergillus niger, Saccharomyces cerevisiae, Alternaria alternata, Penicillium citrinum, Neurospora crassa*, and *Rhizopus stolonifer* as the predominant fungi, while bacterial isolates included *Enterobacter spp., Staphylococcus spp., Proteus spp., Streptococcus spp., and Bacillus spp*. The study determined that the optimum concentration of moringa marinade

for antimicrobial effectiveness was 11.2 g/kg for bacterial inhibition, 12.08 g/kg for yeast suppression, and 10.6 g/kg for antifungal activity.

Mr. Vice-Chancellor, these studies therefore connect the different stages of the aquaculture value chain; from understanding what consumers want, to developing safe, acceptable and market-oriented fish products. The findings provided useful evidence for improving fish marketing, value addition, food safety and profitability within the Nigerian aquaculture industry

Post-Slaughter Quality of Fish: Implications for Processing and Storage

Post-slaughter time significantly affects the sensory, biochemical, and microbiological qualities of fish. Our research on *Heterotis niloticus* and Heteroclarias assessed the effects of post-slaughter time intervals (PSI) on fish quality under ambient storage conditions. The findings revealed that fish retained most of their original sensory attributes up to 12 hours post-slaughter. Key indicators such as eye clarity, gill colour, and mucus integrity were maintained, making the fish visually appealing to consumers. However, beyond this period, notable degradation occurred, leading to diminished freshness and reduced market value (Ayeloja, **Jimoh**... & Abegunde, 2022). Histological analysis confirmed that muscle tissues remained intact for up to 12 hours post-slaughter, after which structural deterioration became evident. Proximate composition analysis indicated a significant decline in crude protein and mineral contents with prolonged storage, while moisture levels increased, leading to textural softening. Biochemical assessments demonstrated an increase in total volatile base nitrogen (TVBN), peroxide value (PV), and free fatty acid (FFA) levels beyond 12 hours, signalling progressive spoilage (Ayeloja**,** **Jimoh**, ..., & Abegunde,, 2022). Microbial evaluations revealed that total viable count (TVC), total coliform count (TCC), and *Escherichia coli* presence significantly increased over time. Although microbial loads remained within acceptable limits for up to 12 hours, further delays led to increased bacterial contamination, compromising food safety. These findings highlighted the

importance of timely processing and proper storage techniques to maintain fish quality and reduce post-harvest losses. The study underscored the need for effective cold-chain logistics and preservation strategies to extend fish shelf life, especially in tropical regions where high ambient temperatures accelerate spoilage. Implementing best handling practices can enhance product quality, ensuring that consumers receive fresh, nutritious, and microbiologically safe fish products. These insights are crucial for stakeholders in the aquaculture value chain, including fish farmers, processors, and retailers, as they strive to optimise fish preservation and reduce economic losses associated with spoilage.

Community Services

I am grateful for the opportunity to serve the university system, the nation, and my community in various capacities. Throughout my career, I have maintained one guiding principle: every assignment is a trust that must be fulfilled with diligence and integrity. Within the university, I have served at departmental, faculty, and institutional levels. As Head of Department, Acting Head, and Postgraduate Coordinator, I provided leadership in academic planning, student mentorship, and programme development. I have also served as Level Adviser, Coordinator of Projects and Seminars, and as a member of several departmental committees, including the Board of Examiners and accreditation teams. These roles enabled me to contribute to student training and the enhancement of our academic programmes.

Throughout these responsibilities, I have focused on building systems rather than simply holding positions. During my tenure, the Aqua Fish Farm was established, providing a practical platform for teaching, research, and production. As Head of Department, I oversaw the construction of a modern hatchery, fish processing facilities, and earthen ponds, which strengthened our capacity for fish seed production and enhanced hands-on student training with the cooperation of teaching staff and technologists in the Department. I was instrumental in facilitating the acquisition of a 200 kg/hr feed pelleting machine for the Department, and I also facilitated the acquisition of a

hammer mill fitted with a 5.5 hp electric motor, thereby enhancing the Department's capacity for efficient feed ingredient processing and aquafeed production, which have strengthened the Department's feed production capability, supported research activities, and improved hands-on training for students.

As part of the infrastructural improvements undertaken by my administration as the HoD, the Departmental Aquafarm has been equipped with a CCTV surveillance system, adequate lighting, and a purpose-built fish processing facility, thereby enhancing security, supporting post-harvest handling and value addition, and providing improved facilities for teaching, research, and commercial aquaculture activities. Mr. Vice-Chancellor, I am delighted to bring to your attention the recently released 2026 University Global Ranking. Compiled by Professor S.F. Ambali, Project Manager for the ranking exercise, on 29th June 2026, and published on 5th July 2026 on the Unilorin website by Yunus AbdulMuqtadir, the report places the University of Ilorin first in Nigeria and eighteenth in Africa in the field of Aquatic Science. This remarkable feat is a testament to the Department's robust research culture, expanding portfolio of scholarly publications, growing global research impact, and commitment to producing world-class graduates during my tenure. The 2024/2025 sets of graduates in the Department were also inducted into the Fisheries Society of Nigeria during my tenure.

200 kg/hr feed pelleting machine

As Postgraduate programmes Coordinator, I facilitated the approval and launch of our postgraduate programmes, witnessing the graduation of the first M.Sc students and the start of the Ph.D. programme. These milestones represent lasting contributions to capacity building and the advancement of aquaculture education.

` At the faculty level, I have contributed to quality assurance and academic development through committee work, supporting accreditation and continuous improvement in teaching and research. At the university level, my roles on the University Mock Accreditation Team and the Farm Planning and Implementation Committee have broadened my perspective on institutional development. Additionally, my service in other academic institutions has enhanced my understanding of academic leadership and strengthened my commitment to service.

Nationally, I have served as an External Examiner and Assessor for several universities across Nigeria, contributing to

postgraduate training and academic quality assurance. I have also participated in national assignments, including examination proctoring and civic duties such as electoral processes, as part of my contribution to national development.

My engagement with the community has been one of the most fulfilling dimensions of my academic career. I firmly believe that the true value of knowledge lies in its application to solving real-life problems and improving the well-being of society. Guided by this conviction, I have actively participated in vocational training and empowerment programmes in fish production, fish processing, and aquaculture agribusiness, equipping farmers, youths, women, and aspiring entrepreneurs with practical skills for sustainable livelihoods and enterprise development. I sincerely acknowledge the invaluable partnership and support of Mr. Shakeeb ur Rahman of Olam Feed and the Association of Fish Farmers, Kwara State Chapter under the leadership of Brigadier General Tayo Saidu Olasupo (rtd), whose collaboration has significantly enhanced the impact of these outreach programmes. Together, these initiatives have not only strengthened technical capacity but have also created economic opportunities, improved livelihoods, and inspired renewed hope among participants.

My commitment to community development also extends to my hometown, where I am privileged to serve as a member of the Oke-Ola Oro Professionals, under the leadership of Prof. Abdullahi Bode Abdulkadri, and the Oke-Ola Oro Think Tank, ably led by Alhaji Taiye Mustapha. Through these platforms, I have contributed to initiatives aimed at promoting educational advancement, youth empowerment, and the socio-economic development of our community. In addition, I served as a Board Member of the Channel for Widow Relief Initiative (CFWRI) under the coordination of Alhaja Fadhilah Omotunde Balogun, where I supported programmes designed to enhance the welfare, dignity, and economic empowerment of widows and other vulnerable members of society. I have also participated in several other initiatives dedicated to educational support, mentorship, and social welfare. Beyond these engagements, I remain an active and committed member of the Muslim Students'

Society of Nigeria (MSSN), an association that has played a significant role in shaping my values, leadership philosophy, and commitment to service. The principles of integrity, discipline, compassion, and selfless service nurtured through the Society continue to guide my personal and professional life.

The Vice-Chancellor, Sir, I have always believed that positions are temporary, but the systems, people and opportunities we create can endure. I am grateful for the opportunities to serve, lead, and contribute, recognising them as privileges. When opportunities to serve arise, I believe we must rise to the occasion. For me, this commitment has always been clear:

I have served where I was called.
I have built, where there was a need.
I have given what I could.

I hope that in every place I have served, I have left something valuable and enduring. If my efforts have contributed to knowledge, people, or society, I will consider this journey worthwhile.

Conclusion

Vice-Chancellor, Sir, throughout this inaugural lecture, I have highlighted the crucial role of sustainable and innovative feeding strategies in aquaculture. My research journey has been dedicated to developing viable alternatives to conventional fish feed ingredients by integrating plant-based protein sources, phytogenic additives, and circular-economy principles. These efforts aimed to reduce dependence on fishmeal and soybean meal, optimise nutrient utilisation, enhance fish health, and improve economic sustainability for fish farmers.

Furthermore, the use of microalgae, prebiotics, and natural plant-based additives such as fenugreek, coriander, and cinnamon has shown potential in boosting fish metabolism, disease resistance, and gut health. The integration of circular economy practices in aquafeed production, such as utilising fish processing by-products (viscera meal) and alternative protein sources (maggot meal), reinforced the economic and environmental sustainability of aquaculture.

Additionally, consumer behaviour studies have provided insights into market preferences, emphasising the importance of aligning fish production and processing with consumer demand. Despite these advancements, challenges remain. Issues such as optimising processing techniques, addressing anti-nutritional factors, and scaling up sustainable feed formulations require continued research and industry collaboration. Future directions should focus on refining feed technology, policy advocacy for sustainable aquafeed development, and fostering partnerships to ensure widespread adoption of innovative feeding solutions.

Recommendations

Building on the insights of this inaugural lecture, advancing sustainable aquaculture requires coordinated actions by government, academia, industry, development partners, and farmers. The following recommendations identify who should do what, for whom, and to what end.

Pillar I: Re-engineering Aquafeeds for a Post-Fishmeal Era

1. Federal and State Ministries of Agriculture, in collaboration with universities, research institutes, and feed manufacturers, should provide dedicated funding and

commercialisation support for the development of alternative protein sources from underutilised plants, insects, and agro-industrial by-products for use by aquafeed manufacturers and fish farmers. This will reduce dependence on imported fishmeal and soybean meal while lowering feed costs.

2. Universities, research institutes, biotechnology companies, and commercial feed millers should jointly develop, optimise, and transfer affordable feed-processing technologies, including fermentation, extrusion, enzyme supplementation, and thermal processing, to feed manufacturers and farmers. This will improve nutrient digestibility, eliminate anti-nutritional factors, and enhance feed efficiency.

3. Government environmental agencies, waste management authorities, private agribusinesses, and aquaculture entrepreneurs should establish integrated waste-to-feed programmes that convert fish processing wastes, insect biomass, and agricultural residues into quality feed ingredients for the aquaculture industry. This will promote circular bioeconomy principles, reduce environmental pollution, and create additional employment opportunities.

Pillar II: Proactive Health Management Through Functional Nutrition

4. Universities, pharmaceutical and nutraceutical companies, aquafeed manufacturers, and research institutes should collaborate to develop, validate, register, and commercialise phytogenic feed additives derived from indigenous medicinal plants for adoption by fish farmers. This will improve gut health, nutrient utilisation, disease resistance, and reduce dependence on synthetic chemotherapeutics.

5. Feed manufacturers, veterinary professionals, fish health specialists, and regulatory agencies should formulate, certify, and promote functional aquafeeds containing probiotics, prebiotics, synbiotics, and natural immunostimulants for routine use by fish farmers. This

will strengthen disease prevention, reduce antibiotic misuse, and improve fish welfare and productivity.

Pillar III: Creating an Enabling Environment Through Policy, Capacity Building, and Market Development

6. The Federal Government, through the Federal Ministry of Agriculture and Food Security, relevant regulatory agencies,and the National Assembly, should formulate and implement policies that provide research grants, tax incentives, and innovation financing for sustainable aquafeed development while enforcing feed quality and safety standards for the benefit of producers and consumers.

7. Agricultural Development Programmes (ADPs), extension agencies, universities, NGOs, and farmers' associations should organise regular hands-on training programmes on low-cost feed formulation, feed processing, fish health management, and sustainable production practices for small-scale fish farmers. This will improve farmers' technical capacity, productivity, and profitability.

8. Universities, market research organisations, agribusiness firms, and government agencies should conduct periodic consumer preference and market intelligence studies and communicate the findings to producers, processors, and marketers. This will ensure that aquaculture production responds effectively to consumer demand for quality, safe, and sustainably produced fish.

9. Government, development finance institutions, commercial banks, private investors, and fish farmers' cooperatives should invest in modern fish processing facilities, cold-chain infrastructure, packaging systems, and value-addition enterprises to support fish producers and processors. This will reduce post-harvest losses, increase profitability, improve product quality, and strengthen food security.

Pillar IV: Institutionalising Collaboration for Sustainable Innovation

10. The Federal Ministry of Marine and Blue Economy, Federal Ministry of Agriculture and Food Security, universities, research institutes, Fisheries Society of Nigeria (FISON), aquaculture industry associations, private-sector stakeholders, and international development partners should establish a National Aquaculture Innovation Compact to coordinate research, technology transfer, policy dialogue, and private-sector investment for the benefit of Nigeria's aquaculture industry. The Compact should serve as a permanent platform for translating research findings into commercial technologies, harmonizing national priorities, mobilising investment, and accelerating the growth of a resilient an globally competitive aquaculture sector.

Finally, I recommend that the Federal Government recognise sustainable aquaculture as a strategic component of Nigeria's food security, nutrition, and Blue Economy agenda by increasing investment in research, innovation, human capacity development, and commercialization of locally developed technologies. Such investment will accelerate the transition towards a resilient, environmentally sustainable, and globally competitive aquaculture industry capable of creating employment, reducing import dependence, and contributing significantly to national economic development. Strategic implementation of this framework will drive fundamental transformation. Aquaculture will become a resilient, environmentally restorative, and economically strong sector. Achieving this vision is essential for ensuring food and nutrition sovereignty, creating dignified employment, and building sustainable livelihoods for current and future generations.

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