AQUACULTURE FEED

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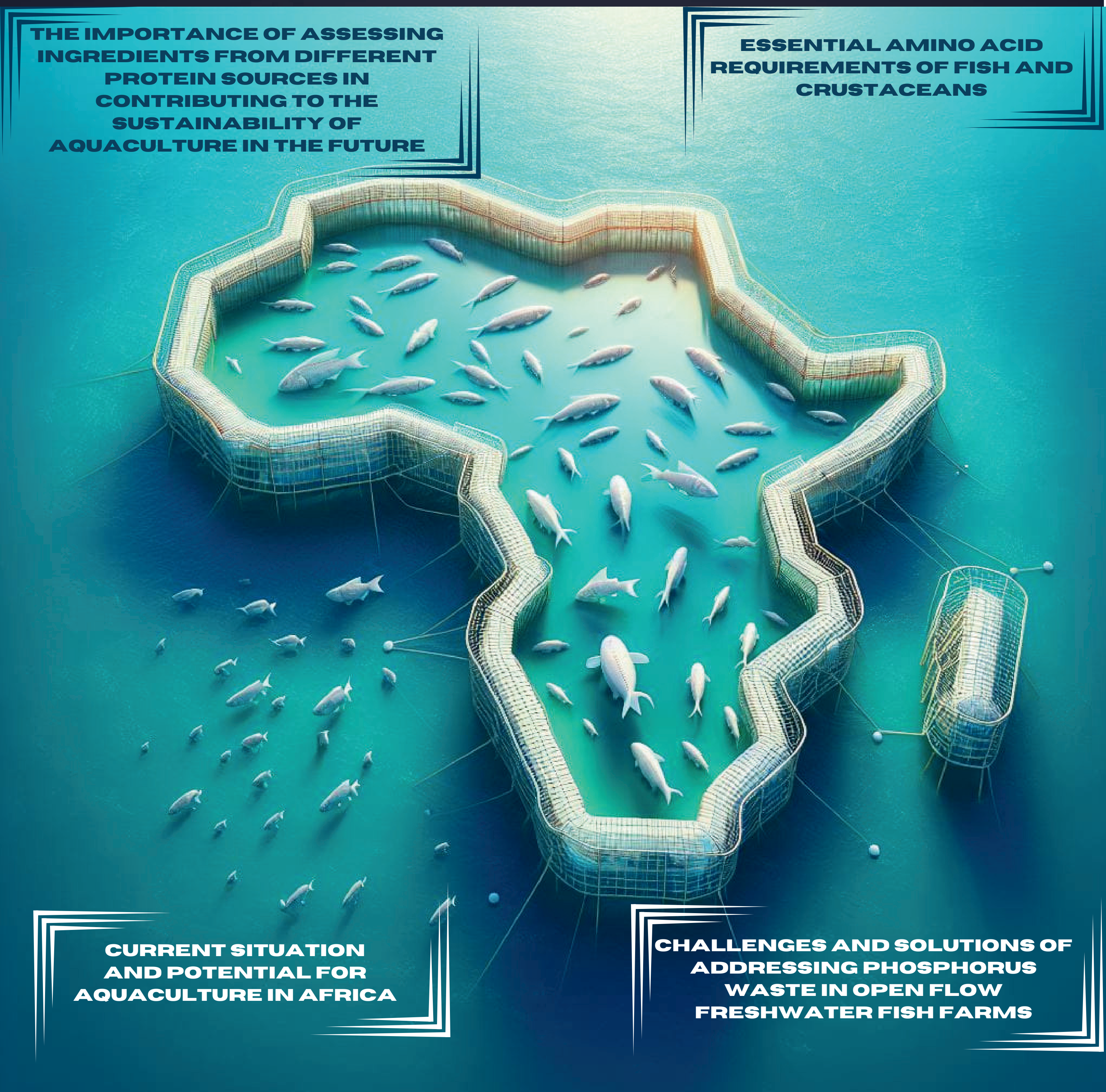


THE IMPORTANCE OF ASSESSING INGREDIENTS FROM DIFFERENT PROTEIN SOURCES IN CONTRIBUTING TO THE SUSTAINABILITY OF AQUACULTURE IN THE FUTURE

ESSENTIAL AMINO ACID REQUIREMENTS OF FISH AND CRUSTACEANS

CURRENT SITUATION AND POTENTIAL FOR AQUACULTURE IN AFRICA

CHALLENGES AND SOLUTIONS OF ADDRESSING PHOSPHORUS WASTE IN OPEN FLOW FRESHWATER FISH FARMS

The African Aquaculture Feed Magazine is an essential tool for the development of aquaculture feed management in the region. Indeed, the magazine offers a valuable and up-to-date source of information on the latest advances in aquaculture feed, new market trends, best management practices and technical recommendations for improving aquaculture production. By providing feature articles, case studies, market analyses and interviews with industry experts, Africa's aquaculture feed magazine enables aquaculture professionals to stay informed and up to date with the latest innovations in fish and shellfish feed. This enables them to adapt their practices in a more sustainable and efficient way, taking into account the environmental, economic and social issues linked to aquaculture production.

In addition, the Africa Aquaculture Feed Magazine also helps to promote good feeding practices in aquaculture, highlighting innovative initiatives and projects that are having a positive impact on the sustainability of aquaculture production in the region. By fostering the sharing of knowledge and experience between industry players, the magazine plays an essential role in building the capacity of aquaculture professionals and in the continuous improvement of aquaculture feed management practices in Africa.

The Africa Aquaculture Feed Magazine is a contributing tool for the development of aquaculture feed management in the region, informing, raising awareness and inspiring industry players to adopt more sustainable practices and contribute to the growth and prosperity of aquaculture in Africa.

LIST OF THE EDITORIAL TEAM OF THE AQUACULTURE FEED MAGAZINE AFRICA

EDITORIAL

DEAR READERS

Food and nutritional security refers to the challenge of providing healthy, sustainable and accessible food for all human beings, with four dimensions covering interconnected issues: availability, access, utilisation and stability. Everyone recognises that the vast majority of the meat we eat does not come from wild animals, but from animals raised by humans, so raising fish, crustaceans (molluscs, aquatic plants and algae) is a key dimension in ensuring food security, increasing the availability of fish or even offsetting the losses suffered by African countries as a result of overexploitation of marine fishery resources. According to the FAO, fish and other aquatic products produced in aquaculture can play an important role in meeting growing food demand, helping to improve the resilience of the global food system.

Africa is the continent with the highest demographic growth, where the population is expected to increase by about 2.4 billion people by 2050, while there is a great challenge with regard to the two sustainable development goals of food security and poverty, in this context, the aquaculture sector in the African continent needs new governance principles that guarantee its expansion and intensification, adopting modern technologies, in an environmentally and socially responsible and economically viable manner.

The expansion of the aquaculture industry on this continent requires feed for aquatic animals, which accounts for more than 60% of production costs. Innovations and good management in the use of aquaculture feed can improve productivity and reduce waste, facilitating greater inclusion of small operators in the sector. These technologies, which are already available, need to be applied in areas where aquaculture has the greatest potential for growth, such as Africa, whose overall contribution to world production is barely 2%, while Asia contributes over 90%.

While aquaculture is a global success story, the sector faces challenges in Africa, where production is low, linked above all to improving food quality, and this is the aim of the series of articles in this issue, which describe the current aquaculture situation in Africa, examining the ingredients of different protein sources for aquaculture feeds, formulating them more cheaply and economically, and the environmental impact of these feeds, so that our continent experiences more sustainable and environmentally-friendly aquaculture, in line with global trends.

Enhancing the nutritional quality of fish in Africa by adopting better feeds that reduce the risk of environmental impact and the spread of aquatic diseases, and producing healthy, good-quality fish, can contribute to the development of sustainable aquaculture in Africa.

Enjoy your reading

SUMMARY

THE IMPORTANCE OF ASSESSING INGREDIENTS FROM DIFFERENT PROTEIN SOURCES IN CONTRIBUTING TO THE SUSTAINABILITY OF AQUACULTURE IN THE FUTURE

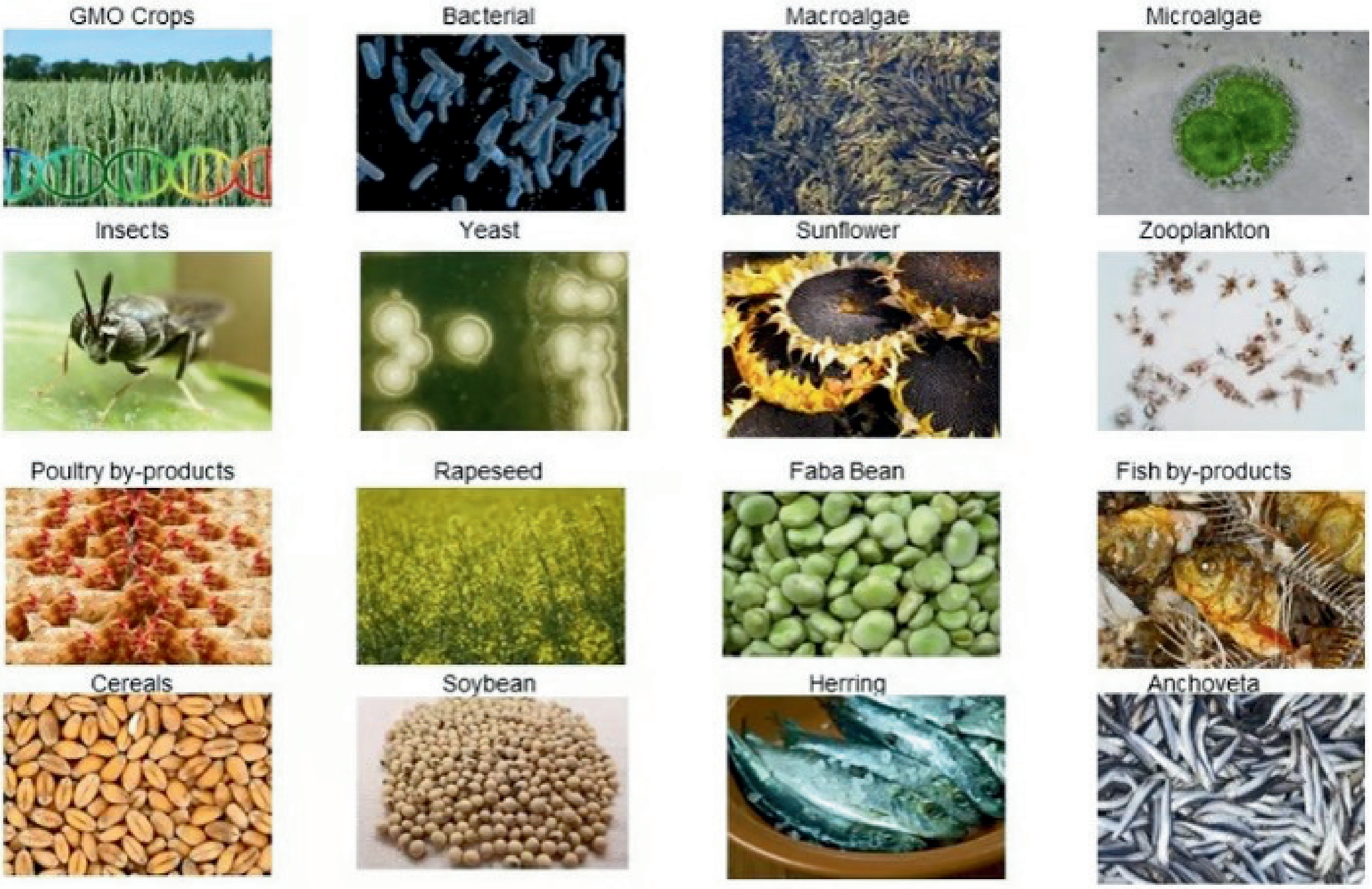
Comparing the nutritional attributes of different ingredients from different protein sources provides an evaluation framework for understanding the essential knowledge required to accommodate any ingredient in a formulation process in aquaculture feed.

Global aquaculture is expanding rapidly to meet the growing demand for seafood. According to projections by the Food and Agriculture Organization of the United Nations (FAO), global aquaculture production is set to more than double, reaching yields of 140 million tonnes by 2050. This also means that feed production must at least double to more than 100 million tonnes (Glencross, 2024) over the same period. One of the fundamental questions underlying this projection is how to obtain the feed ingredients to support this growth and, just as importantly, how to ensure the sustainability of this growth.

To support the future expansion of global aquaculture, the evaluation of ingredients from protein sources in aquaculture feeds is essential to nutritional research and feed development for aquaculture species, especially as the protein used in aquaculture feeds comes from a variety of sources, including fishmeal and other ingredients from a variety of sources.

An assessment of the strengths and weaknesses of protein ingredients for aquaculture feeds shows that no ingredient is perfect, but that a better understanding of their strengths and weaknesses can increase the adaptability of feed formulations, reported in a review led by Brett Glencross, technical director of the marine ingredients organisation, IFFO, and includes comments from Margareth Øverland, professor of aquaculture nutrition at the Norwegian University of Life Sciences (NMBU), and Richard Newton, lecturer in resilient feed systems at Stirling University's Institute of Aquaculture.

The review considers a wide variety of protein sources used in animal feeds: marine ingredients (produced from forage fisheries or by-products from fisheries and aquaculture resources), processed animal proteins (manufactured from terrestrial animals produced for human consumption from which by-products are generated, as well as insect and worm meals), unicellular protein resources (produced from bacterial sources, yeast, fungi or microalgae), cereal protein sources (representing the largest volume of all aquaculture feed worldwide) such as cereals, oilseeds, legumes, including plant resources used unmodified or with varying degrees of processing.



New protein sources for aquaculture feeds. Source: IFFO

The researchers carried out a SWOT (Strength, Weakness, Opportunities, and Threats) analysis of a variety of aquaculture feed ingredients, including traditional sources such as fishmeal and fish oils, finding that no single ingredient represents the perfect solution, but together the ingredients of these alternative aquaculture feeds can offer compelling benefits.
SWOT analysis (strengths, weaknesses, opportunities, threats)
To better understand each ingredient category, a SWOT analysis is applied. This approach takes into account the following factors:

- **Strengths: by showing the advantages of each ingredient.**
- **Weaknesses: by describing their limitations and drawbacks.**
- **Opportunities: by pointing out the uses of these ingredients.**
- **Threats: by showing the potential risks associated with their use.**

The assessment shows that each ingredient has its strengths and weaknesses. In many cases, the weaknesses of one ingredient can be combined with the strengths of other ingredients to identify opportunities for complementarity.

Explains Dr Brett Glencross. For example, soya has the scale and stability of supply and the consistency of product quality, but lacks palatability for many species, while fishmeal offers excellent palatability but faces supply limitations linked to overexploitation of fish resources in the oceans. By recognising the results of the SWOT review of ingredients, the weaknesses of one ingredient can be combined with the strengths of others to identify opportunities for complementarity, suggesting that combining complementary ingredients minimises the trade-offs associated with each, while maximising the beneficial characteristics of the aquaculture feed.

By better appreciating the positive and negative aspects of each ingredient, it is possible to increase our ability to adapt to meet the diverse opportunities for their use in balanced diets and improve the sustainability of the sector for the future.

To ensure the sustainability of the aquaculture feed industry in order to meet the expectations of the development of the aquaculture sector in the future, and the evaluation of the characteristics of ingredients from different protein sources revealed in this review, shows that the complementarity of ingredients is a necessity, as understanding the strengths and weaknesses of ingredients allows the formulation of feeds that are well adapted for aquaculture.

reference (open access)
Glencross, B., Ling, X., Gatlin, D., Kaushik, S., Øverland, M., Newton, R. and Valente, L. M. (2024). A SWOT Analysis of the Use of Marine, Grain, Terrestrial-Animal and Novel Protein Ingredients in Aquaculture Feeds. Reviews in Fisheries Science & Aquaculture, 1-39.
https://doi.org/10.1080/23308249.2024.23150.

CURRENT SITUATION AND POTENTIAL FOR AQUACULTURE IN AFRICA

By : Dr Mustapha ABA. Aquaculture Scientific Expert. Fish Nutrition. Rabat. Morocco.

As the world's population continues to grow exponentially, the issue of food security is becoming increasingly pressing and sustainable food supply is one of humanity's major concerns (Obaisi, 2017), particularly given climate change and the challenges associated with traditional agricultural production (Habib-ur-Rahman et al., 2022).

The relationship between aquatic foods, food security and nutrition is increasingly recognised by several research studies (Kawarazuka and Béné , 2010 ; Bogard et al., 2019, Farmery et al., 2021 ; Zamborain-Mason et al., 2023) and must be supported by the necessary political commitment to explicitly link fisheries and aquaculture to food security and public health (Farmery et al., 2021) in order to support healthy, sustainable diets for all.

In this context, aquaculture has become one of the most promising solutions for strengthening food security in the world and for meeting the ever-increasing demand for food fish, especially in Africa (AUDA-NEPAD, 2021), the continent with the highest demographic growth, with a population of more than 1474 million.

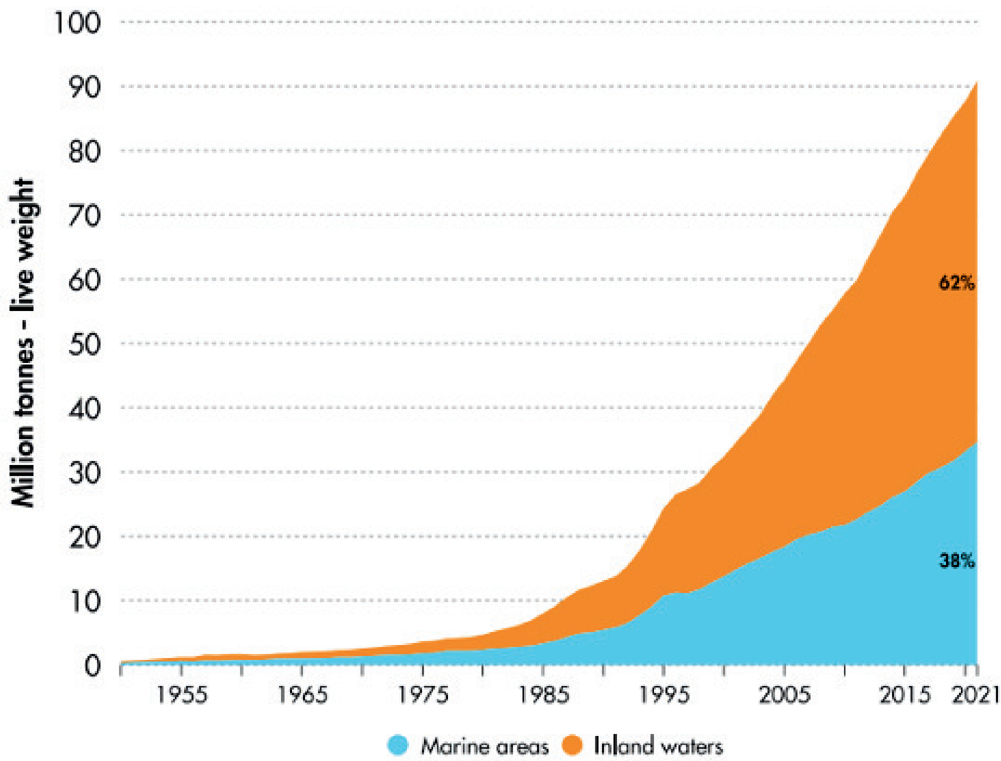


Fig 1: Total aquaculture production of aquatic animals by inland waters and marine areas (FAO, 2024)

Aquaculture remains the fastest growing food production sector in the world (FAO, 2022), with a record contribution of 50 per cent to global aquatic animal production in 2024, compared with only 13.4 per cent in 1990. Aquaculture is the most diversified food production system in the world, with more than 600 species cultivated worldwide since 1950 (FAO, 2022), and its production is divided as follows: 62% for freshwater and 38% for marine (Fig 1), with aquaculture production of fed aquatic animals (fish and shrimp) continuing to outstrip that of non-fed species.

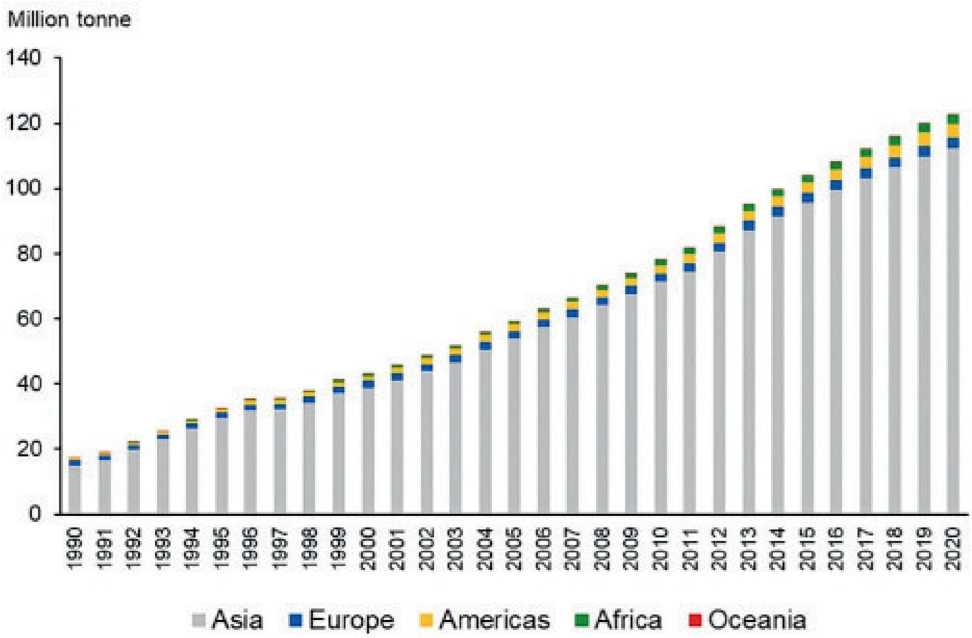


Fig 2: Aquaculture production by region (Chan et al., 2024)

Globally and geographically (Fig 2), Asian countries were the main producers of aquatic animals in 2021, accounting for 70 percent of the total, followed by the Americas, Europe, Africa and Oceania (FAO, 2024).

Despite the domination of aquaculture production by Asian countries, aquaculture in Africa remains an emerging activity in most cases, as it has progressed considerably over the last three decades. In 1995, African aquaculture represented 0.45% of world crops, compared with almost 2% in 2021, for a value of 6 billion US dollars, given that world aquaculture production is 126 million tonnes.
The low production of aquaculture on the African continent is mainly due to the fact that capture fisheries have been largely favoured with a production of more than 10 million tonnes, and the development of aquaculture is lagging behind (Fig 3), but exceptions to this observation are observed in countries where the development of aquaculture is important, for example in Egypt, in the North African region and the continent's leading producer with 1,576,189 tonnes of aquaculture production, and in certain countries in sub-Saharan Africa, such as Nigeria, in the West African region, with 275,645 tonnes of aquaculture production, and Uganda in the East African region, with 138,558 tonnes of aquaculture production, while in Central Africa, Cameroon produces 9,800 tonnes of aquaculture, and South Africa with 10,525 tonnes of aquaculture products in the Southern African region (FAO, 2023).

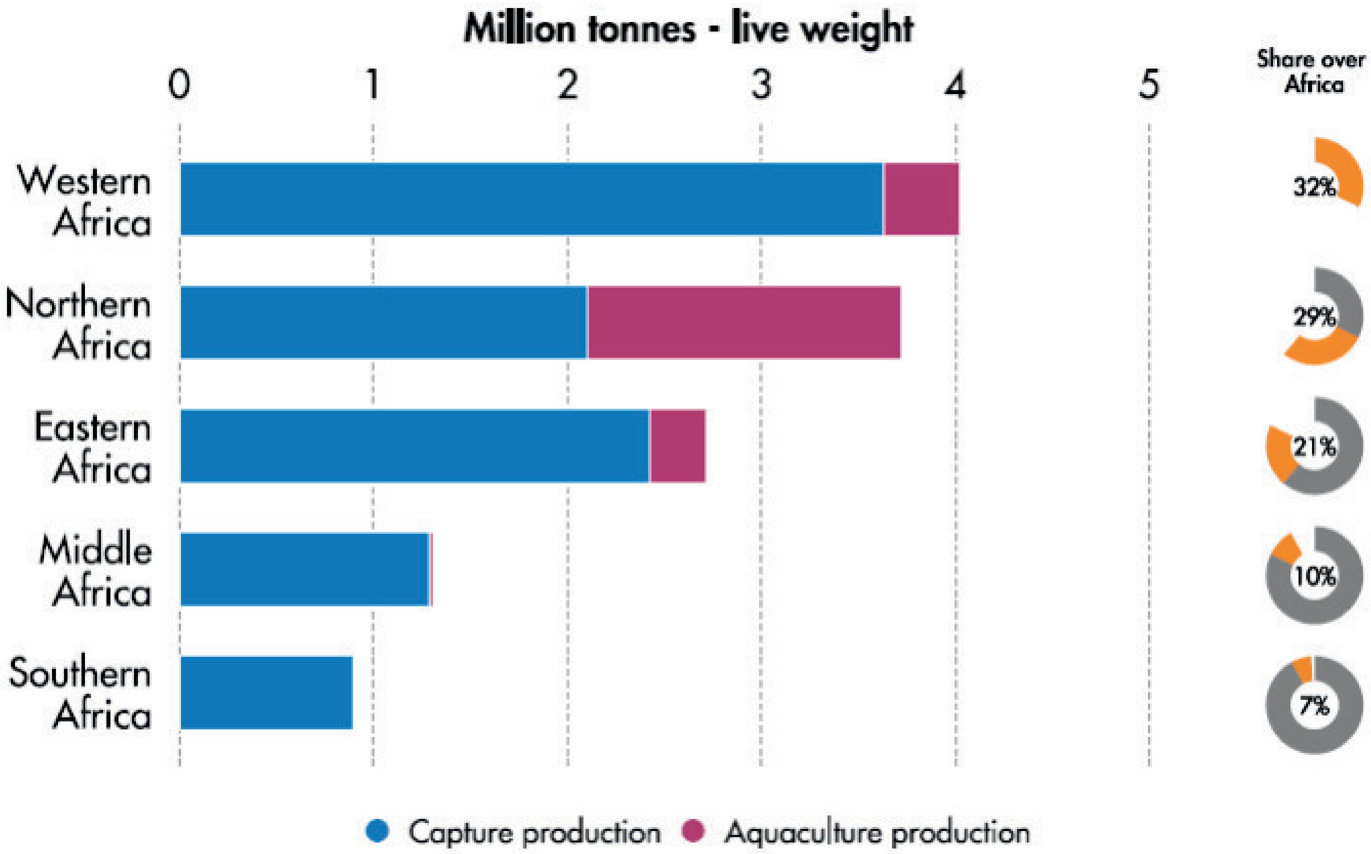


Fig 3: Aquatic animal production by production source and share of total by geographic region of Africa in 2021. (Source FAO, 2024)

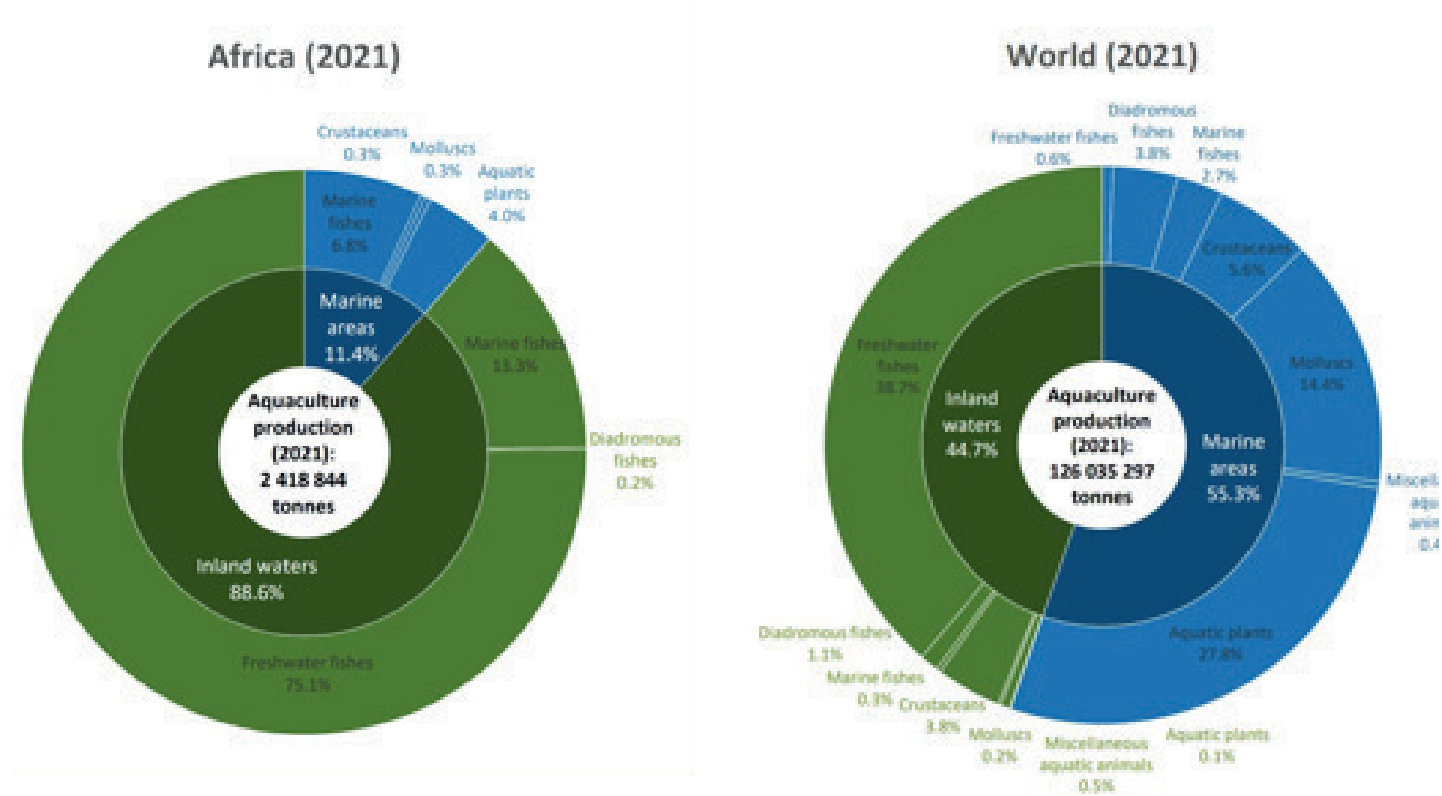


Fig 4: Global and African Aquaculture Production (FAO, 2023)

The 2.4 million tonnes of aquaculture products produced in Africa are not evenly distributed across the continent. African regions have experienced great disparities in aquaculture production for decades (Fig 5), with significant production since the 2000s in the North, West and East African regions, and of the 2.4 million tonnes produced in aquaculture on the African continent, North Africa produces almost 70% (almost all by Egypt), West Africa with 16.06%, while the East African region produces 15.70% of aquaculture products. Central and Southern Africa produce less than 1.3% (FAO, 2024).

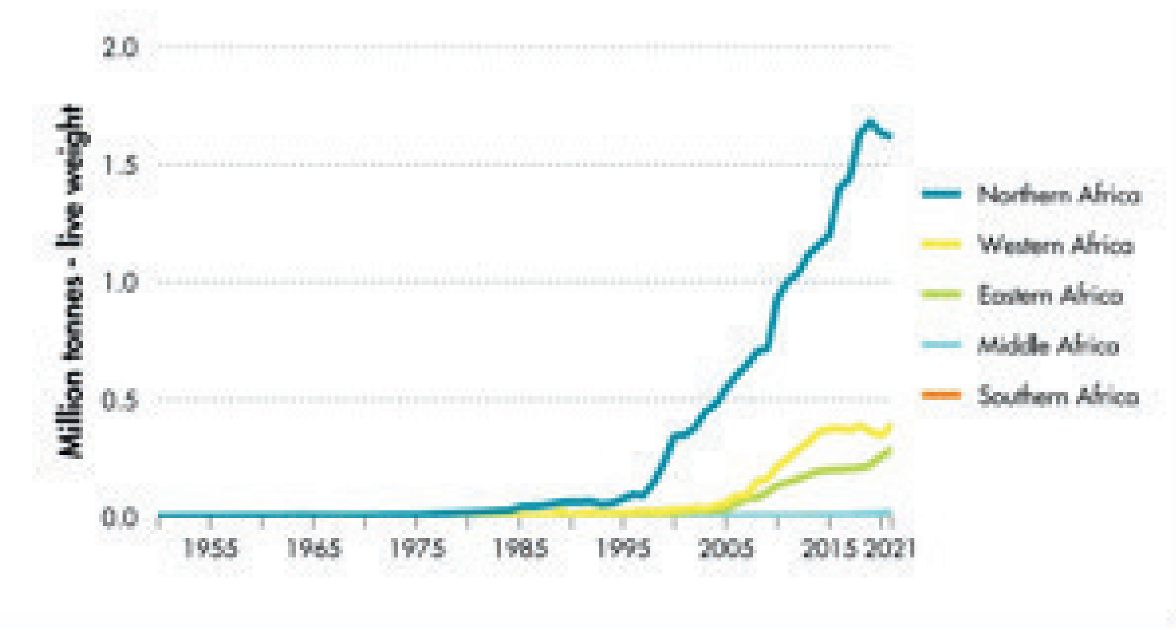


Fig 5 : Aquaculture production in the 5 regions of Africa

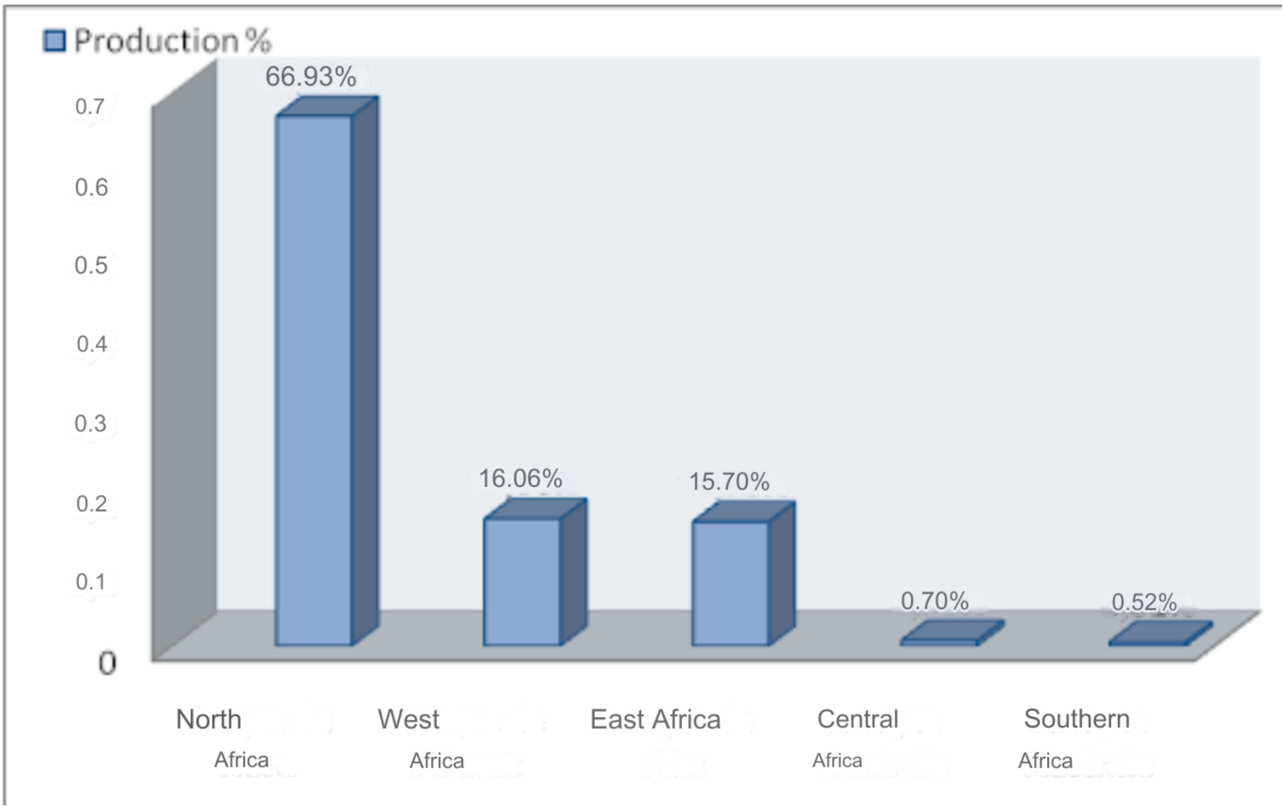


Fig 5 : Aquaculture production in the 5 regions of Africa

MOST PRODUCED AQUACULTURE SPECIES IN AFRICA

Freshwater species

Freshwater aquaculture in Africa is dominated by 3 freshwater species represented by tilapia, catfish, and carp, with a predominance of tilapia aquaculture in North Africa (Egypt).

Freshwater fish	Production in tonnes
Tilapia	1 340 000
Catfish	252 000
Carps	171 375

Marine species

Aquaculture of marine fish is dominated by mullets produced mainly by Egypt, sea bream is produced entirely in Egypt, Tunisia and Algeria, Sea Bass and meagre are produced in large quantities in Egypt followed by Tunisia while crustaceans, they are produced by Madagascar and Egypt.

Marine fish	Production in Tonnes
Mullets	351 527
Gilthead bream	62 720
Seabass	38 968
Meagre	28 401
Crustaceans	7 000

The share of aquaculture in Africa reached 2.418 million tonnes, and aquaculture production on the continent is expected to grow by 35% in aquaculture production in 2030 to 3.25 million tonnes (FAO, 2022).

Jobs in African Aquaculture

According to FAO (2024), employment in the aquaculture sector is even more concentrated in Asia, which is home to nearly 94.6 percent of the total with more than 20 million jobs including 6 million women. Africa represents about 3 percent, the Americas 2 percent, Europe about 0.5 percent, while Oceania represents the remaining share of global employment in aquaculture (Fig 6).

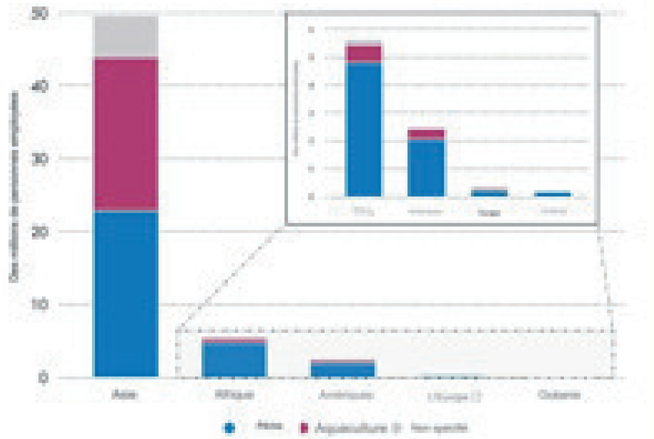


Fig 6: Number of jobs in the fishing and aquaculture sector by continent and by source of production in 2021 (FAO, 2024)

The number of jobs continues to increase in Africa, but remains low compared to that of the fishing sector which generates more than 5 million jobs while the aquaculture sector more than 600 thousand people work in this sector according to the FAO (2024), including 84,000 for female aquaculture employment in Africa with a rate of 14%, while in Asia it is 34%with more than 6 million jobs for Asian women (FAO, 2024),

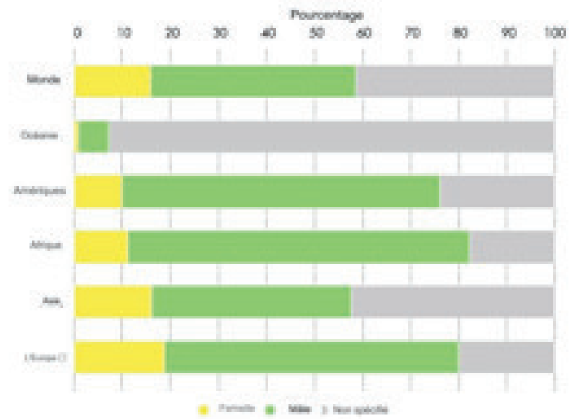


Fig 7: Share of employment in the primary aquaculture sector by continent and gender in 2021 (FAO, 2024)

CONCLUSION

Aquaculture offers prospects for the development of food production in Africa, which allows to provide the African population with more nutritious and respectful of nature in a perspective of improving food and nutritional security, with the generation of income and jobs. This sector in Africa with political support, has the challenge to become more technical (through research and training), and to consolidate as a world-class industry, as it has the potential to become a new pillar of the African blue economy and it is important that it develops in a sustainable way.

ENVIRONMENTAL IMPACTS OF TILAPIA FISH CAGE AQUACULTURE ON WATER PHYSICO-CHEMICAL PARAMETERS OF LAKE KIVU, DEMOCRATIC REPUBLIC OF THE CONGO

By : Sharon Indasi Lubembe. Department of Biology, Section: Hydrobiology, Official University of Bukavu, Bukavu, Democratic Republic of Congo

In Africa, cage aquaculture has been growing due to its potential to address food insecurity concerns, provide livelihoods, and contribute to local economies. However, there is a need for continued research on the sustainability and potential ecological effects of cage aquaculture in African lakes and reservoirs, therefore, continuous monitoring of water quality in these aquatic environments should be carried out to inform management decisions and for sustainable aquaculture.

INTRODUCTION

Fish cage farming has become the most popular aquaculture method of bridging the gap between diminishing wild fish output and increased consumer demand. Expanding fish production in existing water bodies such as lakes, oceans, dams, reservoirs, and large rivers has been used to ensure this is achieved. Curbing food insecurity issues has become less difficult in most places due to the ability to raise fish in cages at high densities for high production, which makes it possible to feed the growing human population driven by urbanization, increased awareness of the nutritional and health benefits of fish, and increases in income.

African inland waters have embraced tilapia fish cage culture operations broadly, and more will do so as the advantages per unit volume of water become more apparent. In addition, the low investment cost, convenience of installation and maintenance are also contributing to the expansion of cage activities. This is evident in Lake Victoria, where a rise in cage numbers from 1,663 to 4,537 between 2016 and 2019 and to 6,000 in 2021 is a glaring sign of sustained acceptance of cage aquaculture. World inland aquaculture production as of 2021 was at 50% of the total fisheries production whereas in Africa, aquaculture contribution was at 18% with inland aquaculture constituting 92% of the total aquaculture production (FAO, 2022).

According to FAO (2022), inland aquaculture in Democratic Republic of the Congo (DRC) has been on a slow but gradual rise. For instance, in 1984 only 81 metric tons were recorded and the amount kept on rising until 2011 when it was 3,030 mt. Thereafter, it dropped to 2,929 metric tons in 2012 and started rising gradually again from 2013 to 2020 when it was reached 3,590 metric tons (FAO, 2022). In 2014, 150 cages were reported in Lake Kivu on the Rwanda side and in 2021, some cages were recognized in the DRC side .

Regardless of the significance of cages for fish production, concerns about the environmental impact of cage aquaculture have been highlighted in different water systems. However, the impacts are determined by the intensity of production, water volume or depth, water exchange rate, and geology of the area. According to Wu (1995), the effects of cage aquaculture on physico-chemical properties are depths-specific. Freshwater systems, for example, are more vulnerable to nutrient loads than marine systems due to their smaller size and frequently poorer biological carrying capacity. Fish cages have a high potential for degrading water quality due to the release of particulate and dissolved nutrients like uneaten feeds, metabolites and wastes directly introduced to the lake, potentially causing eutrophication, which is the main concern of African inland water systems.

For instance, pproximately 132 kg of nitrogen and 25 kg of phosphorus are discharged with each ton of fish produced at the end of each culture period. Furthermore, Gondwe et al. (2011) found that (81–90)% of organic waste released during tilapia cage culture is discharged into the water body, which may have deleterious effects on the cultured fish and the environment.

The enrichment of organic matter and nutrients in the sediment, on the other hand, supports the growth of microorganisms and can ultimately lead to increased greenhouse gas emissions from fish culture areas.

Cages are also characterized by the release of nitrogen, phosphorus and organic matter whose overenrichment in water fastens the rate of primary production leading to eutrophication. Cases of depletion of oxygen levels due to respiration in the cages and degradation of organic wastes end up increasing biochemical oxygen demand (BOD) and chemical oxygen demand (COD). Furthermore, cases of algal bloom, ammonium buildup, increased level of suspended solids, and decreased water clarity (increased turbidity) and pH have been reported. The water quality status of various African lakes has been sufficiently studied, with most studies showing that these waters are increasingly organically polluted over the years. Among other causes of this pollution, floating cages have been mentioned mainly in Lakes Volta and Victoria.

Lake Kivu's ecological functioning and services are gradually declining, and it has received less attention in terms of anthropogenic disturbance documentation. The catchment region has been related to instability by environmental changes in its littoral zone and deterioration of water quality. Several anthropogenic activities, including the rapid urbanization of sizable towns built along the lake, the development of navigation ports, and high human population growth, are directly linked to changes in water quality, both in the Democratic Republic of the Congo (DRC) and Rwanda. Despite the propensity of cage aquaculture in its littoral waters, the effects of these cages on the lake's water quality and ecological condition are virtually undocumented. This study assessed the potential influence of tilapia cage culture on the spatio-temporal dynamics of physico-chemical water quality parameters in Lake Kivu. The specific objective of the study was to determine the spatio-temporal dynamics in water quality and trophic status of Lake Kivu in the Bukavu sub-basin at vertical profiling scale. We hypothesized that there are both spatial and temporal (monthly) changes in water quality and trophic status as a result of the physical location of the cages.

MATERIALS AND METHODS

STUDY AREA

Lake Kivu is located south of the equator between, with an area of 2,370 km2. It has a maximum depth of 475m and an average depth of 240m making it the world's twentieth's deepest lake by maximum depth and thirteenth deepest by mean depth. It forms a natural border between the DRC and the Republic of Rwanda with 58% of the waters in the DRC and the remaining 42% in Rwanda.

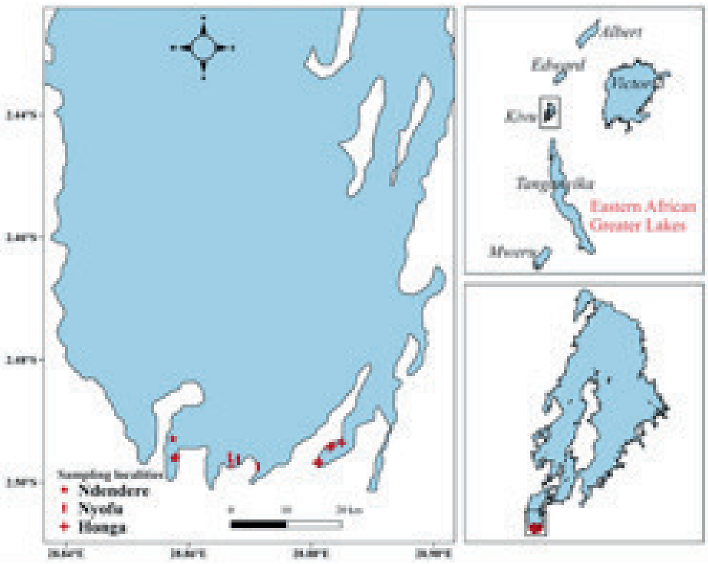


Fig 1: Map of the study area showing the sampling stations in Lake Kivu, Bukavu sub-basin, Democratic Republic of Congo

STUDY STATIONS

Three stations, Ndendere, Honga, and Nyofu (Figure 1) were selected in the Bukavu sub-basin for the current study. The two cage stations, Ndendere and Honga, were chosen because they have been having tilapia cage aquaculture activities for a long time (at least 1 year of operation). On the other hand, Nyofu was chosen as the control station because there were relatively few anthropogenic disturbances and it didn't have cages. Each station had a total of five measures which were represented by the depths sampled (0 m, 5 m, 10 m, 15 m, and 20 m). The geographical coordinates of each sampling station (Table 1) were taken by a handheld GPS navigational unit (Garmin II unit).

Table 1. Location and characteristics of sampling stations considered for this study.

Station name	GPS coordinates	Depth (m)	Characteristics
Ndendere	• S02°29.759′ • E028°51.453′	• 0 m • 5 m • 10 m • 15 m • 20 m	A caged station in the Ndendere bay, 3.09 km from Nyofu with 2 years under its belt, the station has 21 cages in total each with dimensions of 6*6 m^2 and 5*5 m^2, but only 10 active cages eight for post adults fish and two for fingerlings. Major species of culture is *Oreochromis niloticus*. Feed fed to fish is both commercial and locally sourced. Water physico-chemical parameters were taken at each depth.
Honga	• S02°29.612′ • E 028°53.099′	• 0 m • 5 m • 10 m • 15 m • 20 m	Caged station at Honga bay 3.29 km from Nyofu with 12 of the 32 cages at the Honga location, which has been operating for 5 years, extremely active during the time of the study. Of the 12 active six are for fingerlings other 6 for adults. Cage sizes is 6*6 m^2 with major species of culture being *Oreochromis niloticus*. Culture period is10-11 months. Feed fed is commercially sourced. Water physico-chemical parameters were taken at each depth.
Nyofu	• S02°29.747′ • E028°52.002′	• 0 m • 5 m • 10 m • 15 m • 20 m	Cage free station at Nyofu bay, 3.29 km to Honga and 3.09 km to Ndendere with little or no disturbances, hence considered stable station, control for vertical profiling. Water physico-chemical parameters were taken at each depth.

MEASUREMENT AND ANALYSIS OF WATER QUALITY PARAMETERS

UA monthly sampling activity was done for 6 months (April to September 2023) covering the dry (June, July, and August) and wet (April, May, and September) seasons. Water temperature, pH, electrical conductivity and dissolved oxygen concentration (DO) were measured in situ using a Plus multi-parametric Field Probe (YSI 550) from different depths (0 m, 5 m, 10 m, 15 m, and 20 m). Turbidity measurements were done in situ by a portable turbidimeter probe (HACH 21000Q) following APHA et al. (2017).

Extraction and determination of chlorophyll-a concentration

In the laboratory, the water samples collected in the 4L bottles from different depths (0 m, 5 m, 10 m, 15 m, and 20 m) in the field, for the extraction of chlorophyll-a, and determination of chlorophyll-a concentration.

Nutrient analysis

Ammonium (NH4+), nitrite ($NO2^-$), soluble reactive phosphate (PO_4^{3-}) and silicate (SiO2) were determined with respect to standard colorimetric methods of UV-visible spectrophotometric analysis of water samples in the laboratory (APHA et al., 2017).

Water quality index estimation

Indicators of water pollution, such as water quality index (WQI), organic pollution index (OPI) and Carlson trophic state index (CTSI) were estimated in accordance with Debels et al. (2005), Kannel et al. (2007), and Sánchez et al. (2007) methods.

RESULTS AND DISCUSSION

All physico-chemical parameters and Chl-a values showed little to no variation vertically 0 m to 20 m depth and among the stations (Ndendere, Honga, and Nyofu). Most parameters apart from Secchi Disk, pH, Turbidity did not vary both spatially and temporally hence the lack of significant influence of the tilapia fish cages on water quality in the lake. Most of the physico-chemical parameters except pH, were within the standard limits for aquatic life an indication that water quality is currently not a challenge from the fish cage culture. Based on the calculated CTSI results, the depths in the stations ranged from mild to medium eutrophic status. Similarly, the OPI showed little pollution and the WQI showed that the water quality state ranged from medium to good, indicating that cage culture had no significant effect on water quality parameters in the respective stations.

CONCLUSION

As it is advisable to implement rotation planen for aquaculture sites to provide recuperation periods for the ecosystem and prevent localized environmental strain. Furthermore, monitoring of feeds administered to fish should be done to ensure high quality nutrient rich feeds are used to reduce potential-negative effect on water quality. Lastly, regulatory measures on cage design, stocking density and waste management and above all regular monitoring programs should be implemented to assess compliance of aquaculture operations with environmental standards, with penalties for non-compliance. But, to ensure the sustainability of cage farming in Lake Kivu a comprehensive approach that considers both local and systemic factors is needed. As it is advisable to implement rotation planen for aquaculture sites to provide recuperation periods for the ecosystem and prevent localized environmental strain. Furthermore, monitoring of feeds administered to fish should be done to ensure high quality nutrient rich feeds are used to reduce potential-negative effect on water quality. Lastly, regulatory measures on cage design, stocking density and waste management and above all regular monitoring programs should be implemented to assess compliance of aquaculture operations with environmental standards, with penalties for non-compliance.

IN MOROCCO THE NATIONAL AGENCY FOR THE DEVELOPMENT OF AQUACULTURE ORGANIZED THE 3RD MARINE AQUACULTURE FORUM

The National Agency for the Development of Aquaculture (ANDA) in Morocco, organized the 3rd Marine Aquaculture Forum, on February 2, 2024 in Tangier, under the theme: Strong partnership for a sustainable aquaculture industry. This highly anticipated new edition of the aquaculture forum brought together all the actors involved in the aquaculture ecosystem, with Spain as guest of honor. This is an opportunity to reaffirm the commitment of the two countries to work together to strengthen bilateral cooperation, particularly in the aquaculture sector.

The aquaculture activity in Morocco is currently positioned among the promising sectors, contributing to play an important role of lever for an inclusive blue economy. Currently, the sector has 143 farms installed in the various regions of the Kingdom for a production eventually of more than 75,000 tons/ year and the creation of 1700 direct jobs.

In addition, 66 projects are being installed with an annual target production of about 24,000 tonnes/year, generating nearly 626 direct jobs.

This success stems from the development vision of ANDA, which has set up a programme to facilitate procedures for investors, to support them closely and to encourage them.

This program resulted in the drafting of Law No. 84.21 published in January 2023, which governs marine aquaculture in Morocco, and offers investors clear visibility on their rights and obligations.

It should be noted that ANDA has also strengthened the aquaculture sector by carrying out careful planning of the national coastline, identifying a natural potential of nearly 24000 hectares for the development of aquaculture. To this end, 10 regional aquaculture plans have been carried out, covering more than 2,300 kilometres of coastline in 8 regions of the Kingdom.

ESSENTIAL AMINO ACID REQUIREMENTS OF FISH AND CRUSTACEANS

A meta-analysis of literature data on essential amino acid (EAA) requirements of fish and crustaceans was performed to re-estimate EAA requirements and provide ideal amino acid profiles. An extensive search and inclusion of literature on EAA requirements were conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines in this study, resulting in a dataset of 358 studies covering 77 species.

In recent years, the state of global food security and nutrition has been undermined by climate variability, conflict, economic downturns and pandemics. The reliable and stable supply of high-quality protein and energy-rich ingredients as food ingredients with a low environmental footprint is an essential condition for the sustainable development of aquaculture. Reducing dietary protein levels while ensuring an ideal amino acid profile that meets animal needs is an effective way to optimize production costs and minimize nitrogen losses in livestock. It is widely recognized that aquatic animals do not specifically need protein, but rather need a well-balanced blend of amino acids obtained from the diet.

Amino acids serve as substrates for protein synthesis and contribute to the growth of aquatic animals. In addition, they play an essential role in regulating food intake, intermediate metabolism, cell signaling, immune response and health of farmed animals, including fish and crustaceans (EAAE or IAA), conditionally essential amino acids and non-essential (or dispensable) amino acids. In all fish and crustaceans studied, the same 10 EAAs must be provided in their diet: arginine (Arg), histidine (His), isoleucine (Ile), leucine (Leu), valine (Val), lysine (Lys), methionine (Met), phenylalanine (Phe), threonine (Thr) and tryptophan (Trp).

Since any imbalance of amino acids is likely to disrupt protein synthesis and turnover, resulting in harmful consequences such as nitrogen loss in the environment. Therefore, determining the specific requirements and limiting order of AIS is of paramount importance for the sustainable development of aquaculture.

Statistical meta-analysis provides a method for integrating and standardizing information, allowing meaningful comparisons. In animal science, meta-analysis has proven to be an effective way to renew previously published data by creating new empirical models, allowing advances in understanding and prediction.

The study was able to provide accurate estimates of the ideal intake of each EAA in fish and crustaceans, expressed as a percentage of their total intake of crude protein, thus playing a nutritional roadmap, which will help researchers and aquaculturists to feed these aquatic animals with optimal feeding strategies, and thus contribute to more sustainable aquaculture by limiting nitrogen emissions.

The results of the re-estimated requirements for Arg, His, Ile, Leu, Val, Lys, Met + Cys, Phe + Tyr, Thr and Trp by meta-analysis are summarized in Table 1. In animals, tyrosine (Tyr) and cysteine (Cys) can be synthesized from Phe and Met, respectively. Therefore, the dietary requirement for these EAA depend on the dietary concentration of the corresponding precursors.

TABLE: RE-ESTIMATION VALUE OF ESSENTIAL AMINO ACID REQUIREMENTS ACCORDING TO THIS STUDY

	Fish	Crustacean
Arginine	5%	5,1%
Histidine	2%	2,5%
Isoleucine	3,3%	4,3%
Leucine	4,9%	5,7%
Valine	3,8%	4,3%
Lysine	5,2%	4,9%
Methionine + Cysteine	3,5%	3,2%
Phenylalanine+ Tyrosine	6,2%	5,1%
Threonine	3,5%	3,8%
Tryptophan	0,9%	0,8%

Note: Data are expressed as % crude protein.

From the results of the table it turns out that the AAE requirements of fish and crustaceans have many similarities, arginine, isoleucine, leucine, lysine and threonine were particularly important for both groups but with subtle differences in their AIS requirements, as crustaceans seemed to require a little more valine and histidine.

The requirements of the EAA are influenced by several factors such as the diet of aquatic animals, their position in the food chain and water temperature, all these factors influence their needs. So understanding the specific food needs, allows to formulate better and more effective food for fish and crustaceans, to optimize the use of amino acids for protein-rich fish and shrimp production, with less environmental impact and ultimately contribute to more sustainable aquaculture production.

Source: Review Essential amino acid requirements of fish and crustaceans, a meta-analysis. (Kaushik et al., 2023). December 2023. Reviews in Aquaculture DOI: 10.1111/raq.12886.

CHALLENGES AND SOLUTIONS OF ADDRESSING PHOSPHORUS WASTE IN OPEN FLOW FRESHWATER FISH FARMS

In order to reduce phosphorus pollution from open flow fish farms, it is necessary to have a good understanding of the mechanisms that affect phosphorus retention and uptake in aquaculture fish. Knowledge of these mechanisms is essential to enable fish farmers to develop strategies to reduce phosphorus pollution in open flow freshwater farms and improve the sustainability of aquaculture.

1. INTRODUCTION

Aquaculture, like other forms of agriculture, has environmental impacts. Farmed fish release nitrogen and phosphorus, which, if left untreated in water effluents, enter surface water bodies and cause eutrophication. Fresh water fish farms may also discharge veterinary drugs and antibiotics, harming aquatic biodiversity, causing the accumulation of antibiotics, and increasing antibiotic resistance. Aquaculture has experienced rapid growth throughout history, driven by the increasing demand for seafood and the over-exploitation of fish stocks. As the industry strives to address food security concerns, fish nutrition plays a vital role in ensuring the sustainability of the sector.

To achieve this, researchers are exploring new feed compositions and ingredients that can optimize fish health and performance. Phosphorus holds a dual significance in fish nutrition. Firstly, it is an essential ingredient in fish feeds, since it is required for various physiological processes, including bone formation, energy metabolism, and cellular functions. Adequate phosphorus levels in fish diets are crucial for promoting growth and overall well-being. However, phosphorus also presents a potential challenge in terms of environmental pollution. Excessive phosphorus discharge from aquaculture operations can lead to water eutrophication, algal blooms, and other negative impacts on aquatic ecosystems.

Phosphorus runoff from fish farms contributes to the nutrient load in surrounding water bodies, which can have detrimental effects on water quality and biodiversity. To mitigate these environmental concerns, aquaculture endeavours to optimize phosphorus utilization and minimize its environmental footprint. This involves developing innovative feed formulations that enhance phosphorus digestibility and absorption in farmed fish, thereby reducing phosphorus excretion into the environment. Additionally, techniques such as precision feeding, which aim to match feed supply with the nutritional requirements of fish, help prevent excessive phosphorus discharge.

By addressing the dual role of phosphorus as an essential ingredient and a potential parameter of pollution, the aquaculture industry can achieve sustainable growth while minimizing its environmental impact. The efficiency of phosphorus retention or absorption in the fish intestine can be influenced by a complex interplay of dietary, anatomical, and physiological factors. As shown in Figure 1, various factors are implicated in the waste of phosphorus generated by farmed fish. Anatomical and physiological parameters, including active transporters, intestinal alkaline phosphatases, and the anatomy and density of microvilliand intestinal folds, play essential roles in determining the efficiency of dietary phosphorus absorption and consequently, the amount of phosphorus wasted by farmed fish.

Research advancements have identified ways to improve these parameters and reduce phosphorus waste. Improved nutrient utilization, including phosphorus retention, can be achieved through the use of probiotics, which directly or indirectly enhance intestinal phosphorus absorption. Probiotics exert their positive effects on phosphorus absorption in fish by modulating gut health and competing with harmful bacteria.

By influencing the composition and balance of the gut microbiota, probiotics create a favorable environment for nutrient, including phosphorus, digestion and absorption. This leads to improved functionality of the intestinal epithelium and enhanced nutrient transport mechanisms, including active transporters responsible for phosphorus uptake. Moreover, probiotics outcompete pathogenic bacteria for nutrients and adhesion sites in the fish gut, reducing their presence and maintaining a healthier gut environment. This competitive exclusion contributes to optimal nutrient, including phosphorus, absorption, which can positively impact phosphorus waste in farmed fish. As a result, probiotics not only improve the efficiency of dietary phosphorus absorption by enhancing various anatomical and physiological parameters but also indirectly reduce the waste of phosphorus in farmed fish. By promoting gut health and mitigating the negative influence of harmful bacteria, probiotics contribute to improved intestinal phosphorus absorption and subsequently help reduce the environmental impact of phosphorus waste in aquaculture systems.

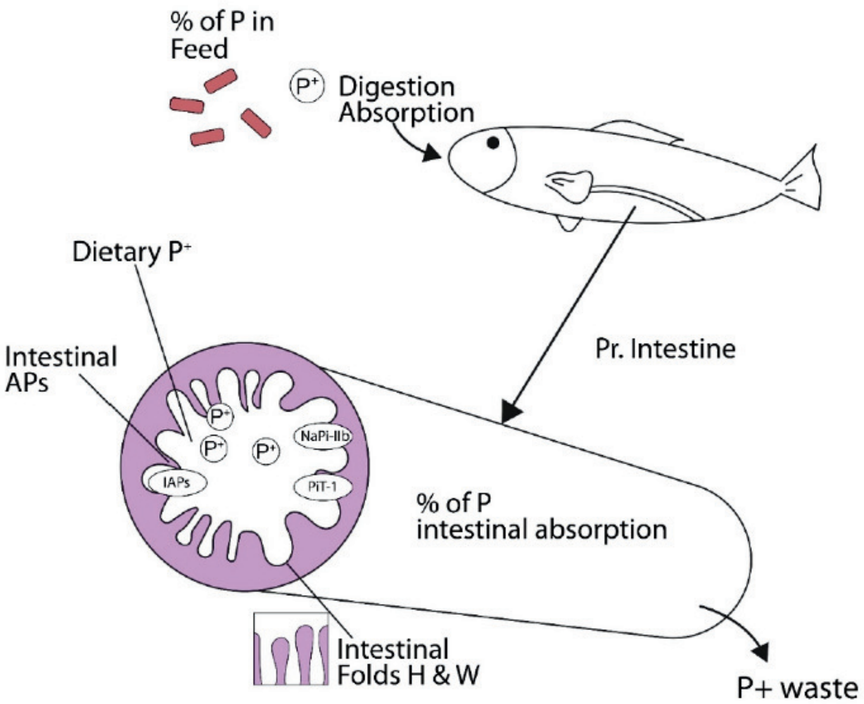


Figure 1.Gut microbiome (epithelium, mucus layer), active transporters (e.g., PiT-1, NaPi-IIb), intestinal alkaline phosphatases (IAPs), and intestinal fold morphology (height and width) are implicated in the efficiency of dietary phosphorus (P+) absorption in the proximal intestinal segment (pr. intestine), affecting the waste of P in farmed fish.

1.1. Phosphorus Requirements of Fish Farmed in Open Flow Aquaculture Systems

Phosphorus is an essential nutrient for fish, playing a crucial role in various physiological functions, including bone formation, tissue growth, acid–base balance, energy metabolism, and reproduction. The phosphorus requirements of fish depend on several factors, such as species, life stage, growth rate, and water temperature. Higher phosphorus requirements are associated with growth and skeletal development, and this is particularly interesting for farmed fish.

Salmonids and other carnivorous fish species are widely cultivated in open flow aquaculture systems, and they require high levelsofproteinintheirdiets. The protein requirement varies depending on the size and life stage of the fish, but generally ranges from 32–45% of the diet. The phosphorus content of salmonids may vary depending on diets composition, it typically ranges from 0.7–1.4%.

1.2. The Environmental Impact of Aquaculture ,with Emphasis on Open Flow Fish Farms

Intensive aquaculture is frequently based on open flow fish farms,which just quickly release the water out flow into neighboring rivers,allowing only limited time for water treatment and resulting in phosphorus release downstream. In most freshwater ecosystems,phosphorus (P) is the limiting nutrient, where as nitrogen (N) is the limiting nutrient in marine ecosystems. As a result, monitoring anthropogenic sourcesof phosphorus in freshwater ecosystems is a useful tool for determining the causes of eutrophication and its environmental impact.

One possible source for phosphorus in rivers and lakes is aquaculture feed. However, farmed fish require phosphorus in their diet. Diets lacking in phosphorus can lead to severe pathological problems in farmed fish. Phosphorus-containing fish feeds can contribute to aquatic pollution by releasing uneaten feed, feces, and metabolic wastes of farmed fish.

2 .IMPORTANCE OF NUTRIENT UPTAKE

The physiological mechanisms involved in the intestinal absorption of phosphorus in farmed fish are complex and multifaceted, and are influenced by various nutritional and physiological factors such as pH, calcium and anti-nutritional factors (Figure 2). Understanding these mechanisms is important for optimising the formulation of fish diets and improving the efficiency and sustainability of aquaculture production.

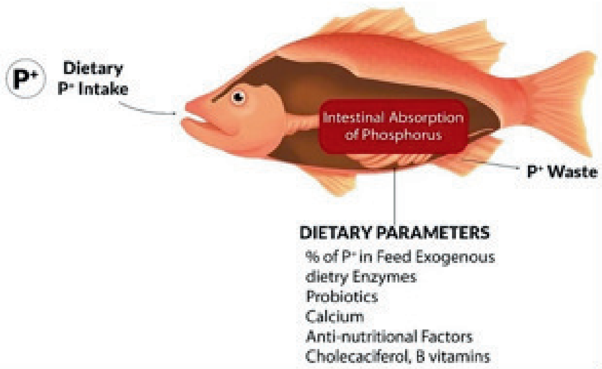


Figure2 :Dietary factors affecting phosphorus waste of farmed fish

3. STRATEGIES FOR REDUCING PHOSPHORUS PLUTION IN FW FISH FARMS

To reduce phosphorus pollution from open flow fish farms and make aquaculture more sustainable, the researchers suggest adopting a sustainable approach on several fronts:

Optimising feed composition: Adjusting the composition of fish feed can have a significant impact on phosphorus discharges. It is essential to develop feeds that maximise nutrient utilisation and minimise phosphorus waste.

Functional ingredients: Incorporating functional ingredients into feeds such as probiotics, which improve nutrient uptake and reduce waste, can play a crucial role in sustainable aquaculture practices.

- Mitigation of anti-nutritional factors: Processing methods and the use of functional feed additives can help mitigate the presence of anti-nutritional factors in fish diets, which can lead to better nutrient utilisation.

- Gut health management: It is fundamental to ensure that fish have a healthy gut. This can be achieved through proper nutrition and disease management, which can improve nutrient retention.

- Phytoremediation and absorbent materials: Treating aquaculture effluent using bioremediation techniques and absorbent materials removes phosphorus from the water and prevents it from entering the environment.

4. CONCLUSION

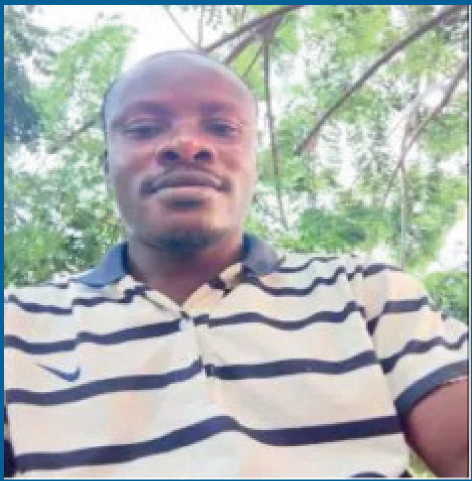
A number of methods and strategies can contribute to reducing phosphorus pollution from fish farms, a holistic approach encompassing various factors must be considered. Good food management, water quality monitoring and nutrient cycling play a critical role in effectively addressing phosphorus-related environmental concerns. By understanding phosphorus uptake mechanisms, dietary factors, antinutritional substances and intestinal morphology, we can optimize aquaculture practices to reduce phosphorus release.

REFERENCE (OPEN ACCESS)

Nathanailides, C.; Kolygas, M.; Tsoumani, M.; Gouva, E.; Mavraganis, T.; Karayanni, H. Addressing Phosphorus Waste in Open Flow Freshwater Fish Farms: Challenges and Solutions. Fishes 2023, 8, 442. https://doi.org/10.3390/fishes8090442

OPTIMIZATION OF FEED FOR NILE TILAPIA USING AN EXCEL PROGRAMMING MODEL IN SMALL SCALE FEED MIXING OPERATIONS IN TOGO

By : Dr Boma Soudah



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Institut Togolais de recherche Agronomique (ITRA), P.O. Box: 1163, Cacavéli-Lomé ; Ministère de l'agriculture, de la production animale et halieutique, Togo /International Center for Research and Development on Livestock in the Subhumid Zone (CIRDES).

Higher input prices for aquaculture feed formulation impede the development of aquaculture, in this regard, fish farmers need tools to cope with the scarcity or rising prices of aquaculture feed.To this end, a research teamTogolais has developed an Excel tool for the formulation of low-cost foods that meet the nutritional needs of tilapia.

INTRODUCTION

Short-term animal breeding, particularly tilapia fish farming in Togo, is growing rapidly after several years of lethargy. Annual aquaculture production from earthen ponds and floating cages increased from 20 tonnes in 2012 to over 132 tonnes in 2017, mainly tilapias, followed by catfish. However, total aquaculture production remains at a deficit of 55,000 tonnes per year. In aquaculture, which was to contribute to reducing imports of fish in the medium term, however, depending on imports, especially in fish feed, the acquisition cost of which is about 80% of the total production costs.

The regional context exacerbated by health (COVID-19 health crisis), security and social crisis is increasingly drowning out government subsidies for food affordability and access, resulting in food shortages. To this end, any efforts aimed at reducing the local production of fish feed, and especially reducing its costs, will have a major impact on the significant improvement in aquaculture productivity in Togo.

DATABASE BUILDING

RAW MATERIALS

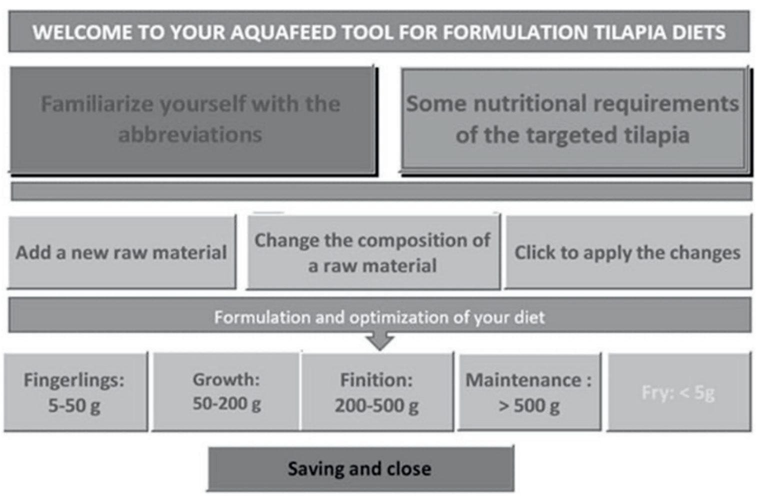
The RMs for feed formulation from various regions of various agroecological zones of Togo were identifed and selected for use. A list of 25 ingredients available in Togo was selected for fsh diet formulation. In the database, by default, the nutritional values specifed in the international databases on aquaculture feed formulation (Lukuyu et al. 2014; IAFFD 2020; Adéyèmi et al. 2020) were used. In addition, to balance the rations to be manufactured, concentrated RMs (vitamin premix, 0.5%, vitamin C, L-lysine, DL-methionine, and salt) were added to the database (Additional Material 1).
These RMs have been selected for Togo's fsh diet formulation because of their nutritional value (including, crude proteins, lipid and starch contents, amino acid profle and digestible energy), availability in Togo and other West African countries, ease of packaging, volume and regularity of production and price .

SPECIFC NUTRITIONAL CONSTRAINTS OF THE INGREDIENTS USED

The formulas were based on the parameterization of maxima/minima restrictions, the costs of the RMs and the nutritional needs of the fsh. Constraints are equations and inequations that defne the user's decision limits regarding the use of ingredients. Decision variables describe the optimal amount of RMs provided to the user.

NUTRIENT REQUIREMENTS

The average specifc intake of nutrients for the growth phases is given in Table 3. It is important to note that, on the national and sub-regional scale (West African) of the study area, there are very little data on these nutrition restrictions/requirements for Nile tilapia. Thus, the data were mainly derived from overseas research. To simplify the tool and take into account the available information on the nutritional value of the RMs in the study area, only 16 nutrients were considered.



Screenshot of the start menu of the tilapia feed formulation tool. Source: Soudah et al. (2023).

FEED FORMULATION

In theory, effective feed formulation involves understanding the energy and nutritional needs of fish, the energy and nutrients present in local raw materials and supplements.

Additionally, factors such as physical properties, inclusion limits, the presence of antinutritional factors and toxic elements, prices, and availability must be considered.

On the other hand, manual arithmetic formulation of low-cost and balanced rations becomes complex when specific ingredient limitations are taken into account.

To address this complexity, some feed formulation tools have been developed.

MODEL CONSTRUCTION PROCESS

The process of developing the feed formulation model for tilapia was as follows:

Exploratory study to investigate the availability of raw materials used in fish feed production.

Construction of a database containing nutritional information of the inventoried ingredients from the previous step.

Programming and testing tool, which was developed using Microsoft Excel's Solver scenario formulation algorithm based on the established database.

EVALUATION OF THE MODEL

"The proposed Excel model in this study for fish feed formulation and cost optimization can be considered as an available solution for Togo, as the Excel formulation makes software access easy and simplifies feed formulation," the scientists emphasized.

Furthermore, the developed tool allows users to choose the cheapest combination of inputs that meet the nutritional needs of tilapia. For example, users can select specific raw materials for formulation according to their environment and modify certain values of the chemical composition of the raw materials.

In the medium term, the model will play an important role in implementing local-scale fish feed production, as the raw materials registered in the database are already being used by local feed manufacturers.

Overall, the feed formulation tool enables the formulation of lower-cost feeds that still meet the nutritional needs of the target animals.

On the other hand, the tool offers the necessary flexibility for users to vary the inclusion limits of all raw materials in the database and add new ones if necessary.

CONCLUSION

"The results obtained from the tool indicate that feed manufacturers with basic knowledge of Excel and the ability to analyze the proximate content of ingredients before formulation can formulate fish feeds at a relatively low cost ranging from $0.4 per kilogram (for growth and final diet) to $1.07 (for juvenile diet), Hence, with this tool, small and medium fsh feed manufacturers will be able to develop new formulations at a lower cost, verify the nutritional qualities of known formulas and thereby improve the technical and economic performance of the fsh farming chain.

OPTIMAL POST-HARVEST FISH HANDLING PRACTICES IN AQUACULTURE: ENSURING SUPERIORITY AND LONGEVITY

Aquaculture Enthusiast and Consultant MD at Enam Deedew Fish Processing Sales Manager at Vees_treets. Accra. Ghana

By : Dorcas (Abena Baawah) Appiah :

Aquaculture plays a pivotal role in meeting the ever-increasing demand for nutritious protein around the world. However, successful aquaculture does not end with production alone. Proper post-harvest management of fish is also crucial to maintain quality, freshness, and market value. In this article, we will explore some of the most effective post-harvest fish handling practices that farmers can implement to ensure excellence throughout the supply chain.

Correct harvesting techniques are essential for maintaining superior fish quality. Selective harvesting allows farmers to choose only those fish that have reached optimal size and maturity levels for peak quality and flavor. By doing so, they can ensure that their products meet the highest standards. This practice involves carefully selecting and harvesting fish that have reached the desired characteristics, such as size, color, and texture. This ensures that the fish have developed the appropriate flavors and textures sought after by consumers.

Gentle handling during harvesting is crucial to preserve flesh quality and overall fish health. Fish are delicate creatures, and rough handling can lead to stress and injury. This can negatively impact the quality of the fish, resulting in flesh damage, and bruising. Gentle handling techniques, such as the use of soft nets, gentle transportation, and avoiding unnecessary agitation, help minimize stress and maintain the integrity and aesthetic value of the fish.

Quick harvesting is another important practice to prevent spoilage and maintain freshness. By reducing the elapsed time between fish removal from water and processing, farmers can minimize the risk of bacterial growth and enzymatic activity. This practice involves efficient and prompt processing immediately after harvesting. It includes streamlined processes, efficient transportation, and effective communication between the harvesting team and processing facilities.

Temperature plays a paramount role in maintaining high-quality fish standards. Proper temperature management is critical for preserving freshness while extending shelf life. One popular method used immediately after harvesting is icing the harvested fish rapidly within a range of 0-4ºC (32-39ºF) to slow bacterial growth and enzymatic activity. Ensure that ice is made from potable water to prevent contamination.

The use of ice helps to maintain the low temperature necessary to slow down bacterial growth and enzymatic activity, ensuring that the fish remain fresh and of high quality. This icing process is often done by placing the fish inside boxes filled with plenty of ice at the bottom of the container and in alternating layers with the fish. The ice acts as a coolant, ensuring that the fish are rapidly cooled to the desired temperature. It is crucial to drain melted ice water correctly from these boxes to prevent fish from sitting in water, which could lead to deterioration in quality. For long-term storage, cold storage facilities with appropriate temperature control should be used to maintain the quality of chilled or frozen fish during transportation and storage.

These facilities provide controlled environments with specific temperature and humidity settings to ensure that the fish remain in optimal condition. By maintaining the proper temperature throughout the entire supply chain, farmers can extend the shelf life of their fish and ensure that it reaches consumers in the best possible condition.

Furthermore, maintaining high hygiene and sanitation standards is imperative to prevent contamination and ensure product safety. Clean workspaces and water supply are essential aspects of maintaining hygiene during post-harvest handling. Using clean tap, filtered, or distilled water at all times is crucial to prevent the introduction of contaminants. Regularly washing equipment, tools, and surfaces used during handling processes helps eliminate potential sources of contamination. This includes thorough cleaning and sanitization of knives, cutting boards, processing equipment, and work surfaces between each batch of fish. Moreover, ensuring good personal hygiene is vital in preventing the spread of pathogens.

Farmers and workers involved in post-harvest handling should maintain good personal hygiene practices, including regular handwashing with soap and water, wearing clean protective clothing, and using gloves whenever necessary. Implementing separation of processing areas for different stages, such as gutting, filleting, and packaging, further reduces cross-contamination risks. By designating separate areas or zones for specific processing tasks, farmers can prevent the transfer of contaminants from one stage to another. This helps maintain the integrity and safety of the fish products throughout the handling process.

This ensures that the fish retains its natural flavors and characteristics, providing consumers with a superior eating experience. Storage conditions, including proper humidity and temperature levels, must be maintained within storage facilities to ensure the integrity of the products. Humidity control helps prevent moisture content fluctuations, which can lead to texture changes and quality deterioration. Additionally, maintaining the proper temperature in storage facilities is essential to prevent the growth of spoilage bacteria and maintain the freshness of the fish. By ensuring optimal packaging and storage conditions, farmers can extend the shelf life of their products and deliver high-quality fish to the market.

Implementing quality control measures and tracing systems ensures consistent quality and addresses potential issues. Regular quality checks should take place at every handling stage before reaching consumers. This includes inspecting the fish for freshness, appearance, odor, and texture, ensuring that only high-quality products reach the market. Quality checks also involve monitoring the temperature throughout the supply chain to ensure that the fish remains within the desired temperature range. Implementing batch tracking systems enables quick identification and resolution of any concerns regarding quality and safety. By tracing each batch from the farm to the market, farmers can quickly identify the source of any issues and take appropriate actions. This ensures that any potential quality or safety concerns are addressed promptly, maintaining the reputation of the farm and the overall quality of the fish products.

CONCLUSION

In conclusion, adopting optimal post-harvest handling procedures in aquaculture operations is critical to ensuring the freshness, and market value of fish products. By implementing adequate harvesting procedures, temperature control, cleanliness and sanitation measures, appropriate packaging and storage, and quality control and traceability systems, farmers can increase consumer satisfaction and contribute to the expansion of their businesses. Customers are willing to pay more for high-quality produce, and by striving for the highest standards in post-harvest fish handling, farmers can meet these demands and contribute to the growth of sustainable aquaculture.

AQUACULTURE IN MALI, A SECTOR SUPPORTED BY THE PRIVATE SECTOR

The fishing and aquaculture sector in Mali is positioned as a key player in economic development through its generation of employment, thus contributing to the fight against unemployment and the improvement of the living conditions of Malian citizens, in addition to its role in food security to meet the nutritional needs of the population.

In 2022, fish production reached an impressive 110,366 tonnes of fish. Of these, 8,752 tonnes come from fish farming, placing Mali among the leading African producers of freshwater fish, especially Nile tilapia species and catfish. These figures reflect the dynamism and potential of the sector, as well as Mali's commitment to developing and promoting the aquaculture sector.

As part of the promotion of this sector in Mali which is in the development phase and in order to boost fish farming in this country, this prmotion is boosted in recent years by private aquaculture companies, including the Boubacar Diallo Fish Farm, founded by its promoter Boubacar Diallo, the CEO of the fish farm, which received the prestigious trophy for "Best African Promoter of the Fish Farming Sector", in Kigali, Rwanda in 2022.

Boubacar Diallo Fish Farm (BDFF) was created in 2008 and covers an area of 10 hectares. This vast estate includes a hatchery, reinforced concrete ponds, and floating ponds and cages.

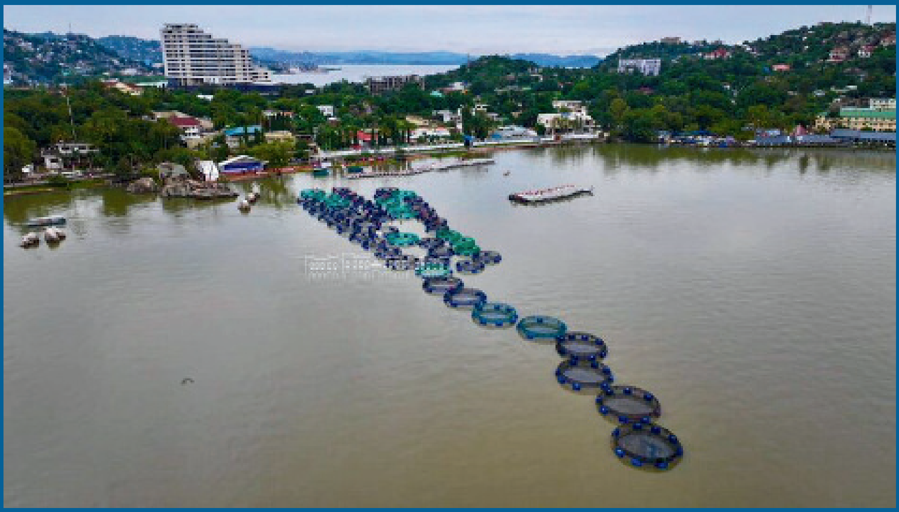
Boubacar Diallo fish farm is also its Centre for technical and practical training in fish farming, for fish farmers and young people wishing to undertake in the professions of fish farming.

Since feeding is the main cost of fish farming, and to feed fish raised on the fish farm, the company Diallo opened a fish feed production plant in 2021 with a production capacity of 30,000 tonnes of floating fish feed per year, in order to solve the problem of fish feed, distributed throughout Mali, as it is exported, to Guinea and Burkina Faso.

TANZANIA PRESENTS STRATEGIC ROADMAP TO BOOST AQUACULTURE AND FISHERIES SECTOR

President Samia Suluhu Hassan of Tanzania unveiled a comprehensive strategic roadmap to fully exploit the potential of the fisheries and aquaculture sector in Tanzania, as she highlighted the key initiatives during the launch and distribution of fish cages in the lake area regions, a project carried out by Aquacaquom Limited of Tanzania.

President Samia also unveiled plans to introduce cage aquaculture in the Great Lakes, Emphasizing the Authority's commitment to maximizing the benefits of the fisheries and aquaculture sector to increase the contribution of these to national income.



Minister Ulega revealed that the fisheries and aquaculture sector provides jobs for more than four million Tanzanians, and that Tanzania is working to revitalize its fisheries sector, these initiatives underscore the Government's commitment to economic growth, job creation and sustainable management of aquatic resources.

For his part, Mwanza Regional Commissioner Amos Makalla discussed the decline of the fish population in Lake Victoria, attributing it to illegal fishing practices, Following a study conducted between 2018 and 2022 that showed that fish in Lake Victoria declined by 30%, the region took decisive action, establishing 11 strategies to control illegal fishing and promote sustainable practices.

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Cage culture aquaculture technique known to raised fishes or other aquatic organism in enclosed enclosures submerged in natural water bodies. The core ideas, benefits, difficulties, and sustainable elements of cage culture are all covered in this article. We want to provide readers a thorough grasp of this cutting-edge practice by looking at its adaptability, advantages and environmental effects.

INTRODUCTION

Fish are raised in net cages that are suspended in water, such as lakes, rivers, reservoirs, and coastal areas, under the practice of cage culture. Fish are commonly raised in cages because they are relatively affordable and simple to maintain. Due to the fact that it doesn't consume fresh water or land, it is also an environmentally sustainable technique of aquaculture.

The ability of cage culture to produce sustainable seafood while reducing the environmental impact of conventional fishing and land-based aquaculture has received respect. Different sizes and shapes of cage culture systems are possible. Typically, nets that are supported by a frame make up the cages. The frames may be made of plastic, metal, or wood. Using anchors and ropes, the cages are fastened to the water body's bottom.

TYPES OF CAGE CULTURE

Since they were first created, cages have advanced significantly, and there are now many different types and designs available. There are numerous ways to categorize different kinds of cages; Beveridge (1996) suggests four fundamental types:

a) Fixed
b) Floating
c) Submersible
d) Submerged

FIXED CAGES

Used most frequently in deep, protected waters, fixed cages are anchored to the ocean floor. They can be used to cultivate a wide range of fish species and are the most popular kind of cage culture system.

FLOATING CAGES

Usually used in shallow, exposed waters, floating cages are anchored to the bottom of the body of water using floats. They are not appropriate for all fish species and are less stable than fixed cages.

SUBMERSIBLE CAGES

Depending on the needs of the fish being raised, submersible cages may be lowered below the water's surface or raised above it. Although they are expensive, they are the most flexible kind of cage culture system.

SUBMERGED CAGES

These are used in deep, swiftly moving waters and are suspended below the water's surface. They are more challenging to manage and less common than other kinds of cage culture systems.

CRITERIA FOR CAGE CULTURE

SITE SELECTION

Choosing a suitable location for the cage culture system is the first step. The location ought to have good water quality, enough depth, and wind and current protection.

STOCKING

Fish fingerlings or young fish are placed in the cages as a stocking measure. Depending on the size of the cage, the species of fish being raised, and the desired water quality conditions, a specific number of fish will be stocked in each cage.

FISH CONDITION

Fish are watched for symptoms of stress or disease to manage their health. Fish that are injured or ill should be taken out of the cages and treated.

CONSTRUCTION OF THE CAGES

A variety of materials, including wood, metal, and plastic, can be used to create the cages. The fish should have enough room to grow in the cages, which should be built to be sturdy and long-lasting.

FEEDING

Fish are fed a high-quality diet that is suitable for their species and growth stage. Fish are fed multiple times per day.

HARVESTING

Lorsque les poissons sont suffisamment gros pour être vendus, ils sont récoltés. Des filets ou des pièges sont utilisés pour attraper les poissons.

SPECIES THAT CAN BE GROWN IN CAGE CULTURE

Fish cage culturing is adaptable and suitable for a variety of species. fish Fish that are frequently produced in cage culture systems:

- Tilapia
- Carp (IMC & EMC)
- Catfishes (Clarias magur, Singhi etc.)

STOCKING DENSITY

FOR CARPS

Fry: 50-100/m3

FOR TILAPIA

Fry: 100-150/m3

FOR CATFISHES

Fry: 150-200/m3

WATER QUALITY PARAMETERS

Dissolved oxygen (DO): Fish respiration depends on DO. To thrive, fish require a DO concentration of at least 5 mg/L.

Temperature: Fish metabolism, growth, and reproduction are all impacted by temperature. Most fish species thrive at temperatures between 25°C and 30°C.

pH: The pH scale measures the water's acidity or alkalinity. The pH range that fish prefers is 6.5 to 8.5.

Salinity: The amount of salt in the water is referred to as salinity. A salinity depends on different types of fish species. Examples is salinity of freshwater is <0.05ppt.

Ammonia and nitrite: These substances are poisonous to fish. Nitrite concentrations should be below 0.1 mg/L and ammonia concentrations should be below 0.05 mg/L.

Nitrates: Although less damaging to fish than ammonia and nitrite, nitrates can still be dangerous in large concentrations. Nitrate levels ought to be less than 30 mg/L.

ADVANTAGES OF CAGE CULTURE

High output: Cage culture systems are capable of producing large quantities of fish per square foot. This is because the fish can swim freely and have access to a lot of water, both of which encourage growth.

Resource efficiency: Cage culture systems employ feed and water in an effective manner. The fish are able to filter their own food from the water, and they can fertilize the nearby waters with their waste.

Flexibility: A range of various water sources, including lakes, rivers, and reservoirs, can be used to set up cage culture systems. They are therefore a versatile choice for aquaculture farmers.

Simple administration: Cage culture systems are comparatively simple to administer. The cages can be cleaned and maintained as necessary, and the fish can be frequently fed and seen.

Reduced environmental impact: Compared to some other aquaculture techniques, cage culture systems have a lesser environmental impact. For instance, they don't call for chemical use or land removal.

DISADVANTAGES OF CAGE CULTURE

Impact on the environment: There are several ways that cage culture can harm the ecosystem. For instance, unconsumed food and fish excrement can contaminate the water, and cages can obstruct sunlight and alter the flow of natural water.

Escapement of fishes:: Fish cages have a tendency to allow fish to escape if the fish are under stress, which could result in the introduction of invasive species into new environments.

Disease: Fish kept in cages are highly susceptible to diseases that can swiftly infect the entire population.

Social conflict: Fish farmers and other users of water bodies, such as fishermen and boaters, may come into conflict due to cage culture.

Predation: Fish kept in cages are susceptible to attack by other fish, birds, and mammals.

Pollution: Water bodies where cage culture is practiced may get contaminated. This is due to the fact that fish produce waste and that uneaten food can decay and contaminate the water.

ENVIRONMENTAL EFFECTS OF CAGE CULTURE

The following are a few environmental effects of cage culture:

- **Eutrophication**: The over-nutrient enrichment of water bodies is known as eutrophication, and cage culture can contribute to it. Algae and other aquatic plants may grow as a result, lowering the water's oxygen level and endangering other aquatic life.

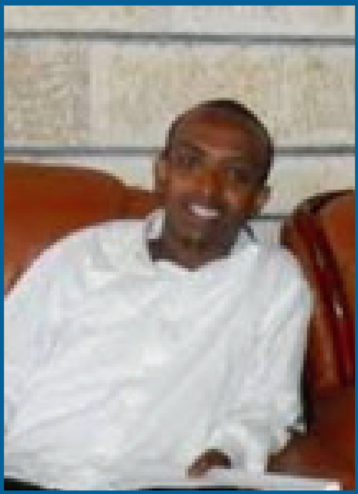
- **Impacts on biodiversity**: By introducing new species to a region or by competing with native species for food and resources, cage culture can have a negative influence on biodiversity.

- **Coral reefs and seagrass beds** are two delicate environments that can be damaged or destroyed as a result of cage culture.

CONCLUSION

Aquaculture has advanced significantly thanks to cage culture, which offers a variety of benefits in terms of species diversity, environmental sustainability, and economic viability. This approach offers a potentially effective way to meet this need while reducing the drawbacks of conventional fisheries and land-based aquaculture. However, careful management, consideration for environmental stewardship, and adherence to ethical farming methods are necessary for cage culture to be effective. Aquaculture professionals, decision- makers, and academics must work together to handle cage culture's obstacles and seize its opportunities if it is to continue to be successful. In conclusion, cage culture is positioned to be a key player in the development of sustainable aquaculture, enhancing global food security, economic growth, and environmental preservation.

BROODSTOCK NUTRITION IN NILE TILAPIA AND ITS IMPLICATIONS ON REPRODUCTIVE EFFICIENCY



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Broodstock nutrition is the most essential constituent of sustainable aquaculture production. Its impact on the reproductive performance and profitability of commercial aquaculture has been the subject of considerable research. The present paper reviews the literature available on the subject, examining the implication of Nile tilapia broodstock nutrition on parameters including maturation, fecundity, fertilization, embryo development, larval quality, and survival rate. The provision of a nutritive diet composed of essential macro and micronutrients including proteins, lipids, carbohydrates, vitamins, minerals, and functional additives, such as prebiotics, enzymes, hormones, and probiotics, in different proportions is discussed. Special emphasis is given to literature dealing with the effects of dietary protein and lipid on vitellogenesis and ovarian maturation, fecundity, egg hatching rate, larval quality, and fry survival number. The impact of the feeding regime on reproductive performance is described.

1 INTRODUCTION

Nile tilapia (Oreochromis niloticus) is one of the most commercially important fish species native to tropical and subtropical water bodies in the eastern and western parts of Africa, such as the Nile and Niger River basins and Lakes Tanganyika, Albert, Edward, and Kivu. This species is also found outside of its native range in many parts of the world. Its suitability to different culture techniques; its broad ecological tolerance to various environmental and physicochemical water quality parameters such as fluctuations in pH and salinity, low dissolved oxygen, and high concentrations of chemical nutrients; and its ability to reproduce in captivity make this species one of the most widely cultivated fish around the globe. For this reason, the commercial importance of Nile tilapia is undeniable, especially in the top tilapia-producing Asian and African countries where the demand for tilapia larvae and juveniles is increasing exponentially . To ensure the sustainable growth and expansion of tilapia farming all over the world, prolific measures such as improved nutrition, feeding, and management, with particular emphasis on broodstock, are essential to providing large and high-quality eggs. Providing a balanced diet for broodstock fish is essential not only for the maximum growth and health of juveniles but also to ensure the prime condition of the broodstock fish.

Proper dietary composition is fundamental to broodstock nourishment, as there is a wealth of evidence on nutrient quality affecting health and both quality and quantity of the supply of offspring. Nutrition, which is highly determined by diet, has direct and indirect effects on fish maturation, fecundity, semen quality and quantity, fertilization, embryo development, larval quality, and larval survival. Despite the importance of broodstock fish nutrition, the nutritional requirements of broodstock fish have become poorly understood and less researched due to both the lack of suitable culture facilities that maintain large groups of adult fishes and to the increased costs of extended broodstock feeding investigation. To date, the nutritional requirements of tilapia broodstock have been summarized in previous reports as key factors in tilapia production strategies. Since then, research has expanded to consider specific dietary needs associated with the improvement of tilapia reproductive performance. However, these results are not presented in an organized manner. Therefore, this review aimed to gather information about broodstock nutrition in Nile tilapia and its implications on reproductive efficiency.

2 METHODOLOGIES

A recent innovative PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis), is a standard that brings together a set of evidence-based practice tools intended to help authors of scientific articles scan a large number of sources when conducting systematic literature reviews or meta-analyses ,checklist approach was used to conceptualize findings, synthesize concepts, and include and exclude articles (Salameh et al., 2020). The literature search for this review was performed using a number of scientific databases, including ScienceDirect, ResearchGate, Google Scholar, Web of Science, SciELO, LibGen, PubMed, Science-Hub, Internet archives, Scopus, CrossRef, and EcoPapers, among others. The searched scientific articles had been published over the previous 30 years.

3 RELEVANCE OF BROODSTOCK NUTRITION

Proper dietary composition is fundamental to broodstock nourishment and to a sustainable aquaculture system. There is a wealth of evidence on nutrient quality being able to considerably affect the reproductive performance in fish. Therefore, for many cultured species, broodstock nutrition coupled with the availability of optimal diet is the most limiting factor in determining the variability and unpredictability of reproductive performance. Apart from improved egg and sperm quality, good broodstock nutrition results in the mass production of juveniles and the enhanced growth of fish in order to reach a large size. Despite speciesspecific variations in fecundity, many large-sized fish species tend to produce more eggs, resulting in larger larvae with enhanced survival benefits. Similarly, the quality and the quantity of broodstock nutrition affect the survival of the young. In some fish species, certain essential dietary nutrients, e.g., proteins, lipids, vitamins, and other inorganic compounds, highly determine the fecundity and gonad development aspect of broodstock nutrition.

Sustainable commercial production of tilapia is ensured by the continuous year-round supply of high-quality fish eggs. For this reason, broodstock tilapia could produce good quality fertile eggs with maximum growth and survival rates if they are supplied with formulated, nutritive diets composed of essential nutrients.

Nile tilapia are also known to reach sexual maturity at a relatively small size. Furthermore, studies have shown that providing broodstock tilapia with a nutritive diet composed of essential nutrients not only reduced age at first maturity, but also improved vitellogenesis, enhancing the egg quality and progeny development.

Although it is evident that broodstock nutrition has a significant impact on the breeding performance of males, females, and juveniles, there is little information regarding the optimal dietary requirement of many farmed broodstock fish species like the Nile tilapia. This might be due to the short history of commercial intensive aquaculture system, the lack of information on the demand of species-specific broodstock diet, technological dependence, and the financial limitations in conducting these studies. Recently, broodstock nutrition research in aquaculture has been given great attention due to the formulation of quality feed and the use of genetically selected stocks that would improve the profitability of commercial aquaculture. Therefore, the production of an adequate amount of quality seeds with the formulation of appropriate nutritive broodstock diets can highly enhance the reproductive potential, such as a short generation time, high fecundity, and low mortality of fishes, making the industry profitable.

3.1 NUTRITIONAL REQUIREMENTS OF NILE TILAPIA BROODSTOCK

The provision of a formulated and balanced nutritive diet composed of proteins, lipids, carbohydrates, vitamins, and minerals, along with ration size and feed frequency, to broodstock tilapia that is low cost and environment-friendly would result in optimum growth and improved reproduction.

3.2 PROTEINS

Protein is an indispensable dietary ingredient in broodstock tilapia feed that provides essential and nonessential amino acids and is used to offer highly available energy when other energy sources are inadequate and for the synthesis of new tissues, hormones, enzymes, and antibodies. Proteins are used as a source of energy for the reproductive process, including the aggressive behavior of the males, for mating, territory defense, and in oral egg incubation. Hence, the inclusion of optimum dietary protein in broodstock nutrition would be fundamental in the formulation of fish feed to avoid poor reproductive performance, stunted growth, and weight loss. Numerous research findings have shown that the breeding results on larval quality and progeny obtained by protein nourishment are better than those by other purified macronutrients. Similarly, the dietary protein level and the feeding regime of female tilapia highly influence oocyte growth, puberty, spawning performance, and egg quality. Subsequently, the quality and performance of larvae will be exceedingly dependent only on the stored nutrients in the yolk.

The provision of an optimum level of dietary protein to broodstock tilapia would improve the growth, development, health, and maintenance of the species, with a knock-on effect on improved reproduction. However, there are great variations in the quality and quantity of the protein requirement of broodstock tilapia.

For example, the water temperature, salinity, age, sex, amino acid composition, maturation, spawning period, feeding frequency, and dietary energy level are major determinants of the protein requirement. Hence, in broodstock tilapia, the optimal amount of dietary protein is the lowest level of protein that results in the best performance under certain circumstances. Thus, quantification of the total dietary protein requirement of broodstock fish is essential for sustainable and profitable aquaculture since the cost of dietary protein is the most expensive component of culture systems, accounting for approximately 50% of the feed costs. Apart from the dietary protein level, the source of protein (i.e., animal, plant, or both) also vastly determines growth, survival, and other outputs.

The contribution of broodstock protein toward improved reproduction could be ascribed to the strong association of body size growth with prior maturation of gonads, as many investigations have reported on the earlier development of eggs in large-sized broodstock species. Thus, for egg development, fishes might use protein from their body reserve, as indicated by the highest amount of protein in the egg being observed from fishes supplied with 40% dietary protein, which conferred an increased amount of dietary protein and led to the increased amount of protein in the egg. it was recommended that using diets containing 44% of crude protein for Nile tilapia brood fish is adequate.

3.3 AMINO ACIDS

A well-balanced broodstock fish diet composed of essential amino acids is crucial for enhancing reproduction and for the normal growth of tilapia: arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine.

Deficiency in any of these amino acids can limit protein synthesis, growth, and metabolic activity, leading to reduced weight and reproductive potential. Furthermore, some amino acids, e.g., arginine and glutamate, are essential in the regulation of hepatic glucose and lipid metabolism. Other amino acids including glutamate, glycine, and tyrosine are also involved in the release of pituitary hormones that regulate food intake and the reproductive behavior of fish.

By including the essential amino acids in the broodstock diet in optimal amounts, tilapia farmers can promote the optimal growth, reproductive performance, and overall health of their fish. Furuya et al. (2023) elucidated three levels of CP (i.e., 350, 380, and 400 g kg-1 of the diet) that corresponded to different broodstock.

3.4 LIPIDS

Dietary lipids are a major source of essential fatty acids and highly digestible energy required by fish to attain optimal growth and development, improved reproductive performance, and health maintenance. Broodstock diets supplemented with oils and fatty acids that are rich in n-3 and n-6 improved the feed flavor, texture, and cell membrane permeability. Moreover, fatty acids play a significant role in the absorption of fatsoluble nutrients such as sterols and vitamins A, D, E, and K. For many freshwater species like the Nile tilapia, the provision of dietary lipids, particularly essential fatty acids, is crucial for numerous physiological functions related to growth and reproduction as they cannot be synthesized in the body.

Although there are variations in requirements due to species, sex, age, breeding stage, and other physiological conditions, the levels of dietary lipids significantly influence reproductive performance, such as the induction of secondary vitellogenesis and ovarian maturation, fecundity, the rate of egg hatching, the quality of larva, and the number of fry survival of many species, including tilapia . Numerous studies elucidated that a lipid level of 10%–20% in fish broodstock diet results in optimal growth without any accumulation of excess fatty tissue. Conversely, the provision of excess dietary lipids to broodstock fish would lead to the excess deposition of fat in the body cavity, which may adversely affect the growth, reproductive performance, value, and storage of processed products and, ultimately, the profitability of the culture system. Limiting the fatty acids in the diet of tilapia broodstock can have a significant impact on their reproductive performance. Several studies have demonstrated that the incorporation of specific lipid sources into the broodstock diet can enhance reproductive outcomes.

3.5 CARBOHYDRATES

Carbohydrates are abundant but nonessential components in the broodstock diet that provide inexpensive energy to spare lipids and proteins for growth and reproduction. Due to its herbivore–omnivore feeding habit, broodstock tilapia has a greater chance of taking more plant materials exposed to higher carbohydrate contents. This species is capable of utilizing dietary carbohydrates as the primary energy source and responds with poor fecundity and spawning efficiency. This might be due to the low nutritional value of the diet for improving reproduction. Carbohydrates in the broodstock diet are used as a major source of energy for courtship, territorial defense, reproduction, mouth brooding, nest building, and osmoregulation, leaving only a small amount of energy for reproductive performance. However, in the case of energy deficiency for these activities, the dietary or stored proteins or lipids will be catabolized for energy production in the sparing process. Although there is no specified amount for the carbohydrate requirement of broodstock tilapia, many authors have suggested a dietary level of 30%–40% digestible carbohydrate as optimal.

3.6 VITAMINS, MINERALS, AND OTHER TRACE ELEMENTS

Vitamins are among the most essential micronutrients required by broodstock tilapia. Since they cannot be synthesized in the body due to the lack of the gulonolactone oxidase enzyme, the only route wherein fish can access vitamins is through formulated feeds or supplements. The most common and basic vitamin supplements used in the broodstock diet are ascorbic acid or vitamins C, D, and E, which play important roles in various metabolic activities such as detoxification reaction, steroid synthesis, collagen formation, and stress tolerance. Furthermore, the inclusion of dietary vitamins in broodstock tilapia diet promotes the release of luteinizing hormone (LH) and follicle-stimulating hormone (FSH), which improve vitellogenesis, spawner number, egg hatching, and fry survival rates with improved immune response in females, as well as the synthesis and maintenance of normal sperm, increased motility, and reduced infertility in males. The optimal dietary vitamin requirements of Nile tilapia ranged between 25 and 119 mg/kg diet. However, the exact values vary due to species-specific demands, the presence of antioxidants, and several environmental parameters. For example, in brood tilapia, vitamin C degradation will be accelerated under conditions of hyperoxia, whereas the dietary vitamin E requirements are highly influenced by the dietary lipid levels.

Nutritionally, minerals and trace elements are those inorganic substances required at the micro or macro level for normal physiological functioning, such as in soft tissue and structural skeletal formation, nerve impulse transmission, osmoregulation, growth, reproduction, and healthy body.

Moreover, minerals are vital components of many enzymes, hormones, and various metabolic activities. Fishes absorb essential minerals either from their diet or from water. Hence, excess or deficient provision of minerals to fish will affect all of the benefits mentioned above. Conversely, optimal dietary supplements of minerals and trace elements could also be wasted through the interactions and formations of complex products. Thus, their deficiency will inhibit reproductive performance. The dietary provision of minerals and trace elements plays a significant role in improving reproductive performance . For instance, Ca is essential during the sexual maturity of females and is used as a major binding component to the vitellogenin in egg and Ca binding protein. It has been shown that optimal supplementation of Fe, Cu, Zn, and Mg is essential to the regulation of enzymatic and hormonal activities, an enhanced immune system, vitamin synthesis, and improved growth.

In contrast, deficient or excess provisions beyond the required limits will cause toxicity and have adverse effects on the physiology of the fish. Despite the paucity of information and the lack of common agreement on quantifying the level of dietary requirement, several studies recommended provision of trace elements within a certain range to enhance hormonal and enzymatic activities (See table).

Table: Optimal requirements of vitamins, minerals, and trace elements in the broodstock Nile tilapia diet.

Micronutriment	Dietary required amount
Vitamins	
Vitamin C	25–119 mg/kg
Vitamin D	400–420 mg/kg
Vitamin E	120 mg/kg
Minerals	
Ca	0.7%
Se	0.21–1.18 mg/kg
P	0.65–0.86 g/100g
Mg	0.2 g/kg
Trace elements	
Fe	30–170 mg/kg
Cu	3–5 mg/kg
Zn	32 mg/kg
Mn	13–15 mg/kg

3.7 FUNCTIONAL ADDITIVES IN BROOD FISH NUTRITION

Functional additives such as enzymes, hormones, prebiotics, probiotics, and synbiotics are substances that exert benefits for a specific biological function. Hence, supplementing broodstock diet with these additives in different quantities will improve the progeny quality, egg viability, hatching rate, and larval survival. Furthermore, functional additives improve the efficiency of commercial diets in meeting the required nutritional demands by reducing the anti-nutritional factor in the diet. However, the provision of some additives like hormones beyond the optimum level will bring about malformations in larvae. The reproductive performance of fish can potentially be improved through the application of functional feed additives. Probiotics as a feed additive have been demonstrated to have a positive impact on reproductive performance through improving the egg diameter, fecundity, fertilization, egg hatching rate, and juvenile survival rate in fish.

The effect of probiotics in indicating the responsiveness of incompetent follicles to maturation-inducing hormones and changing the oocyte chemical composition during vitellogenic development is well established. The positive role of probiotics in testicular cells has also been validated through their role in upregulating the transcription levels of leptin and the bdnf and dmrt1 genes, hence facilitating spermatogenesis. The importance of phytobiotics as an additive in aquaculture feed is increasingly being recognized, i.e., as one agent that improves the reproductive performance of fishes. Thus, administering prebiotic, probiotic, and synbiotic supplements to broodstock species in adequate amounts will provide health benefits and enhance the performance and overall well-being of fish.

4 BROODSTOCK NUTRITION AND ITS IMPLICATION ON REPRODUCTIVE EFFICIENCY

Physical, chemical, and biological factors strongly affect the reproductive performance of broodstock fish. However, the influence of nutrient composition, such as the energy, lipid, and protein levels, in the diet is an inevitable limiting factor for the maturation, fecundity, and survival of larvae. This includes the availability of essential nutrients that initiate gametogenesis, growth, and reproductive control. Various biomolecules and micronutrients only required in minute amounts play fundamental roles in achieving successful reproductive performance. Nevertheless, dietary nutrient deficiency would lead to failure in reproduction, poor hormonal functioning, and delayed puberty, resulting in common reproductive dysfunctions. The feed must therefore provide tilapia broodstock with optimum protein requirements, essential amino acids, lipid and unsaturated fatty acid intake. In addition, feeding tilapia broodstock on a high-energy diet leads to significant oocyte development, higher fecundity with increased egg diameter, and improved fertility and egg hatch rates.

4.1 ROLE OF BROODSTOCK NUTRITION ON TILAPIA FECUNDITY

Fecundity refers to the total number of eggs in the ovaries of female fish before the next spawning season, which is beneficial in determining egg quality and quantity. However, an imbalance in essential nutrients from the diet of broodstock, combined with a decrease in the quantity of food, reduces fecundity. Therefore the food must provide the broodstock with optimal needs for proteins, essential amino acids, lipids and unsaturated fatty acids, in addition, the provision of tilapia from broodstock with a high energy diet leads to the notable development of oocytes. , to higher fecundity with increased egg diameter, and improved fertility and egg hatching rates.

4.2 ROLE OF SPAWNER NUTRITION ON EGG FERTILIZATION IN TILAPIA

Egg fertilization in aquatic ecosystems is strongly influenced by sperm motility and water chemistry, i.e., salinity and hardness, which make it progressively more difficult for the egg to penetrate. In addition, essential fatty acids, for example EPA and arachidonic acid, present in sperm are closely related to motility and fertilization. Conversely, a delay in the moment of spermiation or ejaculation reduces the fertilization rate because the egg remains in the water for a while, making fertilization more difficult.

Fecundity refers to the total number of eggs in the ovaries of female fish before the next spawning season, which is beneficial in determining egg quality and quantity. However, an imbalance in essential nutrients from the broodstock diet, combined with a decrease in the amount of feed, reduces fertility.

4.3 ROLE OF BROODSTOCK NUTRITION ON THE EMBRYO DEVELOPMENT OF TILAPIA

For the normal embryonic development of fertilized eggs, the contributions of essential dietary nutrients such as lipids and vitamins are necessary. The increased level of HUFA such as n-3 in the diet of broodstock reduces the number of morphologically deformed embryos. Because of its phospholipid component, fatty acids play a remarkable role in the structural makeup of numerous biomembranes, enzymes, and cells, and that quality protein consisting of essential amino acids in the diet exerts a significant influence on the embryonic development of larvae.

4.4 ROLE OF BROODSTOCK NUTRITION ON THE LARVAL QUALITY OF TILAPIA

All essential maternal reserves are transferred into the oocytes during the early stages of ovarian development. Thereafter, the provision of high-quality nutritive feed has a significant role in the improvement of larval quality through increased survival, growth, and swim bladder inflation. Hence, the quality of broodstock diet and its nutritional composition highly determine larval quality until the beginning of exogenous feeding.

5 . CONCLUSIONS AND RECOMMENDATIONS

The lack of balanced, nutritive, and formulated diet that improves rapid body growth and other reproductive conditions is the main constraint in commercial aquaculture. The dietary nutrient composition, including lipids and fatty acids, vitamins, minerals, proteins, carbohydrates, and feed size, has a strong influence on the breeding condition and progeny of many broodstock species such as the Nile tilapia.

For successful and profitable aquaculture production, further research focusing on the formulation of a nutritive diet and the implications of each nutritional component, e.g., vitamins, minerals, and trace elements, toward the reproductive performance of broodstock species is recommended.

THE JOURNEY OF LINAH VELMA, AN AQUACULTURE MANAGER AT AQUARECH IN KENYA

Lina Velma is Aquaculture Manager at Aquarech is Kenya's first fish farming platform that is on track to become Africa's first fish farming platform for small and medium-sized fish farmers, for the entire aquaculture value chain.

Linah Velma is an aquaculturist with four years of immersive experience in the aquaculture and fishing sector. I completed a Bachelor's degree in Pure and Applied Aquatic and Fisheries Sciences, my passion for sustainable aquaculture in Kenya and Africa pushed me to work with various aquaculture organizations in the country.

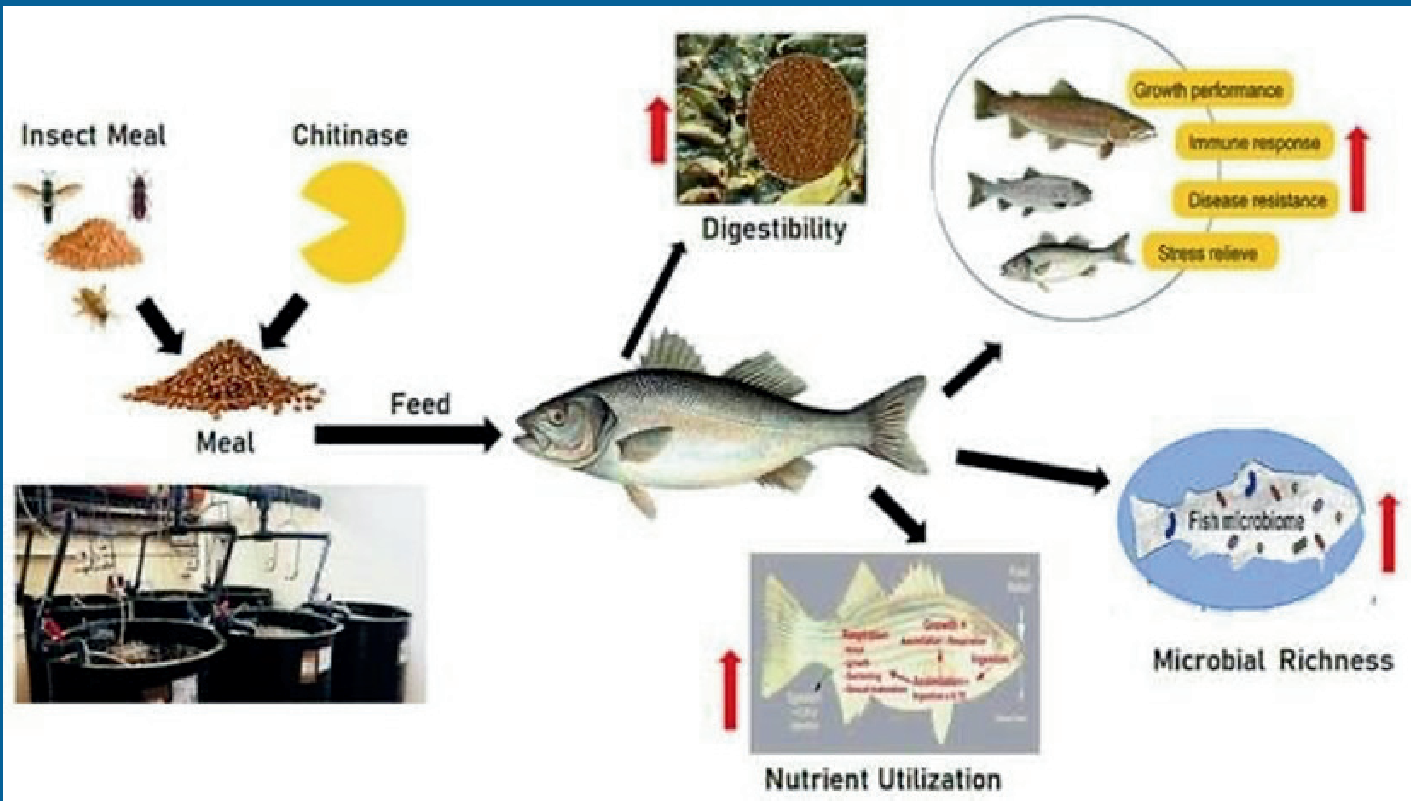
Her journey has been categorically focused on training and capacity building for small and medium-sized fish farmers. Determined to help increase productivity and production in fish farming and not forgetting profitability.
His training covers a number of topics ranging from stocking density, precision feeding, connecting farmers to quality food, farm management, unit economics, data logging, extension services, among others.

Her commitment has enabled her to participate in a number of programs that support and improve fish farming in Kenya and, most importantly, to engage women and youth who have just entered aquaculture.
Continuous advances in aquaculture innovations and technologies excite her as she looks forward to seeing and working towards what the future holds for aquaculture in Kenya, Africa and the world.

CHITINASE: A KEY ENZYME FOR ENSURING THE SUSTAINABILITY OF INSECT MEAL IN AQUACULTURE NUTRITION

By:The Editorial Team

The flourishing aquaculture industry is facing a major challenge in finding sustainable alternatives to traditional fishmeal in fish and shellfish feed. In this context, insect meals appear to be a promising solution, as they are rich in high-quality proteins and have an ideal amino acid profile. However, these nutritional powers have a hidden secret: chitin, a tough fiber found in their exoskeleton. Chitinase, an enzyme that breaks down chitin, is being investigated as a potential solution for improving the nutritional value of insect meals in fish feed. The aim of this article is to present a detailed analysis of the applications, benefits and challenges of using chitinase in aquaculture to exploit the potential of insect meals.



INTRODUCTION

The aquaculture industry is currently facing a crucial challenge: the search for sustainable and economically viable alternatives to conventional fishmeal in fish feeds. A promising solution on the horizon is the use of insect meals as an alternative protein source, due to their optimal nutritional properties, in particular their high protein content and ideal amino acid profile, but also because of their potential to meet the growing demand for alternative protein sources in aquaculture feeds. Their potential is further enhanced by recent advances in processing, economic viability and scalability. Insect meals are increasingly proving that they can partially or fully replace animal meals in aquaculture feeds, as a sustainable alternative in aquaculture feeds, and offer the aquaculture industry a viable means of meeting the challenges of sustainability and economic feasibility.

IMPORTANCE OF INSECT MEALS

Insects offer a unique nutritional profile for aquaculture feeds, and one of their most important components is chitin, a polysaccharide, the second most abundant on earth after cellulose, composed of N-acetyl-2-amino-2-deoxyglucose units. Chitin and its deacetylated derivative, chitosan, represent an important source of insoluble "animal" fibers that may have potential utility as functional ingredients or bioactive compounds in aquaculture feeds. This component adds an interesting dimension to the nutritional value of insect meals, and research has demonstrated the various ways in which chitin can have a positive impact on :

- **Fish growth performance, with weight gain.**
- **Fish health in aquaculture systems. Like cellulose, chitin has the potential to act as a prebiotic in fish feed. Indeed, it can increase bacterial diversity in the gut by promoting the proliferation of beneficial bacteria and chitin-degrading bacteria, contributing to improved gut health and overall fish well-being.**

Research indicates that insect meal can replace a significant proportion of fish meal in aquaculture feeds. For example, mealworms and housefly larvae can replace up to 40-80% and 75% of insect meal in the diets of Nile tilapia and standard catfish, respectively.
Numerous studies have shown that chitosan plays an important role in improving various physiological functions in fish. These effects include improved growth performance, enhanced immunity and improved antimicrobial capabilities, underlining the multiple benefits of chitosan in fish farming. The inclusion of chitin and chitosan in fish feed has several positive effects on different fish species in aquaculture. Although chitosan and chitin in insect meals (IM) offer many advantages, it is important to recognize that the presence of chitin can be a limiting factor in the use of insect feeds in aquaculture, in which context control of the chitin content of insect meal is essential, as the presence of chitin in fish feed can reduce the digestibility of the feed, given that most fish species cannot digest and absorb chitin efficiently, hence the need to use chitinase, an enzyme that breaks down chitin as a potential solution to improve the nutritional value of insect meals (IM) in aquaculture feed.

ROLE AND IMPORTANCE OF CHITINASE

Chitinase is an enzyme that breaks down chitin, a major component of insect exoskeletons, into digestible carbohydrates. This process can increase the nutritional value of IF and make it more digestible for aquatic species. These enzymes have been detected in the digestive tracts of various fish species, including rainbow trout (Oncorhynchus mykiss). The primary function of fish chitinases appears to be to chemically disrupt the exoskeleton or other external chitin-containing structures of the prey so that internal nutrients can be reached by the enzymes, or to prevent blockage of the gut by these structures.
Chitinase has potential applications in aquaculture, notably in the conversion of chitin to a usable form and in aiding chitin digestion in fish. The enzyme chitinase hydrolyzes chitin into digestible carbohydrates that can be used in fish feed, thus increasing the nutritional value of the latter. Once chitin has been broken down into simpler oligosaccharides, these molecules become more bioavailable. This means they can be absorbed more easily in the animal's digestive tract, contributing to overall nutrient absorption. This process effectively converts chitin waste into a usable form that can be added to fish feed, contributing to better nutrient utilization.

- **The introduction of chitinase into fish feed can result in an increase in chitin digestibility and, consequently, an improvement in nutrient digestibility.**
- **The addition of chitinase enables more efficient use of chitin-rich feed ingredients, which can lead to reduced feed waste and improved feed conversion, resulting in more sustainable and profitable farming.**
- **The optimal amount of chitinase to add to aquaculture feed can depend on various factors, such as the type of aquatic animal, the type of feed and the desired result.**
- **Introducing chitinase to fish feed can play an important role in preventing disease and boosting the immune system.**

CHITINASE PRODUCTION TECHNOLOGIES FOR AQUACULTURE

Chitinase production for commercial aquaculture operations generally involves microbial fermentation and enzymatic purification processes.

- Bacterial fermentation is one of the most important means of producing chitinase for commercial aquaculture operations. Chitinase-producing bacteria, such as Bacillus and Pseudomonas strains, are grown in specialized bioreactors to produce large quantities of chitinase. This approach offers several advantages, including the possibility of genetically manipulating the bacteria, which can increase the efficiency of chitinase production.
- Fungal fermentation has proven to be another robust strategy for chitinase production in aquaculture. Chitinase-producing fungi, including Trichoderma and Aspergillus species, are grown under strictly regulated conditions to promote chitinase enzyme secretion. A marine soil isolate Aspergillus terreus, which has chitinase activity, was grown on a sucrose, peptone and yeast extract medium.

CHALLENGES ASSOCIATED WITH THE USE OF CHITINASE IN AQUACULTURE

There are several challenges associated with the use of chitinase:

- **One of the main challenges associated with the use of chitinase lies in the specificity of chitinase enzymes for certain types of chitin structures, which can be different in different insect species. Selecting a chitinase capable of efficiently degrading chitin in the exoskeletons of the target insect species is a major challenge. The insect species used for IF production may have different chitin compositions in their exoskeletons, making it difficult to develop a universal chitinase treatment capable of efficiently degrading chitin in all cases.**
- **In addition, chitinase efficacy is influenced by environmental factors such as pH, temperature and reaction time.**
- **The cost of producing chitinase can be high, which may limit its use in aquaculture. Finding a cost-effective method to produce chitinase is important for the industry.**

CONCLUSIONS

As the aquaculture industry actively seeks environmentally friendly and economically viable solutions, it is essential to understand the interaction between insect meals, chitin and chitosan. Furthermore, the exploration of chitinase as a potential solution for improving the nutritional value of IFs opens up new avenues of research and application. To realize the full potential of this key enzyme, a comprehensive understanding, rigorous research and strategic optimization of chitinases in aquaculture are required.

FUTURE AQUACULTURE EVENTS IN AFRICA AND AROUND THE WORLD

INTERNATIONAL SYMPOSIUM ON FISH NUTRITION AND FEEDING 2024

The XXIII International Symposium on Fish Nutrition and Feeding, focusing on blue and green aquatic foods, will bring together researchers, academics and industry professionals in Puerto Vallarta, Mexico from May 27, 2024 to May 31, 2024. This event aims to promote innovation in aquatic animal nutrition and feeding, supporting the growth of the aquaculture industry. Don't miss the opportunity to network, collaborate and discuss current issues in fish nutrition. Join us in Puerto Vallarta, Mexico.

This biennial event will bring together more than 400 participants from around the world. Organizers expect exceptional contributions on key topics that will advance the science of aquatic animal nutrition and feeding, encouraging innovation for growing aquaculture industries that are seeking new opportunities in a green economy.

For more information: https://www.isfnf2024.com/index.php

AQUACULTURE GHANA 2024 ON 25TH AND 26TH

JULY 2024

Aquaculture Ghana 2024 is an event that provides a common platform for aquaculture stakeholders to network, showcase innovations and promote Ghana's aquaculture industry, to be held from 25 to 26 July 2024 at the World Trade Center, Accra, Ghana.

The conference will be a great opportunity for stakeholders to network and share ideas on the future of Ghana's aquaculture industry. Experts, regulators, industry stakeholders, investors and donors will have the opportunity to discuss challenges or opportunities in the aquaculture industry.

More than 70 exhibiting companies, mainly focused on technology, research, sustainability and aquaculture industry development, will participate in the event.

https://www.aquacultureghana.com/

THE 3RD ANNUAL INTERNATIONAL CONFERENCE AND EXHIBITION OF THE AFRICAN SECTION OF THE WORLD AQUACULTURE SOCIETY (AFRAQ24) WILL BE HELD IN HAMMAMET, TUNISIA, FROM NOVEMBER 19 TO 22, 2024.

Conference location

Tunisia is the northernmost country in Africa and is part of the Maghreb region of North Africa. The conference will take place in the Mediterranean city of Hammamet. The conference provides an excellent opportunity for aquaculture researchers, practitioners, policy makers and other stakeholders to meet, network and discuss all aspects of aquaculture in Africa. Exhibitors from all over the world are expected to display their products in the state-of-the-art exhibition center. Special excursions or aquaculture tours will also be organized to nearby marine fish farms (large, medium and small scale), aquatic feed facilities, fish markets and some aquaculture research and development centers.

AFRAQ24 program themes

AFRAQ24's technical program will aim to cover development issues, including the latest research and development aspects of aquaculture in Africa. The international conference will revolve around the theme "Blue Agriculture: New horizons for economic growth", and will present lessons learned from Tunisia and other countries on the role that sustainable aquaculture continues to play in establishing sustainable food systems for economic growth.
The conference is now open for abstract submission and online registration. Full conference details will be updated on the event page at www.was.org/Meeting/code/AFRAQ24.
For questions about AFRAQ24, please contact worldaqua@was.org or africanchapter@was.org.
To find out more about the exhibition and sponsorship, please email mario@marevent.com.

THE 15TH SOUTHERN AFRICA AQUACULTURE ASSOCIATION CONFERENCE WILL BE HELD IN STELLENBOSCH, SOUTH AFRICA, FROM SEPTEMBER 9 TO 13, 2024

LThe 15th Southern African Aquaculture Association (AASA), co-organized by EU Horizon 2020 ASTRAL (Sustainable, Profitable and Resilient Aquaculture in the Atlantic Ocean), will take place in Stellenbosch, from 9 to 13 September 2024. The project ASTRAL has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement No. 863034. The conference program will focus on classic aquaculture topics such as: animal nutrition and feeding, health and diseases, breeding and genetics, water ecology, marketing and finance, production systems, aquaculture policies, etc. But new relevant topics will also be added to the program such as: sustainability, biotechnology, genomics, aquaponics, new technologies and innovation, algae, IMTA systems, new species and research and development. With this conference we have made a significant investment in the aquaculture sector and hope that you will use this event to facilitate greater regional cooperation, international links and to make new friends and acquaintances. Considering the global demand for aquaculture products and resources that we have in Africa, we look forward to great progress in this sector on our continent. It is with this in mind that we believe we can collectively propel aquaculture to new heights.

Abstract submission begins from March 1, while abstract closing is scheduled for June 3.

For more information, please contact the organizers at conferences@aasa-aqua.co.za

THE THIRD EAST AFRICAN REGIONAL AQUACULTURE CONFERENCE 13 – 15 AUGUST, 2024. MWANZA. TANZANIA

The Third East African Regional Aquaculture Conference, 13 – 15 August, 2024. at Mwanza in Tanzania under the theme : promoting aquaculture investment in East Africa.

Aquaculture in East Africa is advancing rapidly, especially for large-scale producers that are well-connected to technology, science, and opportunity. These large-scale producers are key to the growth of the sector, but in achieving the UN's Sustainable Development Goals, mainstream participation of subsistence, small and medium scale farmers, is also essential. The entire sector development can be accelerated through the creation of investment opportunities.
To create an attractive investment environment in the sector, the entire value chain requires attention and support. This can be done by working towards better access for farmers to quality feed, seed, goods, services, technology, research and capital, in a competitive manner.

THE CENTER FOR RESPONSIBLE SEAFOOD TO HOST SHRIMP SUMMIT 2024 IN CHENNAI, INDIA
JANUARY 23, 2024

The Center for Responsible Seafood (TCRS) is hosting the Shrimp Summit 2024 in Chennai, India–the third biggest shrimp producer in the world–from June 27-29.
The discussions will center around subjects such as enhancing the livelihoods and sustainability of small-scale shrimp producers in Asia, particularly those operating in areas where certification is not feasible.
The event is an opportunity for contacts and meetings between importers, exporters, processors, feed companies, producers, NGOs and government representatives. The summit will take place in Chennai which is the headquarters of many of the largest shrimp-producing companies. It is also a cultural center, and eastward on the coast is a UNESCO World Heritage Site, Mahabalipuram