



(REVIEW ARTICLE)



Improving the quality of aquafeed for an effective food security in small scale African aquaculture

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Abstract

African aquaculture production is growing rapidly compared to world statistics, but it is still not able to fully exploit its potential. Most aquaculture production in Africa is carried out on small-scale aquaculture farms to meet the current demand for aquatic animal products and contribute to the continent's food security. Among the constraints to aquaculture development in Africa, food-related issues are prominent. In this context, both the cost of feed and its quality and nutritional value are concerns for small-scale fish farmers, which leads them to produce their own feed from agricultural by-products. This feed powder has several physical and nutritional disadvantages for fish, which has an impact on aquaculture production, nutritional quality and fish growth time, hence the need to improve the quality of this feed to enhance aquaculture production and contribute to food security in the continent, through the organization of training courses for fish farmers, the formation of cooperatives and the contribution of African research centre and universities to the evaluation of local agricultural by-products used, to contribute to the sustainability of aquaculture in Africa.

Keywords: Aquafeed; Agricultural by-products; Small scale Aquaculture; Africa, Food Security

1. Introduction

In the face of continued population especially in Africa, potentially negative impacts of climate change, and growing resource constraints, and with increasing concern about volatile food prices and the potential impacts of food access and security among poorer and more vulnerable communities [1]. Globally, aquaculture production has doubled every decade for the past 50 years [2]. As the world's fastest growing agri-food production sector, aquaculture has become the predominant source of fish protein, surpassing the amount of fish produced for direct human consumption from wild-caught fisheries [3].

More than 90% of the world's aquaculture production takes place in developing countries, where it contributes to food security directly through consumption or indirectly as a source of income. Seafood is a main source of animal protein in many parts of the world, particularly in developing countries [4]. Being an important part of the African agri-food system, fish has significant potential to contribute to the goal of reducing food and nutrition insecurity in Africa. Fish provides 19% of animal protein intake to Africans and plays a unique role in providing a range of micronutrients and essential fatty acids, especially long-chain polyunsaturated fatty acids, which cannot be easily substituted by other food commodities [5, 6].

In Africa, most fish farmers still rely heavily on imported fish feeds foreign countries, especially European countries, which makes fish farming expensive as fish feed account for at least 60% of the total cost of production. This has contributed in no small measure to the slow pace at which aquaculture is advancing in Africa [7, 8].

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Worldwide aquaculture industry depends on the availability of low cost and high quality feeds. As a result of continuous increase of global fish farming, the requirement of alternative protein source, has become a necessity for the viability of the small-scale aquaculture sector [9]. The high cost of fish feed has prompted small-scale fish farmers to use local ingredients for feed manufacturing, without taking into account the principles of formulation and fish feed management.

Keeping in view of the above facts a review paper is prepared which will reflect the importance of fish feed in small-scale aquaculture in Africa to ensure food security and promote this aquaculture sector in the African continent.

2. Aquaculture in Africa

Although the aquaculture industry in the continent is growing faster than any other part of the world, Africa contributes least to the amount of fish produced, consumed, and traded globally [10]. For instance, aquaculture contributed 17 to 18 % of total fish production in Africa, which is equivalent to a paltry 2.7% of global fish production in 2018 [3]. Globally, Africa has been identified as the region possessing the greatest unexploited potential for aquaculture growth [11].

Most of the production (99%) are from the inland freshwater systems and is mostly dominated by the culture of indigenous and abundant species of tilapia and African catfish while mariculture only contributes a meager 1% to the total production quantity, although it is an emerging and promising subsector [11,12].

Despite suitable natural resource conditions and a growing demand for fish for domestic consumption, and a fish production still below demand, realising the potential of aquaculture development in Africa has faced many shortcomings [13].

The development of aquaculture in rural communities in most African countries, has been very slow for several reasons; lack of feeds and high seeds (fingerlings), poor experience of past attempts at developing aquaculture, inadequate and in appropriate research on the aspects of aquaculture and lack of economic viability studies [14, 15].

Africa's total fish production does not meet the continents food fish requirements. Africa has an estimated population of 1.3 billion people [16]. To meet the ever-increasing demand for fish especially in rural areas where more than 60 percent of the population in Africa live, African countries through their governments need to develop and promote the aquaculture sector especially on a small scale, in order to generate more fish production to satisfy the growing demand and contribute to food security in the African region.

3. Food security and aquaculture

Several studies have suggested that shifting human diet towards increased consumption of fish and seafood could be a solution to the need for protein that would sustain human and environmental health, and thus contribute to food security by aquaculture [17, 18, 19].

The roots of concern about food security can be traced back to the Universal Declaration of Human Rights which recognized that “everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food” (United Nations, 1948).

Food and nutrition security: The term ‘food security’, was defined by FAO (1996) as ‘Food security is a condition when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life’

According to the High Level Panel of Experts on Food Security and Nutrition [20] “A food system gathers all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food and the outputs of these activities, including socio-economic and environmental outcomes”.

In its currently used form, food and nutrition security considers energy, protein, and nutrient needs for a healthy life [21].

- 1-Food availability: sufficient quantities of food available on a consistent basis. Food availability is determined by the level of food production, net trade, and food stock levels.

- 2-Food access: sufficient resources to obtain appropriate food for a nutritious diet. Three elements can be used to describe food accessibility: affordability, preference, and allocation. Accessibility relates to economic access (i.e., food purchasing power), physical access (i.e., transport and infrastructure), as well as sociocultural access and preferences. Addressing concerns regarding food access means greater focus on food prices, incomes, expenditure, and markets.
- 3- Food utilization: appropriate use based on nutritional value, food safety, and social value. Utilization is the result of feeding practices, food preparation, diet diversity, and fair intrahousehold food distribution.
- 4- Stability in food availability, access, and utilization. Crises and shocks such as political instability, adverse weather conditions, or economic factors have an impact on long-term food security.

Food security is the main path to develop the socioeconomic status in any country in the world to defeat malnutrition. Hence the human nutrition deficiencies focus on the importance of animal protein in their regular diet. The aquatic animals are the highly nutritious and cheapest protein sources, which serves as a valuable supplement in diets by providing essential vitamins, proteins, micronutrients, and minerals, for the poor people.

Aquaculture is playing a vital role in the developing countries in national economic development, and global food supply. Food and agricultural organization (FAO) declared that this aquaculture has the continuous potentiality to create a developmental goals for the country economy and better human welfare [22].

Understanding the role of aquaculture to food security and nutrition is of up most importance to the future sustainable management of the aquaculture sector and it is surprising this remains poorly studied [15, 17]. However, few studies have investigated the contribution of small-scale aquaculture on household food security and nutrition [15, 23].

Traditional the sector of aquaculture generally make a positive contribution. Aquaculture fish production is playing an important role on food security through its contribution to overall food supplies for the general population. This impact that must be eminent is aquaculture's participation in the food security of the poor, those most susceptible to malnutrition [15]. Acknowledging the potential contribution of aquaculture to food security and its increasing importance across Africa, since more than 52 percent of fish in the world come from aquaculture [3], hence the need to develop this sector in order for it to play its role in food security on the continent.

Several factors will encourage people to consume more fish, including rapid population growth, rising incomes, increasing appreciation for nutritious fish-based foods, and innovations in processing and packaging technologies and channel distribution, initiated by fish farming cooperatives [24].

4. Small scale aquaculture in Africa

About 70–80 percent of all those actors involved in fish farming worldwide are considered small-scale. The small-scale aquaculture sector is recognized as making an important contribution to food security, poverty alleviation and socioeconomic development [25]. There is growing recognition of the considerable potential of small-scale aquaculture in Africa to diversify farmers' livelihood, in addition, the poor may also benefit from aquaculture through employment on the farms of better-off households or companies and in value chain activities such as seed supply and fish harvesting [26,27]. Most donor and government-driven programs have focused on promoting small-scale aquaculture production in Africa, through an interventionist approach for boosting household consumption for food and nutrition security [13].

5. The nutritional importance of fish

A 'food systems' approach can be useful for understanding the myriad important roles that fish, as food, plays in local communities, and how fish links communities to regional and global systems [28]. The role that fish plays in food and food security is possibly most prominent in small-scale fishfarmers' communities [29]. Currently, the high nutritional value of fish is recognized as an important aspect of how to build and maintain food security at local and national levels [30]. The importance of fish in providing easily digested protein of high biological value is well documented, Proteins are important for growth and development of the body, maintenance and repairing of worn-out tissues, and production of enzymes and hormones required for many body processes.

The fat content of fish varies depending on the variety of species as well as the season, but, in general, fish have less fat than red meat [31]. However, fats from fatty fish species contain the polyunsaturated fatty acids (PUFAs) namely EPA (eicosapentaenoic acid, and DHA (docosahexaenoic acid, [omega 3 fatty acids]), which are essential for proper growth of children and are not associated with the occurrence of cardiovascular diseases such as coronary heart disease. Fish

is a rich source of vitamins, particularly vitamins A and D from fatty species, as well as thiamin, riboflavin, and niacin (vitamins B1, B2, and B3). Vitamin A is required for normal vision and for bone growth. Vitamin D present in fish liver and oils is crucial for bone growth because it is essential for the absorption and metabolism of calcium. [20].

The minerals present in fish include iron, calcium, zinc, iodine, phosphorus, selenium, and fluorine. These minerals are highly “bioavailable,” meaning that they are easily absorbed by the body [32].

6. Aquafeed in small scale aquaculture

The availability of quality and reasonably priced feed is a major constraint to the sustainable development of the aquaculture sector in Africa [33]. Due to the growing awareness of the role of aquaculture in the development of the rural or regional economy and the family economy, the position of food is more and more at stake, especially as the trend in aquaculture in the world and in Africa is moving from extensive aquaculture to semi-intensive or intensive aquaculture [34, 35].

Feed and feeding in small scale aquaculture in Africa vary due to differences in feeding behaviour of the cultured fish species, and also depend on culture system, from extensive systems on a small scale to semi intensive, intensive or floating cage culture [36].

Among the constraints to the development of fish farming in Africa, problems related to food occupy an important place. Thus, both the cost of feed and its quality and nutritional value are concerns for small-scale aquaculture in Africa [37].

Aquafeed is widely recognized as the most expensive component of fish farming depending on the intensity of the culture operation. An analysis of the cost/operating budget shows that feed accounts for 60-70% of production costs, which largely determines the viability and profitability of the fish farming enterprise for smallholder rural farmers in Africa [38, 39, 40].

Therefore, any reduction in the cost of fish feed can effectively increase the income of fish farmers. To achieve this, small-scale fish farmers use two approaches to limit the cost of fish feed. [41]:

- Reductions in quantity of feed used for fish growout
- Reductions in the cost of formulated feeds

However, the first approach i.e. reducing the amount of feed negatively affects fish growth, therefore all fish farmers opt to reduce the cost of fish feed by making the feed from local products [7]. One main reason for the rise in the cost price of fish feed is due to the rise in demand of fish meal which remains the core of the protein supply of the feed. So, the quest for possible alternative protein sources to replace complete/partial fish meal in the feed became paramount [42]. Moreover, use of cheaper and locally available plant sources to substitute the expensive fish meals would mean reduction in the production cost and thereby enhance the profit [43, 44].

The species selected to portray yield potential in Africa for aquaculture production are Nile tilapia (*Oreochromis niloticus*), and African catfish (*Clarias gariepinus*). These species are widely distributed and have already performed well for fish farming in the continent. Under small-scale conditions, these fish because of its tolerance at high temperatures and their resistance to disease is particularly amenable to the farming practices of smallholders, who comprise the majority of farmers in developing countries [45, 46].

Fish farming requires financial resources due to the use of feed, the cost of which is subject to galloping inflation. In terms of expenditure, this type of feed represents about 60% of the production cost of farmed fish [47]. This very often hinders the development of small-scale fish farming, which is mainly carried out by low-income individuals.

An appropriate approach to reduce feed cost for African fish farmers is to formulate and produce cost-effective and nutritionally adequate feeds at farms by using locally available ingredients [48]. In addition, supply is sometimes difficult or even impossible in rural areas, due to the poor regular supply circuit. This leads to stock-outs, which can last for months. Indeed, fish farmers still have great difficulty in obtaining feed easily profitable for the fish, due to the lower quality of the feedstuffs available on the market and the mismatch between the quality of the food and the nutritional needs of different fish species [49].

These factors force users to resort to raw materials of plant origin such as agricultural co-products or by-products and cereals, these have the advantage of being accessible and cheaper. On-farm produced fish feeds can boost productivity and reduce feed cost in aquaculture in developing countries[50]. The availability of raw materials in the right quantity, type and time is a crucial indicator of success and continuity of aquaculture operations.

But these agricultural by-products used have many nutritional disadvantages for fish, they are low in protein, with low protein/energy ratios. Their calcium content is often low, and the rates of celluloses and phosphorus are high compared to the needs of farmed species [51]. Moreover, the low quality of the by-products used would justify the long production times, low market weights and average daily fish gains, as the low protein content and low digestibility of by-product fibre by the fish may have led to low growth [52]. In addition, locally produced feeds rich mainly in carbohydrates may influence the energy content of the feed, which will affect fish growth [53].

The amino acid profile of plant by-products differs from that of fishmeal, which has the best amino acid profile. The amino acids that appear to be the most limiting are lysine and methionine, as the vast majority of vegetable protein sources contain small amounts of these, with the exception of wheat gluten for lysine and maize gluten for methionine. However, other amino acids may also be limiting in some farmed fish: arginine in corn gluten, threonine in wheat gluten and tryptophan in corn gluten [54].

However, the major constraints that limit use of plant proteins in animal feed are the presence of anti-nutritional factors such as saponins, lectin, and phytate being one of importance. They are also limiting in essential amino acids affecting growth and nutrient utilization in fish[55].

Calcium and phosphorus are vital minerals for fish growth and maintenance of physiological functions. They make up to 70% of the total mineral elements in the body and are essential for the formation of bone, energy transfer through ATP and an essential component of buffer systems in the blood[56]. Therefore, the calcium-phosphorus ratio content in the diet of a particular fish must be the quantity that will neither compromise the fish growth nor cause environmental pollution which can lead to off flavour. This balance is difficult to maintain in cases where fish feed is made with local ingredients, which leads to excessive pollution of the aquatic environment and poor fish growth [57].

The small scale fish farmers produce feeds for their own use using locally available machines, or meat mincer to produce both powdery and un-floating pellets. The use of this artisanal technique results in the production of a very moist fish feed that is exposed to the sun for drying, and one of the disadvantages of this feed is that it is too friable and does not float on the surface of the water [58].

Another problem with fish feed encountered in small-scale aquaculture is the feed formulation and fat content. The feed used is generally free of these ingredients, which will affect the nutritional quality of the fish, which will be low in polyunsaturated fatty acids, as the composition of the fish feed reflects the flesh quality of the fish [59]. Feed management plays an important role in aquaculture, but in small-scale aquaculture it is generally noted that the frequency of feeding and the rate of feed intake is not respected, which has an impact on the growth duration of the fish [60]. However, fish growth can only be perceived by the fish farmer through biometric monitoring, considered a simple, fast and extremely effective procedure. The costs of its implementation are also low, since the materials required are not as expensive. The majority of small-scale fish farmers have no idea about biometrics, due to a lack of training. [61].

7. Conclusion

In order to ensure sustainable aquaculture and reconciliation with food security needs in the near future, the improvement of the quality of aquaculture feed, which is one of the main factors hampering the sustainable development of small-scale aquaculture in Africa, is an absolute necessity. For the effective development of this sector in the continent, it is important to identify the main constraining factors that limit the capacity of aquaculture feeds to optimise production. The main challenges of aquafeed that limit its economic and productive potential for small-scale fish farmers can be addressed through training, formation of cooperatives, and a participatory contribution from research centre and universities to improve the quality of local food use in order to contribute to food security but also that the small-scale aquaculture sector can meet the objectives of sustainable development on the African continent.

Compliance with ethical standards

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Disclosure of conflict of interest

The author declare that they have no conflict of interest.

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