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Review Article

Dietary strategies for better production of African Catfish (*Clarias gariepinus*) in aquaculture: A review

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African catfish is one of the cultured fish species in Africa, as well as tropical countries, due to its high meat quantity and quality, fast growth performance, high resistance to poor water quality, ability to be cultured in a high stocking density and suitability for intensive culture system. Therefore, the objective of this paper is to review on dietary strategies employed for better production of African catfish (*Clarias gariepinus*) that may contribute in giving updated dietary information, further investigation and enhance production of African catfish. African catfish has different feed ability based on the size of the fish. They are many factors affecting the production and productivity of the species in different size level. Larval stage has no fully developed digestive system then by the effort of the researchers direction was indicated gradually transition to exogenous feed within 5-7 days weaning period with enhanced survival of larvae. The effects of feed ingredients, plant based diet, and feed additives (Probiotics, prebiotics, phytogenic, enzymes, hormones, binders and organic acids) applied and the best result was reported. Replacement of costly and unavailable feed ingredients with cheap, easily available, low cost, nutritionally acceptable and environmentally friendly plant protein sources were reported. Since the fish has a special feeding strategy based on stage of fish. Fish farmer should have to understand the feeding behavior and nutritional requirement of fish as well as choice ingredients based on nutrient content and availability with respect to sustainability and cost effectiveness.

Key words: Aquaculture, African Catfish, Plant based diet, Feed ingredients, Feed additives.

INTRODUCTION

With the annual increase in global population, there has been an increase in fish demand, causing rapid growth in the aquaculture industry compared to other animal food production. African catfish is a popular species for the aquaculture industry due to their high meat content and quality, fast growth performance, high resistance to poor water quality and disease and suitability for the intensive culture system. It has a high market demand and is preferable to fish farmers due to their potential abilities compared to other species.

The way that African catfish are fed depends on the food supply. The species can effectively use and adapt its diet to other available food sources in the system. Fish farmers may be able to feed and raise African catfish in controlled environments by making feeds from ingredients that are easily accessible nearby because they will consume anything that will fit in their mouths. For instance, catfish in ponds and tanks have been observed to capture sinking pellets before they strike the ground [1].

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As different research shows, the diet of fish is the single largest operating cost item that represents over 50% of the operating costs in intensive aquaculture. However, overdependence of aquaculture feeds on fishmeal is the major challenge facing the growth of aquaculture due to the limited availability of fishmeal, which refers to finding new alternatives to replace fishmeal with other sources. The effort to resolve this challenge can only be achieved by relying on the use of cheaper, locally available feed ingredients based on the fish's requirements.

Formulation of nutritionally balanced diets with efficient conversion of feed into growth remains a major factor that requires knowledge with respect to African catfish species. The availability of cheap feed that meets the dietary requirements of African catfish (*Clarias gariepinus*) would promote catfish aquaculture by increasing its production and profitability.

Therefore, by having this fact, this review aimed to assess the dietary strategies employed to improve nutrient utilization, growth performance, reproduction, survival and healthy condition of African catfish (*Claris gariepinus*) from published documents. This review also tries to determine the extent to which studies on dietary strategies of African catfish have been conducted and try to provide updated nutritional information on different size stage of African catfish for better production and help to identify the gaps and areas that need revalidation in this field to improve the productivity of catfish farming.

LITERATURE REVIEW

Nutritional requirements of African catfish

In order to assure the best possible fish growth and health in the aquaculture of African catfish, new species specific diet formulations are being developed to satisfy the growing demand for affordable, secure, high quality fish and seafood products. All aquaculture species, including African catfish, have dietary needs for nutrients other than water and energy that may be categorized into five different nutrient groups: Protein, lipids, carbs, vitamins and minerals. The goal of the science of aquaculture nutrition and feeding is to supply these dietary requirements to fish either directly through the use of an artificial diet or indirectly by promoting the growth of naturally existing living food organisms in the body of water where the fish are raised [2-5].

From the dietary requirements of fish protein is the most important nutrient used by fish for the purpose of growth, energy and maintenance. The protein requirement for maximum growth of any species is a logical step to the development of a cost effective feed for the fish and entails determining the minimum amount required to produce maximum growth. The use of high protein feed in the diet of African catfish increases the quality characteristics of the fish. According to Craig, lipids are high energy nutrients that can be used to partially spare protein in aquaculture diets. They have an energy density that is about twice that of proteins and carbohydrates. However, boosting dietary lipids has drawbacks such as poor fish health, poor quality and a short shelf life due to liver fat accumulation. On the other hand, it can assist in lowering the high feed costs. As a result, the amount of fat added to fish feed will have an effect and must be supported by scientific evidence based on the findings and any possible adverse effects. Because they can get their energy from lipids and protein, catfish do not require carbohydrates in their diet for optimal growth and function. Yet, because they are the cheapest sources of energy and have a binding effect, carbohydrates (starches and sugars) are sometimes added to fish diets to lower feed costs. The significant carbohydrates can be obtained from starch rich grain byproducts or grains themselves.

They also need trace amounts of vitamins (organic substances) in their food for normal development, wellbeing and reproduction. But, vitamins that are not created by fish should be included in the diet rather than those that are prepared in fish's body. Vitamin C and E need the most attention out of the two sets of vitamins (fat soluble and water soluble) because of their crucial role as an antioxidant (inhibit dietary lipid oxidation, helping to increase shelf life) and because it strengthens the immune system of fish and shrimp.

Minerals are inorganic substances that fish must consume to maintain healthy body functions. Based on the amount required for the diet and the amount contained in fish, they can be separated into macro (calcium, sodium, chloride, potassium, chlorine, sulfur, phosphorous and magnesium) and micro (iron, copper, chromium, iodine, manganese, zinc and selenium) minerals. These macro minerals control osmotic balance, promote bone growth, and support bone integrity. Micro (trace) minerals are needed in minute quantities as parts of enzyme and hormone systems. Since fish can directly absorb several elements from the water through their gills and skin, they can partially compensate for mineral deficiencies in their diet.

Fish farmers must therefore feed farmed fish diets that are economically feasible, environmentally friendly and nutrient-balanced. Assisting in boosting fish growth and output over the long run. Table 1 below displays the dietary requirements for different stages of African catfish. There have been studies on the particular nutritional requirements of African catfish.

Table 1. Size based dietary nutrient requirements of African catfish

Nutrients	Larvae	Fingerling
Crude protein %	50-55	35
	(Hecht, 2013)	(Jamabo and Alfred-Onkiya, 2009)
Carbohydrate %	14	15-32
	(Verreth and Tongren, 1989)	(Hecht, 2013)
Lipid %	14	10-Dec
	(Verreth and Tongren,1989)	(Ahmad, 2008)

DISCUSSION

Effects of feed ingredient quality

A food additive regulation must be followed when using any substance that is directly or indirectly added to an animal food component. Aqua feed covers a variety of feed ingredients, including feed additives, single cell protein sources, lipid sources, other plant ingredients and sources from both animals and plants. Dietary inclusion levels of the main sources of feed ingredients used in practical diets, together with their main qualities and drawbacks, the manufacture of unfeed must also be made more economically feasible. The priciest and most expensive imported feed component is fishmeal. Aquaculture would not produce as much fish as it consumes if fishmeal were not replaced with plant proteins. Plant proteins including soybean, groundnut (*Arachis hypogaea*) cake, bambaranut (*Voandzeia subterranea*) meal and cottonseed cake (*Gossypium* sp.) cake have all been investigated as potential replacements for fishmeal in the diet of the African catfish, *Clarias gariepinus*. The main plant ingredient used in both catfish diets and fish feeds is soybean (Glycine max) meal. In order to produce vegetable oil, biofuel, and food for humans, soybeans are frequently employed. In addition, several uses have made soybeans competitively scarce and expensive for the Sub-Saharan African aquaculture business. Finding alternatives to soy meal in the manufacturing of aqua feed would therefore be beneficial. All over Sub-Saharan Africa, bambaranut is an underutilized secondary food crop. Bambaranuts have a crude protein level of about 24% and they contain more important amino acids than the majority of other legumes. Bambaranut is a potential substitute for both fishmeal and soybean meal in the diets of African catfish due to its moderate protein content and affordable pricing [6-8].

The use of plant proteins is impacted by the presence of nutritional factors like raffinose, gossypol, trypsin inhibitors, phytic acid, protease inhibitors and saponins, as well as a lack of some essential amino acids like lysine, methionine, threonine and tryptophan, which results in poor digestibility. Also, although plant protein derivatives like wheat gluten and soy protein concentrate have desirable properties, their use has been constrained by their high price. Anti-nutritional factors and low protein content problems were resolved by using protein concentrate meals; however, the high cost issue was left unresolved. Typically, the ingredients in feed come from either plant or animal sources. This ingredient has an impact on fish production through the price of the materials, their nutritional value, how they are processed, and the proportion of their inclusion.

This element both negatively and favorably influences the insight strategy by impeding and boosting the feeding target. Feeding *Clarias gariepinus* fermented soybean pulp instead of fish meal improved fish meal's development and general health. After two thousand and one hundred African catfish fry were treated for 70 days, 32% crude protein diets were made using fermented saro posphate for substitution of fishmeal. The diet containing a 50% substitution of soybean meal with fishmeal showed the highest growth performance, Amylase and Lipase activities, muscle amino acid profiles, gene expression, and protein digestibility. Adeyemi's 2022 experiment showed the impact of using toasted sesame meal as a soybean meal replacer in the diet of Clarias gariepinus. Results showed no difference between soybean-based control diets and those fed up to 30% replacement level of the differently roasted sesame seed. This suggests that the degree of ingredient, processing and incorporation can have an impact on the quality of the food. Hence, when using it, it's important to know how to process an item and to add a specific proportion [9-11].

Effects of plant based diets

Plant proteins are the primary alternative for fishmeal in aqua feed manufacturing. A study looked at the impact of feeding an African catfish a plant-based diet on growth performance, reproduction, and healthy factors. Dada found that dietary supplementation with Garcinia kola seed powder improved the growth rate, feed utilization, and survival of C. gariepinus fingerlings. The results showed that fish-fed supplemented diets significantly improved growth performance and feed utilization over the control treatment, resulting in the highest specific growth rate [12]. Found that supplemented diet with medicinal plants (*S. indicum* and *C. zambesicus*) improved growth and reproductive indices of female catfish, *Clarias gariepinus* brood stocks. This has potential pro-fertility properties which can be exploited in fish seed production by hatchery operators. Found that African catfish (*Clarias gariepinus*) fed varying levels of composite meal in replacement of fishmeal indicating potential replace ment for fishmeal without affecting growth and survival. While also reducing cost in a developing country.

The effects of providing a plant-based diet on growth performance, reproduction, and survival have been examined in studies on African catfish. The findings demonstrated that the fish-fed supplemented with plant-based diets considerably outperformed the control treatment in terms of growth performance, and feed consumption, yielding the highest specific growth rate. Also, the female catfish, *Clarias gariepinus* brood stocks, grew and reproduced differently in response to dietary *Sesamum indicum* and *Croton zambesicus* seed powder. In addition, a study on the nutrient uptake and growth performance of African catfish fed varying levels of composite meal in place of fishmeal demonstrates that the composite meal was a potential substitute for fishmeal without impairing growth and survival while also lowering the cost in a developing nation. Therefore, it is possible to replace costly and unavailable ingredients in aqua feed like, fishmeal, soybean meal with alternative plant protein sources; nutritionally balanced, economically viable and environmentally friendly that has no competition as human consumption for sustainable production of fish [13-15].

Effects of feed additives

Feed add ones are substances added in micro quantities to a diet or feed component to enhance or conserve it. Major feed complements act as preservatives, binders, feeding inducements and food colorings. For making the feed more seductive, palatable and digestible: Attractants, Flavors and digestive aids feed complements include those having an

implicit natural or physiological significance used as antioxidants, probiotics, antibiotics, attractants and enzymes, as well as those having a technological significance similar to emulsifying, binding or conserving agents. The primary goal of feed complements is to promote healthy, rapid fire growth that will increase productivity [16].

They are classified as essential additives (vitamins and minerals) that are supplemented in small quantities to promote healthy growth. Growth promoting but non-essential additives. Single cell proteins, materials from plants and animals and some synthetic materials are added to diets as additives to promote faster growth and higher production. They are beneficial when added to feed as growth promoters and attractants. Higher feed efficiency is achieved through the use of auxiliary additives that enhance feed use. In common practice, vitamins, minerals and trace elements are supplied as a premix, which is added to the major ingredient mixture in small amounts in order to avoid any possible interaction between potent components [17].

Live microbial feed supplements known as "probiotics" are added to feeds after pelleting and promote fish growth by influencing the microbial flora population in the stomach. A single species of microbes or a combination of species may make up probiotics. The kinds of microorganisms in the supplement colonize the intestines and drive out harmful species, enabling the fish to avoid expending unnecessary metabolic energy against the effects of harmful organisms. Enzymes are improving the digestion ability of fish for feed. The enzyme is also used to digest collagen in skin and bones, complex polysaccharides and other feed ingredients. Usually, enzymes become inactive at temperatures higher than 65°C. Thus, enzyme supplements are typically spread on feeds after pelleting.

Fish feed needs to be durable enough to resist typical shipping and handling without crumbling. Moreover, fish feed must be somewhat water stable. Starch present in basic feed ingredients is gelatinized during processing and acts as a binder in feed. Materials such as agar agar carboxy methyl cellulose, bentonite, guar gum, lignin sulfate, plaster of Paris, polyvinyl alcohol, sodium alginate and wheat gluten are used as binders used at a concentration of 2%-8% to improve pellet stability. Secondary metabolites produced by different species of fungi are called mycotoxins. These are mainly grown in agricultural products. These mycotoxins can easily impact plant based feed ingredients; when included in formulated feed, they decrease weight gain and feeding effectiveness and harm the fish's liver and kidneys. Aflatoxin is mainly prepared from the following fungal species: *Aspergillus flavus*, *A. parasitcus* and *A. nomius*. Fusarium mycotoxins are also a major threat in aquaculture feeds.

There are a number of binders to counteract the harmful effects of these mycotoxins. Aluminum silicates, bentonite, montmorillonite, hydrated sodium calcium alumina silicates and zeolitic materials are commonly used in feeds at concentrations ranging from 1 g/kg to 10 g/kg.

Aqua feed preparation is the most expensive part of the aquaculture industry. In recent years, studies have been conducted on the utilization of plants' wastes and by products (such as peel, pulp and kernels) as phytogenic materials and sources of protein and nutrients for preparing feed in the aquaculture industry, which has yielded promising results. These wastes are recycled by processing them as feed additives and returning them to the feed chain, and because they are waste products of plants and fruits, prepared phytogenic feed additives cannot be regarded as feed sources for humans. Phytogenic or phytobiotic feed additives are non-destructive bioactive compounds of the environment derived from plants, such as herbs, spices, essential oils and extracts. They are included in the category of functional feed additives [18].

As example Glycyrrhizin, liquiritin, glabridin, polysaccharides, flavonoids, alkaloids, anthraquinone, saponin and azadirachtin are off the active ingredients. The primary use of phytobiotics is to improve the health and productivity of fish and shrimp farming. Evaluation, after the feeding trial, the biochemical (serum total protein, albumin and globulin) and hematological (white blood cells and red blood cells) parameters of the fish were examined. The result shows enhanced serum protein, albumin and globulin in fish fed with all the dosages of garlic peel when compared to the control group. Significantly, the highest red blood cell and white blood cell counts were recorded in garlic peel incorporated diet fed groups compared to the control group. This reveals using garlic peel even in different levels of inclusion in fed African catfish fingerling is more effective in improving resistance to disease, survival rate, and enhancing blood serum.

Organic acids are weak carboxylic short chain fatty acids. Because they partially dissociate in water to form a Hydrogen ion (H^+) and a Carboxylate ion (-COO-). Examples of organic acids are formic acid, citric acid, benzoic acid, lactic acid, acetic acid, propionic, malic and ascorbic acids, and their salts. Organic acids enhanced the growth, nutrient utilization and disease resistance of fish. It decreases pH in the stomach and intestine while at the same time increasing digestive enzyme activity. The organic acids penetrate into the cell wall of bacteria, disrupt normal activities, and inhibit their growth. Its actions depend on various factors like fish species, size, age and type, level of organic acids, feed management and water quality (Table 2).

Table 2. presents studies on African catfish utilizing various additives.

Investigation on	**Stage of fish**	**Result**
Effects of *Garcinia kola* seed powder dietary supplementation	Fingerlings	Improved the growth rate, feed utilization and survival

Effects of Bacillus NP5 supplementation as a probiotic on growth, immune response and resistance of African catfish to *Aeromonas hydrophila* infection	Fingerlings	Treatment of 1.2% Bacillus NP5 results in increased specific growth rate, protein and lipid digestibility, leukocyte, phagocytic index and survival rate, all of which significantly increased the growth rate and resistance to *A. hydrophila* infection
Influence of a commercial probiotic Antox which is a mono strain probiotic consisting of live Saccharomyces cerevisiae at 4.125×10^6 cfu per 100 ml on growth, nutrient utilization and body composition	Fingerlings	The growth performance, nutrients utilization, and body composition of *C. gariepinus* probiotic-treated groups were significantly increased ($P<0.05$) with increasing dosage of the probiotic
Effects of three different dietary prebiotics (FOS: Fructooligosaccharide, GOS: Galactooligosaccharide, and MOS: Mannanoligosaccharide) in two levels (1 g/kg and 2 g/kg) in recirculating aquaculture system	-	Better growth results ($P<0.05$) were obtained in MOS (2 g/kg) supplementation
Effects of different levels of testosterone propionate on growth, survival, and sex ratio, using five different doses (such as 125, 100, 75, 50, 25 mg hormone per kg feed)	Fry	The growth performance in terms of weight and length gain of the fry receiving 100 and 75 mg hormone per kg feed was significantly higher than those receiving 50, 25 and 0 (untreated control) mg hormone per kg feed
Effects of various supplemental exogenous enzyme on the growth performance in African catfish for 12 weeks feeding trial	Fingerling	Food conversion ratio, protein efficiency ratio, protein utilization and growth rate were significantly higher in all enzyme complex groups than control ($p<0.01$)
Effects of dietary lanthanum chloride on the growth and health performance of juvenile *Clarias gariepinus* when fed diets experimentally contaminated with mixtures of aflatoxin B1 and fumonisin B1	Juvenile	The fish fed the diets amended with lanthanum chloride 200 to 400 mg/kg exhibited significantly ($p<0.05$) better performance indices compared with the fish fed only the mycotoxin contaminated diet
Growth performance, feed utilization and survival of catfish fed		Supplementation of an organic acid in the diet of *C. gariepinus* has no

on different types of diet, containing various organic acid supplementations		impact on feed utilization, survival and water quality parameters

Feed formulations and feed management throughout the life cycle

The African catfish diet formulation represents the nutrient and energy requirements of a given species for a given response to an acceptable diet using a balanced mixture of ingredients that is economically sustainable and environmentally suitable. According to the challenge of feeding farmed fish with diets that are nutritious, at the same time economically and environmentally sustainable is a major issue that needs the critical attention of producers. The quality of ingredients, sustainability and cost of ingredient has an impact on quality diet formulation. To use a least cost computer program to formulate feeds, the following information used as a precaution: cost of feed ingredients; nutrient concentrations in feedstuffs; nutrient requirements based on the size of fish; nutrient availability from feedstuffs; and nutritional and non-nutritional restrictions.

Brood stock management and feedings are the factors that greatly affect the survival of the offspring. The type, nature, quantity and quality of feeds provided to the brood fish will influence and affect the quantity and quality of eggs produced; the fertilization rates, hatchability, and survival rates. Brood fish fed a commercial diet (40% crude protein and 10% lipid) at the rate of 2% of the body weight per day. As general feedstuffs, containing 20 percent crude protein or more are considered protein supplements. They are also very important to add different ingredients and additives used in feed to achieve healthy and faster growth leading to higher production of fish [19].

The most important consideration in African catfish brood-stock aquaculture is to ensure the development of a valuable and healthy supply of larvae and/or offspring by using high quality gametes from fish brood stock. This should be achieved by supplementation of feed additives that can enhance the fertility of African catfish. Aqueous extract of *Telfaria occidentalis* leaf powder added to diets has been shown to boost gonadal somatic index and reproductive indices in male *C. gariepinus* brood stocks, suggesting that the herb may have pro fertility properties. The inclusion of Medicinal plants/herbs as natural additives in fish diets enhances reproductive performance in fish brood stock.

The larval stage of *C. gariepinus* requires live feeds since it has immature digestive mechanisms at first feeding. The production of catfish larvae continues to be severely hampered by the lack of appropriate larval diets and feeding methods. Previous research demonstrated that larvae fed live feed could develop their digestive tracts more successfully than those fed artificial feed. The first feeding of fish larvae requires live feed to provide energy for growth and physiological function. Live feeds such as rotifers, copepods and *Artemia nauplii* are the best larval feeds due to their nutrient profile, and easy digestion and assimilation by the larvae.

However, continuously using Artemia is also another challenge due to the reality of expensive food items and its production as live feed also requires specialized facilities to produce. Therefore, feeding diets that reduce dependence on live prey is of technical and economic interest to aquaculture that needs further investigation on larval feeding to result in the success of African catfish production. The main challenge to formulate formulated diets for larval African catfish is the lack of success during the early stages of development and the inability to produce a sufficient amount of digestive enzymes. Exogenous microbes like probiotics can be used to control or enhance the microbial communities of the fish. Probiotic diets can lead to high growth performance and higher survival of catfish larvae fed with probiotics, as well as animal origin for the first feeding of *C. gariepinus* larvae.

The earliest possible weaning period of 5 days from Artemia to crumbles of a commercial trout diet were reported. Result showed the final weights and growth rates of the groups weaned after 5 and 7 days did not differ significantly from the un weaned group. As a result gradual weaning from live feed to formulated diet is used to improve Survival and growth rates of African catfish larvae. In Tanzania that evaluated the performance of two locally formulated feeds as replacements for imported commercial feed in the rearing of African catfish (*Clarias gariepinus* Burchell) fry. The results showed that Feed TAF 1 recorded the best performance with weight gain of 33.72 ± 0.89, FCR of 1.35/0.05 and a specific growth rate of 4.61 ± 0.04, suggesting that Tanzanian farmers can economically raise African cats using locally manufactured diets.

When come to fingerlings initially, small fingerlings (1-2 inches) should be fed once or twice daily to satiation using a crumbled feed or small pellets (1/8-inch diameter). Fingerlings consume large feed pellets by nibbling on the feed after the pellets soften and begin to break up in the water. Fingerlings appear to grow well using this feeding strategy, but nutrient losses, especially micronutrients, are likely due to the leaching of nutrients because of the extended time the pellet is in contact with the water. Maggot Meal (MG) in a fishmeal free Soybean Meal (SBM) based diet was the best alternative to produce best performance in the culture hybrid African catfish. Four isoproteic and iso energetic diets were formulated as positive control (FM-based diet), soybean based diets (MF-free) and diets based on soybeans with additional 14% and 21% MG, referred to as FM, SBM, MG14 and MG21, respectively. After the feeding trial, fish fed MG21 exhibit exceptional performance and improved immuno-physiological indicators such as white blood cell, lymphocyte count, total protein, and globulin values. Supplementation with MG at 21% enhanced the antioxidant capacity of hybrid catfish with no detrimental effect [20].

Fish grown for food are usually stocked as advanced fingerlings of about 5 inches-6 inches in length and fed with a floating feed. Catfish are raised in ponds using a multiple-batch production strategy, and feeding rates should not be higher than what pond organisms can take in, with a recommended 100 120 lb acre/day limit.

CONCLUSION

Due to their high levels of meat production and quality, rapid growth rates, excellent resilience to disease and poor water quality, African catfish (*Clarias gariepinus*) are one of the most widely cultivated fish species. However, feeding African catfish is difficult since the feed is unfit for their needs and abilities. To meet the feed ability and requirement of fish, which vary with fish size, they need size based feeding schemes. Based on the selection of feed materials that meet nutritional needs and in accordance with the ability and level of the fish, feed that meets the needs of fish is formulated. The nutritional value, sustainability and cost of the ingredient should all be taken into consideration while choosing it. Feed composition for African catfish should follow.

AUTHOR CONTRIBUTION

I would like to state that this review was edited by compiling only our personal reviews from published papers. As we work, I “Mekonnen Melesse” draft it and the co-author “Dr. Akewake Geremew” comments on it, to make sure we work together.

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Since the manuscript is a review paper collected from published document, it does not require ethical approval.

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The authors declare no competing interests.

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REFERENCES

1. Abdel-Latif HM, Abdel-Daim MM, Shukry M, Nowosad J, Kucharczyk D (2022). Benefits and applications of Moringa oleifera as a plant protein source in Aquafeed: A review. Aquaculture. 547:737369.
2. Adeshina I, Jenyo Oni A, Emikpe BO, Ajani EK, Abdel-Tawwab M (2019). Stimulatory effect of dietary clove, *Eugenia caryophyllata*, bud extract on growth performance, nutrient utilization, antioxidant capacity and tolerance of African catfish, *Clarias gariepinus* (B.), to *Aeromonas hydrophila* infection. J World Aquac Soc. 50(2):390-405.
3. Adeyemi TF, Adeparusi EO, Dada AA (2013). Dietary effect of some oil seed based methionine on sperm quality of African Catfish *Clarias Gariepinus* (Burchell, 1822). Afr J Sustain Dev. 3(1):158-167.
4. Adeyemo BT, Tiamiyu LO, Ayuba VO, Musa S, Odo J (2018). Effects of dietary mixed aflatoxin B1 and fumonisin B1 on growth performance and haematology of juvenile *Clarias gariepinus* catfish. Aquaculture. 491:190-196.
5. Agbabiaka LA, Ekeocha CA, Ekeledo CB (2010). Study on feeding habit of Clariid Catfish (*Clarias gariepinus* Burchell, 1822) in River Otamiri South Eastern Nigeria. Anim Prod Res Advs. 6(4):283-284.
6. Ahmad MH (2008). Response of African catfish, *Clarias gariepinus*, to different dietary protein and lipid levels in practical diets. J World Aquac Soc. 39(4):541-548.
7. Anater A, Manyes L, Meca G, Ferrer E, Luciano FB, Pimpao CT, et al. (2016). Mycotoxins and their consequences in aquaculture: A review Aquaculture. 451:1-10.
8. Apenuvor T (2014). Crossing, Sex reversal and reproductive capacity of two populations of *Sarotherodon melanotheron* (*Cichlidae*) from the Central Region of Ghana (Doctoral dissertation, university of Cape Coast).
9. Asriqah L, Nugroho RA, Aryani R (2018). Effect of various organic acid supplementation diets on *Clarias gariepinus* BURCHELL, 1822: Evaluation of growth, survival and feed utilization. F1000Res. 7(1465):1465.
10. Azaza MS, Wassim K, Mensi F, Abdelmouleh A, Brini B, Kraïem MM (2009). Evaluation of faba beans (*Vicia faba* L. var. minuta) as a replacement for soybean meal in practical diets of juvenile Nile tilapia *Oreochromis niloticus*. Aquac. 287(1-2):174-179.
11. Bhujel RC, Jha DK, Anal AK (2020). Effects of probiotic doses on the survival and growth of hatchlings, fry, and advanced fry of Rohu (Labeo rohita Hamilton). J Appl Aquac. 32(1):34-52.
12. Binder EM, Tan LM, Chin LJ, Handl J, Richard J (2007). Worldwide occurrence of mycotoxins in commodities, feeds and feed ingredients. Anim Feed sci Technol.137(3-4):265-282.
13. Burr G, Gatlin III D, Ricke S (2005). Microbial ecology of the gastrointestinal tract of fish and the potential application of prebiotics and probiotics in finfish aquaculture. J World Aquac Soc. 36(4):425-436.
14. Chepkirui-Boit V, Ngugi CC, Bowman J, Oyoo Okoth E, Rasowo J, Mugo Bundi J, et al (2011). Growth performance, survival, feed utilization and nutrient utilization of African

catfish (*Clarias gariepinus*) larvae co-fed Artemia and a micro-diet containing freshwater atyid shrimp (*Caridina nilotica*) during weaning. Aquac Nutr. 17(2):e82-89. [Crossref] [Google Scholar]
15. Dada AA, Adeparusi EO (2012). Dietary effects of two medicinal plants (*Sesamum indicum*) and (*Croton zambesicus*) on the reproductive indices in female African catfish (*Clarias gariepinus*) broodstock. Egypt J Aquat Res. 38(4):269-273.
16. Davies OA, Ezenwa NC (2010). Groundnut cake as alternative protein source in the diet of *Clarias gariepinus* fry. Int J Sci Nat. 1(1):73-76.
17. Dennis EU, Uchenna OJ (2016). Use of probiotics as first feed of larval African catfish *Clarias gariepinus* (Burchell 1822). Annu Res Rev Biol. 1-9.
18. Drew MD, Borgeson TL, Thiessen DL (2007). A review of processing of feed ingredients to enhance diet digestibility in finfish. Anim Feed Sci Technol. 138(2):118-136.
19. El-Haroun ER, Goda AS, Kabir Chowdhury MA (2006). Effect of dietary probiotic Biogen® supplementation as a growth promoter on growth performance and feed utilization of Nile tilapia *Oreochromis niloticus* (L.). Aquac Res. 37(14):1473-1480.
20. Enyidi UD, Pirhonen J, Kettunen J, Vielma J (2017). Effect of feed protein: lipid ratio on growth parameters of african catfish *Clarias gariepinus* after fish meal substitution in the diet with bambaranut (*Voandzeia subterranea*) meal and soybean (Glycine max) meal. Fishes. 2(1):1.