



A Mini-Review: Importance of Proper Nutrition for the Growth of Cultured African Catfish (*Clarias gariepinus*)

Gifarri Azanna Yudawan^{1*} and Junianto¹

¹*Department of Fisheries, Faculty of Fisheries and Marine Sciences, Padjadjaran University, Bandung, Indonesia.*

Authors' contributions

This work was carried out in collaboration between both authors. Author GAY prepared the manuscript draft. Author Junianto provided supervising. Both authors read and approved the final manuscript.

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ABSTRACT

Feeding is an important aspect of fish farming activities and could determine the quality of fish. African catfish (*Clarias gariepinus*) is an omnivorous freshwater fish that is high in protein and economical value. Catfish nursery generally uses natural feed and artificial feed to ensure the diet requirements fulfilled. Good feeding, in quality or quantity, is an important aspect to produce a high quality breed. A good feed is the basis of improving cultured catfish growth and survival performance. The purpose of this article is to review types of feed, feeding practices, and their enriched alternatives for catfish rearing.

Keywords: African catfish; aquaculture; feed efficiency; growth performance.

1. INTRODUCTION

The freshwater aquaculture fishery sector of Indonesia is ever-growing and has the potential to be developed further through

intensification [1]. Freshwater fish such as catfish are commodities that have a high demand in the domestic market, reaching more than ±500,000 individuals per week in [2].

*Corresponding author: Email: gifarriay@gmail.com, gifarri19001@mail.unpad.ac.id;

African catfish (*Clarias gariepinus*) is a freshwater fish that are high in demand and economical value. Catfish's are fast growing and its meat has comparatively higher calorie and protein content than other freshwater fishes, yet it is considered healthier because of its low cholesterol levels relative to meat from most other livestock. Study conducted suggests that Catfish has 68.6% of protein, 5.8% of fat, 3.5% of ash, and 59.3% of water [3].

The growth and survivability of juvenile catfish is often determined by the quality of the broodstock, egg quality, water quality and the ratio between the amount of food and the density [4].

Fish nutritional needs are often fulfilled as digested energy from food items that are available, especially in cultured environment. Energy gain is dependent primarily on the protein in the diet [5]. Effective utilization of energy also requires relatively high proportion of non-protein energy in the diet. High-energy diet could lead to an excessive deposition of carcass lipids and reduced growth rate [6].

Catfish farmers have experienced problems in determining the right feed in catfish nursery to get seeds that can be grown optimally without high costs. Good seed and feed preparations, in quality or quantity, are important aspect of fish culture.

A good feeding practices can improve catfish growth and survival performance. Conversely, uncontrolled feeding will deteriorate pond water, forcing the fish to use its energy reserve in order to survive and hinder its growth potential [7]. Catfish breeding and nursery generally uses natural and artificial feed to ensure that their catfish are kept well-fed.

Natural feeds are fish food available in nature as a resource. The advantage of natural feed includes having a high nutritional content and is easily digestible. One of the most common natural feed for fish is silk worms because of its high protein content. The nutritional content of silk worms is 54.73% protein, 13.77% fat, 22.25% carbohydrates [8]. High protein feed as nutrient component in fish feed culture is relatively expensive, particularly for carnivorous fish such as African catfish. Most natural feed are usually limited in nature and its associated cost driven furthermore by the high amount of effort to collect them.

Artificial feeds are made from a mixture of natural and processed ingredients, often in a certain form to stimulate the fish to eat it. The most commonly used artificial feed is pellet flour that contains 40% protein, 5% fat, and 30% carbohydrates [8].

Feed is an important elements that support the growth and survival of cultivated fish. In aquaculture, commercial feed is generally used. The use of commercial feed can take up about 50-70% of the total production costs incurred [9]. As feed cost represents about one-half of variable production costs in catfish culture, careful consideration should be given to feed selection and use. Artificial feed is often introduced to catfish aquaculture to get decent quality, readily available, and affordable feed ingredients.

Growth can only occur if the energy needed for body maintenance and other functions is fulfilled. Protein utilization depends upon its availability, source, energy, growth influencing non-protein in the food, food conversion, nutrient retention efficiency, and body composition [6].

Protein is a major source of energy for fish. While most study reported that freshwater fish has protein requirement of ranging from 35% to 45%, it seems to be a more accurate assessments to ornamental rather than cultured species [10,11]. Older experimentation suggests that most cultured species, especially catfish need high protein content in its diet, mostly hovering around 45 to 55% to able to grow optimally for aquaculture purposes [12].

The availability of good quality protein in catfish diets will yield good growth performance, high survivability, and good quality seeds. The dietary requirements of cultured fish is an important factor influencing the success of any fish farming. Feed that meets the nutritional needs of fish can increase its growth performance and in turn, market value [13]. This is often the reason why choosing the right feed is critical in the early life cycle of catfish.

2. AFRICAN CATFISH AND AQUACULTURE

African catfish (*C. gariepinus*) is a species of catfish of the family Clariidae. African catfish is one of the most highly valued species economically in Africa and Asia. It has a combined body shape with a depressed head and a compressed body, complete set of fins;

namely dorsal, ventral, pectoral, anal, and caudal fins, and a pair of adipose fin, which is an additional fin in the form of fat that is located behind the dorsal fin [14].

It has no scales, and instead produce much more mucus with antibacterial activity than most freshwater fish in order to protect itself from harm [15]. The moniker "catfish" is taken after its prominent barbells which gave it phasing resemblance to cat whiskers. The fish is mostly reared in earthen ponds, though other rearing condition such as tarpaulin pool is also used [12].

C. gariepinus differs from other catfish in having an auxiliary breathing organs pouch attached to the second and fourth gillarches. This organ enables *C. gariepinus* to be cultured in other systems such as tanks and hapas. While able to withstand a poorer quality water, considerable effort is required to induce spawning under culture conditions that are too harsh [16].

The African catfish species is regarded as excellent for aquaculture as it is often either carnivorous or omnivorous, grows fast, and tolerates relatively poor water quality [17]. The length of African catfish ranges from 25-70 cm, average adults is usually 100 cm and can even reach 150 cm peak [18]. *C. gariepinus* is a type of freshwater fish that are high in demand and economical value. Catfish is fast-growing with a high stocking density (150-400 fish/m³ of water), can be kept in limited and narrow land, and can live in stagnant water. A pool area of 15 m² with a water depth of at least 120 cm can be stocked with as many as 6000 catfish seeds, making it a favorite for aquaculture.

Most cultured catfish are sold when it reached its first maturity, because of the high rate of domestic demand and because of its potential for cannibalism in certain breed and conditions [19,20].

3. DIETARY REQUIREMENTS

Protein is a food ingredient which is highly needed for growth, especially for carnivorous species. Protein comprises about 70% of the dry weight of fish muscle [21]. A continual supply of protein is needed throughout life for sustenance. As most living organism, catfish require a source of nonspecific nitrogen and indispensable amino acids.

Catfish are estimated to need high protein content in its diet, around 45 to 55%, and while

common for carnivorous species, is regardless still relatively high for species that is culture-reared intensive and extensively, potentially driving up cost and lowering potential production.

Recent studies may have indicated that a low level protein may be just adequate for grow-out of catfish when the fish are fed full feed during the growing season [22,23]. The rationale behind these studies is that the optimum dietary protein level is driven by economics as much as rate of gain.

Protein utilization for fish growth is mostly influenced by size, age, quality of feed, water temperature, and feeding frequency [24]. If protein reserves exceeds the energy requirement, protein retention can occur where then excess protein will be stored in body tissue increasing mass, and intake of other nutrients including protein will reduce as well [3].

Increase in protein content in the body can help catfish to use the stored energy for repairing damaged cell and increasing growth rate [25]. Catfishes that are well-fed in ideal condition could optimally utilize nutrients from feed so that their body weight increases due to optimum digestion, absorption, and being able to convert the excess energy to flesh.

Catfish diets have generally been based on a fixed formula with little use of a least-cost approach. The primary constraint limiting the use of least-cost programs for formulating catfish feeds is that relatively limited variation of feedstuffs are available that can be used for catfish feeds.

Conversely, when catfish diet and/or energy requirements is not fulfilled, excess reserve protein will be used to fulfill the energy necessity, making the fish unable to grow rapidly, potential for weaker constitution, and increasing vulnerability to all kinds of disease.

The nutrient requirements of *C. gariepinus* are outlined in Table 1.

Fish nutrition often refer primarily to identification and quantification of nutrient requirements for fish at the different steps of its development. Each stages have different nutrient requirements. These concern macronutrients, such as protein and essential amino-acid, during grow-out phases, or micronutrients supply, such specific form of fatty acid, during larval development [24].

Table 1. Dietary requirements of African Catfish (10-1000 g)

Nutrient	Quantity	Ref
Crude protein (% min recommended)	40–43	[25]
Least cost/appetite feeding protein requirement	35–38	[25]
Crude lipid (% min)	10–12	[26]
Carbohydrate (% recommended)	15–35	[26]
Digestible energy (min, kJ/g)	14–16	[25]
Metabolizable energy (min, kJ/g)	13	[25]
Gross energy (min, kJ/g)	22–24	[25]
Protein to energy ratio (mg/kJ)	22–30	[25]
Lipid to carbohydrate ratio	2.47	[26]

The utilization of carbohydrate by catfish appears to rather different from other freshwater fishes. Starch is able to be used more efficiently by catfish than sugars such as glucose or sucrose. Glucose is highly digestible by catfish, but a large portion of the absorbed glucose is unused and excreted [27]. Carbohydrates is more or less used as an supplements in catfish feeds, to reduce the amount of protein used for energy thereby sparing protein for growth.

Energy requirements were largely neglected in the early stages of catfish feed development [25,28]. However, corrected or balanced dietary energy is an important consideration when formulating catfish feeds, too much energy can result in a reduction in food intake and thus reduce nutrient intake.

To achieve those nutrient and/or dietary requirements, often traditional farm-made feed prepared from feedstuffs, such as soybean meal, corn, and fish meal, are used with some sense of defined formula.

4. FEED NUTRIENT FORMULATION AND CONSIDERATION

Nutrient requirements for catfish have been well defined. In formulating and manufacturing catfish feeds, it is essential that the finished feed meet nutrient requirements and be in a form that is readily consumable and is digestible. Feed processing may have a profound effect on certain nutrients, but good feed processing should have the least amount of detrimental effects on the nutrients present.

Many feedstuffs are used in catfish feeds because of their nutritional content or because of cost constraints. Feedstuffs that contains 20% crude protein or more are considered supplements. Protein supplements may be further classified as animal or plant-based proteins.

Animal-based proteins came from inedible tissues such as powdered bone meal and poultry byproduct meal while the main plant protein sources used in catfish feeds are oilseed meals, such as soybean meal. Animal-based feedstuffs are much common while plant-based are generally not available on a timely basis and at an economical cost per unit of protein.

In general, feed ingredients must be economical, consistently available, easily handled in the manufacturing process, and able to withstand the rigors of the manufacturing process. These characteristics are the primary reason that soybean meal and corn have been the main feedstuffs typically used in catfish feeds. Peanut meal for example are technically usable and often priced economically, but their use is limited not only because of their nutritional deficiencies but also because they are not available on a consistent basis during the catfish growing season.

5. COMMERCIAL FEED OF AFRICAN CATFISH

Although natural food organisms may provide certain nutrients, their contribution to the nutrition of intensively cultured catfish is generally considered to be rather insufficient [29]. Thus,

the nutritional requirements of cultured catfish are met either by using feedstuffs or a complete feed formulated to provide all required nutrients in the proper proportions necessary for rapid weight gain, high feed efficiency, and a desirable composition of gain.

Catfish farmers are suggested to use feed that is nutritionally complete to provide the required levels of nutrients and. It is essential to provide a complete diet in readily digestible form because catfish can synthesize only a small portion of the required nutrients and the quantity of nutrients.

Early catfish farmers depended primarily on natural pond organisms to provide essentials for growth. Prepared feeds, mixtures of feedstuffs processed into various forms, were used to supplement natural productivity. Poultry items also encompassed in this processed form.

Dry feeds are later produced, and these ranged from formulated dry mixes fed to dry pellets [30]. Preparation and manufacturing technologies are rather simple, raw materials are milled and cooked then mixed into a dough with water and extruded using a meat mincer. The resultant product is often sun-dried or dried in locally manufactured driers and cut or crumbled into appropriate sizes. Farmers often mix and prepare only quantities that can be used within a few days as to not hike up the materials used.

While traditional-made feed often satisfies the need of catfish and potentially able to produce a Feed Conversion Ratio (FCR) of 1:1:1, in practice it is unfeasible in the long run especially for high demand product such as *C. gariepinus* [30]. As catfish culture became more intensive, with increased emphasis on high yield resulting

in increasing stocking densities, the use of natural and traditional artificial feed became less sustainable.

Feeds that provided all known nutrients required by catfish were developed and manufactured commercially. A typical commercial catfish feed contains a formula with less than 20% protein while substituting it with 25% or more soluble carbohydrate to aid to fulfill energy diets.

Farmers often use these commercial feed as all of the commercial feed essentially fulfill the needs of catfish nutrient intake. However, specifically formulated and extruded pellets (45 - 55% protein) for the early rearing stages of *C. gariepinus* are either relatively scarce, expensive, or made from a substance that does not correspond to a safe feeding practice.

To be more precise, formulating fish feeds are based on amino acid requirements. Nutritionally, amino acids may be classified as essential or nonessential. Essential amino acid is one that can be synthesized by the animal in quantities sufficient for maximal growth while nonessential amino acid is one that the animal cannot synthesize or cannot synthesize in quantities sufficient for body needs; thus, they must be supplied in the diet. Most simple-stomach animals, including catfish, require the same 10 nonessential amino acids outlined in Table 2.

In Indonesia, imported fishmeal is used in commercial production of catfish as the major source of protein. This has created a sustained dependence on importation for the supply of fishmeal. An example of a typical commercial feed and its content are outlined in Table 3.

Table 2. Amino acid requirements of african catfish (10-1000 g)

Amino Acids	Quantity (% in Protein)
Arginine	4.3
Histidine	1.5
Isoleucine	2.6
Leucine	3.5
Lysine	5.1
Methionine + cystine	2.3
Phenylalanine + tyrosine	5.0
Threonine	2.0
Tryptophan	0.5

Table 3. Common commercialized feed for fish

	Crude Protein (% Min)	Crude Lipid (% Min - Max)	Crude Fibre (% Max)	Ash (%)	Ca (%)	P(%)
NutriScience (pre-starter)	45	8	4	-	3	7
NutriScience (starter)	40	8	4	-	3	7
NutriScience (grower)	35	7	4	-	3	7

Regarding feeding and nutrition, fish farmers may be confronted to two successive problems during the nursery stage: to cover specific needs for fish larvae until they can accept compound diets, and then to optimize fingerlings production with compound diet [31]. Thus necessitate the research to find a cheaper alternate feed that are able to cover catfish diet requirements optimally, as to not only reduce the overall production cost driven by conventional feed of cultured catfish but also potentially increasing overall qualities of catfish to satisfy market demand of increasing needs for high-quality livestock products.

6. ALTERNATIVE ENRICHED FEED FOR AFRICAN CATFISH

There have been increasing needs to search for a local, cheap alternative sources of protein that aim to reduce production cost without compromising fish quality [32,17]. These sources should hold the potential to supplement, either fully replace or partly replace the imported fishmeal. There are also many supplements being developed in recent times, though rather than replacement it intends to add as a supplementary to primary commercial feed [33,34].

Fish requires feed with high protein content even with sufficient protein efficiency. The quest for a sustainable development of aquaculture encourages researcher to find alternative protein source to fishmeal [35].

Plant proteins, mainly those issued from proteaginous seeds, were regarded as good alternative protein source as their production is renewable [36]. Protein substitution by plant protein sources were already tested on some pangasiid species and shows promising results. In particular *Pangasius djambal* and *Pangasianodon hypophthalmus*, using soybean, black-eyed pea or mungbean meal [31].

A number of plants continue to be investigated for their potential in supplementing or even replacing fishmeal for catfish culture. Cottonseed meal [28] and cottonseed meal plus supplemental lysine [37] were once researched as a potential replacement, though further evaluation still did not produce a comparable nutrient content to most alternative such as soybean [38]. *Leucaena leucocephala* has been identified to contain about 22.7% crude protein and could be included up to 30% level in *Clarias gariepinus* diets without any negative effects on the growth [39]. *P. guajava* and *M. pudica* can be used as supplement to improve catfish immunoresponse and resilience, potentially improving its long-term growth rate [40]

Other extensively researched alternative includes the use of probiotics as supplement in fish feed. Probiotics are products composed of microbial cultures or microscopic natural feed that are beneficial and have an impact on improving the microbial balance of feed [2].

Probiotic bacteria produce enzymes that are able to break down complex compounds such as proteins into simple ones. In improving feed nutrition, bacteria contained in probiotics have a mechanism to produce several enzymes for feed digestion such as amylase, protease, lipase and cellulase [41]. These enzymes will help hydrolyze feed nutrients, such as breaking down carbohydrates, proteins, and fats into simpler molecules that will facilitate the digestion and absorption process in the digestive tract of fish.

It has been noticed that papain enzyme-enriched diet can boost diet efficiency for many cultured species [42,12]. The dosage of 10 g kg⁻¹ diet brought about the best growth and protein efficiency ratio in cultured *Labeo rohita* and *Oreochromis niloticus* [43,44].

While it is noted that enrichment of papain enzyme into the diet can improve protein content due to its ability to break down protein into

simpler elements as amino acids, the need for papain enzyme depends on the type of fish and their weight. It is discovered that the 6 g kg⁻¹ diet of papain enzyme enrichment could lead protein digestibility and growth of Sangkuriang catfish with the weight of 3.43g fingerling⁻¹ to increase exponentially [45].

Mostly similar result has been achieved with phytase enzyme-enriched diet where it has also been noted that organic matter, protein, and phosphorus were more digestible in fish fed with high phytase level [46]. High efficiency of feed utilization could make fish grow better as high efficiency utilization of feed was manifested by using the most part of the feed for the growth.

Many experiments have been done in recent times to prove that enriched feed, particularly papain-enzyme and phytase-enzimed enriched feed, could be further developed into either supplements or major feed products. Improvement in protein digestibility, their abundance in several often cultivated plant, and most importantly relatively inexpensive to reproduce is promising for better catfish feed in aquaculture.

7. CONCLUSION

A good alternative commercial feeds can improve the growth of catfish. Growth performance and survivability of catfish benefits from good feed efficiency. Because feed is an element that farmers could control in cultured condition, choosing and finding the right feed can make the difference in improving the quality of growing seeds.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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