**Journal of Researches in Agricultural Sciences**

**Journal of Researches in Agricultural Sciences Vol. 7**



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**Ekiti State University, Ado-Ekiti. Nigeria** Vol. 7(1), March 2019 pp – 12-19

**Performance Evaluation of African Catfish (*Clarias gariepinus*) Fingerlings Fed African Locust Bean (*Parkia biglobosa*) Meal Diets**

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**Abstract**

The high cost of conventional feedstuffs, especially the protein sources, due to competitive use in livestock feed and as industrial raw materials has necessitated the search for cheaper, locally available alternative feedstuffs as replacement in order to reduce the cost of production in aquaculture. A feeding trial was conducted to evaluate the growth and nutrient utilization of African catfish (*Clarias gariepinus*) fingerlings (average weight of 3.00 g) using African locust bean (*Parkia biglobosa*) meal (ALBM) to replace soybean meal as plant protein source. The fish fingerlings were stocked in fifteen glass tanks at the rate of ten fish tank-1 and fed five diet treatments in three replicates. The ALBM was used to replace soybean meal at 0, 25, 50, 75 and 100% substitution levels (denoted as D1, D2, D3, D4 and D5 respectively with D1 as the control) in the diets formulated at the 40% crude protein level required for *Clarias gariepinus*. The fish were fed daily to satiation and the experiment lasted for 70 days. The results show that fish fed diet D5 gave the best growth parameters which did not differ from D1 but both were significantly different (P<0.05) from the other diets. The cost of producing 1 kg of feed reduced as the level of inclusion of the ALBM increased in the diets. Therefore, African locust bean meal can replace soybean meal as plant protein source up to 100% in the diet of *Clarias gariepinus* fingerlings without any negative effect on the growth and nutrient utilization while the lower cost of feed production has the potential to increase the profit.

**Keywords:** Soybean meal, African locust bean meal, *Clarias gariepinus*

Cite as: Obe B.W, Akin-Obasola, B.J and Adebayo, I.A (2019). Performance Evaluation of African Catfish (Clarias gariepinus) Fingerlings Fed Boiled African Locust Bean (Parkia biglobosa) Diets. *Journal of Researches in Agricultural Sciences* Vol. 7(2) 12-19

**Introduction**

Fish is one of the most important sources of protein available in the tropics; fish protein improves nutrition because it has a high biological value in terms of high protein retention in the human body (Ogunlade, 2007). The African catfish, *Clarias gariepinus* (Burchell 1822),family Clariidae, is a fresh water fish generally considered to be one of the most important tropical catfish species for aquaculture in West Africa (Clay, 2009).

Aquaculture, as a food production enterprise, has become established in many African countries. A major prerequisite for successful fish farming is the availability of suitable artificial feeds that will supply adequate nutritional requirements for the cultured fishes (Craig and Helfrich, 2017). Fish nutrition is a major aspect of research in aqua-feed operations and for fish culture, the optimum dietary requirement at a reduced production cost is essential in order to maximize profit. One of the major ingredients for preparing such suitable feeds is soybean. In the developing countries, soybean meal is the most widely-used plant protein source in aqua- and other livestock feeds which account for the high cost (Obasa *et. al.*, 2009). Since feeding

cost represents the greatest single high cost item in fish farm operations (Jamiu and Ayinla, 2003; Fagbenro *et. al.,* 2005), the use of costly ingredients will further increase the cost of production, reduce the profit margin and bring about high price tag of fish for consumers. Therefore, the reduction of feed cost is a major challenge in aquaculture nutrition.

The high cost of conventional feedstuffs has brought about the need to have alternative feedstuffs that can replace the very expensive ones in order to reduce the cost of livestock and fish production (Longe, 2006). In the search for plant protein substitutes, the African locust bean (*Parkia biglobosa* (Jacq.) G.Don) is being considered for study. African locust bean (locust bean) is a perennial deciduous leguminous tree (family Fabaceae) which grows in the savannah region of Nigeria, to the southern edge zone (Campbell-Platt, 1980). The tree is particularly valued for its fermentable seeds that are relatively cheaper, more widely available and less competitive in use for both human and livestock consumption than soybean. Due to the savoury taste and high protein and fat values of the seed, it is sometimes described as a meat or cheese substitute (PFAF, 2012). It is rich in protein, lipids and vitamin B2 but deficient in the amino acids such as methionine, lysine and tryptophan. However, the fermented locust bean is rich in lysine (Campbell-Platt, 1980) such that the use as an alternative plant protein source will reduce the challenges faced in fish feed formulation and save fish farmers the high cost of production. This, in turn, will improve fish production and bring about improved profit margin to the fish farmers. Therefore, this study was carried out to evaluate the effect of boiled African locust bean meal as an alternative plant protein source to soybean meal in the diet of African catfish *Clarias gariepinus* (Burchell 1822)fingerlings.

**Materials and Methods**

The study was carried out at the Department of Fisheries and Aquaculture Management, Ekiti State University, Ado Ekiti. The experiment involved fifteen 30-litre plastic tanks, each of 70×45×40 cm dimension with the water level maintained at 2/3rd capacity of the tank throughout the period of the experiment. The dietary ingredients: fish meal, soybean meal, groundnut cake, maize meal and vitamin/mineral premix were purchased from a reputable livestock feed mill; vegetable oil and starch were bought from the city market while African locust bean seeds were sourced from Oko-Egan at Awo-Ekiti.

The African locust bean seeds were washed and cooked in water at a temperature of 100ºC for 6 h and the water was topped up occasionally to compensate for the loss due to evaporation. After cooking, the water was strained away with the aid of a basket lined with mesh. The seeds were de-hulled by pounding in a mortar, washed thoroughly and sieved to remove the hulls. The de-hulled seeds were sun-dried for three days, milled with a locally-fabricated grinding machine and the African locust bean meal (ALBM) packed in air-tight containers until needed for use.

The dietary ingredients were measured according to the gross composition in Table 1. Diet D1 to diet D5 were formulated to replace soybean meal with ALBM at inclusion levels of 0, 25, 50, 75 and 100% respectively. The diets were formulated at 40% crude protein level as required for *Clarias gariepinus* (Wilson and Moreau, 1996, FAO, 2019)*.* Starch was added to act as binder and the feeds were pelletized with a locally-fabricated pelleting machine to 2 mm diameter size. The pellets were sun-dried and packed in labelled air-tight containers and stored in a cool and dry place.

One hundred and fifty (150) fingerlings of African catfish (*Clarias gariepinus*;mean initial weight = 3.00 g) were sourced from the farm of the Directorate of Fisheries, Ministry of Agriculture and Rural Development, Ado-Ekiti. The fish were acclimatized for seven days in the glass tanks and fed with Coppens®. The fish were weighed and randomly stocked at the rate of ten tank-1 and each treatment was replicated thrice. The experiment lasted for 70 days during which the fish were fed to satiation twice daily between the hours of 8-9 a.m. and 5-6 p.m. The left-over feeds and faeces were siphoned out of the tanks on daily basis to reduce water pollution. The water was changed twice a week. The fish were weighed fortnightly and at the end of the experiment, the final weight of each batch of fish was taken. The water quality parameters were monitored weekly: temperature using an ordinary mercury-in-glass thermometer, pH by a pH meter and Dissolved Oxygen (DO) analysis using Winklers’ titration method.

. Table 1: Gross Composition of Experimental Diets (g/100g)

|  | D1 (0%) | D2 (25%) | D3 (50%) | D4 (75%) | D5 (100%) |
| --- | --- | --- | --- | --- | --- |
| Fishmeal (72%)  | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 |
| ALBM (41.14%)  | - | 4.90 | 9.80 | 14.70 | 19.60 |
| SBM (45%)  | 24.50 | 19.60 | 14.70 | 9.80 | 4.90 |
| GNC (38%)  | 23.00 | 23.00 | 23.00 | 23.00 | 23.00 |
| Yellow Maize (10%)  | 23.50 | 23.50 | 23.50 | 23.50 | 23.50 |
| Vegetable Oil  | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Starch  | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| \*Vit/Min. Premix  | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |

\*Each kg contains: Vit A: 4,000,000 IU; Vit B 800,000 IU Vit E: 16,000 mg; Vit K3: 800 mg; Vit B1: 600 mg; Vit B2 :2,000 mg; Vit B6 :1,600 mg; Vit B12: 8 mg; Niacin: 16,000 mg; Caplan: 4,000 mg; Folic Acid: 400 mg; Biotin: 40 mg; Antioxidant: 40,000 mg; Chlorine: 120,000 mg; Manganese: 32,000 mg; Iron: 16,000 mg; Zinc: 24,000 mg; Copper: 32,000 mg; Cobalt: 120 mg; Selenium: 800 mg (manufactured by DSM Nutritional Products Europe Limited, Basle, Switzerland)

The growth and nutrient utilization parameters in the fish were assessed as follows:

1. Weight gain = final weight of fish (W2)-Initial weight (W1)
2. Specific growth rate (SGR)

= Loge W2–Loge W1 x 100

 T2-T1

where W2 = Final Weight

 W1= Initial Weight

 T2-T1= Number of Days.

Loge = Natural Logarithm to Base e

1. Protein efficiency ratio (PER) = fish weight gain (g)

 Protein consumed (g)

1. Feed conversion ratio (FCR ) = weight of feed (g)

 Fish weight gain (g)

The proximate analysis of the test ingredient and the fish after the experiment was carried out to determine the moisture content, crude protein, crude fibre, ash content, lipid and carbohydrate using the methods described in AOAC (2000).

The costs of producing 1 kg of the different feeds with ALBM at different inclusion levels were calculated and compared with the production cost of 1 kg of the control diet which has no ALBM. The costing was done based on the prevailing market prices of the ingredients used in the diets at the time of the experiment.

Data (mean weight gain, specific growth rate, protein efficiency ratio, feed conversion ratio) obtained were subjected to One-Way Analysis of Variance (ANOVA) using the SAS package and differences between treatments separated using the Duncan Multiple Range Test at P=0.05 level.

**Results**

Table 2 shows the proximate composition of the test ingredient (boiled African locust bean meal, ALBM). The ALBM contained 41.14±0.00% crude protein, 1.20±0.01% total ash and 6.25±0.01 fat.

Table 2: Proximate analysis of the test ingredient.

|  |  |
| --- | --- |
| Composition%  | Average ±SD |
| Protein  | 41.14±0.00 |
| Ash Content | 1.20±0.01 |
| Moisture Content | 8.60±0.01 |
| Crude Fibre | 10.90±0.00 |
| Fat | 6.25±0.01 |
| Carbohydrate  | 31.91±0.06 |

 Laboratory analysis, 2018

Table 3 shows the growth performance and nutrient utilization of the experimental fish. The highest final mean weight of 6.10 g was obtained in fish fed diet D5, followed by diet D1 (5.69 g) while the least was in the fish fed diet D2 (4.64 g). The final mean weights in fish fed diet D5 and diet D1 were not significantly different (p>0.05) but differed significantly from other diets. The final weights were also not different among diet D1, diet D3 and diet D4. The highest weight gain (3.10 g) was in the fish fed diet D5 followed by diet D1 (2.69 g) which did not differ significantly while the least weight gain (1.64 g) was in the fish fed diet D2. The daily weight gain and specific growth rate followed the same trend with the fish fed diet D5 recording the highest values and fish fed diet D2 recording the lowest values. The best food conversion ratio (FCR) was obtained in the fish fed diet D5 (2.16) while fish fed diet D2 had the poorest (2.51).

Table 3: Growth parameters and nutrient utilization of the fish fed African locust bean meal

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameters | D1 | D2 | D3 | D4 | D5 |
| Initial weight (g) | 3.01±0.006a | 3.00±0.006a | 3.00±0.000a | 3.01±0.006a | 3.01±0.006a |
| Final weight (g) | 5.69±0.189ab | 4.64±0.275c | 5.36±0.331b | 5.37±0.482b | 6.10±0.195a |
| Weight gain (g) | 2.69±0.189ab | 1.64±0.276c | 2.36±0.331b | 2.37±0.478b | 3.10±0.190a |
| Daily weight gain (g) | 0.04±0.000a | 0.02±0.006b | 0.03±0.006a | 0.03±0.006a | 0.004±0.006a |
| Specific growth rate (%/day)  | 0.91±0.045ab | 0.62±0.078c | 0.83±0.085b | 0.82±0.129b | 1.01±0.045a |
| Protein efficiency ratio | 0.51±0.031ab | 0.31±0.053c | 0.44±0.064b | 0.45±0.091b | 0.58±0.035a |
| Feed conversion ratio | 2.51±0.031ab | 3.15±0.053a | 2.94±0.403a | 2.90±0.539a | 2.16±0.130b |

 Means with different superscripts along the same row are significantly different (P<0.05)

Fig. 1 shows the graph of the growth curve of the fish fed with the experimental diets. Fish fed diet D5 (100% ALBM) peaked faster than all other diets while fish fed diet D2 (25% ALBM) was the lowest in growth. The growth curve from 0 to 2 weeks represented the slow growth phase while from 8 to10 weeks represented the marginal growth phase

.

Weeks

Weight (g)

Fig. 1: Growth of fish fed ALBM diets

A = D1 (control diet), B = D2, C = D3, D = D4, E = D5, init weight = initial weight

Table 4 shows the carcass composition of the fish after 70 days of feeding with the experimental diets. The moisture content differed significantly (p<0.05) among the fish fed the various diets, being least in the fish fed diet D1 (17.48±0.001%) and increased to the highest in fish fed diet D4 (22.76±0.001) and followed by decrease to 20.22±0.02% in diet D5. The protein content differed significantly (p<0.05) among the fish fed the diet treatments. The fish fed diet D1 contained the highest protein (42.07±0.001%) while the least value was in the fish fed diet D5 (26.25±0.002%). The protein content increased with the level of ALBM inclusion to diet D4 and followed by decrease in fish fed diet D5. The lipid contents differed significantly (p<0.05) among the fish fed the diets with the highest value obtained with diet D5 (2.51±0.001%) while the fish fed diet D2 contained the least (0.41±0.002%). The lipid content increased with the level of ALBM inclusion rising from 0.41±0.002% in fish fed diet D2 to the highest value at D5 (2.51±0.001%). The lipid content was the same in the fish fed diets D1 and D3 (1.91±0.001%). The fish fed diet D4 contained the highest total ash and diet D3 contained the least. All the values differed significantly among the diets and had no particular trend in relation to the level of ALBM inclusion.

Table 4: Carcass composition of the experimental fish

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Composition  | D1(Control) | D2 | D3 | D4 | D5 |
| Moisture  | 17.48±0.001d | 19.76±0.001c | 22.23±0.002a | 22.76±0.001a | 20.22±0.00b |
| Crude protein  | 42.07±0.001a | 28.20±0.002d | 29.24±0.002c | 30.38±0.002b | 26.25±0.002e |
| Crude fat  | 1.91±0.001c | 0.41±0.002d | 1.91±0.001c | 2.10±0.001b | 2.51±0.001a |
| Carbohydrate | 37.23±0.003e | 49.82±0.004b | 45.92±0.006c | 42.46±0.009d | 49.93±0.003a |
| Total ash  | 1.31±0.002c | 1.82±0.002b | 0.70±0.002e | 2.29±0.003a | 1.10±0.001d |

 Means with different superscripts along the same row are significantly different (P<0.05)

Table 5 shows the water quality parameters during the period of the experiment. The temperature and the dissolved oxygen in the water were 25.52-25.68ºC and 5.26-5.30 mg l-1 respectively throughout the period of the experiment, while the pH values ranged between 6.81 and 6.89. However, there were no significant differences (p>0.05) between all the treatments for all the parameters. The cost of replacing soyabean meal with ALBM in the diets is shown in Table 6. The costs of the diets decreased with increasing levels of ALBM.

Table 5: Water quality parameters during the experiment

|  |  |  |  |
| --- | --- | --- | --- |
| Tanks  | Temperature ºC | pH | DO (mg/l) |
| D1 | 25.53±0.142a | 6.81±0.133a | 5.30±0.049a |
| D2 | 25.52±0.214a | 6.89±0.039a | 5.29±0.010a |
| D3 | 25.62±0.128a | 6.88±0.040a | 5.27±0.035a |
| D4 | 25.68±0.172a | 6.86±0.050a | 5.26±0.025a |
| D5 | 25.62±0.202a | 6.89±0.036a | 5.29±0.040a |

Means with same superscripts along same column are not significantly different (P<0.05)

Table 6: Costs of the experimental diets fed to African catfish (₦ kg-1)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ingredients | D1 (Control)  | D2 | D3 | D4 | D5 |
| Fish Meal (72%) | 843.75 | 843.75 | 843.75 | 843.75 | 843.75 |
| Groundnut cake (38%) |  73.60 |  73.60 |  73.60 |  73.60 |  73.60 |
| Soybean meal (45%) | 111.48 |  89.18 |  66.89 |  44.59 |  22.30 |
| ALBM (41.14%) |  - |  18.38 |  36.75 |  55.13 |  73.50 |
| Yellow Maize (10%) |  65.80 |  65.80 |  65.80 |  65.80 |  65.80 |
| Vegetable oil |  13.75 |  13.75 |  13.75 |  13.75 |  13.75 |
| Starch  |  2.50 |  2.50 |  2.50 |  2.50 |  2.50 |
| Fish Premix |  82.50 |  82.50 |  82.50 |  82.50 |  82.50 |
| Total  | 1193.39 | 1189.46 | 1185.54 | 1181.62 | 1177.70  |

**Discussion**

This study has revealed the possibility of utilizing cooked African locust bean meal (ALBM) in the diet of African catfish and as a potential substitute for soybean meal in enhancing its productivity. The proximate analysis of ALBM used in this study shows higher crude protein (CP) level than 25.57-30.12%, 31.00-40.00% and 30.04-31.07% reported by Femi-Ola *et al*. (2008), Anyanwu *et al.* (2012) and Olujobi (2012) respectively. The cooking, sun-drying and milling of the African locust bean to prepare the ALBM could have been responsible for the higher CP recorded and this is in agreement with Femi-Ola *et al*. (2008) that the CP in boiled *P. biglobosa* seeds was higher than in the raw seeds. The variation in the values of CP could be attributed to environmental factors as indicated by Olujobi (2012) that location significantly affected the nutritional composition of African locust bean fruits.

The CP of ALBM recorded in this study is slightly higher than the CP at 40% and 37.69% reported for soybean meal by NSRL (2013) and Ogbemudia *et a*l. (2017) respectively and slightly lower than 43-44% reported for “conventional” soybean meal (Heuze *et al*., 2019). Thus, the CP in ALBM compares favourably with soybean which is responsible for its ability to replace soybean in this study without any adverse growth effects or defects.

Cooking was employed as a processing method for ALBM in this study in order to deactivate anti-nutritional factors present in the ingredient and make the nutrients readily available for fish (Aletor, 1993, Ajaiyeoba, 2002). This agrees with Nwanna *et* *al*. (2005) who found cooking as the best processing method that produced the highest numerical total phosphorus, mean weight gain, specific growth rate, mineral liberation and best feed conversion ratio from the study on the effects of different treatments of dietary soybean meal and phytase on the growth and mineral deposition in *Clarias gariepinus*.

The diet D5 (100% inclusion of ALBM) performed better than all other diets including the control diet. This implies that ALBM can totally replace soybean meal in the diet of *Clarias gariepinus* without any adverse effect. The result obtained in this study is similar to that reported by Obasa *et al*. (2003) that pressure-cooked pigeon pea seeds would replace 60% of soybean meal in the diet of *Oreochromis niloticus* with improved growth performance in the fish over that fed the control diet. Robinson and Li (1994) and Olude *et al*. (2008) reported better growth performance over the control diet when soybean was replaced at 30% with cottonseed meal and soaked copra meal in catfish and *Oreochromis niloticus* diets respectively.

The growth curve represented by a slow growth phase from 0 to 2 weeks and the marginal growth phase from 8 to 10 weeks is in line with natural exponential growth situation in fish. The growth curve indicated a general increase in weight gain from the first week to the last week of the experiment with the highest weight observed in the fish fed diet D5 which shows that the fish was able to utilize the nutrients in the diet efficiently and that the nutrients were sufficient to bring about an increase in weight gain. The feed conversion ratio of 2.1 obtained in fish fed diet D5 is lower than in other diets which indicates that the fish is of better quality. The result agrees with Olele *et al*. (2003) that low food conversion ratio indicates higher protein efficiency ratio thereby resulting in better growth. Adikwu (2003) also noted that the lower the FCR, the better the feed utilization by the fish. The lowest FCR of fish fed diet D5 indicates better feed utilization which obviously accounted for the better growth performance of *Clarias gariepinus*.

High priority is given to protein requirement in any nutritional study because it is the single nutrient that is required in the largest quantity for growth, development and the most expensive ingredients in formulation of diet (Craig and Helfrich, 2017), such that studies aimed at replacing the conventional and expensive protein source with a less expensive and less competitive protein source are worthwhile. The cost of producing 1 kg of the experimental diets decreased as the inclusion levels increased such that the control diet without ALBM had the highest production cost. The reduction was progressive being ₦4.93, 3.91, 3.92 and 3.92 between D1 and D2, D2 and D3, D3 and D4 and D4 and D5 respectively such that the cost of production in D5 was lower by ₦16.68 representing 1.40% of the production cost kg-1 of diet D1.

**Conclusion**

This study found that 100% replacement level of soybean with boiled African locust bean seeds as an alternative plant protein source in the diet of fish increased growth rate of *Clarias gariepinus* than the control diet. The study also found out that feeds from 25-100% inclusion levels of ALBM were less costly compared to the soybean-based diet. The diet containing 100% replacement level of ALBM was the cheapest, the most economical and can effectively replace soybean meal-based diets in fish feed composition to bring about enhanced growth to fish and reduce the cost of feeding which would guarantee higher profit.

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