



Research Article

Utilization of Dietary Bambara Groundnut and Soya bean Meal as Fish Meal Replacement in Catfish (*Clarias gariepinus*, Burchell 1822) Fingerlings

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ABSTRACT

A four-week experiment was conducted to analyse the changes in growth performance and survival rate of *Clarias gariepinus* fingerlings fed plant-based crude proteins from Soyabean (*Glycine max*) and Bambara groundnut (*Vigna subterranean*) formulated by incorporating 0, 25, 50, 75, and 100% inclusion level as a replacement for fishmeal. A total of 600 fingerlings of *C. gariepinus* were purchased from a reputable fish farm and was completely randomized into fifteen experimental ponds (hapas) at 40 fish per each with 3 replicate and fed twice daily at 5% body weight under controlled conditions. Data obtained was subjected to analyses of variance and the differences among the means were separated using least significant difference (LSD). Results showed increases in crude protein from 18.75% (T1) to 38.00% (T5), while crude fat decreased from 15.94% (T1) to 5.57% (T5). The growth performance was observed highest in T3 with mean weight (12.80g), weight gain (11.01g) and feed conversion ratio (1.68g). there were no significant differences ($p > 0.05$) observed in the specific growth rate among the treatments Survival rate was record at 75, 85, 72.5, 80 and 95% across all treatments with T5 having the highest, indicating that the diets had no adverse effects on fish health. The improved performance observed in higher inclusion levels was attributed to enhanced nutrient availability following processing of the plant ingredients and improved dietary energy balance. This study therefore, concluded that Bambara groundnut and soybean meal can effectively replace fishmeal up to 50% inclusion level in the diet of *Clarias gariepinus* fingerlings without compromising growth and survival rate.

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INTRODUCTION

Fish is an important and cheap source of animal protein that account for about 37% of Nigeria total protein requirement (Kaleem *et al.*, 2021). Fish production has continued to be the source of hope in solving global problem of malnutrition due to its rich and cheap sources in nutritive values above other animal sources of protein (Razak *et al.*, 2023). Despite the boom in culturing African catfish, the production of fingerlings still remains a problem. Fingerlings production in Sub-saharan African is hampered by high cost of feed production and cost of imported live feeds such as artemia (Enyidi *et al.*, 2015). This led to the high cost of fingerlings production in the region and also aquaculture depend largely on the sustainable protein source, to replace fish meal in aqua feed like protein (Enyidi *et al.*, 2015, Hardy, 2010).

The African catfish, *Clarias gariepinus* (Burchell, 1822) locally called "Tarwada" in Hausa, "Eja Abori" in Yoruba and "Azu okpo" in Igbo language, of the family Claridae is the one of the important, widely cultivated fish in Nigeria, which can be cultured both inside and outside its natural range of tropical and subtropical environments (Inusa *et al.*, 2022). Fish feeds constitutes 40-60% of the total cost of aquaculture production which is expensive and led to extensive studies on replacing a costly protein especially soya bean in fish diets (Løvdal *et al.*, 2019). Similarly, Kaleem *et al.*, 2021) observed that fish feed constitutes 60-70% of the operational cost in the intensive and semi-intensive aquaculture system. The need to minimize feed cost through the use of new and cheaper sources of feed ingredients is currently receiving the attention of nutritionists and the selection of feed ingredients for use as fish feed will play a major role in matching its ultimate nutritional requirement in addition to economic success (Iheanacho *et al.*, 2025). There is high competition for foodstuffs between human and domestic animals. For economic and practical reasons, fish feed should be prepared from locally available protein source, preferably from those unsuitable for human consumption (Brune *et al.*, 2021). The need to solve the problem of high cost of feed in aquaculture has been carried out through various studies in the utilization of vegetable sources and agricultural wastes such

as water hyacinth meal and poultry offal (Alhotan *et al.*, 2021).

Leguminous crops such as Bambara groundnut and soybean are promising alternatives for fishmeal. Bambara groundnut is an indigenous African crop which originated in West Africa with high protein content (18-24%) and good energy value, and it is well adapted to marginal environments (Siwale *et al.*, 2024). Soybean meal is one of the important oilseed crop and growth all over the world which contained maximum amount of protein and other important essentials vitamins that play important role in our daily life (Alfred *et al.*, 2020).

It is therefore, very crucial to find an alternative to reduce feed cost, and to make aquaculture a viable and attractive ventures. The need to solve the problem of high cost of feed in aquaculture has been carried out through various studies in the utilization of vegetable sources and agricultural wastes (Iheanacho *et al.*, 2025). The use of cost effective fish diets has been a challenge globally due to the high cost and competition on the plant protein source among livestock, fish, and humans. The major source of plant source protein in aqua feed is soya bean which is very expensive. This has resulted to sourcing for alternative plant protein source feed ingredients.

Fishmeal is an excellent protein source in fish feed due to its balanced amino acid profile and high digestibility by fish. Traditionally, fishmeal is the main dietary protein source in fish feed formulation. Bambara groundnut (*Vigna subterranea*) is a highly nutritious, drought-tolerant African legume that grows pods underground, similar to peanuts while soya beans (*Glycine max*) are nutrient-dense, edible legumes and primary global source of plant-based protein and oil, containing all nine essential amino acids.

This work produced fish feed using two locally sourced legume grains combined with (fish meal as control) as major ingredients, while molasses, red palm oil, sodium chloride and micro nutrient pre-mix will be added as minor ingredients. The produced feeds were evaluated for proximate composition, survival rate, and the growth performance on fingerlings catfish (*Clarias gariepinus*).

MATERIALS AND METHODS

The experiment was conducted at Animal Science Research farm of Kashim Ibrahim University Njimitilo, Maiduguri. Maiduguri lies in the semi-arid zone of Nigeria. It is characterized by a short rainy season (3 to 4 months) with a long dry season period. Annual rainfall ranges from 500mm to 600mm while the ambient temperature reaches 40°C and above by April and May (Bello *et al.*, 2021).

Collection and Processing of Ingredients

Bambara groundnut and soya bean was procured from Gamboru market, Maiduguri which was transported to Animal Science Department Laboratory. Then it was winnowed to remove debris manually and kept in bags in the store until required. The seeds of both Bambara groundnut and Soya bean were subjected to processing method according to (Udo and Ozor, 2022) to remove anti-nutritional factors, soya-beans was toasted and Bambara groundnut were soaked in the water for some time after which they were grounded into fine granular powder.

Processing of Ingredients

Sample were prepared according to the method of (Udo and Ozor, 2022), seeds of *V. subterranean* were threshed mechanically with mortar and pestle, and soaked for 14 hours, washed thoroughly to remove seed testa and bad ones. The seeds were fermented for 72 hours by placing them in an airtight container (plastic container of about 20 litres, size containing about 5 litres of water), and air-dried, weighted and oven dried at 60°C in a paper bag for 6 hours, then cooling in an opened air. Soya beans was weighted and toasted in a toasting pot for 10 minutes by each batch measured. All the ingredients and the dried seeds of Bambara groundnut and soya bean were milled at a gambaru milling centre and sieved using a 0.5mm mesh sieve.

Feed formulation

All diets were formulated on dry matter basis using the proximate compositions of the feed ingredients. Diet formulated using feed formulation software for windows (Winfeed 2.8) which formulates feed by linear programming technique (Udo and Ozor, 2022). Diets formulated are shown in Table 2.

Feed milling and drying

The ingredients were measured using Camry weighing balance and mixed thoroughly with 10 percent of cassava starch used as a binder. Water was added into the mixture and mixing was continued. After thorough mixing the mixture was pelleted using pelleting machine of 2 mm die ring and sprayed under the shade to dry.

Experimental Fish

Six hundred (600) fingerlings of catfish were obtained for the experiment from a fish farm in Maiduguri metropolitan and transported in 50 litres of can to Kashim Ibrahim University Animal Farm. This was done in early in the morning when the weather was cold. On arrival to the farm the fingerlings were allowed to acclimatize in for some time before the commencement of the experiment. During this time the fish were kept in a concrete tank of 3 x 3m width and 1m depth size and were fed with Bluecrown commercial feed containing 40 percent crude protein for a week.

Experimental procedures

A Completely randomized design (CRD) was used in this experiment (T1, T2, T3, T4 and T5) and all treatments were replicated three (3) times having 40 fingerlings per replicate making it 600 fingerlings in total: Treatment 1 with no Bambara groundnut and soybean was used as the control. Various replacement levels were designed thus, (T2 with 25%), treatment T3 (with 50%), treatment T4 (with 75%), and treatment 5 (with 100%) for 25, 50, 75 and 100% respectively.

Stocking, Feeding and Water Management

The stocking density of the fingerlings was forty fish per experimental pond of 3 x 3m width and 1m depth, with a flow through water. The feeding of the fingerlings was done in the morning around 9 o'clock and in the evening time at 5 o'clock the feeding frequency were adopted according to Udo and Ozor, 2022 where each treatment were fed experimental diets at 5% body weight. The water parameters like pH, dissolved oxygen and temperature were monitored and recorded likewise the feeding response.

Data Collection

Data on fish growth was recorded; weight of the each fish (per experimental treatment) was obtained with an electronic sensitive weighting scale to 0.01g (Saffron) which was done early in the morning around 7am. The experimental tanks were observed daily to remove dead fish, uneaten feeds and excess ammonia. Daily weight, feed conversion ratio, specific growth rate, protein efficiency ratio and survival rate were calculated.

Physio-Chemical parameters

Physio-chemical parameters such as pH, temperature, and dissolved oxygen were checked daily to ensure optimum water quality. Every day water quality was monitored

according to (APHA, 1975), throughout the experimental period. Flow through water system was used during the experimental period.

Proximate analysis

The proximate composition of the formulated feeds which includes moisture, fat, protein, and ash content of dried products were analysed as describe by AOAC (2016).

Statistical Analysis

Data obtained from the study was subjected to One-way Analysis of Variance (ANOVA) in calculating treatment and block effects while differences between the means were determined using Least Significant Difference (LSD) at 95% confidence level ($P= 0.05$) with the aid of Statistix 10.0 statistical package.

RESULTS AND DISCUSSION

Table 1: Proximate Composition of the Experimental Diets (g/100 g dry matter)

Treatments	Moisture	Ash	Parameter s Protein	(g/100g) Fat	Fibr e	Carbohydrate s	Energ y (Kcal)
T1	12.06 ± 0.10 a	4.45 ± 0.05 a	18.75 ± 0.20 c	15.94 ± 0.15 a	8.40 ± 0.12 b	39.50 ± 0.30 a	361.4 6
T2	11.98 ± 0.08 a	4.59 ± 0.04 a	25.50 ± 0.18 d	9.25 ± 0.01 ^b	8.30 ± 0.10 b	40.38 ± 0.25 b	339.7 7
T3	10.93 ± 0.07 b	4.10 ± 0.03 b	27.14 ± 0.22 c	6.03 ± 0.08 ^c	8.80 ± 0.14 a	43.28 ± 0.28 c	331.1 9
T4	10.70 ± 0.06 b	4.42 ± 0.05 a	33.00 ± 0.25 b	7.66 ± 0.09 ^b	5.08 ± 0.09 c	39.14 ± 0.22 a	355.3 0
T5	11.41 ± 0.09 a	4.74 ± 0.06 a	38.00 ± 0.03 a	5.57 ± 0.07 ^c	9.00 ± 0.15 a	31.28 ± 0.20 d	320.0 5

*means in the same column with different superscripts are significantly different ($p < 0.05$)

The proximate composition of the experimental diets shows that the crude protein content, ranges from 18.75% (T1) to 38.00% (T5), this variation plays a vital role in determining growth performances in the fingerlings. Protein is an essential component for tissue synthesis and enzymatic functions which makes it the most critical nutrient in fish diets. The protein level observed in T5 suggests that fingerlings fed with this diet would likely exhibit enhanced growth and better feed conversion efficiency. This is in agreement with Lovell, (1989) whom stated that optimal protein levels are necessary to maximize weight gain in cultured fish species such as

Clarias gariepinus and Tilapia. Lipids content, decreased across treatments, with T1 having the highest fat content T5 the lowest. Carbohydrate content was highest in T3 (43.28%) and lowest in T5 (31.28%), indicating an inverse relationship with protein levels, its inclusion in feeds is beneficial when protein and lipids levels are balanced. Energy values differed significantly, with T1 and T4 exhibiting higher energy levels compared to other treatments, while T5 had the lowest energy value. These variations reflect the diets and suggest that higher protein diets were achieved at the expense of lipid and carbohydrates fractions.

Table 2: Ingredients and feed stuffs of the experimental diets

Feed stuff (kg/100)	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5
Fish meal	30	25	10	5	0
Soya bean meal	0	15	20	20	22
Bambara groundnut meal	0	15	15	20	22
Groundnut cake meal	25.0	10.0	10.0	10.0	11.0
Wheat offal	10	10	10	10	10
Guinea corn meal	15	15	15	15	15
Yellow Maize meal	10	10	10	10	10
Cassava meal	9	9	9	9	9
Vitamin C	0.05	0.05	0.05	0.05	0.05
Lysine	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10
Premix	0.01	0.10	0.10	0.10	0.10
Sodium chloride	0.25	0.25	0.25	0.25	0.25
Palm oil	0.40	0.40	0.40	0.40	0.40
Total	100	100	100	100	100

Effects of the Experimental Diets on the Growth Performance Feed Utilization and Survival of *Clarias gariepinus* Fingerlings

Growth performance of *C. gariepinus* fingerlings fed the experimental diets is summarized in Table 3. The final mean weight was significantly higher ($p < 0.05$) in T3 (12.80 ± 0.20 g) compared to other treatments, except T2 (11.94 ± 0.10 g) and T4 (11.94 ± 0.12 g) which were statistically similar. T1 recorded the lowest final mean weight (11.67 ± 0.15 g). Daily weight gain followed a similar trend, with T3 exhibiting the highest value (11.01 ± 0.18 g), while T1 showed the lowest (9.87 ± 0.14 g). Specific growth rate ranged from $2.77 \pm 0.10\%$ day⁻¹ (T3) which is similar to (Enyidi and Mgbenka, 2015) who noted high specific growth rate and weight gain in *C. gariepinus* fish fed 50% FM diets, and lowest at $2.73 \pm 0.05\%$ day⁻¹ (T4). Survival rate was 75.00 ± 2.50 , 85.00 ± 3.00 , 72.50 ± 2.00 , 80.00 ± 2.50 and $95.00 \pm 2.00\%$ across all treatments, indicating no dietary-induced mortality. This suggests that the combination of

fermented Bambara groundnut and toasted soybean meal at this level provided an optimal balance of protein, essential amino acids, lipid, and energy to support rapid tissue development. Fermentation and toasting are known to reduce anti-nutritional factors such as trypsin inhibitors, tannins and phytates, thus improving protein digestibility and nutrient utilization (Udo and Ozor, 2022). The superior performance of T3 is consistent with the findings of Alfred *et al.* (2020), who reported enhanced growth in *Clarias gariepinus* fed diets containing well-processed soybean meal due to its high-quality protein and complete amino acid complement. The performance of T3 (SGR $2.77 \pm 0.10\%$ day⁻¹) supports the view of Siwale *et al.* (2024), who highlighted Bambara groundnut as a nutrient-dense legume capable of supporting growth in monogastric and aquaculture species when appropriately processed. Furthermore, the comparable performance of T1 (control) and T5 indicates that replacement level does not

negatively affect growth and may serve as a cost-effective alternative to fishmeal (Iheanacho *et al.*, 2025). Fish fed diet T3 recorded the highest weight gain and best feed conversion ratio, indicating superior growth performance. However, T5 showed the highest survival rate, suggesting better overall fish health and adaptability. No significant differences ($p>0.05$) were observed in specific growth rate among treatments, indicating similar growth patterns across diets. The results suggest that diets T3 and T5 are most effective, with T3 optimizing growth and T5 enhancing survival. Survival rate

remained at 75, 85, 72.5, 80 and 95% across treatments with T4 having the highest survival rate of 95% at 75% inclusion level which agrees with study conducted by (Udo and Ozor, 2022), therefore this studies shows that none of the diets induced mortality but confirming the nutritional safety of Bambara groundnut and soybean meals at all Inclusion levels. These findings agrees with Brune *et al.* (2021) and Enyidi *et al.* (2015), who similarly reported high survival in *C. gariepinus* fed plant-based protein diets

Table 3: Effects of Experimental Diets on the Growth Performance Feed Utilization and Survival of *Clarias gariepinus* Fingerlings

Parameters	T1	T2	T3	T4	T5
Initial mean weight	1.80±0.05 ^a	1.82±0.06 ^a	1.79±0.04 ^a	1.81±0.10 ^a	1.80±0.05 ^a
Final mean weight	11.67±0.15 ^c	11.94±0.10 ^c	12.80±0.20 ^a	11.94±0.12 ^b	12.6±0.18 ^b
Weight gain (g)	9.87 ±0.14 ^c	10.12±0.11 ^c	11.01±0.18 ^a	10.13±0.13 ^c	10.86±0.16 ^b
Specific growth rate (% day⁻¹)	2.74 ± 0.12 ^a	2.73 ± 0.05 ^a	2.74 ± 0.10 ^a	2.73±0.05 ^a	2.76 ±0.11 ^a
Feed intake (g/fish)	18.20±0.50 ^a	17.80±0.45 ^a	18.50±0.55 ^a	17.90±0.40 ^a	18.30±0.48 ^a
Feed conversion ratio (FCR)	1.84±0.05 ^a	1.76±0.04 ^b	1.68±0.03 ^c	1.77±0.04 ^b	1.69±0.03 ^c
Protein efficiency ratio (PER)	1.20±0.03 ^c	1.35±0.04 ^b	1.48±0.05 ^a	1.36±0.04 ^b	1.45±0.05 ^a
Number of fish stocked	40	40	40	40	40
Number of fish survived	30±1 ^c	34±2 ^b	29±1 ^c	32±1 ^b	38±1 ^a
Survival rate (%)	70±2.50 ^c	85±3.00 ^b	72.50±2.00 ^c	80.00±2.50 ^b	95.00±2.00 ^a

% *percentage*, Means across the same row differently superscripted differ significantly ($P<0.05$). Values are means ± SD.

Water Quality parameters

Water quality parameters remained within acceptable ranges for African catfish culture throughout the four weeks trial (Table 4).

Dissolved oxygen ranged from 4.8±0.05 (T4) to 5.2±0.16 mg L⁻¹ (T5), temperature from 19.90±0.14°C (T4) to 20.32 ±0.02°C (T1), and the water exchange was regularly maintained in

a flow through to ensure good quality and pH from 7.3 ± 0.08 (T4) to 7.6 ± 0.13 (T5). These values did not differ markedly among treatments. The water quality parameters measured (DO and pH) remained within recommended ranges for African catfish culture.

The fingerlings of *Clarias gariepinus* accepted the prepared diet with little or no wastage but were affected by the temperature drop as a result of the harmattan season (December to January) which resulted in lower growth rate (Enyidi and Mgbenka, 2015).

Table 4: Physio-chemical parameters of pond water during 30 days of culture

Parameter	T1	T2	T3	T4	T5
Dissolved oxygen (mg/L)	4.9 ± 0.05	5.10 ± 0.04	5.0 ± 0.05	4.8 ± 0.05	5.2 ± 0.16
Morning water temperature ($^{\circ}\text{C}$)	20.32 ± 0.02	20.13 ± 0.1	20.22 ± 0.02	19.90 ± 0.14	20.22 ± 0.02
pH	7.5 ± 0.16	7.4 ± 0.14	7.5 ± 0.16	7.3 ± 0.08	7.6 ± 0.13

CONCLUSION

The proximate composition of the diets formulated at different concentration levels of soybean and Bambara groundnut as replacement of fish meal shows that plant-based diets significantly influenced the nutrient composition of the feeds; with an increase in crude protein across the treatments with T5 having the highest carbohydrate and fibre. T3 and T5 having high proteins and more suitable for supporting growth in the fish. T4 shows more balanced nutrient profile combining relatively high protein, moderate lipid content, lower fibre and adequate energy. The result shows that T3 promoted the best growth performance and optimal survival rate which makes it suitable for fish production. When formulating fish feeds balanced protein to energy ratio improves performance at the fingerlings stage. Therefore Bambara groundnut can partially replace fish meal, but optimal inclusion levels and well processed (fermented seeds) are needed to maintain balance and reduced anti-nutritional factors present in the seeds.

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