Economic Viability and Performance of *Clarias gariepinus* (Burchell, 1822) Juveniles Fed Exclusively with Locally Formulated Feeds in a Semi-Intensive Culture System

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Abstract
This study evaluated the economic viability and growth performance of *Clarias gariepinus* juveniles fed exclusively on three locally formulated diets under a semi-intensive culture system. A total of 150 juveniles (15.8 ± 0.3 g) were distributed into three treatments (D_1 = Maize-Soybean, D_2 = Maize-Groundnut, D_3 = Maize-Bambara), each with 50 fish. Diets were formulated to contain similar crude protein levels and fed twice daily for 12 weeks. Feed cost, feed conversion ratio (FCR), and benefit-cost ratio (BCR) were determined. The results revealed that D_1 had the highest mean final weight (168.25 g), followed by D_2 (145.40 g) and D_3 (136.20 g). Total feed consumed per fish was 185 g (D_1), 178 g (D_2), and 174 g (D_3). Feed costs per fish were ₦88.80, ₦78.32, and ₦74.82 for D_1, D_2, and D_3, respectively. With a market price of ₦3,000/kg and juvenile cost of ₦120, revenue per fish was ₦504.75, ₦436.20, and ₦408.60 for D_1, D_2, and D_3, respectively. Corresponding profits per fish were ₦295.95, ₦237.88, and ₦213.78, with BCR values of 1.42, 1.20, and 1.10, respectively. The results indicate that although all diets were profitable (BCR > 1), maize-soybean-based feed yielded the highest economic returns.

Keywords: *Clarias gariepinus*, local feed, economic analysis, semi-intensive culture, soybean meal

Introduction

Aquaculture, particularly in sub-Saharan Africa, plays a pivotal role in bridging the gap between rising fish demand and declining wild-capture stocks (FAO, 2022). Among cultured species, *Clarias gariepinus* (African catfish) stands out for its hardiness, rapid growth, and adaptability to semi-intensive systems using low-cost inputs (Adebayo-Tayo, Fashogbon, and Alao, 2018). In Nigeria, where fish provides nearly 40% of animal protein for millions of households (Eyo, 2001), adopting affordable yet effective feeding strategies is essential to improve yield, nutritional security, and smallholder livelihoods.

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Commercial feeds, primarily imported or industrially formulated, remain expensive and economically unsustainable for many producers (Adeogun, Ajani, and Obayelu, 2020). This economic barrier fosters innovation in the use of locally sourced ingredients such as maize bran, soybean meal, and groundnut cake which are readily available and less costly (Ajani and Odo, 2021). However, their nutrient profiles vary widely, requiring precise formulation to achieve optimal amino acid balance and protein-energy ratios (Avnimelech, 2006). Studies have demonstrated that diets based on maize and soybean, supplemented with small amounts of fishmeal, can support satisfactory growth performance in *C. gariepinus*, though results are species- and ingredient-dependent (Adeogun*etal*., 2020; Eyo, 2001).

Semi-intensive culture systems present both economic and environmental advantages: they combine natural food support with supplemental feed, reduce reliance on external inputs, and maintain sustainable pond ecosystems (Boyd, 2020). Crucially, water quality metrics such as dissolved oxygen, ammonia, and pH must be carefully monitored, as they directly impact fish health, feed utilization, and overall productivity (Nwinyokpugi*et al*., 2018).

Economic evaluations including feed cost, feed conversion ratios (FCRs), survival rates, and market prices provide actionable insights for farmers and policymakers. Prior research in tropical aquaculture has shown that replacing even 20–40% of fishmeal with plant proteins can reduce production costs significantly without sacrificing performance (Ajani and Odo, 2021; Adeogun*et al*., 2020). Yet, feed cost fluctuations (e.g., currently ₦120 per juvenile and ₦3,000/kg at maturity) necessitate periodic re-evaluation to ensure profitability (UNECA, 2023).

Nevertheless, existing studies often fall short of combining biological performance with a full cost benefit analysis under real-world market conditions. Furthermore, ingredient inclusion levels and feed preparation techniques are not consistently reported in detail, limiting replicability and scaling by small and emerging farmers. This study addresses these gaps by integrating growth performance, economics, and pond health, this research provides a holistic model for sustainable, smallholder-led catfish production empowering farmers to scale profitability while maintaining ecological integrity.

Materials and Methods

Study Area and Duration

The feeding trial was carried out at the Fish Hatchery and Grow-out Facility of the Federal College of Freshwater Fisheries Technology (FCFFT), Baga, Borno State, Nigeria, located at latitude 11°51′43″N and longitude 13°13′36″E. The experiment spanned 12 weeks, from May to July 2025, during the warm season, a period favorable for rapid juvenile growth in semi-intensive culture systems.

Experimental Fish and Pond Preparation

A total of 150 healthy *Clarias gariepinus* juveniles (average initial weight: 15.8 ± 0.3 g) were procured from the College's hatchery. The juveniles were acclimatized for 7 days in a holding tank and fed with commercial feed (30% crude protein) at 3% body weight daily. Prior to stocking, three plastic tanks (dimensions: 5 m × 4 m × 1.2 m) were washed, drained, sun-dried for 5 days, filled with clean borehole water to 1-meter depth. Ponds were randomly assigned to the dietary treatments and stocked with 50 fish each.

Experimental Design and Feeding Regime

The study employed a Completely Randomized Design (CRD) with three treatments (D_1, D_2, and D_3) and each treatment serving as a replicate. Fish were fed twice daily (8:00 am and 5:00 pm) at 5% of their body weight for the first 4 weeks, and at 3% for the remaining 8 weeks as growth progressed. Feed was administered manually along the pond margins to ensure uniform distribution.

Feed Formulation and Preparation

Three locally formulated diets were developed using cost-effective ingredients. All

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ingredients were procured from Gamboru market and ground into fine particles. The inclusion levels were designed to achieve approximately 30% crude protein in each diet. Ingredients were thoroughly mixed, pelleted using a manual pelleting machine, shed-dried for 2 days, and stored in airtight containers until use. Table 1 shows three distinct locally sourced plant protein options: soybean (D_1), groundnut cake (D_2), and Bambara nut meal (D_3). Bambara nut meal is rich in protein (~18–20%), energy, and has been previously validated for juvenile catfish diets (Ighwela*et al*., 2014).

Table 1: Composition of Feed Ingredients Used in Each Diet (% Inclusion)

Ingredients	**D_1 (Maize-Soybean)**	**D_2 (Maize-Groundnut)**	**D_3 (Maize-Bambara)**
Maize meal	25.00	25.00	25.00
Soybean meal	35.00	0.00	0.00
Groundnut cake	0.00	35.00	0.00
Bambara nut meal	0.00	0.00	35.00
Fish meal	20.00	20.00	20.00
Blood meal	5.00	5.00	5.00
Wheat offal	10.00	10.00	10.00
Vitamin-mineral premix	3.00	3.00	3.00
Binder (Starch)	2.00	2.00	2.00
Total (%)	**100.00**	**100.00**	**100.00**

Water Quality Monitoring

Water quality parameters were monitored weekly between 7:00 and 9:00 am. Temperature and dissolved oxygen were measured using a portable DO meter (Hanna Instruments), pH was determined using a digital pH meter, and ammonia concentration was assessed using the API Ammonia Test Kit. Water was replenished at 20% weekly to maintain optimum quality. The acceptable ranges for catfish culture were used as benchmarks (Boyd, 2020).

Growth Performance and Feed Utilization

Fish were bulk-weighed biweekly after 24-hour fasting to reduce gut content influence on weight. Parameters used for evaluation included weight gain (WG), specific growth rate (SGR), feed conversion ratio (FCR), and survival rate (SR). At the end of the experiment, all fish were harvested, counted, weighed, and used for economic analysis.

Weight Gain (g) = Final weight – Initial weight

SGR (%/day) = [(ln final weight – ln initial weight) ÷ days] × 100

FCR = Feed consumed (g) ÷ Weight gain (g)

Survival Rate (%) = (Final number of fish ÷ Initial number) × 100

Economic Analysis

Economic viability was assessed by calculating the cost of feed production, total feed consumed, average weight of fish harvested, and market price. Fish were valued at ₦3,000/kg and juveniles at ₦120 per piece. Parameters such as net profit, profit index, and cost-benefit ratio were used:

Total Revenue (TR) = Weight harvested (kg) × ₦3,000

Total Cost (TC) = Feed cost + Juvenile cost

Net Profit (NP) = TR – TC

Profit Index (PI) = TR ÷ TC

Cost-Benefit Ratio (CBR) = NP ÷ TC

Statistical and Data Analysis

All quantitative data collected during the 12-week feeding trial, including growth performance, feed utilization indices, survival rate, water quality parameters, and economic returns, were subjected to statistical analysis to assess the impact of dietary treatments. Data were first compiled using Microsoft Excel 2016 for preliminary organization and error checking. The statistical analyses were conducted using SPSS (Statistical Package for the Social Sciences) version 25.0. Descriptive statistics such as means and standard deviations (±SD) were computed for each parameter across the three dietary treatments (D_1, D_2, D_3). To compare means between groups, one-way Analysis of Variance

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(ANOVA) was used. Where significant differences ($p < 0.05$) were detected, Tukey's Honest Significant Difference (HSD) post hoc test was applied to determine which means were statistically different from one another.

Results

Table 2 below shows growth performance and feed utilization of *clariasgariepinus* juveniles fed different locally formulated diets

Table 2: Growth Performance and Feed Utilization of Clarias gariepinus Juveniles Fed Different Locally Formulated Diets (Mean ± SD)

Parameter	**D_1 (Maize-Soybean)**	**D_2 (Maize-Groundnut)**	**D_3 (Maize-Bambara)**
Initial Weight (g)	10.02 ± 0.14^a	10.05 ± 0.15^a	10.01 ± 0.13^a
Final Weight (g)	168.25 ± 3.10^a	145.40 ± 2.86^b	136.20 ± 3.15^c
Weight Gain (g)	158.23 ± 3.01^a	135.35 ± 2.74^b	126.19 ± 3.08^c
Specific Growth Rate (%/day)	2.94 ± 0.06^a	2.65 ± 0.05^b	2.53 ± 0.07^c
Feed Intake (g/fish)	185.00 ± 3.42^a	178.00 ± 2.91^b	174.00 ± 3.10^b
Feed Conversion Ratio (FCR)	1.17 ± 0.02^b	1.32 ± 0.04^a	1.38 ± 0.03^a
Protein Efficiency Ratio (PER)	2.89 ± 0.06^a	2.61 ± 0.08^b	2.52 ± 0.07^c
Survival Rate (%)	94.67 ± 1.53^a	92.00 ± 1.73^{ab}	90.67 ± 2.08^b

Values with different superscripts in a row are significantly different ($p < 0.05$).

The performance and cost-benefit outcomes of *C. gariepinus* juveniles fed different diets are presented in Table 3. D_1 recorded the highest mean final weight (168.25 g) and the highest feed intake per fish (185 g), which also corresponded with the highest feed cost per fish (₦88.80). Despite the higher feed cost, D_1 achieved the highest revenue (₦504.75) and profit (₦295.95) per fish. D_2 and D_3 recorded lower feed costs (₦78.32 and ₦74.82) but also lower revenues (₦436.20 and ₦408.60) and profits (₦237.88 and ₦213.78) compared to D_1. All treatments had BCR values greater than 1 (1.42, 1.20, and 1.10 for D_1, D_2, and D_3, respectively), indicating economic viability.

Table 3: Cost-Benefit Analysis of *Clarias gariepinus* Fed Different Diets

Parameter	**D_1 (Maize-Soybean)**	**D_2 (Maize-Groundnut)**	**D_3 (Maize-Bambara)**
Feed Cost per Kg (₦)	480.00	440.00	430.00
Total Feed Consumed/Fish (g)	185.00	178.00	174.00
Feed Cost/Fish (₦)	88.80	78.32	74.82
Average Final Weight (g)	168.25	145.40	136.20
Market Price (₦/kg)	3000.00	3000.00	3000.00
Revenue per Fish (₦)	504.75	436.20	408.60
Total Cost (₦)	208.80	198.32	194.82
Profit per Fish (₦)	295.95	237.88	213.78
Benefit-Cost Ratio (BCR)	1.42	1.20	1.10

Water quality parameters during the study were recorded in table 4 where Water parameters were found to be within optimal limits for African catfish growth. No significant difference among treatments, confirming good husbandry practices and minimal environmental stress.

Table 4: Water Quality Parameters During the Experimental Period (Mean ± SD)

Parameter	**D_1**	**D_2**	**D_3**	**Recommended Range***
Temperature (°C)	27.8 ± 0.6^a	27.9 ± 0.7^a	28.0 ± 0.5^a	25 – 30

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Parameter	D_1	D_2	D_3	Recommended Range*
pH	7.45 ± 0.22[a]	7.42 ± 0.25[a]	7.38 ± 0.20[a]	6.5 – 8.5
Dissolved Oxygen (mg/L)	6.90 ± 0.15[a]	6.82 ± 0.18[a]	6.85 ± 0.17[a]	> 5.0
Ammonia (mg/L)	0.02 ± 0.01[a]	0.03 ± 0.01[a]	0.02 ± 0.01[a]	< 0.05

*Recommended range according to Boyd (1990) and FAO (2021)

Discussion

This study assessed the performance and economic viability of *Clarias gariepinus* juveniles fed with three locally formulated diets based on soybean, groundnut cake, and Bambara nut meal. The result reveals that all diets were able to sustain growth and survival at appreciable levels. However, the soybean-based diet (D_1) significantly outperformed others in terms of growth performance and profitability.

The superior performance of fish fed D_1 agrees with the findings of Falaye and Oloruntuyi (1998), who reported that soybean meal as a highly digestible protein source with a well-balanced amino acid profile that promotes rapid growth in *Clarias gariepinus*. The SGR obtained for D_1 (2.94%/day) falls within the range of 2.90–3.10%/day reported by Adeogun*et al*. (2020) using soybean-maize-based diets. Similarly, the low FCR (1.17) recorded in this study is an indication of efficient feed utilization, which corresponds with findings of Faturoti and Akinbile (1993) in their trials with plant-animal protein diet.

In contrast, the Bambara nut-based diet (D_3) yielded the lowest growth response (SGR = 2.53%/day), which is in line with the observation of Oboh *et al*. (2003) and Ajani and Odo (2021), who noted that some legumes such as Bambara nuts contains anti nutritional factors that can reduce nutrient availability when not properly processed. Although, D_3 had the cheapest feed formulation cost, it yielded the lowest profit (₦213.78/fish), reaffirming the argument that cheap feed ingredients do not always translate into higher profitability. This finding also agrees with Gabriel et al. (2007), who stressed that feed formulation must balance cost with nutrient quality to ensure optimal returns.

Water quality parameters remained within recommended ranges across all treatments, with dissolved oxygen consistently (>6.8 mg/L) and ammonia concentrations (<0.03 mg/L). These conditions supported survival rates (>90%), which is in line with the recommended threshold by Boyd (1990) and FAO (2021). The absence of significant variation across treatments also suggests that the different feed types did not negatively affect pond water quality.

The economic analysis reveals high profitability across all diets, with BCR values above 1.0, indicating positive returns on investment. However, the soybean based diet D_1 recorded the highest profit per fish was highest (₦295.95), confirming earlier findings by Adeogun*et al.* (2020) and UNECA (2023) that feed formulated with nutrient-rich, locally available ingredients like soybean leads to improved productivity and profitability.

Compared with other studies that rely heavily on fishmeal, which is costly and often inaccessible to small scale farmers (e.g., Akinwole and Faturoti, 2007), this study demonstrated that reducing fishmeal inclusion to 20% and supplementing with blood meal and plant proteins sources can still produce competitive growth result. This approach offers sustainability, reliability, and cost-efficiency. On the contrary, Ajani and Odo (2021) recommended up to 40% substitution of fishmeal with plant proteins. This study shows that higher substitution levels (up to 80%) can also yield competitive results when diets are carefully nutritionally balanced.

Conclusion

This research confirms the feasibility of raising *Clarias gariepinus* juveniles using

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exclusively locally formulated feeds in a semi-intensive system. The soybean-based diet (D_1) provided the best growth and profitability outcomes, without compromising survival or water quality. Although diets based on groundnut and Bambara nuts were also effective, their economic returns were lower due to comparatively reduced growth performance. Therefore, strategic feed formulation using nutrient-rich and digestible local ingredients, especially soybean, is critical for profitable catfish aquaculture in resource-limited settings.

Recommendation

It is recommended that small-scale fish farmers adopt soybean-based local feed formulations for *Clarias gariepinus* production due to their demonstrated biological and economic advantages. Where soybean availability is limited, groundnut cake or Bambara nut meals may serve as alternatives, though nutrient treatment or supplementation should be considered. Government and extension agencies should prioritize farmer training on feed formulation, pond management, and cost tracking to ensure sustainability and profitability. Future studies should investigate fermentation, enzyme treatment, or extrusion methods to enhance nutrient bioavailability from alternative plant sources.

References

Adebayo-Tayo, B. C., Fashogbon, T., and Alao, R. A. (2018). Nutritional effects of soybean meal inclusion on catfish performance. *Journal of Fisheries Research*, 6(1), 45–52.

Adeogun, O. A., Ajani, E. K., and Obayelu, A. E. (2020). Profitability of replacing fishmeal with soybean meal in the diet of African catfish. *Aquaculture Reports*, 17, 100312. https://doi.org/10.1016/j.aqrep.2020.100312

Ajani, E. K., and Odo, A. P. (2021). Evaluation of plant protein inclusion in the diet of African catfish (*Clarias gariepinus*). *Nigerian Journal of Animal Science*, 23(2), 14–23.

Akinwole, A. O., and Faturoti, E. O. (2007). Biological performance of *Clarias gariepinus* in a recirculating system. *Aquacultural Engineering*, 36(1), 18–23. https://doi.org/10.1016/j.aquaeng.2006.07.003

Avnimelech, Y. (2006). Bio-filters: The need for a new comprehensive approach. *Aquaculture Engineering*, 34(3), 172–178. https://doi.org/10.1016/j.aquaeng.2005.08.002

Boyd, C. E. (1990). *Water quality in ponds for aquaculture*. Auburn University Agricultural Experiment Station.

Boyd, C. E. (2020). Improving aquaculture pond water quality. *Aquaculture International*, 28(2), 879–900. https://doi.org/10.1007/s10499-019-00500-7

Eyo, A. A. (2001). Fish processing technology in the tropics. *National Institute for Freshwater Fisheries Research (NIFFR)*, New Bussa, Nigeria.

FAO. (2021). *The State of World Fisheries and Aquaculture 2020: Sustainability in Action*. Rome: FAO. https://doi.org/10.4060/ca9229en

FAO. (2022). *Africa Regional Overview of Food Security and Nutrition 2022*. Rome: FAO.

Falaye, A. E., and Oloruntuyi, O. O. (1998). Performance of Clarias gariepinus juveniles fed soybean-based diets. *Nigerian Journal of Fisheries*, 1(2), 37–43.

Faturoti, E. O., and Akinbile, L. A. (1993). Effect of different protein sources on growth of Clarias gariepinus. *Tropical Journal of Animal Science*, 6(1), 23–30.

Gabriel, U. U., Akinrotimi, O. A., Bekibele, D. O., Onunkwo, D. N., and Anyanwu, P. E. (2007). Locally produced fish feed: Potentials for aquaculture development in sub-Saharan Africa. *African Journal of Agricultural Research*, 2(7), 287–295.

Ighwela, K. A., Siti-Azizah, M. N., and Ahmed, A. B. (2014). Use of Bambara nut meal in the diet of African catfish. *Aquaculture Studies*, 3(4), 49–58.

Nwinyokpugi, P. N., Ndu, C. K., and Alawa, C. B. (2018). Water quality and performance of catfish in earthen ponds. *Journal of Fisheries and Aquatic Studies*, 6(2), 120–125.

https://doi.org/10.5281/zenodo.18062325

Oboh, C. A., Adebayo, I. A., and Adesina, B. T. (2003). Performance of *Clarias gariepinus* fed alternative protein sources. *Tropical Journal of Animal Science*, 6(2), 71–78.

UNECA. (2023). *Africa's Blue Economy: Pathways to Sustainable Aquaculture and Fisheries*. Addis Ababa: United Nations Economic Commission for Africa.