

GROWTH PERFORMANCE, FEED UTILIZATION, AND ECONOMIC EVALUATION OF AFRICAN CATFISH (*CLARIAS GARIEPINUS*) FED IMPORTED AND LOCALLY PRODUCED COMMERCIAL FEEDS: IMPLICATIONS FOR SMALL SCALE AQUACULTURE IN NIGERIA

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Abstract

Aquaculture contributes substantially to food security, employment, and income generation in Nigeria, yet the high cost of commercial feed remains a decisive constraint for small scale producers. This study evaluated the effects of imported and locally produced commercial feeds on the growth performance, feed utilization, survival, somatic indices, and economic efficiency of African catfish (*Clarias gariepinus*) fingerlings. Fingerlings with an initial mean weight of 3.84 ± 0.08 g were randomly assigned to two dietary treatments in triplicate and fed to apparent satiation for six weeks under controlled conditions. Growth, feed utilization, survival, condition factor, and somatic indices were assessed, while economic efficiency was expressed as feed cost per fish and feed cost per gram of weight gain. Fish fed the imported feed attained a significantly higher final weight (20.84 ± 1.25 g) than those fed the locally produced feed (11.97 ± 0.70 g; $p < 0.05$). Weight gain, specific growth rate, feed intake, and feed conversion ratio were numerically superior in the imported feed group but did not differ significantly between treatments ($p > 0.05$). Survival, condition factor, and hepatosomatic index were unaffected by feed type, whereas the viscerosomatic index differed significantly. Economic analysis showed that although the imported feed promoted superior growth, it incurred markedly greater feed expenditure. Feed cost per fish was ₦141.14 for the imported feed compared with ₦31.25 for the locally produced feed, while the cost of producing one gram of weight gain was ₦8.43 and ₦3.78, respectively. Consequently, the locally produced feed lowered biomass production cost by approximately 55 percent relative to the imported feed. The findings reveal a clear trade off between biological performance and economic efficiency: imported feed enhanced growth, while locally produced feed offered a more cost effective option for fish production. Locally manufactured feeds can therefore serve as a practical alternative for resource constrained farmers, provided sustained efforts are directed at improving feed quality and processing standards.

Keywords: African catfish, commercial feeds, economic efficiency, feed utilization, small scale aquaculture

1. Introduction

Aquaculture is one of the fastest growing food production sectors in the world and plays a vital role in global food security, income generation, and rural livelihoods (Mohd and Mushtaq, 2025; Pradeepkiran, 2019). In Nigeria, fish farming has emerged as an important source of affordable animal protein and a means of supporting small scale enterprises across both urban and peri urban settings (Ogunji and Wuertz, 2023). Among the cultured species, the African catfish (*Clarias gariepinus*) is particularly prominent because of its rapid growth, hardiness, high market demand, and remarkable adaptability to diverse culture systems (Sanda et al., 2026; Somdare et al., 2025). Despite these advantages, the sector continues to grapple with structural challenges that constrain productivity and erode profitability, with feed quality and feed cost consistently identified among the most critical determinants of enterprise viability.

Feed typically accounts for between 50 and 70 percent of the total variable cost of aquaculture production (Ansari et al., 2021; Solomon et al., 2025), and reliable access to nutritionally adequate diets remains limited for many smallholders. Imported commercial feeds are generally effective in promoting rapid growth because they are formulated with advanced processing technologies and consistently sourced ingredients; however, their elevated purchase price and irregular availability restrict their use in low resource settings (Mustapha et al., 2014). Locally produced feeds, in contrast, are more accessible and considerably more affordable, but they may vary widely in ingredient quality, nutrient digestibility, and amino acid balance, which can constrain growth performance and feed efficiency (Munguti et al., 2021a).

Beyond biological performance, economic efficiency is a central consideration for the farmer because feed represents the single largest operating expense in catfish culture (Engle et al., 2020). Although imported feeds may support faster growth, their higher cost can depress economic efficiency, especially in smallholder systems where working capital is scarce. Locally produced feeds may offer a more affordable pathway capable of reducing production cost while sustaining acceptable growth and survival. Evaluating both the biological and the economic responses is therefore essential for designing feeding strategies that are simultaneously productive, profitable, and sustainable. Accordingly, the present study evaluated the effects of imported and locally produced commercial feeds on the growth performance, feed utilization, survival, condition factor, somatic indices, and economic efficiency of African catfish fingerlings, with particular attention to the implications of feed selection for small scale aquaculture farmers in Nigeria.

2. Materials and Methods

2.1 Ethical Statement

The study involved routine husbandry and feeding of African catfish (*Clarias gariepinus*) fingerlings under

standard aquaculture conditions. No invasive procedures, surgical interventions, or experimental manipulations likely to cause pain or distress were performed. Under the institutional guidelines applicable at the time the study was conducted, formal ethical approval was not required for a feeding trial of this nature. Nevertheless, all fish were handled in accordance with accepted aquaculture management practices to minimize stress and to safeguard animal welfare throughout the experiment.

2.2 Experimental Fish and Acclimation

African catfish fingerlings were obtained from a reputable hatchery in Lokoja and transported to the experimental facility. On arrival, the fish were acclimated for two weeks in plastic tanks and fed a standard basal diet. Water quality variables, including temperature, dissolved oxygen, and pH, were monitored daily and maintained within the optimal ranges for African catfish culture (temperature 26 to 28 °C; dissolved oxygen at least 5 mg L⁻¹; pH 6.5 to 7.5).

2.3 Experimental Diets

Two commercially available pelleted feeds were compared: an imported feed and a locally produced feed. Both feeds were formulated to contain comparable crude protein (40 percent) and crude lipid (10 percent) levels, and their nutritional composition was verified by proximate analysis before the trial commenced. This design isolated the influence of ingredient quality and feed processing from that of gross nutrient concentration.

2.4 Experimental Design

The feeding trial followed a completely randomized design with two dietary treatments, each replicated three times. After acclimation, and 24 h before the start of the experiment, the fish were fasted to empty the gastrointestinal tract and to reduce handling stress during stocking. The fingerlings were then graded manually to ensure uniform size and weighed individually to determine initial weight. They were randomly distributed into six tanks, at three replicates per treatment, each holding a water column of 30 cm at a stocking density of fifteen fish per tank. The fish were hand fed their respective diets to apparent satiation twice daily, at 09:00 and 17:00, for six weeks. Feed intake was recorded after the final feeding of each day for use in the feed utilization calculations, and the fish were bulk weighed every two weeks to monitor growth.

To maintain good water quality, water was renewed twice weekly and temperature, dissolved oxygen, and pH were measured on each sampling day. Mean water temperature, dissolved oxygen concentration, and pH were 27.8 ± 0.2 °C, 6.3 ± 0.1 mg L⁻¹, and 7.4 ± 0.1, respectively. These values remained within the acceptable range for the culture of African catfish fingerlings and were considered suitable for normal growth and survival throughout the trial.

2.5 Sampling and Data Collection

At the end of the feeding trial the fish were fasted for 12 h before sampling to reduce handling stress. They were then

counted and weighed individually to determine survival rate and final body weight, respectively.

2.6 Growth Performance Evaluation

Fish were weighed individually at the start and end of the trial to determine growth performance, including final weight, weight gain, and specific growth rate. The indices were computed using standard formulae, where W_f and W_i denote the final and initial body weights and t is the duration of the trial in days:

$$WG (g) = W_f - W_i \quad (1)$$

$$SGR (\% \text{ day}^{-1}) = [(\ln W_f - \ln W_i) / t] \times 100 \quad (2)$$

2.7 Feed Utilization and Survival

Feed utilization was assessed through feed intake and feed conversion ratio, and survival was expressed as the percentage of fish surviving to the end of the trial. The parameters were calculated as follows, where N_f and N_i are the numbers of fish at the end and start of the experiment:

$$FCR = \text{feed intake (g)} / \text{weight gain (g)} \quad (3)$$

$$SR (\%) = (N_f / N_i) \times 100 \quad (4)$$

2.8 Economic Analysis

To evaluate the economic implications of feed selection, feed cost per fish and feed cost per gram of weight gain were computed following a standard aquaculture economic evaluation procedure (Agbayani, 2002). The imported feed was purchased at ₦9,700 kg^{-1} , whereas the locally produced feed was purchased at ₦2,800 kg^{-1} . The economic indices were derived as:

$$\text{Feed cost per fish (₦)} = \text{feed intake per fish (kg)} \times \text{feed price (₦ kg}^{-1}) \quad (5)$$

$$\text{Feed cost per gram gain (₦ g}^{-1}) = \text{feed cost per fish} / \text{weight gain per fish} \quad (6)$$

These indices were used to compare the relative cost effectiveness of the two feeds, following an established approach for evaluating feed cost relative to fish biomass production (Agbayani, 2002).

2.9 Somatic Indices

At the end of the trial, three fish per tank were sampled at random to assess somatic indices. Fish were euthanized humanely, and total length, total body weight, visceral weight, and liver weight were recorded. The condition factor, viscerosomatic index, and hepatosomatic index were calculated as follows, where W is body weight and L is total length:

$$CF = (W / L^3) \times 100 \quad (7)$$

$$VSI (\%) = (\text{visceral weight} / \text{body weight}) \times 100 \quad (8)$$

$$HSI (\%) = (\text{liver weight} / \text{body weight}) \times 100 \quad (9)$$

2.10 Statistical Analysis

All data are expressed as mean $\pm$ standard error of the mean. Before analysis, the data were tested for normality and homogeneity of variance using the Shapiro and Wilk

and the Levene tests, respectively. Differences between fish fed the imported feed and those fed the locally produced feed were evaluated using an independent samples Student t test. Statistical significance was accepted at $p < 0.05$. All analyses were performed in IBM SPSS Statistics version 25 (IBM Corp., Armonk, NY, USA).

3. Results

3.1 Growth Performance

Initial weights were comparable between the two treatments (Table 1). African catfish fingerlings fed the imported feed attained a significantly higher final weight than those fed the locally produced feed (20.84 ± 1.25 g versus 11.97 ± 0.70 g; $p < 0.05$). Weight gain and specific growth rate were numerically greater in the imported feed group (weight gain 16.75 ± 1.70 g; specific growth rate 3.95 ± 0.17 percent per day) than in the locally produced feed group (weight gain 8.27 ± 0.75 g; specific growth rate 2.77 ± 0.21 percent per day), although these differences were not statistically significant ($p > 0.05$). The grouped comparison of initial weight, final weight, and weight gain is illustrated in Figure 1, and the specific growth rate is shown in Figure 2.

Table 1. Growth performance of African catfish (*Clarias gariepinus*) after a six week feeding trial

Parameter	Imported feed	Local feed
Initial weight (g)	4.01 ± 0.12	3.66 ± 0.12
Final weight (g)	20.84 ± 1.25^b	11.97 ± 0.70^a
Weight gain (g)	16.75 ± 1.70	8.27 ± 0.75
Specific growth rate (% day^{-1})	3.95 ± 0.17	2.77 ± 0.21

Values are means $\pm$ standard errors. Different superscripts within a row indicate a significant difference ($p < 0.05$). IW, initial weight; FW, final weight; WG, weight gain; SGR, specific growth rate.

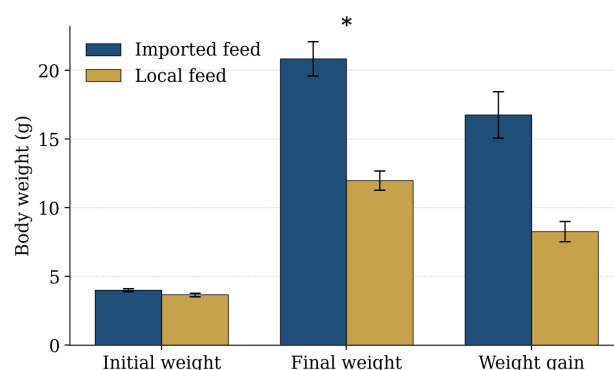


Figure 1. Initial weight, final weight, and weight gain of African catfish fed the imported and locally produced feeds after six weeks. Bars are means and whiskers are standard errors; the asterisk denotes a significant difference in final weight ($p < 0.05$).

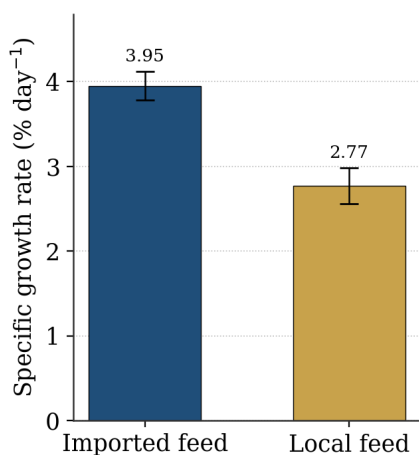


Figure 2. Specific growth rate of African catfish fed the imported and locally produced feeds. The difference was numerically higher for the imported feed but was not statistically significant ($p > 0.05$).

3.2 Feed Utilization and Survival

Feed intake and feed conversion ratio followed a similar pattern, with fish fed the imported feed showing slightly higher feed intake and marginally improved feed efficiency, although the differences were not statistically significant ($p > 0.05$). Survival was high and comparable between the treatments, with both groups recording rates between 88 and 91 percent (Table 2, Figure 3).

Table 2. Feed utilization and survival of African catfish over six weeks of feeding

Parameter	Imported feed	Local feed
Feed intake (g)	14.55 ± 0.71	11.16 ± 0.44
Feed conversion ratio	0.88 ± 0.04	1.36 ± 0.09
Survival rate (%)	88.87 ± 4.43	91.10 ± 8.90

Values are means ± standard errors. FI, feed intake; FCR, feed conversion ratio; SR, survival rate.

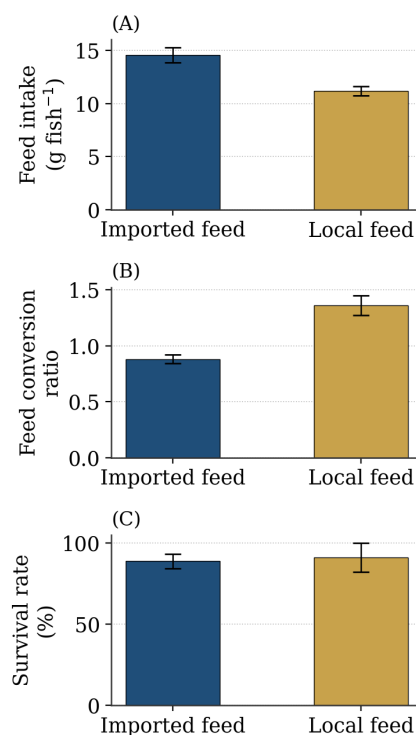


Figure 3. Feed utilization and survival of African catfish fed the imported and locally produced feeds: (A) feed intake, (B) feed conversion ratio, and (C) survival rate. None of the differences reached statistical significance ($p > 0.05$).

3.3 Economic Analysis

The economic evaluation revealed pronounced differences in production cost between the two dietary treatments (Table 3, Figure 4). Although the fish fed the imported feed achieved greater weight gain, the substantially higher unit price of that diet translated into markedly greater feed expenditure. Feed cost per fish was ₦141.14 for the imported feed compared with ₦31.25 for the locally produced feed. Likewise, the feed cost required to produce one gram of weight gain was ₦8.43 in the imported feed treatment and ₦3.78 in the locally produced feed treatment, a reduction of approximately 55 percent in favour of the local feed under the prevailing market prices.

Table 3. Economic analysis of imported and locally produced feeds used for African catfish culture

Parameter	Imported feed	Local feed
Feed price (₦ kg ⁻¹)	9,700	2,800
Feed intake (g fish ⁻¹)	14.55 ± 0.71	11.16 ± 0.44
Feed cost per fish (₦)	141.14	31.25
Weight gain (g fish ⁻¹)	16.75 ± 1.70	8.27 ± 0.75
Feed cost per gram gain (₦ g ⁻¹)	8.43	3.78

Feed cost calculations were based on market prices of ₦9,700 kg⁻¹ for the imported feed and ₦2,800 kg⁻¹ for the locally produced feed.

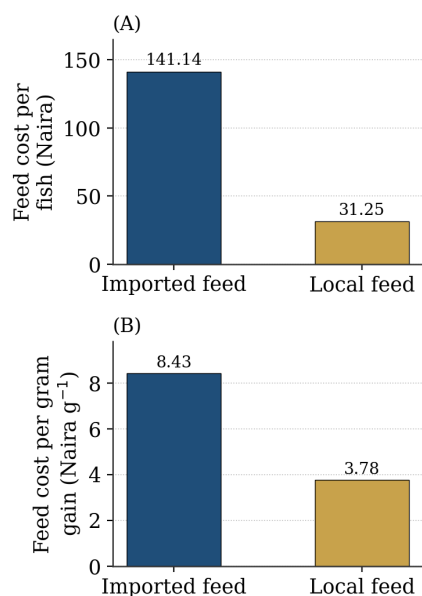


Figure 4. Economic indices of the two feeds: (A) feed cost per fish and (B) feed cost per gram of weight gain. The locally produced feed reduced the cost of producing one gram of fish by approximately 55 percent.

3.4 Somatic Indices

The somatic indices are presented in Table 4 and Figure 6. Only the viscerosomatic index differed significantly between the treatments (8.09 ± 0.05 percent for the imported feed versus 7.91 ± 0.01 percent for the locally produced feed; $p < 0.05$). The condition factor and hepatosomatic index were similar between the two groups ($p > 0.05$). The biweekly growth trajectory reconstructed from the periodic bulk weighings is shown in Figure 5 and indicates a progressively widening divergence between the treatments from the fourth week onward.

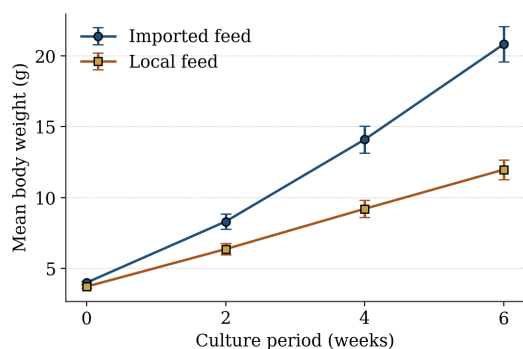


Figure 5. Biweekly growth trajectory of African catfish fed the imported and locally produced feeds over the six week trial. Points are means and whiskers are standard errors.

Table 4. Condition factor and body indices of African catfish after six weeks of feeding

Parameter	Imported feed	Local feed
Condition factor	0.52 ± 0.01	0.60 ± 0.01
Viscerosomatic index (%)	8.09 ± 0.05^b	7.91 ± 0.01^a
Hepatosomatic index (%)	2.41 ± 0.02	2.02 ± 0.03

Values are means $\pm$ standard errors. Different superscripts within a row indicate a significant difference ($p < 0.05$). CF, condition factor; VSI, viscerosomatic index; HSI, hepatosomatic index.

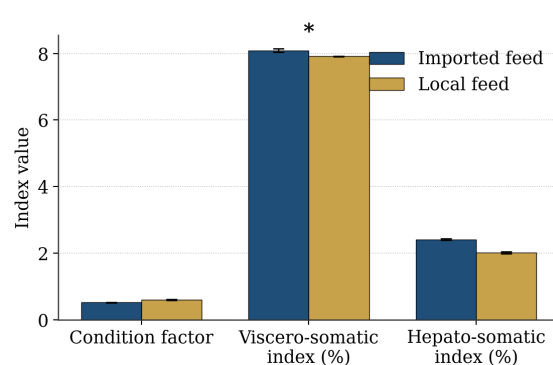


Figure 6. Condition factor, viscerosomatic index, and hepatosomatic index of African catfish fed the two feeds. The asterisk denotes a significant difference in the viscerosomatic index ($p < 0.05$).

4. Discussion

The present study demonstrates that African catfish fingerlings fed the imported commercial feed achieved a significantly higher final weight than those fed the locally produced feed, even though the two diets carried comparable crude protein and crude lipid concentrations. Because gross nutrient content was held broadly constant by design, the divergence in growth is most parsimoniously attributed to differences in ingredient quality, nutrient digestibility, and amino acid balance rather than to differences in the declared proximate composition. Imported feeds are typically formulated with highly digestible protein sources that supply the indispensable amino acids, notably lysine and methionine, in forms that are readily mobilized for protein synthesis and muscle accretion (Munguti et al., 2024). Locally produced feeds, by contrast, frequently incorporate plant based byproducts or lower grade ingredients whose antinutritional factors and less favourable amino acid profiles can depress nutrient absorption and protein utilization (Villasante et al., 2025). The present pattern is consistent with the earlier observations of Mustapha et al. (2014), who reported superior growth and feed efficiency in African catfish fed commercial diets relative to locally formulated feeds.

A particularly instructive feature of the present data is that the significantly higher final weight recorded on the imported feed was not accompanied by significant differences in specific growth rate or feed conversion ratio. This dissociation suggests that the growth advantage of the imported feed arose primarily from greater cumulative feed consumption rather than from a markedly superior capacity to convert ingested feed into body mass. Throughout the trial the fish offered the imported feed consumed more feed, and this accumulated difference in intake plausibly accounts for the higher terminal weight. The finding directs attention to the physical and sensory attributes of the diet, including palatability, pellet texture, buoyancy, and water stability, all of which shape voluntary feed intake independently of nutrient concentration (Pennells et al., 2025; Welker et al., 2018). It follows that measures taken by local feed manufacturers to improve feed acceptance and stimulate consumption may deliver substantial gains in growth without any change in the underlying nutrient formulation.

Feed processing and pellet quality provide a complementary explanation for the observed differences. Imported feeds are commonly manufactured by extrusion or by advanced pelleting, processes that enhance water stability, curtail nutrient leaching, and improve palatability. These attributes promote voluntary intake and efficient nutrient retention, as reported by Welker et al. (2018) and Pennells et al. (2025). Locally produced feeds, in contrast, often exhibit lower pellet durability, so that a portion of the feed disintegrates in the water column before it is consumed, with attendant nutrient loss and a deterioration in apparent feed conversion. The phosphorus and organic load released by unstable pellets can further compromise water quality in intensive systems (Nathanailides et al., 2023), creating a secondary pathway through which processing quality influences growth. Taken together, these mechanisms indicate that the gap between imported and locally produced feeds is as much a problem of feed engineering as it is of nutrient specification.

The somatic indices offer additional physiological context. The significantly higher viscerosomatic index recorded in fish fed the imported feed points to greater visceral development and more extensive energy storage, both of which are consistent with the higher feed intake and larger body size attained on that diet. In contrast, the condition factor and the hepatosomatic index did not differ between the treatments, which indicates that overall body proportion and hepatic status were preserved under both feeding regimes. The stability of the hepatosomatic index is reassuring because pronounced hepatic enlargement can signal excessive lipid deposition or metabolic strain associated with diets rich in poorly balanced ingredients (Villasante et al., 2025). The maintenance of comparable condition factor and liver status therefore suggests that the locally produced feed, while promoting slower growth, did not impose a detectable physiological penalty on the fish over the experimental period.

Survival was uniformly high and statistically indistinguishable between the treatments, ranging from 88 to 91 percent. This outcome demonstrates that both feeds met the minimum nutritional and husbandry requirements for survival of African catfish fingerlings under the prevailing culture conditions. The robustness of survival across diets is agriculturally meaningful because, from the standpoint of a smallholder, the avoidance of catastrophic mortality is frequently a more decisive determinant of enterprise survival than the marginal optimization of growth. The comparable survival recorded here reinforces the view that the locally produced feed is a biologically viable option even where its growth performance trails that of the imported alternative.

The economic evaluation reframes these biological findings in the terms that matter most to the producer. Although the imported feed generated superior growth, its far higher purchase price translated into disproportionately greater feed expenditure. Feed cost per fish was more than fourfold higher for the imported feed, and the cost of producing one gram of weight gain was more than double

that of the locally produced feed. Because feed constitutes the largest single component of aquaculture production cost and frequently governs the profitability of the whole operation (Adelesi and Baruwa, 2022; Engle et al., 2020; Ike and Chuks-Okonta, 2014), a 55 percent reduction in the cost of biomass production is a substantial commercial advantage. These results underline the importance of weighing economic efficiency alongside biological performance whenever commercial aquafeeds are compared, and they caution against equating faster growth with greater profitability.

The implications for small scale aquaculture in Nigeria are direct and consequential. Imported feeds are attractive for their capacity to accelerate growth, yet their high cost imposes considerable financial pressure on producers operating with limited capital and narrow margins. The locally produced feed, by supporting acceptable survival and moderate growth at a fraction of the cost, offers a pragmatic means of containing production expense and financial risk. For many smallholders the ability to achieve satisfactory growth and survival at a substantially lower feed cost may be more valuable than maximizing growth through expensive imported diets. Lower feed expenditure also liberates scarce resources for other critical elements of production, including pond maintenance, water quality management, fish health, and gradual farm expansion. Comparable conclusions have been drawn by Gabriel et al. (2007), Munguti et al. (2021b), and Johnson et al. (2025), who observed that appropriately formulated and managed local feeds can support acceptable growth and survival in smallholder systems.

These findings nonetheless carry a clear mandate to improve the quality of locally manufactured feeds. Nutrient formulation remains fundamental, but the present results indicate that feed processing exerts an equally decisive influence on intake, digestibility, nutrient retention, and ultimately growth (Nathanailides et al., 2023; Pennells et al., 2025). Extrusion technology can improve pellet durability, water stability, buoyancy, and nutrient availability, thereby enhancing feed acceptance and reducing nutrient losses before ingestion. Standardized manufacturing practices, in turn, help to secure consistency in pellet size, texture, density, and nutrient composition across production batches. Since the fish on the imported feed consumed more feed despite similar conversion efficiency, targeted improvements in processing and pellet quality represent a realistic and relatively low cost pathway for raising the performance of local feeds. Efforts to strengthen the local feed industry should therefore address not only ingredient sourcing and nutrient balancing but also the adoption of appropriate extrusion and quality control measures.

The results should be interpreted within the boundaries of the study design. The trial ran for six weeks and compared a single imported feed with a single locally produced feed, so the outcomes reflect the performance of the specific diets tested during the fingerling stage and may not represent the full range of commercial feeds available to farmers. The relatively short duration may also fail to

capture longer term growth responses, feed utilization patterns, and economic outcomes that could emerge over a complete production cycle to market size. Future work should extend the culture period to harvest, broaden the range of feeds evaluated, and incorporate whole enterprise budgeting so that the biological and economic trade offs identified here can be assessed across the entire grow out phase. Within the wider context of a national aquaculture sector that has become the second largest in Africa (Ogunji and Wuertz, 2023) and a growing contributor to food security and nutrition (Mohd and Mushtaq, 2025; Pradeepkiran, 2019), such evidence is essential for guiding feed policy and farmer decision making.

Collectively, the evidence indicates that feed selection should be guided not by growth performance alone but by a considered balance of biological performance, economic efficiency, and the production objectives of the farmer. Imported feeds are well suited to producers who target rapid growth and command sufficient capital, whereas locally produced feeds provide a cost effective alternative capable of sustaining aquaculture under resource constrained conditions. Continued investment in the improvement of local feed quality, coupled with farmer training and better feed management, will be essential for raising productivity, protecting profitability, and securing the long term sustainability of small scale aquaculture in Nigeria.

5. Conclusion

This study showed that the imported commercial feed produced a higher final weight in African catfish fingerlings than the locally produced feed, despite both diets having similar crude protein and crude lipid levels. The improved final weight of fish on the imported feed was, however, accompanied by substantially higher feed cost. The economic evaluation demonstrated that the locally produced feed lowered the cost of producing one gram of weight gain by approximately 55 percent, a decisive advantage in cost efficiency. Feed selection thus entails a trade off between maximizing growth and minimizing production cost. Whereas imported feeds may suit farmers who seek rapid growth and possess adequate financial resources, locally produced feeds constitute a practical and economically attractive alternative for resource constrained producers, for whom acceptable growth and survival at a much lower feed cost may outweigh the benefit of marginally faster growth. The study further underscores the importance of improving local feed quality through better ingredient selection, nutrient balancing, and feed processing technologies, which could enhance growth while preserving the economic advantages of local feeds. Future studies extending to market size and evaluating a wider range of commercial feeds are recommended to provide a more comprehensive assessment of the long term biological and economic implications of feed selection in African catfish production.

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Declaration of Competing Interest

The authors declare that there are no conflicts of interest.

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