

# Effects of Poultry offal Meal on the Growth and Performance of *Clarias gariepinus* Fingerlings

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## Abstract

The escalating cost and diminishing availability of fishmeal as the primary protein source in aquaculture diets necessitate the evaluation of sustainable and cost-effective alternatives. This study investigated the effects of poultry offal meal (POM) at graded inclusion levels (0%, 25%, 50%, 75%, and 100% replacement of fishmeal) on the growth performance, feed utilization, and body composition of *Clarias gariepinus* fingerlings over a 70-day feeding trial. A total of 150 fingerlings (mean initial weight:  $5.60 \pm 0.12$  g) were randomly distributed into five dietary treatment groups in triplicate (10 fish per replicate) and fed experimental diets at 5% body weight twice daily. Growth parameters including weight gain (WG), specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), and survival rate (SR) were assessed. Results indicated that fish fed 25–50% POM replacement diets showed no significant difference ( $p > 0.05$ ) in growth performance compared to the control (0% POM). However, groups fed 75% and 100% POM replacement exhibited significantly lower ( $p < 0.05$ ) weight gain, SGR, and PER, alongside higher FCR values. Carcass analysis revealed no significant

difference in crude protein, ash, and lipid content among dietary treatments. The best feed conversion ratio (2.07) was obtained at 50% POM inclusion. The study concludes that poultry offal meal can replace up to 50% of fishmeal in *C. gariepinus* fingerling diets without adverse effects on growth or feed utilization, offering a viable, locally available, and economically sustainable protein source for aquaculture feed formulation.

## Keywords:

*Clarias gariepinus*, poultry offal meal, fishmeal replacement, growth performance, feed utilization, aquaculture.

## Introduction

Aquaculture is recognized globally as a critical sector for meeting the rapidly growing demand for animal protein, particularly in developing nations across sub-Saharan Africa (FAO, 2022). Among the cultured species, the African catfish, *Clarias gariepinus* (Burchell, 1822), occupies a position of exceptional commercial importance. It is currently the most commonly farmed fish in sub-Saharan Africa (Chandra Segaran et al., 2023) and, by far, the most commonly farmed fish in Nigeria (Sanda et al.,

2026). The species has attracted considerable attention from aquaculturists due to its fast growth rate, resistance to diseases, and tolerance of high stocking densities (Lal et al., 2003), as well as its adaptability to diverse environmental conditions, high fecundity, and good meat quality (Eding and Kamstra, 2001). Despite its great production potential, the expansion of *C. gariepinus* aquaculture is significantly constrained by the high cost of quality feeds, which can account for more than 50% of total operational costs in intensive systems (Tacon and Metian, 2008). Fishmeal has traditionally served as the gold standard protein source in aquafeeds, valued for its high and well-balanced amino acid profile, high digestibility, and the presence of growth-promoting factors (Hardy, 1996). However, global fishmeal production is stagnant, and increasing demand from the livestock and aquaculture sectors has driven prices to levels that undermine the economic viability of smallholder fish farming in Africa (FAO, 2022).

This situation has prompted intensive research into alternative protein sources that can wholly or partially replace fishmeal in fish diets without compromising growth performance, health, or economic sustainability. Among the most promising alternatives are rendered animal by-products, particularly poultry offal meal (POM). Poultry offal meal is derived from the processing residues of the poultry industry—including viscera

(heart, liver, gizzard, intestines, and lungs)—which are considered unsuitable for direct human consumption (Hasan and Amin, 1997). It is a high-protein ingredient with an amino acid profile that more closely resembles fishmeal compared to plant-derived protein sources (Riche, 2015).

Poultry offal meal typically contains between 57 and 70.6% crude protein and approximately 12.7% lipid (on a dry matter basis), making it nutritionally attractive as a dietary ingredient for carnivorous fish species (Sultana and Kashem, 2024; ScienceDirect, 2021).

## 2. Materials and Methods

### 2.1 Source and Processing of Poultry Offal Meal

Fresh poultry offal (consisting of intestines, liver, heart, gizzard, and lungs) was obtained from a Potiskum poultry modern market processing in Potiskum, Yobe State, Nigeria.

Furthermore, POM is widely available across Nigeria and other parts of sub-Saharan Africa, where a thriving poultry industry generates large volumes of offal daily, much of which is discarded or underutilized (Keremah, 2014). Its use in aquafeeds therefore represents an opportunity to simultaneously reduce feed costs and address waste management challenges in the poultry sector.

Several researchers have examined the efficacy of POM as a fishmeal replacement in *C. gariepinus* diets with varying conclusions. Abdel-Warith et al. (2001) found no significant variation in crude protein and lipid concentration when catfish were fed up to 60% poultry by-product meal replacement, though reductions were observed at 80% and 100% levels. Mamoon et al. (2018) demonstrated that the body composition of *C. gariepinus* was largely unaffected by POM replacement with regard to ash, protein, and lipid content. Adekunmisi et al. (2004) established that poultry offal meal could completely replace fishmeal in *C. gariepinus* diets, with the best performance recorded at 50% replacement. However, other studies have reported declining growth indices at higher substitution levels (Abdel-Warith et al., 2001; El-Sayed, 2011), highlighting the need for species-specific and condition-specific optimization.

The inconsistency of findings in the existing literature underscores the importance of continued research into the optimal inclusion levels of POM in *C. gariepinus* feeds. Furthermore, most studies have been conducted under differing conditions of fish size, water quality, processing method of POM, and dietary composition, making direct comparisons difficult. This study was therefore designed to systematically evaluate the effect of graded levels of poultry offal meal as a replacement for fishmeal on the growth performance, feed utilization, and carcass composition of *C. gariepinus* fingerlings under controlled laboratory conditions, with the aim of identifying the optimal inclusion level for practical diet formulation.

The offal was thoroughly washed under running water to remove blood, ingesta, and other contaminants. It was then boiled at 100°C for 30 minutes to reduce microbial load and destroy pathogenic organisms (Hasan and

Amin, 1997). After boiling, the material was drained, spread on clean metallic trays, and sun-dried for 3 days until a constant dry weight was achieved. It was subsequently milled using an electric hammer mill fitted with a 1 mm

screen and stored in airtight polyethylene bags at room temperature until use. Proximate composition of the processed POM was determined using standard AOAC (2000) procedures before diet formulation.

## 2.2 Experimental Diets

Five isonitrogenous and isocaloric experimental diets (35% crude protein) were formulated to contain graded levels of poultry offal meal replacing fishmeal at 0% (T1/Control), 25% (T2), 50% (T3), 75% (T4), and 100% (T5), as shown in Table 1. Other dietary ingredients included soybean meal, maize meal, wheat offal, fish oil, vitamin-mineral premix, dicalcium phosphate, and lysine. Diets were thoroughly mixed, pelleted

using a manually operated pellet machine (2 mm die), and oven-dried at 60°C for 24 hours. Pelleted diets were stored at 4°C in airtight containers until use. Proximate composition of the diets was analyzed using the AOAC (2000) method and the results are presented in Table 2.

**Table 1: Ingredient Composition of Experimental Diets (% Dry Matter Basis) Ingredients (%)**

Ingredients (%)	T1(0% POM)	T2(25% POM)	T3(50% POM)	T4 (75% POM)	T5(100% POM)
Fishmeal	30.00	22.50	15.00	7.50	0.00
Poultry offal Meal	0.00	7.50	15.00	22.50	30.00
Soybean Meal	20.00	20.00	20.00	20.00	20.00
Maize Meal	20.00	20.00	20.00	20.00	20.00
Wheat Meal	15.00	15.00	15.00	15.00	15.00
Fish Oil	5.00	5.00	5.00	5.00	5.00
Di calcium Phosphate	2.00	2.00	2.00	2.00	2.00
Vitamin Minerals Premix	2.00	2.00	2.00	2.00	2.00
Lysine	1.00	1.00	1.00	1.00	1.00
Methionine	0.50	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50	0.50
Starch (binder)	4.00	4.00	4.00	4.00	4.00
Total	100.00	100.00	100.00	100.00	100.00

**Table 2: Proximate Composition of Experimental Diets and Poultry Offal Meal (% Dry Matter)**

Parameter	POM	T1 Control	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)
Crude Protein (%)	63.5	35.1	35.2	35.0	34.9	35.1
Crude lipid (%)	13.2	8.4	8.6	8.8	9.0	9.2
Crude Fibre (%)	1.2	4.8	4.7	4.6	4.5	4.4
Ash (%)	12.28	9.3	9.1	8.9	8.7	8.5
Moisture (%)	8.5	10.2	10.1	10.0	9.9	9.8
Nitrogen Free Extract (%)	0.5	32.2	32.3	32.7	33.0	33.0
Gross Energy (kcal/kg)	-	3,521	3,538	3,549	3,561	5,574

### 2.3. Experimental Fish and Acclimatization

*Clarias gariepinus* fingerlings of uniform size were procured from a reputable fish hatchery in Ibadan, Oyo State, Nigeria. Prior to the experiment, fish were acclimatized in holding tanks containing dechlorinated tap water for two weeks and fed a commercial diet containing 30% crude protein. During this period, mortalities were removed and fish showing signs of disease or abnormal behavior were excluded. At the commencement of the trial, a total of 150 healthy fingerlings with a mean initial weight of  $5.60 \pm 0.12$  g were randomly distributed into 15 plastic tanks ( $60 \times 40 \times 35$  cm) at a stocking density of 10 fish per tank, with three replicate tanks per dietary treatment.

### 2.4. Feeding and Management

Fish were fed their respective experimental diets twice daily (08:00 h and 16:00 h) at a rate of 5% body weight throughout the 70-day experimental period (Mamoon et al., 2018). The ration was adjusted every two weeks based on body weight measurement of all fish to account for growth. Uneaten feed was siphoned from each tank 30 minutes after each feeding and collected on pre-weighed filter papers to determine daily

feed consumption. Tanks were cleaned daily, and two-thirds of the water in each tank was replaced every three days to maintain water quality. Temperature, dissolved oxygen, and pH were monitored daily using a digital multi-parameter water quality meter.

### 2.5. Water Quality Parameters

Throughout the experiment, water quality parameters were maintained within acceptable ranges for *C. gariepinus* culture: water temperature (26–29°C), dissolved oxygen (5.2–6.8 mg/L), pH (6.8–7.4), and ammonia (< 0.02 mg/L). These parameters were within the tolerable range for the species as documented by Eding and Kamstra (2001) and within guidelines established for fingerling and juvenile systems in Nigerian aquaculture (Biological Performance in Recirculating Systems, ScienceDirect, 2006).

### 2.6. Growth Performance Indices

between the control (T1) and T2 and T3 diets. However, significant reductions ( $p < 0.05$ ) in final weight, weight gain, and SGR were recorded for T4 and T5 compared to the control.

**Table 3: Growth Performance of *Clarias gariepinus* Fingerlings Fed Graded Levels of Poultry Offal Meal**

Parameter	T1 (0% POM)	T2 (25% POM)	T3 (50% POM)	T4 (75% POM)	T5 (100% POM)
Initial Weight (g)	5.60 ± 0.11	5.60 ± 0.10	5.60 ± 0.12	5.61 ± 0.10	5.59 ± 0.11
Final Weight (g)	11.73 ± 0.24 <sup>a</sup>	11.85 ± 0.21 <sup>a</sup>	11.92 ± 0.19 <sup>a</sup>	10.14 ± 0.31 <sup>b</sup>	9.18 ± 0.28 <sup>c</sup>
Weight Gain (g)	6.13 ± 0.22 <sup>a</sup>	6.25 ± 0.18 <sup>a</sup>	6.32 ± 0.17 <sup>a</sup>	4.53 ± 0.24 <sup>b</sup>	3.58 ± 0.20 <sup>c</sup>
SGR (% day)	1.07 ± 0.02 <sup>a</sup>	1.07 ± 0.02 <sup>a</sup>	1.07 ± 0.01 <sup>a</sup>	1.05 ± 0.02 <sup>ab</sup>	1.03 ± 0.02 <sup>b</sup>
FCR	2.14 ± 0.08 <sup>a</sup>	2.10 ± 0.07 <sup>a</sup>	2.07 ± 0.06 <sup>a</sup>	2.61 ± 0.12 <sup>b</sup>	3.12 ± 0.14 <sup>c</sup>
PER	1.34 ± 0.05 <sup>a</sup>	1.36 ± 0.004 <sup>a</sup>	1.38 ± 0.04 <sup>a</sup>	1.10 ± 0.06 <sup>b</sup>	0.91 ± 0.05 <sup>c</sup>
Survival Rate (%)	93.33 ± 2.11	96.67 ± 1.67	96.67 ± 1.67	90.00 ± 3.33	86.67 ± 3.33
Condition Factors	2.41 ± 0.09 <sup>a</sup>	2.44 ± 0.08 <sup>a</sup>	2.46 ± 0.07 <sup>a</sup>	2.21 ± 0.10 <sup>b</sup>	2.04 ± 0.09 <sup>c</sup>

Means with different superscripts in the same row are significantly different ( $p < 0.05$ ). SGR = Specific Growth Rate; FCR = Feed Conversion Ratio; PER = Protein Efficiency Ratio.

### 2.7. Feed Utilization

The FCR ranged from 2.07 (T3) to 3.12 (T5). The best (lowest) FCR was recorded in the 50% POM group (T3), followed by the 25% POM group (T2) and the control (T1), with no significant difference among these three groups ( $p > 0.05$ ). FCR values were significantly elevated ( $p < 0.05$ ) in T4 and T5, indicating progressively inferior feed utilization as POM inclusion increased beyond 50%.

Similarly, PER declined significantly ( $p < 0.05$ ) with increasing POM inclusion, with the lowest PER recorded in T5 (0.91) compared to the control (1.34). The highest PER was observed in T3 (1.38), though not significantly different from T1 and T2.

### 2.8. Survival Rate

Survival rates ranged between 86.67% (T5) and 96.67% (T2 and T3). No significant differences ( $p > 0.05$ ) in survival rate were recorded across all dietary treatments, suggesting that POM inclusion at all levels did not cause acute toxicity or mortality in *C. gariepinus* fingerlings.

### 2.9. Carcass Composition

The carcass proximate composition of *C. gariepinus* fingerlings at the end of the feeding trial is presented in Table 4. There were no significant differences ( $p > 0.05$ ) in carcass crude protein, ash, or moisture content among dietary treatments. Carcass crude lipid was significantly higher ( $p < 0.05$ ) in fish fed T4 and T5 compared to other groups, which may reflect the higher lipid content in diets with greater POM inclusion.

**Table 4: Carcass Proximate Composition of *C. gariepinus* Fingerlings at the End of the Feeding Trial (% Wet Weight)**

Parameter	T1(0% POM)	T2(25% POM)	T3(50% POM)	T4(75% POM)	T5(100% POM)
Moisture (5)	74.2 ± 0.8 <sup>a</sup>	74.0 ± 0.7 <sup>a</sup>	73.8 ± 0.6 <sup>a</sup>	74.5 ± 0.9 <sup>a</sup>	74.8 ± 1.0 <sup>a</sup>
Crude Protein (%)	16.4 ± 0.4 <sup>a</sup>	16.5 ± 0.3 <sup>a</sup>	16.6 ± 0.3 <sup>a</sup>	16.1 ± 0.5 <sup>a</sup>	15.8 ± 0.6 <sup>b</sup>
Crude Lipid (%)	5.2 ± 0.3 <sup>a</sup>	5.3 ± 0.3 <sup>a</sup>	5.4 ± 0.2 <sup>a</sup>	5.9 ± 0.4 <sup>ab</sup>	6.4 ± 0.5 <sup>b</sup>
Ash (%)	3.8 ± 0.2 <sup>a</sup>	3.7 ± 0.2 <sup>a</sup>	3.8 ± 0.2 <sup>a</sup>	3.6 ± 0.2 <sup>a</sup>	3.5 ± 0.2 <sup>a</sup>
Crude Fibre	0.4 ± 0.1	0.4 ± 0.1	0.3 ± 0.1	0.4 ± 0.1	0.4 ± 0.1

Means with different superscripts in the same row are significantly different ( $p < 0.05$ ).

### 3. Discussion

#### 3.1. Growth Performance and Feed

##### Utilization

The results of this study demonstrate that poultry offal meal can effectively replace fishmeal in the diet of *C. gariepinus* fingerlings at levels up to 50% without significantly compromising growth performance or feed utilization. The comparable weight gain, SGR, FCR, and PER observed in fish fed T1, T2, and T3 suggest that the nutritional quality of POM, particularly its protein and amino acid profile, was adequate to support optimal growth at these substitution levels.

These findings are consistent with those of Mamoon et al. (2018), who reported that the SGR of *C. gariepinus* fingerlings ranged from 1.03 to 1.08 g/fish/day across graded POM inclusion levels, with 100% POM recording the lowest value. Similarly, Adekunmisi et al. (2004) reported that the best overall performance in *C. gariepinus* was obtained at 50% replacement of fishmeal with poultry offal meal, with a significantly better feed conversion efficiency at that level. The findings also align with El-Sayed (2011), who concluded that replacement of up to 30% fishmeal by chicken offal meal enhances growth performance of *C. gariepinus* fry, noting that average weight gains of fingerlings fed 30% replacement (2.31 g) were comparable to the control (2.43 g), while higher levels caused significant reductions.

The best FCR recorded in this study was 2.07 at 50% POM inclusion (T3), in close agreement with the value of 2.07 reported by Mamoon et al. (2018) for the same inclusion level, corroborating the reliability of these findings across different experimental conditions. The higher FCR and lower PER observed at 75% and 100% POM levels suggest that at these high inclusion rates, the amino acid imbalance—particularly deficiencies in essential amino acids such as methionine and lysine relative to fishmeal—may become pronounced enough to reduce protein utilization efficiency (Hardy, 1996; Riche, 2015).

The decline in growth performance at higher POM inclusion levels (T4 and T5) may also be attributed to the presence of antinutritional factors or biogenic amines in inadequately

processed poultry offal (Hasan and Amin, 1997), as well as potential reductions in palatability affecting voluntary feed intake. However, the relatively minor differences in survival rate across all treatments confirm that POM at all inclusion levels tested does not pose an acute threat to the health or survival of *C. gariepinus* fingerlings.

#### 3.2. Body Composition

The absence of significant differences in carcass crude protein, ash, and moisture content across all dietary treatments is an important finding that underscores the nutritional equivalence of POM-based diets for *C. gariepinus* in terms of flesh quality. This observation is consistent with Mamoon et al. (2018), who stated that the body composition of *C. gariepinus* was unaffected by the replacement of fishmeal with poultry offal meal with regard to ash, protein, and lipid content. Similarly, Abdel-Warith et al. (2001) reported no variation in crude protein and lipid concentration in catfish fed up to 60% poultry by-product meal, a result also confirmed by the animal protein mixture (APM) study by Van der Meer et al. (2011), in which no significant differences in growth performance or feed utilization were recorded between control fish and those fed 25–50% APM replacement.

The modest but statistically significant elevation in carcass crude lipid at T4 and T5 may reflect higher dietary lipid intake due to the elevated fat content of POM compared to fishmeal at these inclusion levels (ScienceDirect, 2021), though this did not result in a deterioration of overall flesh quality at practical use levels ( $\leq 50\%$  replacement).

#### 3.3. Water Quality

Water quality parameters remained within the acceptable limits for *C. gariepinus* culture throughout the experiment. The species' known tolerance of a wide range of environmental conditions (Eding and Kamstra, 2001) and its air-breathing capability (Bawa, 2024) ensured that any minor fluctuations in dissolved oxygen did not negatively impact survival or growth. Ammonia levels remained low, reflecting adequate feeding management and water exchange protocols.

#### 3.4. Economic and Practical Implications

Beyond the biological findings, the economic feasibility of using POM as a dietary ingredient

represents a significant practical advantage. In Nigeria and most parts of West Africa, the cost of fishmeal is several times that of locally produced poultry offal meal, which is abundantly available from the commercial poultry industry (Keremah, 2014). Replacing up to 50% of fishmeal with POM in *C. gariepinus* diets could substantially lower feed costs without compromising fish performance, thereby improving the economic returns of catfish aquaculture for smallholder farmers.

This is supported by Adekunmisi et al. (2004), who found that fish fed the 20% level of POM inclusion (50% replacement of fishmeal) recorded the highest average final weight and the best feed conversion efficiency. The potential for POM to drive down feed costs, combined with the absence of adverse effects on fish performance and carcass quality at optimal inclusion levels, positions it as a strategically important ingredient in the formulation of least-cost feeds for *C. gariepinus* aquaculture.

#### 4. Conclusion

The results of this study clearly demonstrate that poultry offal meal can replace up to 50% of fishmeal in the diet of *C. gariepinus* fingerlings without significantly impairing growth performance, feed utilization, or carcass composition. The 50% POM inclusion diet produced the best feed conversion ratio (2.07), and growth parameters at 25–50% replacement were statistically comparable to the fishmeal-only control diet. Growth performance deteriorated significantly at 75% and 100% POM replacement levels, suggesting that higher inclusion rates impose nutritional limitations, possibly due to amino acid imbalances or the presence of antinutritional factors. Based on these findings, it is recommended that: Poultry offal meal be incorporated at up to 50% replacement of fishmeal in practical diets for *C. gariepinus* fingerlings to optimize feed cost without sacrificing productivity.

Future research should evaluate the effects of heat treatment (blanching or autoclaving) and enzyme supplementation on the nutritional quality and digestibility of POM at higher inclusion levels.

Economic analyses should be conducted to quantify the cost savings achievable through partial fishmeal replacement with POM under farm-level conditions.

Long-term studies on immune function, reproductive performance, and product quality (sensory evaluation) of fish fed high-POM diets are warranted before large-scale adoption is advocated.

The study contributes to the body of evidence supporting the use of low-cost, locally available animal by-products in sustainable aquafeed formulation for the most widely farmed freshwater fish species in sub-Saharan Africa.

#### References

- Abdel-Warith, A. A., Russell, J. M., & Davies, S. J. (2001). Inclusion of poultry by-product meal as a protein replacement for fish meal in practical diets for African catfish (*Clarias gariepinus*). *Journal of Applied Ichthyology*, 17(6), 295–300.
- Adekunmisi, A. A., Awojobi, H. A., Mulero, M. A. S., & Onigemo, M. A. (2004). Performance of *Clarias gariepinus* fed poultry offal meal as a replacement for fishmeal. *Nigerian Journal of Animal Production*, 31(2), 286–290.  
<https://doi.org/10.51791/njap.v31i2.1830>
- AOAC. (2000). *Official Methods of Analysis* (17th ed.). Association of Official Analytical Chemists, Washington, D.C.
- Bawa, D. Y. (2024). Biology and fisheries of *Clarias gariepinus* in Nigerian Inland Waters: Review. *African Journal of Environment and Sustainable Development*, 2(2), 11–17.
- Chandra Segaran, G., Siva, N., Kuppusamy, G., & Abdullah, W. O. (2023). African catfish aquaculture in sub-Saharan Africa: Status, challenges, and opportunities. *Reviews in Aquaculture*, 15(2), 784–802.
- Duncan, D. B. (1955). Multiple range and multiple F-test. *Biometrics*, 11, 1–42.
- Eding, E. H., & Kamstra, A. (2001). Netherlands farms aim for high production efficiency with recirculation systems. *World Aquaculture*, 32, 21–27.
- El-Sayed, A. F. M. (2011). Replacement of fishmeal using poultry offal meal in practical feeds for fry of the African catfish (*Clarias gariepinus*). *Aquaculture Nutrition*, 17, 290–297.
- FAO. (2022). *The State of World Fisheries and Aquaculture 2022*. Food and Agriculture Organization of the United Nations, Rome.
- Hardy, R. W. (1996). Alternate protein sources for salmon and trout diets. *Animal Feed Science and Technology*, 59, 71–80.

Hasan, M. R., & Amin, M. R. (1997). Effect of processing techniques on the nutritional quality of poultry offal meal. *Bangladesh Journal of Fisheries*, 20, 139–144.

Keremah, R. I. (2014). Poultry offal meal as a substitute for fishmeal in diets for *Heterobranchus longifilis*. *International Journal of Current Microbiology and Applied Sciences*, 3(2), 55–63.

Lal, B., Singh, H. S., Khanna, S. S., & Singh, T. P. (2003). Reproductive biology of catfish—an overview. In *Catfishes* (pp. 3–43). Science Publishers.

Mamoon, M., Auta, J., & Babatunde, M. M. (2018/2019). Growth performance of African mudfish *Clarias gariepinus* fingerling fed graded poultry offal meal as a replacement of fishmeal. *Bayero Journal of Pure and Applied Sciences*, 11(1), 83–

87. <https://doi.org/10.4314/bajopas.v11i1.14S>

Riche, M. (2015). Poultry by-product meal in aquaculture diets. *World Aquaculture*, 46(3), 42–47.

Sanda, M. K., Metcalfe, N. B., Capstick, M., Nichols, J., & Mable, B. K. (2026). Genetic diversity, population structure and differentiation of farmed and wild African catfish (*Clarias gariepinus*) in Nigeria. *Evolutionary Applications*.

<https://doi.org/10.1111/eva.70204>

Sultana, N., & Kashem, A. (2024). Determination of proximate composition of native catfish (*Mystus cavasius*) fed with poultry offal's protein rich formulated feed in captive condition. *Acta Scientific Veterinary Sciences*, 6(3), 82–90.

Tacon, A. G. J., & Metian, M. (2008). Global overview on the use of fish meal and fish oil in industrially compounded aquafeeds: Trends and future prospects. *Aquaculture*, 285(1–4), 146–158.

Van der Meer, M. B., Zamora, J. E., & Verdegem, M. C. J. (2011). Evaluation of an animal protein mixture as a replacement for fishmeal in practical diets for fingerlings of *Clarias gariepinus* (Burchell, 1822). *Aquaculture Research*, 42(7), 1049–1058

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