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Comparative Length-Weight Relationship, Condition Factor and Nutritional Value of Cultured African Catfish, *Clarias gariepinus* Fed with Two Feed Types and Their Mixture

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Abstract

Indicators for assessing healthy food fish include length-weight relationship (LWR), condition factor (K), and nutritional value (NV). A study was conducted to compare the LWR, CF and NV of African catfish, *Claries gariepinus* of initial size range 1.2 to 1.5 g and initial mean weight 1.3±0.1 g. They were fed separately with commercial catfish feed (*A*), commercial tilapia feed (*B*) and their equal mixture (*C*) in hapa-in-pond systems for 77 days. The LWRs were computed by least squares method applied to the log transformed data. A linear regression analyses were carried out on a log transformed LWR equation to establish K and the NV determined by proximate analyses of fillets of the cultured fish. The computed K were 1.2, 1.2 and 0.9 for *A*, *B* and *C*, respectively. Aside from ash, there were significant differences (Tukey's HSDT, P<0.05) in nutrient and gross energy contents among the fillets. However, all recorded values were within the nutritional range required by humans. Fat contents of the fillets were less than 5.0%, indicating lean fish. Hence, depending on availability and costs a catfish feed, a tilapia feed or their equal mixture could be fed to *C. gariepinus* during its culture.

Introduction

The length-weight relationship (LWR) of fish is often used as a general indicator of the well-being of a fish species and it provides information on the growth pattern of the fish (Jisr et al., 2018; Ali et al., 2023). Besides, LWR is useful in comparing the same fish species in different aquatic environment as well as their different growth stages (Kuriakose, 2017; Kim et al., 2023). Assessing the length-to-weight ratio of a fish provides key indicators for its economic viability as food source and its role in sustaining postharvest technology of processing (Ikape and Solomon, 2018; Khillare and Khandare, 2020; Tahany et al., 2022).

The condition factor, K of a fish is used as an indicator of its health status and it is important in assessing viability of commercial fish products (Rasyadi, et al., 2023). The K is a tool used in fisheries science to assess the health and nutritional status of fish and it may be used to monitor the quantity of food a fish consumes and its growth rate (Getso et al., 2017). The K determines the welfare of a fish and the overall fitness of fish species is assumed when K values are equal or close to 1.0 (Yilmaz et al., 2012; Mensah, 2015).

The nutritional value of a fish affects its marketing. A high level of stored fat in fish affects its postharvest processing as its dress-out percentage is reduced since the fat is mostly removed during processing (Akintola, et al., 2022). Additionally, a high level of body fat increases rancid off-flavour during storage, reducing consumer acceptance. Some buyers object to buying fish containing high levels of carcass fat (Brooks, 1982). The high body fat contents of farmed fish have been attributed to addition of excess (above 2.5%) fats to fish feeds (Brooks et al., 1982). Excessive addition of fats to fish feeds cause increase in the body fats of the cultured fish they are fed to; resulting in quality reduction of the fish when frozen (Brooks et al., 1982).

Fish farming has led to an increase in the prospects of fish feed as it is the major input in fish production. Hence, feeds are being specially designed to meet the nutritional needs of specific fish species life cycle and its health conditions (Rawling et al., 2012). Fish feed is the most expensive operating cost item in fish culturing and the success of fish farming depends on it (Craig and Helfrich, 2002). Good fish growth, health and profitability of fish farming depends on the availability of high quality nutritionally balanced and affordable fish feeds in quantity (Gabriel et al., 2007; Anani et al., 2024). Depending on the species and the culture environment, feed could account for between 40 to 80% of the total production cost (FAO, 2009; Torsabo et al., 2019). The prices of fish feeds for various stages of a particular fish species correlate positively with the declared crude protein (CP) contents by the producers. However, feeds for catfish and tilapia having the same CP contents attract different prices; with those of catfish being higher.

Currently, the North African catfish, *Clarias gariepinus* (Burchell, 1822) is the second most farmed fish species in Ghana, contributing about 20% of cultured fish production (FC, 2023). It is produced in diversified culture systems such as earthen ponds, concrete tanks, plastic tanks, tarpaulin tanks and in floating fish cages. The fish has high economic importance and it is remarkably adaptable to a wide ecology (FAO, 2015; Laboni et al, 2024). The farming of *C. gariepinus* has increased over the years due to its ability to survive a wide range of environmental conditions, high stocking densities and relative fast growth under culture conditions (FAO, 2015; Laboni et al, 2024).

Depending on availability and costs, farmers who produce both catfish and tilapia feed their cultured fish with either catfish feed or that of tilapia and sometimes a mixture of them. However, to successfully monitor and tackle insufficient nutrition in cultured fish, it would be beneficial to evaluate important biological indicators such as LWR and the K of the fish the various feed types are fed with (Kasper et al, 2022). For this reason, the present study was undertaken to compare the LWR, K and the nutritional value of *C. gariepinus* cultured and fed separately with commercial catfish feed, commercial tilapia feed and their equal mixture in hapa-in-pond systems, with the view of establishing whether all the feed types are appropriate for *C. gariepinus* production.

Materials and Methods

Study Site

The study was carried out for a period of 11 weeks (77 days) at the Aquaculture Research and Development Centre (ARDEC) of Water Research Institute (WRI) of the Council for Scientific and Industrial Research (CSIR), Ghana. The site lies between latitude 6° 13′ North and the longitude 0° 4′ East at Akosombo in the Eastern Region of Ghana.

Experimental System and Fish Culture

The experiment was conducted in hapa-in-pond systems consisted of nine (9) fine mesh netting hapas, each of dimensions 5.0x2.0x1.2 m (i.e. length, width and height), installed along the lengths of a 0.2-hectare earthen pond at a distance of about 5 m apart. The hapas were randomly labelled according to three (3) treatments, viz. *A* (catfish fingerlings fed with catfish feed), *B* (catfish fingerlings fed with tilapia feed), and *C* (catfish fingerlings fed with equal mixture of catfish and tilapia feeds) with 3 hapas allocated to each treatment.

Nutritional Properties of Experimental Feeds and Feed Management

The experimental feeds were the same brand of a commercial type formulated for catfish and tilapia, procured from a commercial fish feed retail outlet near the study area. The feeds were in the forms of extruded pellets of diameter 2.0 mm, with each having 40.0% crude protein (CP) content as declared on the labels of the feed bags by the producer (Table 1).

Within the first four (4) weeks of the study, about 30.0 kg of each feed type was crushed into smaller sizes (0.4 to 0.8 mm) that the experimental fingerlings could

Table 1. Nutritional properties of the experimental feeds as declared by the producer

Parameter	Tilapia Feed	Catfish Feed
Crude Protein (%)	40.0	40.0
Crude Fat (%)	10.0	6.5
Crude Fibre (%)	5.0	4.0
Moisture (%)	10.0	10.0
Ash (%)	10.0	12.0
Phosphorus (%)	1.0	1.2
Calcium (%)	1.0	1.5
Manufacturing Date	10 May 2023	30 May 2023
Expiration Date	10 Nov. 2023	30 Nov. 2023

pick. A third feed was obtained by homogeneous mixing of equal portions of the two (2) feed types. Crushing of the feeds to sizes that the fingerlings could pick continued until they were able to pick the 2.0 mm pellet sizes. The individual and the mixed excess feeds were weighed into separate plastic containers, sealed and labelled accordingly. The labelled feeds were kept in a cool, dry and well-ventilated room which was inaccessible to unauthorized personnel.

Proximate Composition Analyses

In all, a sample of 9 harvested fish (3 from each treatment) was taken to determine their nutritional values based on proximate analyses of the flesh. The analyses were carried out in triplicates following standard methods (AOAC, 2019). The protocol was employed to determine percentage (%) dry matter (DM), % crude protein (CP), % ash, % crude lipid (CL) or crude fat or oil and % crude fibre (CF). Percentage carbohydrate (Nitrogen-free extract, %NFE) was computed using the formula: % NFE = %DM - (CP + Ash + CL + CF) %. The gross energy contents of the fish was computed by using the average physiological fuel values of 23.64, 39.54 and 17.15 MJ kg^{-1} for protein, fat and carbohydrate respectively (Anani et al., 2024).

Data Analyses

The day following the end of the eleventh week, using a scoop net all the fish from each of the replicates of each treatment were harvested and the total length (TL) and weight (W) of each were determined. The TL was measured to the nearest 0.1 cm using a graduated fish measuring board whilst the weight was measured to the nearest 0.1 g using top loading electronic balance (EMB 500-1-Kern). To establish the condition factor, K of *C. gariepinus* fed with the various feed types, a linear regression analyses were carried out using the length-weight relationship equation, $W = aL^b$ (Paully, 1983) which was log transformed as: $\mathrm{LogW} = \mathrm{loga} + \mathrm{blogL}$, where *W* is the body weight of the fish in grams, *L* is its total length in centimetres, *a* and *b* are the intercept (constant) and the exponent (slope), respectively, obtained from the linear regression of the logarithm of *L* and *W*. The *K* was computed by employing the formula:

$$K = 100W/L^b$$ (Gayanilo and Pauly, 1997).

Where W= weight of fish (g), L= Length of fish (cm). Linear regression analyses were carried out using Microsoft Excel spreadsheet.

Results

Length-Weight Relationship and Condition Factor

Results of the length-weight analyses of the cultured African catfish, *C. gariepinus* fed with the various feeds are presented in Table 2. The lengths of the harvested fish fed with the catfish feed (*A*), the tilapia feed (*B*)and their equal mixture (*C*) ranged from 12.0 to 23.6, 9.9 to 21.6 and 10.1 to 22.9 cm, respectively, whilst their corresponding weights ranged from 11.2 to 76.1, 7.1 to 67.3 and 5.8 to 75.7 g, respectively. The computed mean lengths were 16.7±2.1, 16.5±2.2 and 17.1±2.4 cm for fish fed with *A*, *B* and *C*, respectively. The computed mean weights were 31.8±11.5, 30.2±10.7 and 33.9±13.9 g for *A, B* and C, respectively.

The length-weight relationship among pairs of plotted data, corresponding equations and the determination coefficient (R^2) are demonstrated in Figures 1, 2 and 3 for *C. gariepinus* fed with *A*, *B* and *C*, respectively. The *C. gariepinus* fed with the various feed types had similar exponential (*b*) values which were 2.8, 2.8 and 2.9 for *A*, *B* and *C*, respectively. The R^2 ranged from 0.93 to 0.96 whilst the computed condition factors (*K*s) were 1.2, 1.2 and 0.9 for *A*, *B* and *C*, respectively.

Nutritional Values of Cultured *C. gariepinus*

The analysed nutritional values of *C. gariepinus* fed with feeds *A*, *B* and *C* are presented in Table 3. There were significant differences (Tukey's HSDT, P<0.05) in the major nutrients (i. e. crude protein, crude fat and carbohydrate) among the cultured fish fed with the various feed types. The values of analysed crude protein which ranged from 14.5±0.3 to 17.8±0.2% was highest

Table 2. Length-weight relationship, regression coefficient and condition factor parameters of African catfish, *Clarias gariepinus* fingerlings fed separately with commercial catfish feed, tilapia feed and their equal mixture for 77 days

Parameter	Feed Type		
	Catfish fed with catfish feed	Catfish fed with tilapia feed	Catfish fed with mixed feed
Minimum Weight (g)	11.2	7.1	5.8
Maximum Weight (g)	76.1	67.3	75.7
Mean Weight (g)	31.8±11.5	30.2±10.7	33.9±13.9
Minimum Length (cm)	12.0	9.9	10.1
Maximum Length (cm)	23.6	21.6	22.9
Mean Length (cm)	16.7±2.1	16.5±2.2	17.1±2.4
b	2.8	2.8	2.9
K	1.2	1.2	0.9
N	115	136	67

in the fish fed with *B* (tilapia feed). Recorded crude fat levels ranged from 3.4±0.1 to 4.1±0.1% with that of fish fed with *A* (catfish feed) being the highest. Carbohydrate levels ranged from 2.7±0.2 to 5.4±0.1% with the highest recorded in fish fed with *B*. Ash contents ranged from 0.9±0.6 to 1.2±0.1% and there were no significant difference (ANOVA, P>0.05) among the various feed types. The gross energy contents ranged from 7.11±0.3 to 8.91±0.2 with that of *B* being significantly higher (Tukey's HSDT, P<0.05).

Discussion

The values (2.8 and 2.9) of regression coefficients *b* obtained in the current study for *C. gariepinus* were near to 3.0. For fish exhibiting isometric growth, the value of *b* should not differ much from 3 (Beverton and Holt, 1957; Subba and Adhikaree, 2011). This suggests that the cultured *C. gariepinus* fed with the catfish feed (*A*), tilapia feed (*B*) and their equal mixture (*C*) exhibited isometric growth. Deviation from the cube law were observed by many researchers in many fish species (Nehemia et al., 2012; Kumari et al., 2019; Sadauki et al., 2023; Akeem et al., 2025).

Generally, a condition factor (*K*) nearer or greater than 1 indicates good fish health (Bhattacharya and Banik, 2012; Jisr et al., 2018). Aside from the *K* of the African catfish, *C. gariepinus* fed with *C* being 0.9, those fed with *A* and *B* were each 1.2. This suggests that the cultured *C. gariepinus* was in good condition (Chukwu and Deekae, 2010). Besides, the values of *K* recorded in the current study were within 0.9 and 2.0 recorded of the silver catfish, *Chrysichthys nigrodigitatus* caught from the New Calabar River (Abu and Agaria, 2016).

However, the values of *K* recorded in the current study were below 1.5 to 1.7 recorded for *C. gariepinus* by Okwodu et al. (2022) at five study sites in Orashi River, Nigeria and 1.3 K value recorded by Ndome et al.

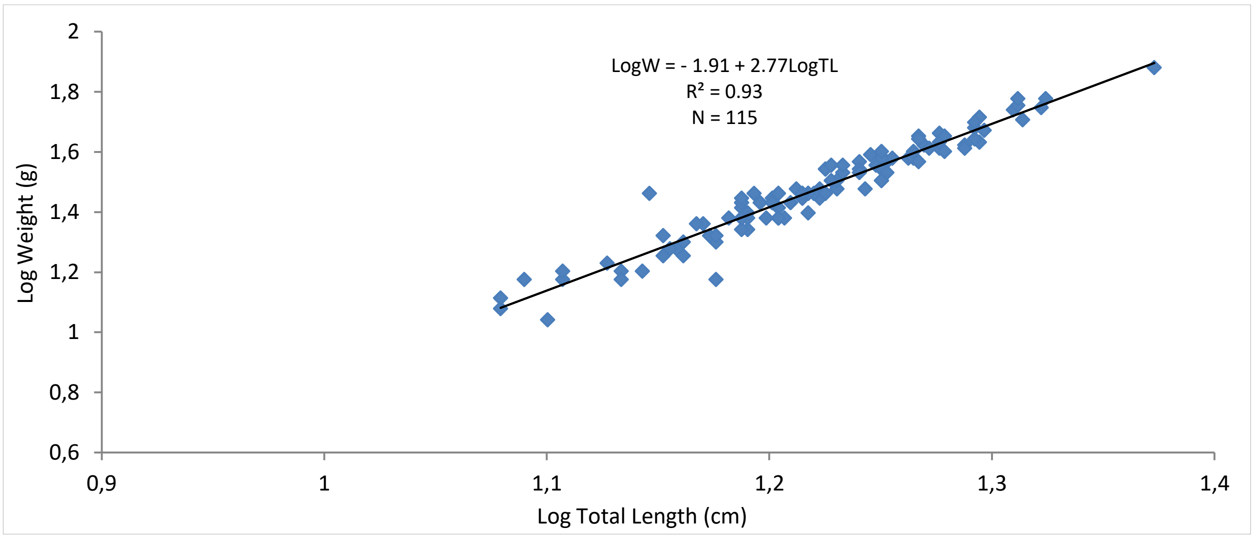

Figure 1. Length-weight relationship of African catfish, *Clarias gariepinus* fed with catfish feed.

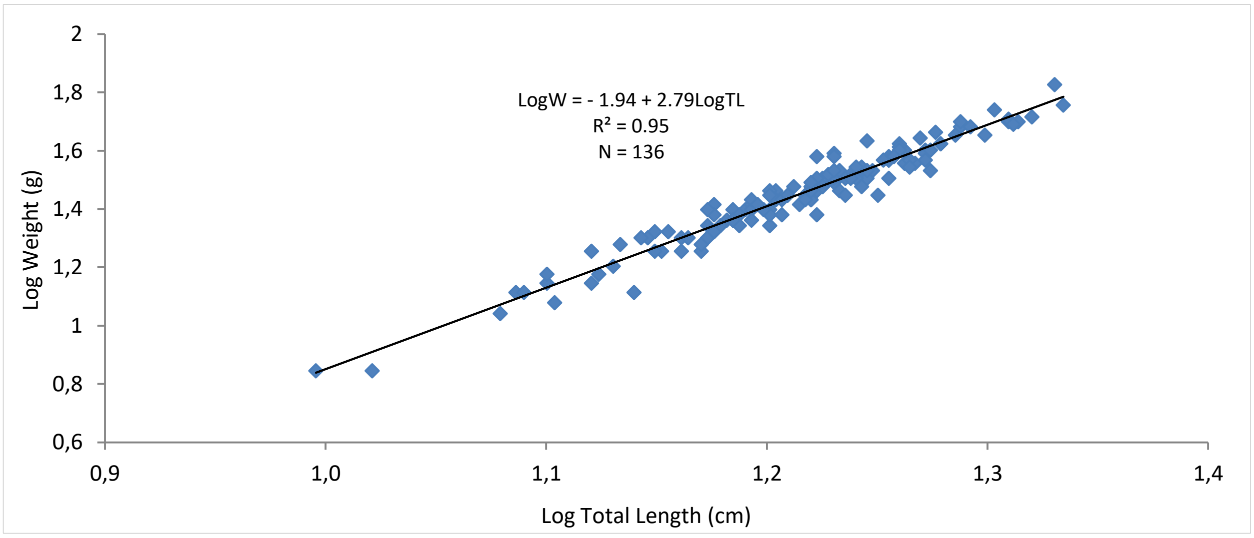

Figure 2. Length-weight relationship of African catfish, *Clarias gariepinus* fed with tilapia feed.

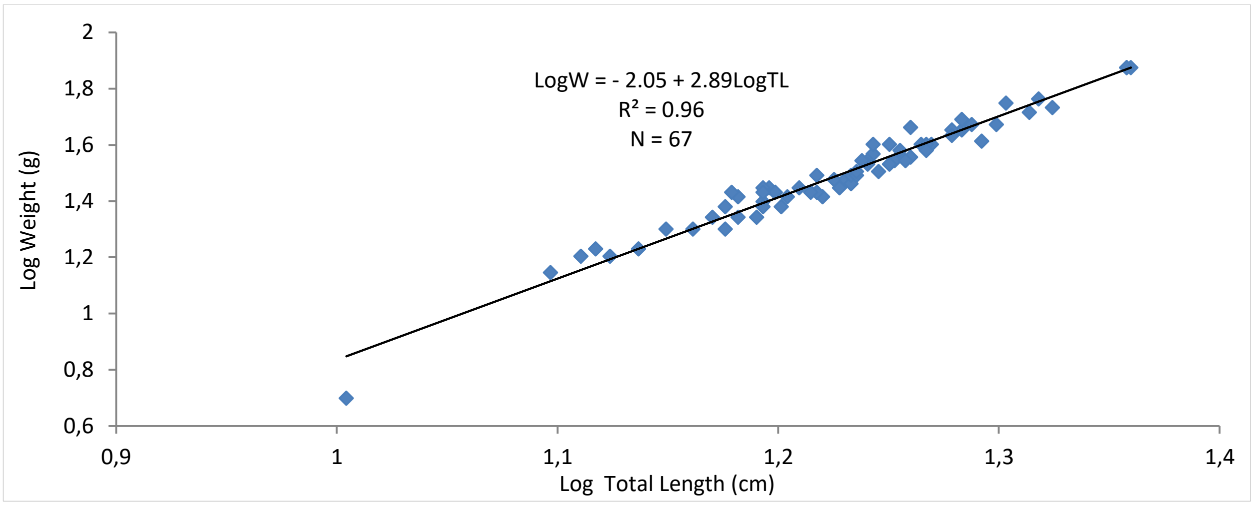

Figure 3. Length-weight relationship of African catfish, *Clarias gariepinus* fed with equal mixture of catfish and tilapia feeds.

Table 3. Proximate composition of African catfish, *Clarias gariepinus* fingerlings fed separately with commercial catfish feed, tilapia feed and their equal mixture for 77 days

Parameter	Feed Type		
	Catfish fed with catfish feed	Catfish fed with tilapia feed	Catfish fed with mixed feed
Moisture (%)	75.5±0.3^{b}	71.5±0.5^{c}	77.3±0.2^{a}
Crude Protein (%)	14.5±0.3^{b}	17.8±0.2^{a}	14.8±0.3^{b}
Crude Fat (%)	4.1±0.1^{a}	3.4±0.1^{b}	3.6±0.5^{b}
Carbohydrate (%)	4.2±0.4^{b}	5.4±0.1^{a}	2.7±0.2^{c}
Fibre (%)	0.6±0.2^{b}	0.8±0.2^{a}	0.7±0.1^{b}
Ash (%)	1.1±0.3^{a}	1.2±0.1^{a}	0.9±0.6^{a}
Gross Energy (kJ g^{-1})	7.44±0.3^{b}	8.91±0.2^{a}	7.11±0.3^{b}

Values are means±standard deviations of three replicates. Means within the same row with different letters are significantly different (Tukey's HSDT, P<0.05).

(2012) of the smooth-mouth marine catfish (*C. heudelotii*) harvested from Ibeno Local Government Area of Akwa Ibom State, Nigeria. In another study, Ayo-Olalusi (2014) observed *K* of 0.8 for *C. gariepinus* reared in flow-through tank systems whilst Atawodi et al. (2025) recorded values ranging from 0.64 to 0.77 in cultured and wild species. This suggests that a particular fish species is able to attain varying values of *K* depending on the habitat, its prevailing conditions as well as food availability.

The fillet moisture contents (71.5±0.5 to 77.3±0.2%) of fresh *C. gariepinus* recorded in the current study were within the range 72.18-83.65% observed by Rubbi et al. (1987) in 27 freshwater fish species. Also, they are in agreement with the suggested range of 70 to 80% moisture contents of fishes in general (Igbinosun and Talabi, 1983; Gboko et al., 2019). However, they are higher than the ranges between 64.0 and 68.0% recorded by other researchers (Umar et al., 2018; Egun and Oboh, 2022; Mohammed et al., 2023; Egun et al., 2024) in *C. gariepinus*.

The recorded crude protein (CP) contents range of 14.5±0.3 to 17.8±0.2% were not fully within the general range of 16.0 to 18% CP contents of fish (WHO, 2007). However, CP levels above this range were recorded in *C. gariepinus* in other related studies. For instance, Adewumi et al. (2014) recorded 18.3% of fish obtained from Osinmo reservoir whilst Agali (2018) recorded 18.8% of fish from Obueyinomo River, Edo State Nigeria. Nutritionally, the quality of fish meat is dependent on its protein content and in consistent with other studies, the protein contents recorded in this study were the highest components of the dry matter of *C. gariepinus* (Umar et al., 2018; Egun and Oboh, 2022; Mohammed et al., 2023; Egun et al., 2024).

Depending on the crude fat contents of fishes, Gülyavuz and Ünlüsayın, (1999) and Çaklı (2007) classified fishes as lean fish (fat content ≤ 5.0%), fatty fish (fat content above 5.0 to 10.0%) and very fatty fish (fat content above 10.0%). Hence, the cultured *C. gariepinus* fed with the 3 feed types in the current study can be described as lean fish since the recorded fat contents were less than 5.0%. However, the range of fat contents recorded in the current study was lower than those observed in *C. gariepinus* in other studies. Egun and Oboh (2022) recorded a value of 6.5% in fish from wild sources. Similarly, Agali (2018) recorded 8.8% in a study on capture fisheries.

Ash contents of food materials are reflection of their total mineral contents (Adewumi et al., 2014). The values (0.9±0.6 to 1.2±0.1%) recorded in the current study indicate that the cultured *C. gariepinus* were of low mineral contents compared to 5.2% recorded in fish from the wild by Egun et al. (2024). This could be attributed to differences in the feed types that the fish fed on. In the current study, the observed significant differences in the nutritional value of *C. gariepinus* could be attributable to the types of feeds the fish was fed with.

Conclusion

The computed condition factor, K of the African catfish, *Clarias gariepinus* fed with catfish feed only, tilapia feed only or their equal mixture were near or greater than 1.0, suggesting the fish were in good health. All the recorded nutritional values were within the range required by humans. The body fat contents of the cultured fish were less than 5.0%, indicating lean fish. Hence, depending on availability and costs, *C. gariepinus* under culture may be fed with a catfish feed, a tilapia feed or their equal mixture.

Ethical Statement

Not applicable.

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Author Contribution

All Authors: Conceptualization, Methodology, Data Collection and Analyses; First Author: Drafting of first version of manuscript; All Authors: Reviewing and Editing of final version.

Conflict of Interest

The authors declare that they have no known competing financial or non-financial, professional, or personal conflicts that could have appeared to influence the work reported in this paper.

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