PERFORMANCE OF LOCALLY FORMULATED FEEDS FOR FEEDING AFRICAN MUD CATFISH *Clarias gariepinus* (BURCHELL, 1822)

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Abstract: Aquaculture production is considered as the future global solution to declining wild fish capture. However, insufficient production of fish due to lack of affordable quality feeds is a major challenge in aquaculture development. The study investigated the growth performance of fingerlings of African mudcatfish (*Clarias gariepinus*) fed on some nutritional diets (Fish meal, Soya bean meal, Feather meal and Poultry meal). The diets were formulated to contain 40% feed additives and 60% local feed ingredients. A total of 120 fingerlings with mean weight 0.362 ± 0.089 g were obtained and the experiment was conducted for 6 weeks. Water quality parameters were recorded, while the nutritive values of the diets were determined using recommended methods. Effects of the feed on specific growth rate (SGR%), survival rate (SR%) and water quality parameters was determined. Results indicated that water quality parameters such as temperature, dissolved oxygen and pH were within the acceptable range. Nutritional composition of the diets ranged as follows; crude protein: 31.3 – 50.6%, ash: 12 – 21.4%, fat: 5.6 – 9.1%, moisture: 8.2 – 12.2%, fibre: 4.9 – 8%. The energy content ranged from 1937.5 – 2593.4 Kcal/kg and the fish body weight increased progressively throughout the experimental period which was significantly higher at the end of the experiment (Mean = 3.4 g) compared to the commencement of the experiment (Mean = 0.4 g).

Keywords: Growth rate, fish meal, poultry meal, soyabean meal

Introduction

Feeding in aquaculture aims at producing the maximum weight of marketable fish within the shortest time at least cost. Feed should provide required energy for all the activities that fish engage in and nutrients for body maintenance, growth and reproduction. It must contain all the nutrients in right proportions to bring about sustainable growth (De Silva and Hassan, 2007). Feeding increases fish growth which must be nutritious and economical in any farming system and must be effectively managed.

Fish can be sustained exclusively on natural foods and or on artificial (formulated) feedstuffs. Natural foods in fish ponds are mainly phytoplankton, zooplankton, detritus, insect larvae and other aquatic macroinvertebrates. Fertilization of the water using inorganic or organic fertilizer enhances the growth of phytoplankton and zooplankton in culturing water bodies. Droppings of farm animals (such as poultry, pigs, cattle) and compost are the most commonly used organic fertilizer that enhances the natural food which is insufficient in quantity and quality for the adequate growth (Abowei and Ekubo, 2011). Leaves of legumes and other agricultural by-products such as rice bran, wheat bran, groundnut peels and cake among others can be used as supplementary feeds (Adewumi and Olalaye, 2011).

Formulated or compounded feeds can be used as supplementary feeds or as a sole source of nutrients for culturing fish which may be given to fish in dry, moist or wet form. Dried compounded feeds can be presented to fish as powder or pellets which their shape and size depend on the age or size of the fish. Floating and sinking pellets feeds are desirable for pelagic and benthic fishes, respectively (Madu and Ufodike, 2003). The quest for protein source in fish feed is a major challenge and competition with human and other livestock that majorly depends on protein for body growth. Therefore, there is a need for innovative ways of developing quality fish feeds with alternative to the competitive protein source and reducing high cost of value has to be adopted for aquaculture.

Soyabean meal is potentially considered as an alternative protein source to fish meal because of its global availability and cost which possess 47 – 49% protein and 3% crude fiber obtained from dehulled seeds (Steinfeld *et al.*, 2006; Brown *et al.*, 2008; Cromwell, 2012). Feather meal is a by-product of processing poultry which can be ground into powder for use as a nitrogen source for animal feed (mostly ruminants) or as an organic soil amendment (Nachman *et al.*, 2012). Poultry meal is an important source of animal protein from poultry processing plants used in feeding domestic animals, along with meat and bone meal, blood meal, feather meal and fish meal (Honikel, 2011).

A complete diet must be nutritionally balanced, palatable, water stable, and have the proper size and texture. If natural foods are not incorporated in fish diets, the feed must be supplemented with natural or synthetic pigments (Fasakin *et al.*, 2001; Madu and Ufodike, 2003; Gabriel *et al.*, 2007). The processing methods which include sourcing, mixing, pelleting, drying and storing are very crucial as they determine the bioavailability of nutrients, feed acceptability, palatability and durability that often has profound effects on performance of the culturing fish (Ogunji and Wirth, 2001; Royes and Chapman, 2003; Adewumi and Olalaye, 2011).

Clarias gariepinus can be omnivorous or predatory with a relatively high dietary protein requirement (40 – 50% of crude protein), 10 – 12% for dietary lipid and 15 – 32 % for carbohydrate as fingerlings feed exclusively on zooplankton and phytoplankton of about 70% of feeding occurs at night (Potongkam and Miller, 2016; FAO, 2017). Feeding in fishes depend on food availability (Bruton, 1979). Feeding a single type of food may neither be incomplete nor balanced as all the nutrients needed in fish diet might be absent (Adewumi and Olalaye, 2011; Azim *et al*., 2012).

The growth of aquaculture in Nigeria is largely being boosted by a steady rise in catfish culture. Inadequate availability of seed for stocking and feed used to be a major problem since the culture of *Clarias gariepinus* through hypophysation was initiated in Western Nigeria in 1973 (FAO, 2004). The research was aimed to assess the nutrition level of different locally compounded feeds for African Mudcatfish (*Clarias gariepinus*) fingerlings in view of their comparative growth rate and protein substitution.

Materials and Methods

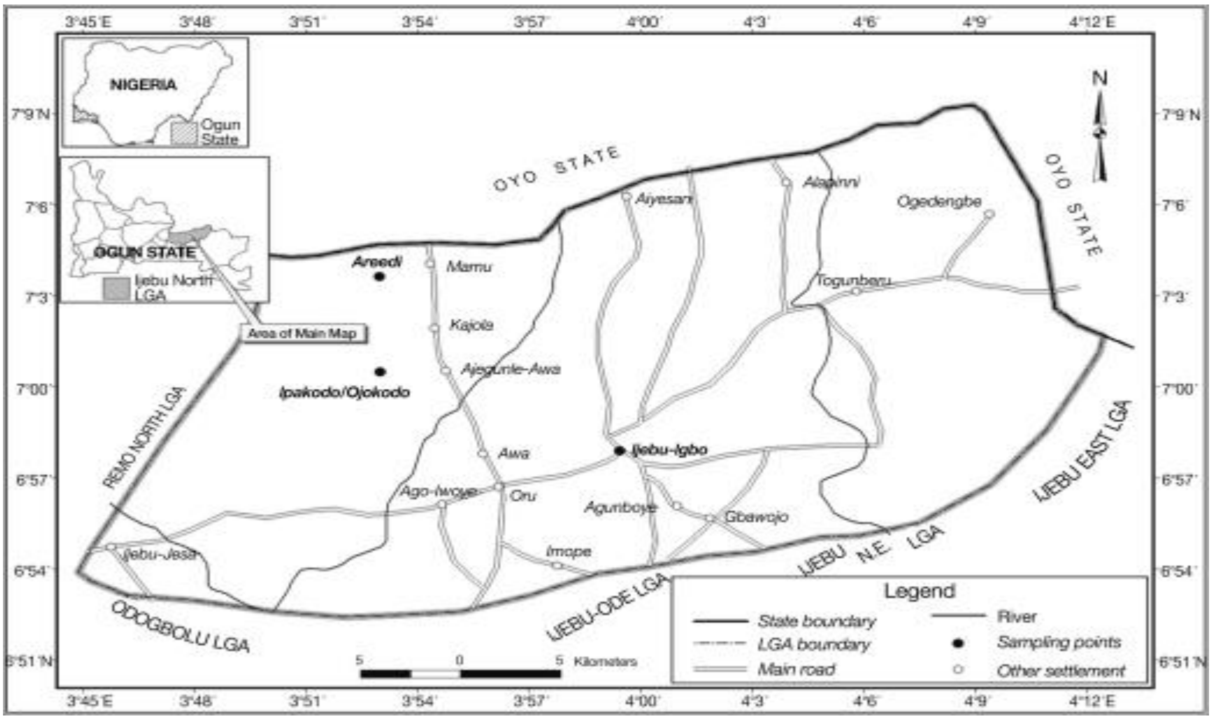
Study area

The study was conducted in Ijebu-Igbo; the headquarter of Ijebu-North Local Government Area of Ogun State, South-Western Nigeria (Fig. 1). Its geographical coordinates lies between latitude 6.9792^0N and longitude 3.9980^0E. They are inhabited by people of mixed cultural background and languages predominantly Ijebu/Yorubas. Its indigenous people are mostly farmers of Cocoa, Cassava, Kolanuts and Aquaculture, while some engage in poultry businesses (Akinola, 1996).

Experimental set-up

One Hundred and Twenty (120) African Mudcatfish fingerlings (*Clarias gariepinus*) of mean weight 0.362 ± 0.089 g were procured from Fasolad Farm Limited in Ijebu – Igbo in August, 2019. The fingerlings at the time of purchase were shown on Plate 1. Forty fingerlings in each aquarium of 35 litres (37 x 25 cm) were acclimatized for 14 days. After acclimatization, ten fingerlings were randomly sampled and weighed using an Electronic balance (Scout Pro Balance, Ohaus) and mean body weights was recorded. Wheat bran, Groundnut cake, Rice bran, Premix, Soyabean meal, Fish meal, Poultry by-product, Bone meal, Blood meal, Palm kernel cake other feed additives were obtained from Fasolad animal feeds and cereals store, Ijebu- Igbo, Ogun State, Nigeria.

Each diet mixture was dried in an oven at 50°C for 12 h. Fish meal, soya bean meal, poultry meal and feather meal prepared were introduced to fingerlings in each aquarium making a total of four (4) aquaria used. All the aquaria were placed on a separate laboratory benches for accessibility and observation. Clean water was supplied from a reservoir tank into each aquarium and the effluent water was drained through inlet and outlet pipes respectively. A constant photoperiod of 12 h of light and 12 h of darkness was maintained throughout the experimental period.

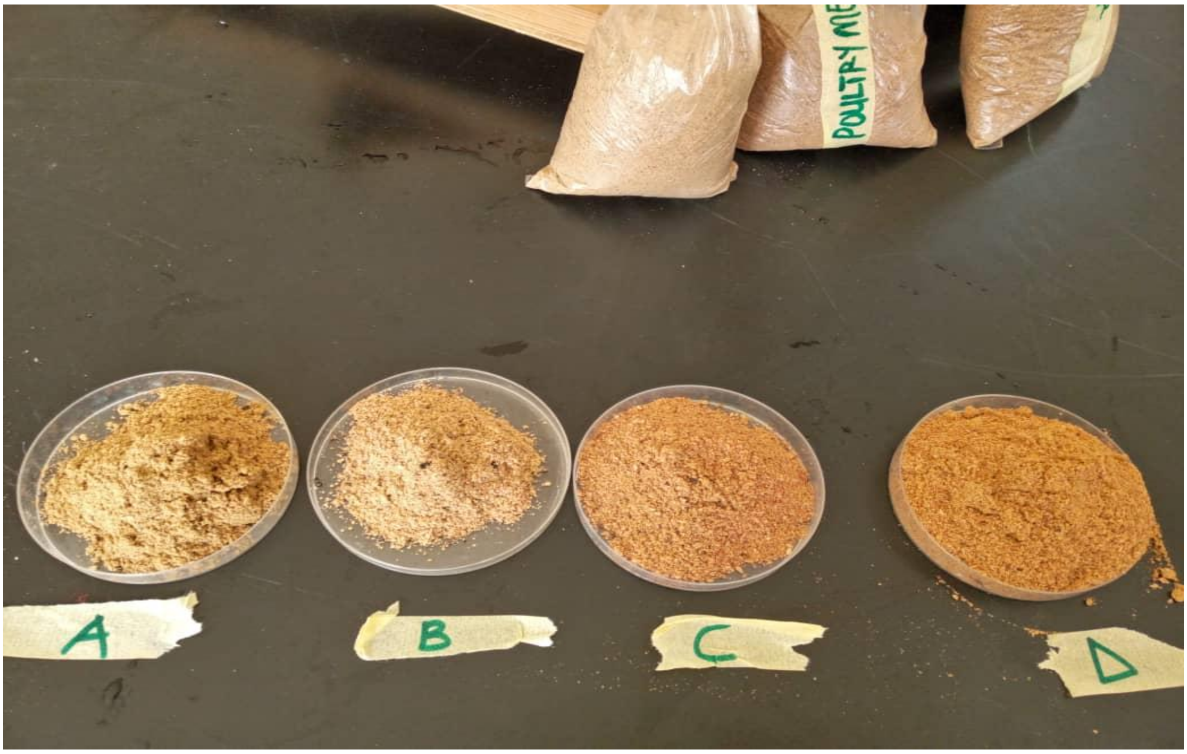


Source: Ijebu-North Local Government Secretariat, Ijebu-Igbo, Ogun State

Fig. 1: Map of the study area; Ijebu North Local Government, Ogun State, Nigeria

Source: Authors' Field Work

Plate 1: Catfish fingerling (10 x 1.8 cm) in a fish culture tank (Mg x 0.5)



(A) Fish Meal **(B)** Soya Bean Meal **(C)** Poultry Meal **(D)** Feather Meal

Plate 2: Photograph showing the experimental diets

Feed formulation and feeding protocol

Four experimental diets were formulated to contain 40% feed additives and 60% crushed local feed ingredients. The experimental diets were homogenized into powder using a dry mill kitchen blender (BL1012, Khind, Malaysia). The dried homogenized diets were sieved using control testing sieve, to remove irregular and large size pieces before weighing out the quantities required (Plate 2). Samples of all homogenized experimental diets were analyzed for proximate nutrient composition.

The fingerlings were fed daily to satisfaction at 10% body weight two times daily at 10.00 h in the morning and 4.00 h in the evening. Aquaria were cleaned daily prior to feeding by draining the water with fecal matter and leftover feed at the bottom of the tank. Experimental tanks were refilled with (27±2°C) dechlorinated water from the reservoir tank. The water quality parameters which include temperature, dissolved oxygen, total Ammonium Nitrate and pH were measured twice weekly.

Proximate analysis of the locally formulated feed

Proximate analysis was done at the Department of Feed Analysis and Quality Control Laboratory, Animal Care, Ogere, Ogun State. The local feeds were analyzed for moisture content, total ash, crude fat, crude fiber and crude protein using Control laboratory methods (AOAC, 2005). The moisture content was determined by drying the samples overnight in a conventional oven (oven-drying method) to a constant weight at 105°C. Crude fat was determined by extracting ground samples continuously for 6 hours in petroleum ether using Soxtec HT2 1045 extraction system. Crude protein (N x 6.25) was determined by micro kjeldahl method (Jones, 1991).

The samples were digested in concentrated sulphuric acid using a Digestor 2040 (FOSS, Denmark) followed by distillation using a Kjeltec 2300 auto-analyser (FOSS, Denmark) to determine nitrogen content which was converted to crude protein using a conversion factor of 6.25. Total Ash was analyzed by ignition at 650°C for 12 h in electric furnace (Eyela-TMF 3100) to constant weight. Crude fiber was determined by digesting dried lipid-free residue with 1.25% H2SO4, 1.25% NaOH and calcites. Gross energy was calculated using conversion factors for protein, lipids and carbohydrates.

Proximate analysis of the experimental fingerlings

Proximate composition of the experimental fishes was determined using methods of AOAC (2005). Fingerlings were oven dried at 70^{o}C for 24 h and ground into powder for proximate analysis. Moisture content was measured by weighing differences before and after oven drying for 16 h. Lipid determination was carried out using the modified Bligh and Dyer procedure (1959), the ash content of the fish was determined by igniting the sample at 550^{0}C for 5 - 6 h until the sample was completely free from carbon particles in a carbolite muffle furnace while the total nitrogen was determined by Kjedahl method as described by AOAC (2005) and a factor of 6.25 was used for converting the total nitrogen to crude protein of the fish sample.

Determination of specific growth and survival rate of the fingerlings

The growth performance of the fingerlings was assessed in terms of weight gain and specific growth rate for each treatment. Five fingerlings were randomly scooped out using a hand scoop net from each aquarium. To achieve accurate fingerlings weight, the excess water on the hand scoop net was carefully wiped using a kitchen towel. The fingerlings were then introduced into a zeroed half-filled water bowl on a weighing balance (Scout Pro Balance, Ohaus) and the weight was recorded. After weighing, they were returned to their respective aquarium immediately.

Dead catfish fingerlings, if any, were removed daily and the mortality were used to determine the number of live fish left in each aquarium. Survival rate was determined at the end of the experiment by counting the number of life fingerlings remain in each aquarium and expressed as a percentage of the stocked fish as follows;

$$SR\% = \frac{Nt}{N0} x\, 100$$

Where SR is the survival rate (%); *Nt* is the number of fish collected at sampling time *t; N0* is the number of fish initially stocked.

Data analysis

Data obtained were subjected to statistical analyses using the Statistical Package for Social Sciences (SPSS) version 20.0 (IBM Corp., 2011). Mean values were compared using Analysis of Variance (ANOVA). Results were presented as Mean±Standard error of mean. Post hoc test was done using the Student-Newman-Keuls (SNK). Probability value (p – value) less than 0.05 was considered to be statistically significant.

Results and Discussion

Proximate composition of the experimental feeds

The proximate composition of the different protein diets is shown in Table 1. Crude protein content and moisture content was significantly higher ($p < 0.05$) in the fishmeal than those of the other experimental diets. Similarly, Soyameal was significantly higher than the fat content, crude fibre content and metabolizable energy. On the other hand, ash content was significantly higher in the poultry meal than the other experimental diets.

Weekly change in length and weight

The length of the experimental catfish fingerlings fed on the varying protein diets is represented in Fig. 2. Result showed increase in the body length of the catfish fingerlings over the study period. This was lowest at week 1 and highest at week four. Similarly, all the experimental catfish fingerlings recorded increase in body weight throughout the study period (Fig. 3). Catfish fingerlings fed with fishmeal recorded a decline in weight at week 3. This however recorded increase in body weight at week 4 of the experiment.

Body weight gain

There was no significant difference ($p > 0.05$) in the mean initial and final body length of the fingerlings fed with the different protein diets (Table 2). Final length gain was also not significantly different between the different experimental groups. However, feather meal had the highest mean initial and final body length and body length gain (Table 2).

Table 1: Proximate composition of the experimental feeds

Parameters	CP	Fat	Moisture	Fibre	Ash	M. Energy
Fish meal	50.56±0.03a	7.30±0.17b	12.23±0.13a	4.89±0.05b	17.30±0.17b	2467.86±1.15b
Soy meal	31.28±0.12d	9.10±0.06a	11.49±0.23b	7.97±0.52a	11.98±0.58c	2593.44±1.73a
Feather meal	47.63±0.02b	5.60±0.35c	8.81±0.46c	5.00±0.23b	12.13±0.08c	2220.39±0.17c
Poultry meal	39.32±0.18c	5.90±0.52c	8.20±0.12c	4.98±0.01b	21.42±0.24a	1937.46±0.27d

^{abcd}Mean (±Standard error of mean) in the same column having similar alphabet are not significantly different at $p < 0.05$

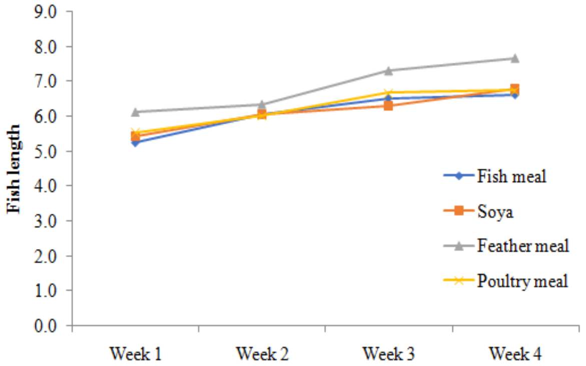


Fig. 2: Weekly length (cm) of fingerlings fed with different protein diets

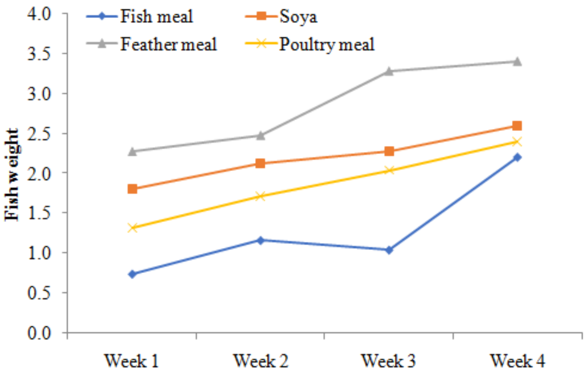


Fig. 3: Weekly weight (g) of fingerlings fed with different protein diets

Table 2: Length of fingerlings fed with different protein diets

Parameter	Initial length	Final length	Length gain
Fish meal	5.24±0.14a	6.62±0.10a	1.38±0.08a
Soya meal	5.42±0.15a	6.80±0.13a	1.38±0.12a
Feather meal	6.12±0.22a	7.66±0.25a	1.54±0.19a
Poultry meal	5.54±0.30a	6.74±0.20a	1.20±0.31a

^{abcd}Mean (±Standard error of mean) in the same column having similar alphabet are not significantly different at $p < 0.05$

Table 3: Weight of fingerlings fed with different protein diets

Parameter	Initial weight	Final weight	Weight gain
Fish meal	0.74±0.22c	2.20±0.20b	1.46±0.04a
Soya meal	1.80±0.15b	2.60±0.24b	0.80±0.25a
Feather meal	2.28±0.29a	3.40±0.24a	1.12±0.42a
Poultry meal	1.32±0.16b	2.40±0.24b	1.08±0.17a

^{abcd}Mean (±Standard error of mean) in the same column having similar alphabet are not significantly different at $p < 0.05$

Body length gain

Table 3 presents the mean initial body weight, final body weight and body weight gain of catfish fed with fishmeal, soyabean meal, feather meal and poultry meal. Initial and final mean body weight was significantly higher in feather meal. There was no significant difference recorded in the mean final body weight of the fishmeal, soyabean meal and poultry meal.

Similarly, there was no significant difference recorded in the mean body weight gain of all the experimental groups except in soyabean meal which was found lowest.

Proximate composition of the experimental fish

The proximate composition of the different protein diets is shown in Table 4. Crude protein content and dry matter was significantly higher ($p < 0.05$) in the fishmeal than other diets. Similarly, soyameal had significantly higher metabolizable energy. On the other hand, ash content was significantly higher in the poultry meal than the other diets.

Table 4: Proximate composition of the experimental fish

parameter	Crude Protein	Ether Extract	Ash	Moisture Content	Dry matter
Fish meal	65.1±0.03a	7.910±0.17b	12.1±0.13a	73.16±0.05b	26.84±0.17b
Soy meal	59.5±0.12d	8.09±0.06a	10.9±0.23b	74.21±0.52a	25.79±0.58c
Feather meal	58.1±0.02b	7.62±0.35c	12±0.46c	73.44±0.23b	26.56±0.08c
Poultry meal	64.4±0.18c	6.35±0.52c	13.2±0.12c	74.1±0.01b	25.9±0.24a

^{abcd}Mean (±Standard error of mean) in the same column having similar alphabet are not significantly different at $p < 0.05$

Table 5: Physico-chemical parameters in the aquaria of experimental diets

Parameter	pH	TDS	TAN	EC	Temperature
Fish meal	7.8±0.1a	277±0.17b	2.8±0.45a	590±0.05b	26.4±0.21a
Soy meal	7.9±0.02a	273±0.06a	2.7±0.43a	582±0.52a	26.9±0.24a
Feather meal	7.9±0.02a	264±0.35c	2.8±0.46c	548±0.23b	27.3±0.25a
Poultry meal	8±0.3c	229±0.52c	3.4±0.14c	481±0.01b	28.5±0.24a

^{abcd}Mean (±Standard error of mean) in the same column having similar alphabet are not significantly different at $p < 0.05$

Water quality parameters

The physico-chemical parameters observed were shown in Table 5. Water temperature ranged from 26.4 to 28.5°C with a mean of 27.3 ±2°C but the variation among the different treatments was not significant. There was no significant variation in the mean pH values among the four diets. The Total dissolved solids (TDS) ranged from 229 to 264 ppm with a mean of 260.8 ppm but did not differ significantly among the different treatments. The mean Total Ammonium Nitrogen (TAN) significantly varied among the treatment within the study period being highest (3.4 mg/L) poultry meal and lowest (2.5 mg/L) in soya bean meal.

In this study it was observed that crude protein content of the experimental diet was higher in Fish meal and Feather meal compared to Soya bean meal and Poultry meal. High protein content of feather meal contributed to the higher growth of catfish in Feather meal and Fish meal compared to Soyabean meal and Poultry meal. Several studies have reported high crude protein in locally produced feed which varies from 45 – 63% and optimal dietary crude protein of 30-35% (Viveen *et al.,* 1985), 40 - 50% (Hecht *et al.,* 1996) and 28 - 32% (Halver, 2013). Catfish fingerlings require diet with at least 35% protein in diet (Potongkam and Miller, 2016).

Protein is mainly used for growth so long as energy giving nutrients are in adequate levels (Natacha *et al.,* 2012; Craig, 2017). Except Soya bean meal that had 31% protein, all other protein sources had adequate protein for catfish growth. The optimum dietary protein levels depend on the fish growth rate, feed intake, amount of non-protein energy in the diet, protein quality, presence of natural food and management practices (Davis *et al.,* 2009) rearing environment, water temperature, water quality, feeding rate and genetic composition (Craig, 2017). Although, the study showed various fat contents varied among the experimental diets and significantly higher in Soya bean meal compared to others. But the high fat content in the Soya bean meal seems not advantageous in fish growth as against the conclusion of Honikel (2011) that fat are highly digestible and important source of concentrated energy which play several key roles in the growth and development of fish.

However, the high ash content in poultry meal that was significantly higher and fish meal had a positive influence on the specific growth and survival rates of *C. gariepinus* in this study as Kiriratnikon and Kiriratnikon (2012) reported high ash content of >12% in feed produce better growth performance in *Clarias* species. Chicken liver had slightly lower fat content, and chicken heart had higher fat content compared with beef liver and heart as reported by Seong *et al.* (2018). Daily fat intake is important for human health as it contributes to energy and helps in vitamin absorbance which has been associated with some diseases such as; obesity and cardiovascular disease (Bray *et al*., 2004).

The crude fibre in the Soya bean meal might have contributed to the growth rate of the fish, possibly due to the ability of the fish to digest and utilize the high crude fibre in the diet. Fibre in feed improves binding and moderates the passage of feed through the alimentary canal (Laubscher and Leisegang, 2013). However, high levels of fibre content greater than 8 - 12% in the fish feed are not advisable as it lowers the digestibility of nutrients and slows the growth (Kiriratnikon and Kiriratnikon, 2012).

Moisture content recorded in this study significantly varied among the experimental diets with Fish meal having the highest and lowest in Poultry meal which Halver (2013) opined that moisture content in feeds should not exceed 12% to prevent the feed from moulding and maintain palatability. High moisture level predispose fish feed to decompose if unpreserved for extended period after harvest (Laubscher and Leisegang, 2013). Proximate compositions of Poultry meal revealed that the moisture content varied among the by-products, ranging from 76.68 - 83.23%, with the highest and lowest value in lung and liver respectively. In general, chicken by-products had higher moisture content compared with corresponding by-products from pork and beef origins (Njieassam, 2016; Seong *et al*., 2018).

In this study, the energy content was below the optimum requirements despite significantly higher values in Soya bean meal and Fish meal compared to Poultry meal and Feather meal might have played a role in slow growth and survival rates of the fish fed on Feather meal. Energy requirement reported for catfish, generally been expressed as a ratio of digestible energy to crude protein (digestible energy/protein), range from 7.4 – 12 kcal/g, while a digestible energy/protein

ratio of 8.5 – 10 kcal/g is adequate for use in commercial catfish feeds (Honikel, 2011; Natacha *et al.*, 2012). Increasing the levels of energy in catfish diets above the required range may increase fat deposition, reduction in food intake and if the energy value is low, the fish will grow slowly (Kiriratnikon and Kiriratnikon, 2012).
The weight of the fish increased at the 4th weeks of the experimental period with the highest mean weight gain observed on fish fed with Fish meal was consistent with of Talamuk (2016) findings. High nutritional composition in the experimental diets could be evidently attributed to the increase in body weight especially in fish fed on Fish meal and Feather meal as high nutritive feed promotes better growth and higher yield in fish (Halver, 2013; Njieassam, 2016).
Specific growth-rates of the fish fed on Fish meal was significantly higher compared to other diets which showed high-quality growth performance and indication that the diet contained well balanced nutrients coupled with high digestibility and nutrient utilization in the fish. Adewumi and Olalaye (2011) stated that the quality of a feed is a function of how well the feed meets the nutrient requirements of a fish which palpably shown as Soya bean meal and Poultry meal resulted in the least specific growth-rate during the study period. Also, this could be attributed to the fact that Soya bean meal contained very high fat contents that reduce digestibility of the diets.

Conclusion

The study showed that water quality parameters such as temperature, pH, dissolved Oxygen, and Total ammonium nitrate in different treatments diet are relatively unchanged throughout the study period. The water parameters: temperature, pH and dissolved oxygen were within the recommended range and did not negatively influence the growth of the fish. However, the Total ammonium nitrate was above the recommended range which could have negatively influenced the general growth rate of the fish. The assessment of the nutrients composition (crude protein, fat, moisture content, fibre and ash content) in the experimental diets was within the recommended range for catfish fingerlings rearing.
Weight gain, specific growth rate and survival rates were best when fed with Fish meal and Feather meal. The highest weight and growth rates observed in fish fed with Fish meal correlated to the balanced nutritional content responsible for growth. The slow growth performance of fish fed with Soya bean meal may be attributed to high anti-nutritional factors which depressed the feed intake, growth and low palatability of these diets. Therefore, the growth rate and the survival of fish depend on the quality and quantity of feed available and its nutritional composition.

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