International Journal of Fisheries and Aquatic Research
ISSN: 2456-7248
Impact Factor: RJIF 5.44
www.fishjournals.com
Volume 2; Issue 5; September 2017; Page No. 09-17

Substitution of fish meal with hydrolyzed poultry feather meal in the diet of *Clarias gariepinus* fingerlings

[*1] KV Absalom, [2] OG Uzodigwe, [3] Igoche LE, [4] Ujah AI

[1, 2, 4] Faculty of Natural Sciences, Department of Zoology (Hydrobiology and Fisheries Unit), University of Jos, Plateau, Nigeria
[3] Department of Animal Production, Faculty of Agriculture, University of Jos, Plateau, Nigeria

Abstract

The suitability of substituting fish meal with hydrolyzed poultry feather meal in the diet of *Clarias gariepinus* fingerlings of mean weight (3.08±0.21g) was evaluated for 12 weeks (84days) under laboratory conditions. Five diets were formulated to contain 35% crude protein, with diet 1 containing 100% fish meal (control diet 1) and diet 2, 3, 4 and 5 were 25%, 50%, 75%, and 100% inclusion levels of hydrolyzed poultry feather meal substituting equal proportion of fish meal respectively. Coppens® feed, diet 6 (control diet 2) was used to compare the performance of fish meal and the feather meal-based diets. Six plastic bowls (20 litres capacity); were stocked with 10 fingerlings of *Clarias gariepinus* each and two replicates per treatment bowl. The experimental fish were fed at 3% of their body weight twice daily at 9.00am and 4.00pm. The results obtained from the analysis of this study showed that there was significant difference ($P<0.05$) in weight gain, specific growth rate, feed conversion ratio, and protein digestibility but not in all the treatments diets. However there was no significant difference ($P>0.05$) in the survival rate of the fish in all the treatments except in diet D_5 (100% feather meal) whereby (33.33%) mortality was recorded. The deduction from this study is that the growth of *Clarias gariepinus* fingerlings was not compromised by substituting up to 25% (7.21% of the total diet) of fish meal with hydrolyzed poultry feather meal.

Keywords: substitution, fish meal, hydrolyzed poultry feather meal, *Clarias gariepinus*, coppens® feed

1. Introduction

Aquaculture generally in most of African countries is faced with the problem of expensive and deviant supply of conventional fish feeds. In Nigeria, many semi-intensive farmers particularly in the rural and semi urban cities are faced with the problem of high cost of fish feed (Ejere, Adetoun, Chidinma, Chinweike, and Christian 2014) [8]. In order to solve this problem, many of these farmers formulate local fish feeds with various ingredients of plants and animal proteins. According to (Omitoyin, 1995.) [17]. Majority of feed ingredients required for fish feeds can be met by using agro-industrial waste products.

According to FAO (2014) [10], Nigeria is by far the largest producer of farmed catfish in official statistics. However, there are still limitations to the fish farming potentials of the country. FAO (2014) [10] also observed that the cost of running a fish farm in Nigeria remains high when compared to other countries of the world. This is because presently in Nigeria there are different commercial fish feeds with different compositions ranging from Coppens, Eurofeeds, Skrettings, Top feed, Aquaplus, Vital feed etc, these feeds compete with each other and more so, many are imported highly expensive (Auta, Yashim, Dambo and Tiamiyu 2013) [5].

Fish meal has been a vital animal protein source usually used in formulation of fish feed. This is because of its high percentage of crude protein and complete amino acid profile (Eyo, 1994) [9]. It has been reported by (Raumsey, 1993), to give a quality growth rate in the African catfish *Clarias gariepinus* and other Clarid and Cichlids fishes. Due to high cost and scarcity of fish meal in Nigeria, other plants and animal proteins such as soybean meal, cotton seed meal blood meal, grasshopper meal etc have been used to replace fish meal in the diet of fishes (Okoye and Nnaji 2003) [16].

2. Materials and Methods

2.1 Procurement of the Experimental Fish

Four weeks old of one hundred and eighty (180) mixed sex fingerlings of same brood stock of African catfish (*Clarias gariepinus*) of mean weight (3.08±0.21g) were obtained from the hatchery of a private fish farmer (Global Aquaculture and Allied Ventures) Rantya, Jos Plateau State Nigeria. These were transported to the Hydrobiology and Fisheries research laboratory of the Zoology Department University of Jos Plateau State. The fingerlings were acclimated under the laboratory conditions for a period of one week (7days) after which they were randomly distributed into six plastic bowls (20 litres capacity); these bowls were stocked with 10 fingerlings of *Clarias garienpinus* each and two replicates per treatment bowl. During this period, the fingerlings were fed with 2mm commercial Vital feed at 3% of their body weight twice daily (9.00am and 4.00pm). To maintain good quality of water, the water was subjected to change in every 2days during each change; the bottom of the culture bowls was washed thoroughly to prevent accumulation of toxic wastes or ammonia build up in the water as described by (Audu & Adejoh 2003) [4]. The culture bowls were covered with nets to prevent the fishes for jumping out.

2.2 Collection and Processing of Dietary Ingredients

1. **Feather meal:** 3kg of fresh poultry feathers was collected from poultry slaughter houses at west of mind market Jos, and was hydrolyzed by heating the fresh poultry feathers in a very hot steam of 140^0C for 2hours. This was done to break keratin complex protein bonds present in the feather and also to increase its digestibility to the fish (Fowler, 1990). After which it was sun dried for 48 hours before milled to powder using Corolla Model grinding machine and was sieved with 0.1mm mesh size net.
2. **Soybean:** 1.5kg of raw soybean seeds was purchased from Katako market in Jos. The soybeans were toasted at 100^oC for sixty minutes before milled to powder to eliminate or reduce the effects of anti-nutritional factors and improve digestibility (Tiamiyu, Ataguba and Jimoh 2013). After which it was sieved with 0.1mm mesh size net.
3. **Fishmeal:** 1.5kg of dried Anchovy fish meal of 63% crude protein was also purchased from Katako market in Jos and was sieved with 0.1mm mesh size net to remove some of the remains of its by product and sand particles.
4. **Other ingredients:** 1.5kg of maize flour, Cassava flour and 25g of Bone meal were also purchased in the same market and were incorporated in the diet of the fish.

2.3 Formulation of Experimental Diets

The experimental diets which are composed of feather meal, fishmeal, soybean meal, maize flour, cassava flour, bone meal, corn oil, vitalyte, and chromic oxide were weighed out appropriately using with Mettler MD-2000 electronic weighing balance. Five experimental diets were prepared to contain varying percentages of crude protein with varying proportion of feather meal and fishmeal (Table 1). The experimental formulated diet ($D_1$0%) served as the first control; it was prepared to contain all the ingredients without feather meal. Other experimental diets ($D_2$25%), ($D_3$50%), and ($D_4$75%), were prepared to contain varying percentage of feather meal and fishmeal. The diet ($D_5$100%), was prepared to contain only feather meal as the protein source. The second control Coppens® feed (D_6) was not formulated however it is a commercial test feed used.

The experimental diets were formulated with 35% crude protein level. Pearson's square method was used to calculate the various proportions of feed ingredients inclusion levels. All the calculated proportions were weighed out correctly before properly mixed for thorough blending. Boiled water (100^0C) was carefully added and mixing continued until complete homogenization was obtained. The mixture was then allowed to cool after which a prepared solution of weighed vitalyte was added and mixed thoroughly with the main dough. The semi-moist (dough) obtained was extruded through a hand pelleting machine using 2mm dice. The pelleted feeds were collected in flat trays and sun dried for 96 hours to constant weight, after which the diets were crunched into crumps by breaking them with hand. The broken crumps were packed in polythene bags, sealed and appropriately labeled before stored in a freezer. Each sample of the dried experimental diet was subjected to proximate analysis according to the method of Association of official Analytical Chemistry (AOAC, 1984) [2] to determine the percentage composition of the various components of the diets.

Table 1: Percentage composition of experimental diets fed to *Clarias gariepinus* fingerlings for 12 weeks

	Diet 1	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**
Ingredients	**0% Control**	**25%**	**50%**	**75%**	**100%**
Fishmeal	28.85	21.64	14.42	7.21	——
Feather meal	——	7.21	14.43	21.64	28.85
Soybean meal	28.85	28.85	28.85	28.85	28.85
Maize flour	16.90	16.90	16.90	16.90	16.90
Cassava flour	16.90	16.90	16.90	16.90	16.90
Bone meal	0.50	0.50	0.50	0.50	0.50
Corn oil	5.00	5.00	5.00	5.00	5.00
Vitalyte	2.50	2.50	2.50	2.50	2.50
Chromic oxide	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00

Note: The five experimental diets were formulated to contain 35% crude protein level.
Note: Crude protein composition of fish meal and feather meal used were 63% and 82% respectively.

2.4 Experimental Design

At the end of the acclimation period, 20 fingerlings were randomly selected, sacrificed and used in determining the initial carcass proximate composition. 18 plastic bowls (20 litres capacity) were filled with water up to 15 litres level and arranged into in to six feeding treatments tagged (D_1 0%, D_2 25%, $D_3$50%, $D_4$75%, D_5 100% and D_6 Coppens®). Each treatment was replicated twice and designated R_1 and R_2. Ten (10) fingerlings were randomly selected and weighed before stocking in each of the labeled plastic bowls. Each plastic bowl was covered with nets to prevent the fishes for jumping out and at the same time prevents the entrance of unwanted materials. The experimental fish were fed 3% of their body weight daily. The weighed feed samples were divided into two equal parts and fed twice daily at 9.00am and 4.00pm. In addition, an accurate record of amount of feed fed, weight gain, and mortality was kept. The siphoned faecal droppings however were also kept for protein digestibility determination. Biweekly weighing of the fish was done using Mettler MD-2000 electronic weighing balance. Fish in each bowl was weighed collectively and the mean weight was taken. Biweekly standard length (ST) was obtained using a transparent ruler to measure (from the tip of the snout to the end of the caudal fin) of each fish in the bowl and the mean length was taken.

2.5 Determination of water quality parameters

Water quality parameters in each of the plastic bowls were determined weekly using the method described by American Public Health Association (1985). The parameters determined include temperature, pH, dissolved oxygen, free carbon dioxide and alkalinity. Temperature was measured using mercury-in- glass thermometer; pH was measured by a pH metre (Jenway model 9060), while dissolved oxygen, free carbon dioxide and alkalinity were obtained by titration.

2.6 Growth and Feed Utilization Indices of *Clarias gariepinus* fed feather meal and Coppens® feed

At the end of the experimental period, the following growth indices of feed utilization by the fish were calculated thus;

Growth indices

$$1.\ \text{Mean weight gain (MWG) (g)} = \text{Final weight (g)} - \text{Initial weight (g)}$$

$$2.\ \text{Percentage weight gain (\% WG)} = \frac{\text{Final weight (g)} - \text{Initial weight (g)}}{\text{Initial weight (g)}} \times \frac{100}{1}$$

3. Specific growth rate (SGR) (% /day) This is the mean percentage increase in the body weight per day over a given period of time interval. Formula described by (Chumlong and Rakyuttithamkul 2006) [7] was used in obtaining the specific growth rate value of the fish at the end of the feeding period.

$$\text{Specific growth rate (\% /day)}: \frac{\text{Log}_e \text{ final weight} - \text{Log}_e \text{ initial weight}}{T_2 - T_1} \times \frac{100}{1}$$

Where

Log_e = Base of natural logarithm

W_2 = Mean final body weight of fish

W_1 = Mean initial body weight of fish

T_2 = final time (in days)

T_1 = Initial time (in days)

4. Length gain (LG) (cm) = Final length (L_2) – initial length (L_1)

$$5.\ \text{Condition factor (K- Factor)} = W \times \frac{100}{L^3}$$

Where

W = Mean body weight (g)

L= Mean standard length (cm)

(Chumlong and Rakyuttithamkul, 2006.) [7]

Feed Utilization Parameters

1. Feed Conversion Ratio (FCR)

This is the measure of the quantity of feed required for a unit weight gained by the fish. Thus the lower the FCR value the better the feed.

$$\text{(FCR)} = \frac{\text{Weight of dry feed fed (g)}}{\text{Weight gain by fish (g)}}$$

2. Feed conversion efficiency (FCE)

This is the efficiency by which diets are converted into biomass by the fish. The higher the FCE value, the better the ability of the fish in utilizing the feed.

$$\text{(FCE)} = \frac{\text{Live weight gain (g)}}{\text{Dry weight of feed fed (g)}} \times \frac{100}{1}$$

$$3.\ \text{Total Protein Intake (TPI)} = \text{(Quantity of diet consumption)} \times \text{(\% Protein in diet)}$$

$$4.\ \text{Protein efficiency ratio (PER)} = \frac{\text{Live weight gain (g)}}{\text{Protein Intake (g)}}$$

$$5.\ \text{(\%) Survival} = \frac{\text{No of survival after culture}}{\text{No of fish stocked}} \times \frac{100}{1}$$

6. Apparent Protein Utilization (APU)

This indicates the efficiency of transforming the dietary protein into tissue protein by the fish. It was calculated thus:

$$\text{APU (\%)} = \frac{\text{Final carcass protein} - \text{Initial carcass protein}}{\text{Protein fed}} \times \frac{100}{1}$$

2.7 Determination of Protein Digestibility of Experimental Diets

The chromic oxide (Cr_2O_3) was incorporated into the diets served as an inert digestibility maker in the formulated diets. The faecal matters obtained from the respective experimental bowls during the course of the feeding were sun dried for 5days and analysed for apparent protein digestibility. The analyses of dry matter, crude protein of the experimental diets and of the digesta, as well as chromic oxide concentration in the digesta were conducted. The crude protein in the samples was determined using the Kjedahl digestion technique, while the apparent protein digestibility in the formulated diets was determined by calculating the indigestibility factor according to the equations proposed by (Rostagno and Featherson 1977) as follows:

$$\text{Indigestibility Factor (IF)} = \frac{Cr_2O_3 \text{ in the diet}}{Cr_2O_3 \text{ in the digesta}}$$

$$\text{Apparent protein digestibility (APD) \%} = \frac{\text{CP diet} - (\text{CPE}_1 \times \text{IF}_1) \times 100}{\text{CP diet}}$$

Where CP = Crude Protein;

E_1 = Digesta of the evaluated diet

IF_1 = Indigestibility factor of the tested diet.

Apparent protein digestibility in the Coppens® diet was calculated using the method of Inaba *et.,al* (1962).

$$\text{Apparent protein digestibility} = \text{(APD) \%} \frac{\text{Protein consumed} - \text{Protein in the faeces}}{\text{Protein consumed}} \times \frac{100}{1}$$

2.8 Data Analysis

The data collected was analyzed using one-way analysis of variance (ANOVA) and the least significance difference (LSD) test was used to compare which pairs of means differed significantly from the other, that is at (P=0.05) level of probability.

3. Results
3.1 Proximate Composition of feather meal and the experimental diets
The result of the proximate analysis of feather meal used in the experimental diet formulation is presented in Table 2. The analysis as presented indicated that the meal contains relatively high crude protein, moderate moisture, lipid and fibre content, low ash content and high metabolized energy.
The result of the percentage proximate analysis of the experimental diet is presented in Table 3. The crude protein was a major constituent of the diets, giving a mean value of (35.65±0.31%). Statistical analysis using one-way analysis of variance (ANOVA) showed that the expected value 35.00% of isonitrogenous formulated diet level was not significantly different (P > 0.05) in all the diets

Table 2: Proximate composition of a feather meal

Nutrient content	Composition (%)
Moisture	82.14
Crude protein	6.78
Crude lipids	0.08
Ash	2.94
Crude fibre	1.18
Nitrogen free extract (N.F.E)	0.54
Calcium	0.16
Phosphorus	
M.E. (Kcal/kg)	3526.40
Total	100.00

Table 3: Percentage proximate composition of the experimental diets (feather meal) and Coppens® fed to *Clarias gariepinus* fingerlings for 12 weeks.

Composition (%)	Diet designation					
Ingredients	$D_1$0% Control 1)	$D_2$25%	$D_3$50%	$D_4$75%	$D_5$100%	D_6Coppens®(Control 2)
Crude protein	34.96	35.09	35.46	36.26	——	43.75
Crude lipids	10.88	10.38	10.00	9.96	28.85	11.93
Mo	6.62	6.84	6.92	7.09	28.85	8.10
Ash	10.09	9.96	9.74	9.69	16.90	9.44
Crude fibre	4.00	4.39	4.63	3.98	16.90	7.43
N.F.E	33.45	33.34	33.25	33.02	0.50	19.35
Total	100.00	100.00	100.00	100.00	5.00	100.00

Note: The experimental diets were formulated to contain 35% crude protein level.
Note: Proximate analysis on Coppens® the commercial diet, showed the above compositions.

3.2 Percentage Proximate Composition of the fish Carcass
The proximate composition of the experimental fish carcass at the beginning and at the end of the feeding trials is presented in the Table 4. The highest protein content of (56.11±0.65%) was in the fish fed with diet $D_4$75%, while the lowest protein content of (50.79±0.12%) was observed in the diet D_6 Coppens®. However, statistical analysis indicated that there was no significant difference (P > 0.05) in the protein content of the fish carcass. Fish fed with diet ($D_1$0%) had the highest level of Lipid deposit (21.91±0.45%), while diet ($D_4$75%) had the least Lipid deposit (9.65±0.22). There was however, no significant difference (P > 0.05) amongst diets $D_2$25%, $D_3$50%, $D_5$100%, and D_6 Coppens®, while diet ($D_1$0%) was significantly different (P < 0.05) from the others except diet ($D_4$75%).
The percentage moisture content was highest (21.20±0.25%), in diet (D_6 Coppens®) and lowest (11.07±0.64) in diet ($D_1$0%). There was also, no significant difference (P > 0.05) among all the treatment diets. The ash content was highest (16.08±0.44) in the diet ($D_5$100%) and lowest (8.62±0.64) in diet (D_6 Coppens®). There was no significant difference (P > 0.05) in ash content amongst the fish fed the six experimental diets. The crude fibre content was highest (4.41± 0.20) in diet ($D_3$50%) and lowest (3.19±0.04) in the diet ($D_5$100%), of which is significantly (P < 0.05) different from other experimental diets. Calcium content was highest (4.88±0.12) in diet ($D_4$75%) and lowest (2.25±0.09) in diet (D_6 Coppens®). There was no significant difference (P > 0.05) in all the experimental diets except in diet ($D_1$0%). Nitrogen free extract (N.F.E.), in all the experimental diets were not significantly different at (P > 0.05)

Table 4: Percentage proximate composition of the carcass of *Clarias gariepinus* fed varying levels of feather meal and Coppens® feed for 12 weeks

	Final carcass	D1	D2	D3	D4	D5	D6
Composition (%)	Initial	0%	25%	50%	75%	100%	Coppens®
Crude protein	46.62	51.47 (0.24)^a	54.11 (0.23)^a	54.47 (0.11)^a	56.11 (0.65)^a	53.47 (0.22)^a	50.79 (0.12)^a
Crude Fat	10.13	21.91 (0.45)^b	14.23 (0.13)^a	14.03 (0.16)^a	9.65 (0.22)^{ab}	14.03 (0.38)^a	15.45 (0.74)^a
Moisture	23.89	11.07 (0.64)^a	15.72 (0.74)^a	14.45 (0.22)^a	14.36 (0.52)^a	12.43 (0.11)^a	21.20 (0.25)^a
Ash	9.88	11.21 (0.14)^a	11.67 (0.63)^a	12.33 (0.44)^a	15.48 (0.32)^a	16.08 (0.44)^a	8.62 (0.64)^a
Crude fibre	5.11	4.31 (0.25)^a	4.22 (0.64)^a	4.41 (0.20)^a	4.18 (0.12)^a	3.19 (0.04)^b	3.19 (0.14)^a
Calcium	4.02	3.50 (0.84)^b	3.65 (0.93)^a	3.88 (0.34)^a	4.88 (0.87)^a	5.28 (0.34)^a	2.25 (0.85)^a
N. F E.	4.37	0.03 (0.84)^a	0.03 (0.93)^a	0.02 (0.34)^a	0.02 (0.87)^a	0.03 (0.34)^a	0.03 (0.85)

Note: values within the same row with same superscripts are not significantly different (P>0.05)
Note: values in the parenthesis are the standard error of the mean.

Growth Performance of *Clarias gariepinus* Fed fFather Meal and Coppens® feed for 12Weeks.

Mean weight gain and length increase

The results obtained from the analysis of this study showed that weight gain, were significant (P<0.05) but not in all the treatment diets, as some of the treatment diets were not significantly different (P>0.05) from the other (Table 5). However, the weight gain decreased with increase in feather meal inclusion.

Length increase on the other hand, showed no significant difference (P>0.05) in all the treatment diets. The length and weight relationship (condition factor), there was no significant difference (P > 0.05) in all the experimental diets except in diet D_6 (Coppens®)

Table 5: Mean weight gain (g) of *Clarias gariepinus* fingerlings fed with the experimental diets for 12 weeks

Week	D_1 0%	D_2 25%	$D_3$50%	$D_4$75%	$D_5$100%	Coppens®
Week 0	30.25±0.22^{a}	30.11±0.20^{a}	30.64±0.47^{a}	30.96±0.86^{a}	31.04±0.93^{a}	30.63±0.42^{a}
Week 2	34.55±0.77^{ab}	32.82±0.98^{a}	31.89±1.13^{a}	33.00±0.47^{a}	31.45±0.68^{a}	38.30±0.60^{b}
Week 4	40.08±0.50^{ab}	36.80±0.46^{c}	33.29±1.72^{a}	37.39±0.86^{c}	32.27±0.32^{a}	45.79±0.55^{b}
Week 6	43.88±0.22^{a}	42.85±0.68^{a}	39.57±0.70^{a}	40.89±0.85^{a}	37.41±0.32^{ab}	56.51±0.67^{b}
Week 8	51.70±0.66^{ab}	47.69±0.10^{c}	44.76±1.18^{a}	45.57±1.05^{a}	40.77±1.24^{bc}	79.90±0.50^{b}
Week 10	58.26±0.49^{ab}	56.15±1.02^{c}	51.68±0.73^{a}	50.11±0.79^{a}	43.46±1.29^{bc}	106.09±0.58^{b}
Week 12	66.55±0.22^{ab}	62.39±0.68^{c}	58.47±0.66^{a}	56.94±1.16^{a}	45.10±0.84^{bc}	126.86±0.81^{b}

Note: Values within the same row with same superscripts are not significantly different (P>0.05)

Table 6: Mean length increase (cm) of *Clarias gariepinus* fingerlings fed with the experimental diets for 12 weeks

Week	**D_1 0%**	**D_2 25%**	**$D_3$50%**	**$D_4$75%**	**$D_5$100%**	**Coppens®**
Week 0	7.55±0.11^{a}	7.57±0.12^{a}	7.51±0.12^{a}	7.59±0.12^{a}	7.57±0.11^{a}	7.56±0.10^{a}
Week 2	7.86±0.06^{a}	7.87±0.06^{a}	7.85±0.05^{a}	7.88±0.04^{a}	7.84±0.06^{a}	7.87±0.04^{a}
Week 4	8.14±0.44^{a}	8.03±0.04^{a}	8.02±0.03^{a}	8.08±0.02^{a}	8.01±0.02^{a}	8.50±0.10^{a}
Week 6	8.40±0.05^{a}	8.20±0.05^{a}	8.17±0.02^{a}	8.25±0.04^{a}	8.15±0.02^{a}	9.39±0.06^{a}
Week 8	8.62±0.08^{a}	8.49±0.07^{a}	8.24±0.05^{a}	8.55±0.15^{a}	8.24±0.05^{a}	9.57±0.06^{a}
Week 10	8.85±0.06^{a}	8.65±0.07^{a}	8.38±0.04^{a}	8.71±0.02^{a}	8.33±0.05^{a}	9.88±0.06^{a}
Week 12	10.08±0.07^{a}	9.65±0.10^{a}	9.48±0.15^{a}	9.83±0.08^{a}	9.29±0.08^{a}	11.55±0.14^{a}

Values within the same row with same superscripts are not significantly different (P>0.05)

3.3 Specific growth rate of *Clarias gariepinus* to the experimental diets

This is the mean percentage increase in the body weight per day over a given period of time. Among all the diets, (D_6 Coppens®) produced the best mean specific growth rate in Clarias (1.70±0.01). This was significantly higher than those of other test diets. This performance was followed by that obtained from fish diet ($D_1$0%) which has a mean specific growth rate of (0.94±0.01). Statistical analysis showed that all the diets (D_1-D_6) were significantly (P<0.05) different form each other.

3.4 Survival rate of *Clarias gariepinus* to the experimental diets

The percentage survival of the fish on weekly basis is presented in the Table 7 below. The final survival rate was highest (90.00%) in the diets ($D_2$25% and D_6Coppens®) while the lowest rate (66.67%) was observed in diet ($D_5$100%). Statistically, there was no significant difference (P > 0.05) among the experimental diets (D_1, D_2, D_3, D_4 and D_6) whereas there was significant difference in the diet ($D_5$100%).

Table 7: Percentage Survival Rate of *Clarias gariepinus* to the experimental diets for 12 weeks.

Weeks	**Diet designation**					
	$D_1$0%	**$D_2$25%**	**$D_3$50%**	**$D_4$75%**	**$D_5$100%**	**D_6Coppens®**
0 (Initial)	100.00	100.00	100.00	100.00	100.00	100.00
1	100.00	100.00	100.00	100.00	100.00	100.00
2	100.00	100.00	100.00	100.00	100.00	100.00
3	100.00	100.00	100.00	100.00	100.00	100.00
4	100.00	100.00	100.00	100.00	90.00	100.00
5	100.00	100.00	100.00	100.00	86.67	100.00
6	100.00	100.00	100.00	100.00	86.67	100.00
7	100.00	100.00	96.67	96.67	83.33	100.00
8	100.00	100.00	96.67	96.67	83.33	100.00
9	93.33	96.67	86.67	96.67	73.33	100.00
10	93.33	96.67	83.33	96.67	73.33	90.00
11	90.00	96.67	76.67	90.00	70.00	90.00
12 (Final)	83.33	90.00	73.33	86.67	66.67	90.00

Table 8: Mean growth performance indices of *Clarias gariepinus* fed varying levels of feather meal and control diets (fishmeal and Coppens® feed) for 12 weeks.

Growth Indices	Diet designation					
Initial weight (g)	**$D_1$0%**	**$D_2$25%**	**$D_3$50%**	**$D_4$75%**	**$D_5$100%**	**D_6Coppens®**
Final weight (g)	30.25 (0.22)^{a}	31.10 (0.20)^{a}	30.64 (0.47)^{a}	30.96 (0.86)^{a}	31.04 (0.93)^{a}	30.63 (0.42)^{a}
Weight gain (g)	66.55 (1.16)^{a}	62.39 (0.68)^{ab}	58.47 (0.66)^{b}	56.94 (1.66)^{a}	45.10 (0.84)^{a}	126.86 (0.81)^{a}
Weight gain (%)	36.30 (1.00)^{c}	31.29 (0.84)^{a}	27.83 (0.90)^{ab}	25.98 (1.95)^{b}	14.06 (1.75)^{d}	96.23 (0.50)^{e}
Initial length (cm)	119.97 (2.51)^{c}	100.98 (2.93)^{a}	90.95 (4.07)^{ab}	84.91 (7.47)^{b}	45.71 (7.00)^{d}	314.27 (3.06)^{e}
Final length (cm)	7.55 (0.11)^{a}	7.57 (0.12)^{a}	7.51 (0.12)^{a}	7.59 (0.12)^{a}	7.57 (0.11)^{a}	7.56 (0.10)^{a}
Length increase (cm)	10.08 (0.07)	9.65 (0.10)^{a}	9.48 (0.15)^{a}	9.83 (0.08)^{b}	9.29 (0.08)^{a}	11.55 (0.14)^{a}
Length increase (%)	2.53 (0.06)^{a}	2.08 (0.16)^{bc}	1.97 (0.06)^{bc}	2.24 (0.19)^{ab}	1.72 (0.18)^{bc}	3.99 (0.06
S. G. R. (%/day)	33.53 (1.20)^{a}	27.59 (2.37)^{bc}	26.19 (0.84)^{bc}	29.49 (2.98)^{ab}	22.72 (2.65)^{bc}	52.76 (0.63)^{d}
Condition factor (K)	0.94 (0.01)^{a}	0.83 (0.02)^{a}	0.77 (0.02)^{ab}	0.73 (0.05)^{bc}	0.44 (0.15)^{c}	1.70 (0.01)^{d}
Survival Rate (%)	3.54 (0.07)^{a}	3.48 (0.11)^{a}	3.27 (0.16)^{a}	2.74 (0.06)^{a}	1.75 (0.04)^{a}	6.25 (0.24)^{b}
Initial weight (g)	83.33 (2.41)^{a}	90.00 (1.43)^{a}	73.33 (4.05	86.67 (1.84)^{a}	66.67 (5.18)^{b}	90.00 (1.84)^{a}

Note: values within the same row with same superscripts are not significantly different ($P>0.05$)
Note: values in the parenthesis are the standard error of the mean.

3.5 Analysis of feed and Protein Utilization in *Clarias gariepinus* fed experimental diets

The lowest mean feed intake (78.50±0.07g) was in fish fed diet 5 (100% feather meal). The feed intake was significantly lower than those of other diets. However, there was no significant difference ($P > 0.05$) in the feed intake of fish fed diets 2, 3 and 4. However the consumption of diet 1 (100% fishmeal) was significantly different from those of feather-based diets. The fish fed the commercial ration (D_6) had the best mean feed intake and this was significantly different ($P < 0.05$) from the control diet (D_1) and the feather-based diets. Mean feed intake was highest (145.10±0.41g) in the commercial ration (D_6) followed by that of D_1 (97.50±0.15g). Among the feather-based diets there was no significant difference ($P > 0.05$) in the feed intake by *C. gariepinus* except for the D_5 which was the least consumed by the fish. The best Feed Conversion Ratio (FCR) of (1.51) was obtained in fish fed D_6 (commercial ration). The fish fed D_1 (100% fishmeal) performed creditably next to those of the commercial feed with FCR of (2.69). With the exception of diets $D_1$0% and $D_2$25% all other feather–based diets, were significantly different ($P<0.05$) from each other in the feed conversion ratios. The best feed conversion efficiency (66.32±0.34%) was obtained in the fish fed with commercial feed (D_6 Coppens®) and the least (17.91±4.44%) was obtained in the diet ($D_5$100% feather meal). However, there was significant difference ($P < 0.05$) in all the experimental diets (Table 9).The commercial diet (D_6) produced fish with significantly highest ($P<0.05$) mean protein efficiency ratio (PER) value (1.51±0.00) while diet ($D_1$100% fishmeal) performed next to D_6 Among the feather meal – based diets, $D_2$25% and $D_3$50% produced fish with the best PER values (0.97 and 0.90), which were not significantly ($P>0.05$) lower than those of D_1 (100% fishmeal inclusion) and D_6 (commercial feed) with PER values of (1.07 and 1.51) respectively. Apparent Protein Digestibility (APD) result showed that diets D_1 (100% fishmeal inclusion) and D_6 (commercial feed) had the best protein digestibility of values (80.23% and 88.15%) respectively, compared to the feather-based diets (42.32%, 52.99%, 26.57% and 12.15%) respectively. Statistically, there was significance difference ($P>0.05$) in all the experimental diets. These results indicate that the protein in feather meal was not digested appropriately and utilized efficiently by the fingerlings of African catfish (*Clarias gariepinus*), when compared with the control diets ($D_1$0% and D_6 Coppens®). All the experimental diets with the exception of ($D_2$25% and $D_5$100%) showed a significantly difference ($P<0.05$) in the Apparent Protein Utilization (APU). Diets D_1 (100% fishmeal inclusion) and D_6 (commercial feed) had the least APU values (14.24 and 6.57) respectively, when compared with diets ($D_2$25% - $D_5$100%) with APU values of (23.91, 25.63, 29.70 and 23.22) respectively. This result indicates that large amount of protein is utilized in building of fish carcass in diets ($D_2$25% - $D_5$100%) and vice versa in D_1 (100% fishmeal inclusion) and D_6 (commercial feed).

Table 9: Mean values feed utilization indices of *Clarias gariepinus* fed varying levels of feather meal and control diets (fishmeal and Coppens® feed) for 12 weeks.

Feed Indices	Diet designation					
Feed Intake	97.50 (0.15)^{ab}	92.20 (1.43)^{a}	86.90 (0.12)^{a}	88.45 (0.11)^{a}	78.50 (0.07)^{b}	145.10 (0.41)^{a}
Protein Intake	34.09 (0.43)^{a}	32.35 (1.43)^{a}	30.81 (1.17)^{a}	32.05 (1.25)^{a}	28.64 (1.44)^{b}	63.74 (0.15)^{a}
Feed Conversion Ratio	2.69 (0.03)^{a}	2.95 (0.24)^{a}	3.12n (0.11)^{ab}	3.23 (0.13)^{b}	5.58 (0.32)^{c}	1.51 (0.15)^{d}
Feed Conversion Efficiency	2.95 (0.24)^{a}	33.94 (2.41)^{a}	32.03 (3.19)^{ab}	29.39 (3.27)^{b}	17.91 (4.44)^{d}	66.32 (0.34)^{e}
Protein Efficiency Ratio	1.07 (0.01)^{c}	0.97(0.03)^{a}	0.90 (0.04)^{a}	0.81(0.13)^{b}	0.49 (0.03)^{d}	1.51 (0.00)^{e}
Apparent Protein Digestibility	80.23 (0.18)^{a}	42.32 (0.62)^{b}	52.99 (1.95)^{c}	26.57 (1.08)^{d}	12.15 (0.17)^{e}	88.15 (0.02)^{f}
Apparent Protein Utilization	14.24 (0.18)^{b}	23.19 (0.62)^{a}	25.63 (0.94)^{c}	29.70 (1.21)^{d}	23.22 (0.70)^{a}	6.51 (0.02)^{e}

Note: values within the same row with same superscripts are not significantly different ($P>0.05$)
Note: values in the parenthesis are the standard error of the mean.

3.6 Cost benefit analysis of the experimental diets

The cost of raw ingredients used in the formulation of the experimental diets and Commercial test diet (Coppens®) fed to the fingerlings of *Clarias gariepinus* for 12 weeks is presented in the Table 10 below. From the table, diet 6 (Coppens®) had the highest cost (N 1200.00 cost of 1.5Kg of Coppens feed) per kilogram of feed. This was followed by D_1 (100% fishmeal) that cost N606.10. The cost of ingredients used in the feather based – diets (D_2 –D_5) are in the order (N 512.47, N 492.76, N471.81, and N 449.55) respectively. Generally, the cost of feed per kilogram formulated diet decreased with increase in the feather meal inclusion. This showed that the cost of formulating fish feed (at a particular inclusion level) using feather meal is cheaper compared to formulating with fish meal as a sole source of animal protein or using Coppens® as a commercial feed.

Table 10: Cost benefit analysis of ingredients used in the formulation of the experimental diets fed to fingerlings of *Clarias gariepinus* for 12 weeks.

Ingredient	Cost of Diet (N)					
	$D_1$0% (Control 1)	$D_2$25%	$D_3$50%	$D_4$75%	$D_5$100%	D_6Coppens® (Control 2)
Fishmeal	300.80	173.12	115.36	57.68	-	-
Feather meal	-	36.05	72.10	108.20	144.25	-
Soybean meal	201.95	201.95	201.95	201.95	201.95	-
Maize flour	33.80	33.80	33.80	33.80	33.80	-
Cassava flour	33.80	33.80	33.80	33.80	33.80	-
Bone meal	0.75	0.75	0.75	0.75	0.75	-
Corn oil 15.00	15.00	15.00	15.00	15.00	15.00	-
Vitalyte	15.00	15.00	15.00	15.00	15.00	-
Chromic oxide	5.00	5.00	5.00	5.00	5.00	-
Total ₦/kg	606.10	512.47	492.76	471.18	449.55	1200.00

Note: Official exchange rate = ₦ 400.00 per US$.

4. Discussion

Certain crude protein requirement has been documented for optimum growth in *Clarias gariepinus.* Rumsey (1993) [19] reported that 30% crude protein diet had the highest protein efficiency and highest growth rate in *Clarias gariepinus* fingerlings while Charles *et al.*, (1995) [6] and Faturoti (2003) [13] used crude protein level of 35%, and obtained a maximum growth (weight) performance in fingerlings and juveniles of *Clarias gariepinus*. Similarly, the percentage dietary crude protein of 35% used in this study gave a maximum growth on *Clarias gariepinus* fingerlings. The highest weight gain and length increase was recorded in fish fed the control diets ($D_1$0% and D_6Coppens®) which are significantly different ($P<0.05$) from other experimental diets. Weight gain decreased linearly as levels of feather meal inclusion increased.

The Specific Growth Rate (SGR) mean values (1.70±0.01 and 0.94±0.01) were significantly higher ($P<0.05$) in D_6 (commercial feed) and D_1 (100% fish meal inclusion) respectively when compared with the feather-based diets. This could be attributed to absence of anti-nutritional factors in the fishmeal. Auta *et., al* (2013) [5] also reported a high (0.89) SGR value with *Clarias gariepinus* more than other commercial feeds. The significantly lower SGR mean values ($P<0.05$) of Diet $D_4$75% and $D_5$100% (0.73±0.05 and 0.44±0.15) could be ascribed to low levels of amino acids or the presence of anti-nutritional factors in the feather meal may have constrained the proper assimilation of nutrients by the fish and its conversion to tissue.

The best Feed Conversion Ratio (FCR) of (1.51) was obtained in fish fed D_6 (commercial ration). This could be related to its highly nutritive qualities such, edibility of the feed with suitable feeding stimulants. The fish fed D_1 (100% fishmeal) performed creditably next to those of the commercial feed with FCR of (2.69). With the exception of diets $D_1$0% and $D_2$25% all other feather–based diets, were significantly different ($P<0.05$) from each other in the feed conversion ratios. Chumlong, (2006) [7] reported the same, in the feed conversion ratio of hybrid Clarias catfish using fermented feather meal as a of fish meal replacement.

Apparent Protein Digestibility (APD) result showed that diets D_1 (100% fishmeal inclusion) and D_6 (commercial feed) had the best protein digestibility of values (80.23% and 88.15%) respectively, compared to the feather-based diets (42.32%, 52.99%, 26.57% and 12.15%) respectively. Statistically, there was significance difference ($P>0.05$) in all the experimental diets. These results indicate that the protein in feather meal was not digested properly and utilized efficiently by the fingerlings of African catfish (*Clarias gariepinus*), when compared with the control diets ($D_1$0% and D_6 Coppens®). The result of protein digestibility in this study is also similar to that of Lee (2002) [15], where he reported that feather meal attained the lowest apparent digestibility coefficient of crude protein compared to other tested protein sources in the test diets for grower rockfish *Sebastes schlegeli*.

All the experimental diets with the exception of ($D_2$25% and $D_5$100%) showed a significantly difference ($P<0.05$) in the Apparent Protein Utilization (APU). Diets D_1 (100% fishmeal inclusion) and D_6 (commercial feed) had the least APU values (14.24 and 6.57) respectively, when compared with diets ($D_2$25% - $D_5$100%) with APU values of (23.91, 25.63, 29.70 and 23.22) respectively. This result indicates that large amount of protein is utilized in building of fish carcass in diets ($D_2$25% - $D_5$100%) and vice versa in D_1 (100% fishmeal inclusion) and D_6 (commercial feed).

The highest survival rate (90.00%) was noted in fish fed diet ($D_2$25% and D_6commercial feed). The lowest survival rate (66.67%) was obtained from fish fed diet ($D_5$100% feather meal). Significant mortalities (33.33%) and retardation in growth of fish fed with diet ($D_5$100% feather meal) could be as a result of decrease in palatability of the diet and starvation, due to poor feed consumption.

5. Conclusion

Based on the results obtained from this study, it could be concluded that diet D_6 (commercial feed) and diet D_1 (100% fish meal inclusion) had the best specific growth rate of mean values (1.70±0.01 and 0.94±0.01) which were significantly higher ($P < 0.05$) when compared with the feather-based diets, which decreased as the feather meal inclusion level increased (D_2 0.83, D_3 0.77, D_4 0.73, and D_5 0.44).

Commercial feed (D_6 Coppens®) had the best feed conversion ratio (1.51±0.00), the fish fed D_1 (100% fishmeal) performed next to those fed D_6 which showed no significant difference ($P > 0.05$) with diet D_2. However, there was significant difference ($P < 0.05$) between diets $D_3$50% and $D_4$75%, while diet D_5 (100% feather meal) had the least FCR of (5.58±0.32). Diet D_6 (commercial feed) and diet D_1 (100% fish meal inclusion) also had higher protein digestibility (80.23% and 88.15%) compared to the feather-based diets D_2 – D_5 (42.32%, 52.99%, 26.57% and 12.15%) respectively.

The highest survival rate (90.00%) was recorded in diets ($D_2$25% and D_6Coppens®) while the lowest rate (66.67%) was recorded in diet ($D_5$100%) which was statistically ($P > 0.05$) different from other experimental diets (D_1, D_2, D_3, D_4 and D_6). Based on this conclusion, for creditable performance 25% (7.21% of the total diet) of hydrolyzed poultry feather meal could be incorporated as alternative source of protein in the diet of *Clarias gariepinus* fingerlings without any significant effect in the weight gain or other growth parameters, and without compromising the quality of the diet.

Hence hydrolyzed poultry feather meal of 25% inclusion level and below is recommended in aquaculture for *Clarias gariepinus* since it is readily available and much cheaper when compared to using fish meal entirely in the diet.

6. Acknowledgements

I wish to express my profound gratitude to my able supervisor Dr. (Mrs.) K.V. Absalom for her guidance, suggestions, support, corrections, painstaking patience and constructive criticisms which made this work worthwhile. I am also grateful to Mr. Igoche, L. E for his time and energy expended in providing the necessary materials used in this research work. My special thanks go to Mr. Ujah, for his companionship and assistance during the numerous laboratory analyses. I am immensely grateful to my beloved parents Mr. and Mrs. Uzodigwe Felix for their financial support, encouragements and prayers.

7. References

1. American Proteins Incorporation. Hydrolyzed poultry feather meal. Internet retrieved from http//www.american proteins.com/ hydrolyzed- meal, 2015. html. Date accessed: 06/10/2015.
2. AOAC. Official method of analysis of the Association of Official Analytical Chemistry, Horwitz, W. (Ed), 14th Edition published by Official Analytical Chemistry, 1984. Virginia, USA. 1984, 1141.
3. APHA, (American Public Health Association). Standard methods for the examination of water and waste water. Washington, DC. 1985, 1268.
4. Audu BS, Adejoh IS. Subtitution of fishmeal with Dipteran Latrin- fly (*Lucilia caecer*) larval in the feeding of *Oreochromis niloticus* under laboratory conditions. African Journal of National Science. 2003; 6:44-47.
5. Auta J, Yashim YE, Dambo A, Tiamiyu BB. Growth responses of African catfish *Clarias gariepinus*. To imported and local feeds. International Journal of Applied Biological Research. 2013; 5(1):55-61.
6. Charles DB, Angus RA, Watts SA. The use of feather meal as a replacement for fish meal in the diet of Oreochromis niloticus fry. Bioresource Technology. 1995; 54 (3):291-295.
7. Chumlong A, Rakyuttithamkul. Utilization of fermented feather meal as replacement of fish meal in the diet of Hybrid Clarias catfish. Kasetsart Journal of Natural Science. 2006; 40:436-448.
8. Ejere VC, Adetoun OA, Chidinma AL, Chinweike NA, Christian OC. Evaluation of poultry feather meal as a dietary protein source for *Clarias gariepinus* and *Heterobranchus bidorsalis* Hybrid, 2014.
9. Eyo AA. The requirements for formulating standard artificial fish feeds. A paper presented at the 11th Annual Conference of the Fisheries Society of Nigeria at the Lagos State Auditorium Secretariat Alausa, Ikeja Lagos State, 1994, 2-9.
10. Food and Agriculture Organisation (FAO). Report highlights on growing sole of fish in feeding the World. FAO technical conference on aquaculture annual publication Rome, Italy, 2014. Internet: retrieved from http://www.fao.org.docrep/fao. Date accessed: 30-06-2015.
11. Fowler LG. Feather meal as a dietary protein source during parr-smolt transformation in fall Chinook salmon diets. Aquaculture. 990; 89:301-314.
12. Falaye AE. The use of hydrolyzed feather meal alone or in combination with supplemental amino acids as a dietary source for Tilapia (*Oreochromis niloticus*). MSc thesis, University of Stifling, UK, 1982.
13. Faturoti EO. Commercial fish feed development and aquaculture. From paper presented at a National workshop on fish development and feeding practices in aquaculture, New Bussa. 2003, 43-45
14. Inaba D, Ogino C, Takamatsu C, Sugamo S, Hata H. Digestibility of dietary protein components in Rainbow trout. Bull. Japanese Social Science. 1962; 28:367-71.
15. Lee SM. Apparent digestibility coefficients of various feed ingredients for juvenile and grower rockfish (*Sebastes schlegeli*). *Aquaculture.* 2002; 207:79-95.
16. Okoye FC, Nnaji JC. Effect of substituting fish meal with grasshopper meal on growth and food utilization of Nile Tilapia, *Oreochromis niloticus* fingerlings. Journal of Science of Agriculture, Food and Environment. 2003; 1:15-18.
17. Omitoyin BO. Utilization of poultry by products (feathers and offal) in the diets of African Catfish *Clarias garienpins*. (Burchell). PhD Thesis, University of Ibadan, Nigeria. 1995, 219.
18. Rostagno HS, Featherston WR. Methods of determination of indispensible amino acids. Revisional Brazil

Zoological technology. 1977: 1(6):64-75.
19. Rumsey GL. Fishmeal and Alternate sources of protein in fish feeds update. Journal of Fisheries. 1993; 18(7):14-19.
20. Tiamiyu LO, Ataguba GA, Jimoh JO. Growth Performance of *Clarias gariepinus* fed different levels of Agama agama meal diets. Pakistan Journal of Nutrition. 2013; 12(5):510-515.