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Nutritional Evaluation of Animal By-Products Meal as Partial Substitute for Fishmeal in the Diet of African Catfish, Clarias gariepinus (Burchell, 1822)

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ABSTRACT

The effects of substituting fishmeal with Animal By-products Meal (ABM) in six experimental diets for African catfish fingerlings, Clarias gariepinus (mean weight=2.05g±0.11) with 0%, 20%, 40%, 60%, 80% and 100% substitution were investigated for 70 days. In general, the best growth and feeding performance were obtained with a control diet (D1) based on fishmeal as the sole protein, but he result was not statistically different (P>0.05) from those obtained with 20%, 40%, and 60% ABM inclusion. A significant (P<0.05) growth depression was observed with diet treatments containing 80%, and 100% ABM inclusion. Whole body percentages of moisture, lipid, ash, and NFE were not significantly affected by the dietary treatments. Crude protein contents however, were highest for fish fed higher levels of dietary protein. The result of this study suggest that 60% ABM/40% fishmeal can be incorporated in the diet of African catfish without adversely affecting growth or any other aspect of performance, and as well as, improving the economics of feeding in comparison with fishmeal.

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Introduction

The increasing population of human being necessitates the increase in the production of food especially the refined proteinous food from fishes. According to Audu and Adejor, fish have enormous nutritional and economic values and the current high demand for fish and its products as a healthier source of protein lead to the realization that captured fisheries from the wild alone cannot meet the demand of the human population [1]. The extensive fish culture system is not reliable due to pollution; bioaccumulation of some substances in water organisms and the pressure of fishermen per unit area have led to poor harvest. In view of these practices, fish farmers tend to look toward intensive fish culture system in order to meet the demands for fishes and fishery products. This in turn has generated a need for development of suitable fish diets for economic and practical reasons. There has been an increasing tendency to use alternative plant and animal proteins as a low cost substitute for fishmeal, but in general the nutritional value of these proteins is lower than that of fishmeal, resulting in lower growth rates or a reduction in performance of the cultured animals [2-5].

Individual by-product meals, such as blood meal, hydrolyzed feather meal or meat and bone meal often have deficiencies, or excesses in essential amino acids; nonetheless these meals can be mixed in certain proportions to produce a nutritionally balanced and economic fish diets [6-9].

This study aims to determine the nutritional value of Animal By-products meal, their optimal 44level of inclusion in C. gariepinus diets and to investigate the performance of the experimental fish on the formulated diets.

Materials and Methods

Mixed sex of the same broodstock of African catfish (Clarias gariepinus) fingerlings with average weight of 2.05g±0.11g were obtained from rock water fish farm Jos, Nigeria. The fish were transported to the laboratory in plastic bags with well oxygenated water in the early hours of the morning. The fish were acclimated to laboratory conditions for 7 days in circular plastic baths with a capacity of 50 litres prior to feeding trials. The plastic bags contained dechlorinated tap water. During the acclimation period, the fish were fed with commercial feed at 4% of their body weight daily divided into 2 equal feedings. The feeding of the fish was at 09:00 and 16:00 hours. Before each feeding, leftover food and faecal matter were siphoned out to prevent depletion of dissolved oxygen and accumulation of toxic wastes in the water. Temperature of water, pH, free carbon dioxide and dissolved oxygen were determined by method of APHA [10].

At the end of acclimation period, ten (10) fingerlings were randomly selected to determine their initial carcass proximate composition. Twelve green plastic baths of 40cm diameter, 10cm depth and 16 litre capacity were filled and maintained with dechlorinated municipal water to 10L level and arranged into 6 feeding treatments tagged D1-D6. Each treatment was replicated and designated 'a' and 'b' for each diet. Ten fingerlings were weighed before stocking in each of the labeled plastic baths. Each bath was then covered with a square net mounted on a wooden frame to ensure the fingerlings did not jump out of the tanks and at the same time preventing entrance of unwanted materials. The experimental baths were washed fortnightly and treated with 20% KMnO4 solution, after which they were properly rinsed with water. Fish in each treatment tank were fed at 4% body weight daily as recommended by Dupree and Huner [11]. Each diet contained different level of Animal By-product Meal (ABM) and fishmeal. The diets were prepared using methods described by Eyo and Olatunde [7]. Chromic oxide was incorporated into the diets as an inert digestibility marker following the method suggested by Furukawa and Tsukahara [12]. The average body weight was used to adjust the amount of food to be given. Faecal matter and any uneaten food were siphoned out before feeding. Each of the six (6) diets was administered two (2) times daily at 09:00 and 16:00 hours.

All fish in each tank were bulk weighed at the beginning of the experiment and thereafter on a bi-weekly basis. To facilitate weighing, fish were collected with a scoop net and dried by blotting with soft damped tissue paper and weighed in a small plastic container using a metler P20110 top loading balance. During the weighing, faeces for the protein digestibility analysis were collected by siphoning before the second feeding, drying the faeces at 105°c for 24h and storing them in air-tight vials under refrigeration (4°c) for subsequent chromic oxide and protein analysis. The feeding trials lasted for 70 days.

The six (6) experimental diets were analyzed for moisture content, crude protein, lipid, fibre, ash and carbohydrate using the method of Association of Official Analytical Chemists (Table 1) [13]. During the experimental period, the water parameters (pH, dissolved oxygen, free carbon dioxide and alkalinity) of the experimental tanks were determined fortnightly as described by APHA while temperature (°C) was determined on daily basis throughout the 70 days period [10].

Growth and feed utilization indices such as percentage live weight gain (LWG %) were determined as described by Cho et al specific growth rate (SGR) were determined as described by Jauncy and Ross food conversion ratio(FCR),protein efficiency ratio (PER) and apparent net protein utilization (ANPU) were determined as described by Halver [14-16].

To test for significant difference between treatments, the one-way Analysis of Variance (ANOVA), single classification was used to test which pairs of means differed significantly from the other.

Result

Result of the proximate composition of the experimental diets (Table 2) showed that all the diets contained between 31-35% crude proteins with exception of diet D1 which had 36.79% crude protein. Diet D2 had the highest fibre and ash contents compared to the other diets. The result of growth performance indices and protein digestibility are given in Table 3. Variations in the mean weight of fish in each treatment group at the start of the experiment was not significant (P>0.05). However, variations in the cumulative weight gain among the different treatments at the end of the experiment was significant (P<0.05). although fish fed the control diets (D1), weighed more than those fed diets D2, D3, and D4, no significant difference were obtained among the final weight gain of fish in this treatments. The groups fed diets D5 and D6 weight significantly less than those of the other treatments.

Other growth and food utilization parameters namely, Mean Growth Rate (MGR), and Specific Growth Rate (SGR) followed the same trend as the final weight gain.

The percentage proximate composition of the fish carcass at the beginning and end of the experiment expressed as percentage wet matter is shown in Table 4. Difference in protein deposition observed between fish fed the control diet, D1 and diet D2 and D3 was not significant (LSD=0.99). Final whole body percentage of moisture, ash, lipid and NFE were not affected by dietary treatment.

Table 1: Percentage Composition of Experimental Diets Fed to C. gariepinus for 10 Weeks

Diets						
Ingredients	D1	D2	D3	D4	D5	D6
Fish meal	54.0	43.2	32.4	21.6	10.8	0.0
ABMa	-	10.8	21.6	32.4	43.2	54.0
Cassava flour	18.0	18.0	18.0	18.0	18.0	18.0
Maize flour	18.0	18.0	18.0	18.0	18.0	18.0
Vegetable oil	5.0	5.0	5.0	5.0	5.0	5.0
Premix						
(vitalyte)	4.5	4.5	4.5	4.5	4.5	4.5
Chromic oxide	0.5	0.5	0.5	0.5	0.5	0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0
Fish meal Replaced By ABM (%)	0.0	20.0	40.0	60.0	80.0	100.0

a: ABM = Animal By-products Meal: is a mixture of blood meal, poultry offal and shrimp meal.

Table 2: Percentage Proximate Composition of Experimental Diets Fed to C. gariepinus Fingerlings for 10 Weeks

Proximate Composition (% Dry Weight)	D1	D2	D3	D4	D5	D6	±SE
Crude Protein	36.79	35.10	34.25	33.75	33.04	31.18	0.77
Lipid	11.86	13.55	13.18	12.98	13.44	13.60	0.27
Fibre	1.01	1.62	O.33	0.22	0.19	0.13	0.25
Ash	4.87	5.53	4.60	4.63	3.53	4.41	0.27
Moisture	7.33	6.02	6.29	6.40	6.85	7.05	0.20
*NFE	38.14	38.18	41.35	42.02	42.95	43.63	0.97
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	

*NFE (Nitrogen Free Extract) = 100 – (% moisture +% lipid + % ash + % fibre + % crude protein)

Table 3: Table of Means for Food Utilization Indices for C. gariepinus Fingerlings Fed Experimental Diets for 10 Weeks

Exp. Diets	TOTAL FOOD FED (g)	CRUDE PROTEIN FED (g)	INITIAL WEIGHT (g)	FINAL WEIGHT (g)	WEGHT GAIN (g)	FCR	PER	ANPU (%)	APD (%)
D1 ± SE	16.60 (0.29	6.11 (0.11)	3.26[a] (0.02)	13.83[a] (0.09)	10.57[a] (0.28)	0.64[a] (0.00)	1.74[ab] (0.01)	86.84[a] (1.49)	71.00[a] (0.05)
D2 ± SE	16.41 (0.60)	5.42 (0.12)	3.36[a] (0.13)	13.72[a] (0.94)	10.36[a] (0.81)	0.63[a] (0.07)	1.93[a] (0.21)	75.76[b] (1.75)	69.00[ab] (1.00)
D3 ± SE	15.43 (0.13)	5.39 (0.15)	3.41[a] (0.09)	13.41[a] (0.50)	10.00[a] (0.13)	0.65[a] (0.01)	1.90[a] (0.04)	63.20[c] (0.54)	64.00[bc] (1.10)
D4 ± SE	14.97 (0.61)	5.06 (0.21)	3.53[a] (0.10)	12.92[a] (0.99)	9.36[a] (0.89)	0.63[a] (0.03)	1.86[a] (0.10)	26.34[e] (1.68)	59.00[c] (0.10)
D5 ± SE	13.51 (0.64)	4.47 (0.22)	3.42[a] (0.20)	9.92[a] (0.01)	6.50[b] (0.21)	0.48[a] (0.02)	1.46[c] (0.02)	40.18[c] (1.94)	58.00[c] (0.00)
D6 ± SE	13.83 (0.09)	4.31 (0.03)	3.30[a] (0.22)	9.97[a] (0.01)	6.67[b] (0.21)	0.48[a] (0.01)	1.55[bc] (0.04)	15.78[f] (0.10)	58.30[c] (0.20)

*values in parenthesis are standard errors of means (±SE).
*Within columns, values with the same superscripts are not significantly different (P>0.05).

Table 4: Percentage Proximate Composition of Clarias Gariepinus Carcass Before and After Feeding the Experimental Diets for 10 Weeks

Diets								
*proximate Composition	Before Feeding	D1	D2	D3	D4	D5	D6	±SE
Moisture	76.68	71.56a	72.03c	74.13a	76.57a	76.21a	77.10a	0.81
Crude Protein	12.30	17.60a	16.40a	15.64a	13.63c	14.09bc	12.96a	0.67
Lipid	3.56	4.15a	4.75a	4.01a	3.89a	3.75a	3.62a	0.14
Ash	4.82	5.44a	5.38a	4.36a	4.23a	4.19a	4.13a	0.19
NFE	2.64	1.25a	1.26a	1.86a	1.68a	1.76a	2.19a	0.17
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	

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

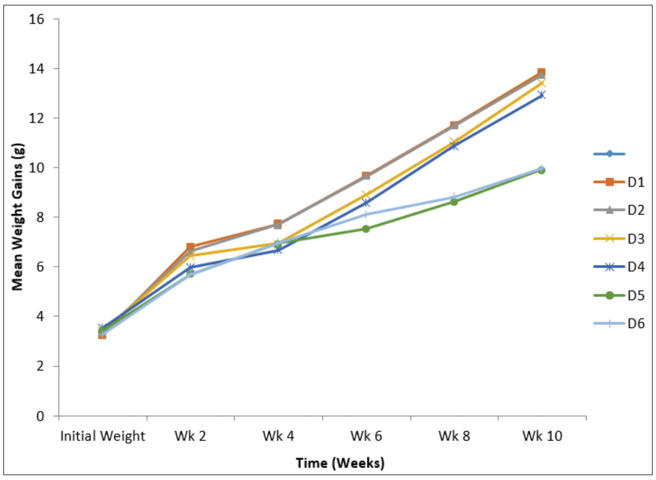

Figure 1: Mean Weight Gains of C. gariepinus Fingerlings Fed Experimental Diets for 10 Weeks

The water quality parameters monitored during the experimental period were all significantly the same (P>0.05). Water temperature ranged from 21.5- 23.70°C with a mean of 22.82°C (±0.33°C). pH values fluctuated from 6.59 to 6.75 with an average of 6.68(±0.02). Dissolved oxygen ranged from 2.15mgl-1 to 3.90mgl-l with a mean of 3.08 ± 0.24mgl-l. Free carbon (IV) oxide ranged from 1.70 to 2.00mgl-l with an average of 1.85 ± 0.04mgl-l and total alkalinity fluctuated from 20.10 to 23.60mgl-l with a mean of 21.84 ± 0.51mgl-l.

Discussion

Protein requirement for optimal growth and feed efficiency of juvenile fish usually ranged from 31-35%. Ayinla and Akande gave a percentage crude protein requirement of 31-34% for fingerlings and juveniles of C. gariepinus. Rumsey reported that 31% crude protein diet had the highest protein efficiency and highest growth rate in C. gariepinus fingerlings, while Faturoti suggested a percentage crude protein requirement of 35% for fingerlings and juveniles of C. gariepinus. In line with this findings, the percentage dietary crude protein (35%) used in this study is in good range that maximize growth of C. gariepinus [5, 17, 18].

The present study shows that 60% ABM can be used with 40% fishmeal in the diet of C. gariepinus fingerlings without affecting the overall performance (table 2). Although final body weight and growth rate were higher in fish fed the control diet, no significant differences (P>0.05) were detected between the control and the treatments with 20-60% ABM inclusion. Significant growth depression was observed when a higher level of ABM was added to the diets. Although diet D5 with 80% of ABM inclusion resulted in the poorest growth, there was no statistical difference (P>0.05) between growth in diet D5 and diet D6 with 100% of ABM inclusion. The low performance obtained from these diets may be due to amino acid imbalances. Audu and adejor [1].
reported that although optimal dietary crude protein is important in promoting growth, other factors such as lipid and crude fibre are usually very important parameters. The suggestion by Rodriguez et al. that higher levels of ABM in fish diets be supplemented with oils (e.g. soy bean oil) to enhance its performance, may perhaps be related to a better supply of essential fatty acid [8]. The result for Protein Efficiency Ratio (PER) and Apparent Net Protein Utilization (ANPU), used as an indicator for the protein productive value, were also within a good range. PER values ranged from 1.93 in fish fed diet D2 to 1.46 in the group fed diet D5. In all but 2 treatments, the values of ANPU were over 40%, showing good nutritional quality of ABM for catfish feeds. These figures are relatively similar to those reported by Rodriguez et al using ABM for Oreochromis niloticus, but however higher than those reported by Steffens using poultry by-product meal for rainbow trout, Onchorynchus mykiss [8, 19].

Throughout the study period, there was a relatively narrow fluctuation in temperature. The least mean temperature of 21.50± 0.30°C was recorded in bath D5, while bath D6 had the highest mean temperature value of 23.70 ± 1.10°C. The average temperature was 22.82 ± 0.33°C. this value is within tolerant range but however falls below the recommended range of 25 to 32°C for optimum growth of fresh water fishes [20]. Average pH was 6.68± 0.02. This value is within acceptable limit as FAO fisheries report reported that pH values range of 6-9 is best for growth. Dissolved oxygen fluctuated from 2.15 ± 0.30mgl-1 to 3.90±0.20mgl-1 with an average 3.08±0.24mgl 1 [21]. This value falls below the optimum dissolved oxygen content for normal growth and reproduction in tropical waters which should be in the range of 5mgl-1 to saturation level (FAO Fisheries report, 2001). Free carbon dioxide content was in the range of 2.00±0.40mgl-1 to 1.7±0.30mgl-1 with an average of 1.85±0.04mgl-1. This value is well within acceptable limit as FAO (2001) stated that sub lethal effects including respiratory stress and nephrocalcinosis will occur when the free carbon (IV) oxide content is in the range of 12-50mgl-1. Total alkalinity ranged from 20.10±1.82mgl-1 to 23.60±1.25mgl-1 with an average of 21.84±0.50mgl-1. These values were within the optimum range, as according to Wurts and Masser 20-300mgl-1 alkalinity is ideal for warm water fishes [22, 23].

Conclusion

The result of this experiment showed that it is feasible to use animal by-product meal as a substitute for fishmeal in catfish feeding without adverse effects on growth and at the same time, improving the economics by reducing costs of feeding. In the experiment, good growth performance was obtained in fish fed the 60% ABM/40% fishmeal diet. Increasing dietary ABM above 60% resulted in depressed weight gain and food conversion. Inclusion of 60% ABM in the diet of African catfish may be a way of reducing the amount of expensive fishmeal in formulated diets without reducing the growth performance of the fish.

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