Use of Rendered Animal Protein Meals as Fish Meal Replacer in the Diets of the African Catfish, *Clarias gariepinus* (Burchell, 1822) Juveniles

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Summary

Feeding trials were conducted to investigate the growth response, nutrient utilization and the flesh quality of the juveniles of the African catfish, Clarias gariepinus *fed with five different dietary protein sources. Five dry diets containing shrimp meal, blood meal, maggot meal, LT 94 fish meal and tilapia meal respectively were prepared and fed to duplicate groups of* C. gariepinus *juveniles (18.8 ± 0.7 g) to satiation for 70 days. Weight gain, growth response and feed utilization indices, and carcass composition did not vary significantly (P> 0.05) between treatments. Average daily growth was highest (0.93 g) in diet AM1 (fish meal), followed by diet AM5, 0.91 g (maggot meal) and the least (0.83 g) was recorded in diet AM2 (shrimp meal). The highest specific growth rate (SGR) was recorded (0.93) in diet AM1, while the least (0.87) was from diet AM2. Results indicate that diet fortified with fish meal as protein source had the highest final body weight (83.36 g), followed by maggot meal (82.21 g). Diet with shrimp meal gave the poorest average daily growth. The most cost effective diet in terms of cost per unit gain in weight of fish was obtained from maggot meal.*

Résumé

Utilisation de différentes protéines animales remplaçant la farine de poissons pour alimenter des juvéniles du poisson-chat africain *Clarias gariepinus* (Burchell, 1822)

Les essais ont été conduits pour enquêter sur la réponse de la qualité de la chair des juvéniles du poisson-chat africain, Clarias gariepinus *nourris avec cinq sources de protéines différentes. Cinq aliments secs qui contiennent la crevette, du sang, du ver, LT 94 du poisson et du tilapia ont été préparés pour nourrir en duplicats des* C. gariepinus *juveniles (18,8 ± 0,7 g) à satiété pendant 70 jours. Gain du poids, et indice de conversion de l'aliment, et composition de la carcasse n'ont pas varié considérablement (P> 0,05) entre traitements. La moyenne de croissance journalière était plus haute (0,93 g) avec l'alimentation AM1 (repas de poisson), suivi par AM5; 0,91 g (repas de ver) et la plus faible (0,83 g) a été enregistrée avec AM2 (repas de crevette). Le plus haut taux d'augmentation spécifique (SGR) a été enregistré (0,93) avec EST 1, alors que le plus le plus petit (0,87) l'a été avec AM2. Les résultats indiquent que l'alimentation avec repas de poisson comme source de protéines permet d'atteindre le plus haut poids du corps (83,36 g), suivi par repas de ver (82,21 g). L'alimentation avec repas de crevette a donné l'augmentation journalière la plus faible. Le coût de l'alimentation le plus efficace quant au coût par gain de poids de poisson a été obtenu avec le repas de ver.*

Introduction

Research in fish nutrition is focused on reducing the cost of fish feed which accounts for 40-60% of the running cost of intensive system (10).

Protein is the most expensive component in fish feeds, and the commonest source is usually fish meal, which is often scarce and generally expensive. There is growing concern to substitute fish meal with less expensive protein sources. Various sources already considered include both plant and animal origin. Replacing fish meal partially or wholly with less expensive plant and animal residues in practical diets of warmwater fish has had varying degrees of success. According to Rumsey (13) increased use of plant protein supplements in fish diets will reduce cost. However a draw back to the use of plant proteins in fish diets is the presence of a variety of endogenous anti-nutritional factors (15). The need to emphasize and investigate the use of animal based protein sources for fish production has become very important. Clarrid catfishes (*Clarias* spp. and *Heterobranchus* spp.) are highly valued food fishes in Africa and constitute prominent commercial aquaculture species widely cultivated in Africa, mainly under semi-intensive systems reaching average production levels of 40 MT/ha/yr (11). Shrimp waste-meal as alternative protein source has been effectively utilized in poultry production (12). Its prospect for fish can be investigated. It has been observed that if well prepared, blood meal can be properly substituted for fish meal in the diet of fish (Binyotubo, 2003). Maggot meal fed to *C. gariepinus* resulted in significant growth compared to ordinary supplementary diets (16). Unsold tilapias from fish farms after total harvest are often wasted (1). From the above, fish farmers, especially in integrated fish farming systems should be educated on the best and cheapest alternative local protein source(s) to be used for high fish production in aquaculture.

Clarias gariepinus is the second most important (to Tilapia) and it is widely cultivated in the tropics. This species is omnivorous with propensity for being carnivorous. There is need for low cost feeds in order to increase its production in culture systems. This study evaluates the nutritive potentials of the common animal protein sources as partial replacement for fish meal in practical diets for the African catfish based on the effects on growth response, protein utilization carcass composition and cost implication.

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Table 1
Formulation (g.100 g-1 of dry matter), ingredient, nutrient composition (g/100 g) and cost* structure (N.kg-1 as fed basis) of experimental diets for *Clarias gariepinus* juveniles

	AM1	AM2	AM3	AM4	AM5
Ingredient					
Fish meal	400	100	100	100	100
Shrimp meal	-	464	-	-	-
Blood meal	-	-	514	-	-
Tilapia meal	-	-	-	431	-
Maggot meal	-	-	-	-	471
Rice grain	4.5	4.5	4.5	4.5	4.5
Oyster shell	5.5	5.5	5.5	5.5	5.5
Salt (NaCl)	0.5	0.5	0.5	0.5	0.5
Vegetable oil	2	2	2	2	2
Vitamin/Premix	4	4	4	4	4
Starch binder/chronic oxide	1.5	1.5	1.5	1.5	1.5
Nutrient Content					
Crude protein	36.53	37.25	39.06	38.37	35.38
Crude lipid	9.58	8.17	8.27	9.01	9.33
Crude fibre	9.34	8.54	8.80	7.86	7.48
Moisture	8.86	12.65	9.48	9.85	8.78
Ash	12.20	12.65	12.10	10.45	11.05
NFE[1]	28.57	25.26	22.29	24.46	27.98
Total cost of diet ($N.kg^{-1}$)	85.4	75.9	63.1	75.8	67.6
Cost of weight gain/fish ($N.kg^{-1}$)	142.76	132.78	141.32	136.94	148.75

N means Naira, i.e. Nigeria's currency. 1 US $= N130.00).

[1] Nitrogen Free Extracts= 100-(moisture+ crude protein+crude lipid+crude fibre+ash)
AM1 (Fish meal); AM2 (Shrimp meal); AM3 (Blood meal); AM4 (Tilapia meal); AM5 (Maggot meal)
* Cost of feedstuffs at the prevailing market prices in Nigeria (October 2005).

Materials and methods

Experimental diets

Shrimp meal, blood meal, maggot meal, LT 94 fish meal and tilapia meal were obtained from reputable feedstuff suppliers in Nigeria. Each feedstuff was separately milled, screened to fine particles size (< 250 µm), and triplicate samples were analyzed for proximate composition (moisture, crude protein, crude lipid, crude fibre, total ash) according to AOAC (2). Crude protein was determined using Kjeltec Auto 1030 Analyzer after digestion with concentrated H_2SO_4 in a digester. Crude lipid was estimated by extracting in chloroform: methanol (2:1) using a Soxtec extraction HT6 unit. Crude fibre was determined using a Fibretec System 1020 Hot Extractor and ash content was determined by igniting at 550 °C in a muffle furnace for 12 hours. Gross energy content was determined with a Gallenkamp adiabatic bomb calorimeter. Nutrient composition and energy content of the protein feedstuffs are presented in Table 1.
These feedstuffs were then incorporated to the measured experimental diets. The proximate composition of dietary ingredients used for the experiment is shown in Table 2. A control diet, (AM1) contained fish meal as the main protein source which was replaced with the other protein meals.

Experimental procedure

The experiment was carried out at the Hatchery complex of the FADEB Fish farm of the Department of Aquaculture and Fisheries, University of Agriculture, Abeokuta.
C. gariepinus juveniles were acclimated to experimental conditions for 14 days prior to the feeding trial. Five groups of 20 *C. gariepinus* juveniles (mean weight, 18.8 ± 0.7 g) were randomly stocked into each of 10 rectangular concrete tanks (50-litre capacity) in an outdoor system (water flow, 1 $L.min^{-1}$; pH, 8.2- 9.6; temperature, 25.8-32.9 °C; dissolved oxygen, 8.84-12.9 $mg.L^{-1}$; total ammonia, 0.19-0.4.22 mg. L^{-1}). Water quality analyses followed the methods outlined by APHA (1980). Water temperature and dissolved oxygen were measured daily using a combined digital YSI dissolved oxygen meter (YSI Model 57 YSFI; pH was monitored weekly using a pH meter (Metler Toledo-320, Jenway, UK). Each diet was fed to *C. gariepinus* in duplicate tanks per treatment to apparent satiation twice daily (09.00 hours and 16.00 hours) for 70 days. Fish mortality was monitored daily. Individual fish in each tank was weighed at the start and every 15 days to monitor growth and feed utilization using the appropriate indices (14). At the end of the growth trial, five *C. gariepinus* juveniles were randomly selected from each tank, and frozen (-20 °C) for subsequent carcass analyses.

Table 2
Proximate composition of dietary ingredients (g/100 g dry matter)

Component	Crude protein	Lipid	Crude fibre	Ash	Moisture	NFE
Fish meal	72.7	8.2	1.1	11.6	7.8	11.3
Shrimp meal	39.5	4.1	3.0	2.8	6.9	73.7
Blood meal	81.5	1.3	1.9	12.3	9.3	49.2
Raw Tilapia flesh	20.6	8.8	12.3	9.1	5.5	53.7
Maggot meal	53.0	10.0	2.0	16.5	12.0	6.3

Table 3
Water parameters in experimental tanks for the duration of the experiment

Parameter	Range
pH	8.2 - 9.6
Temperature ^{0}C	25.8 - 32.9
Total ammonia (mg/l NH_3-N)	0.19 - 4.22
Total alkalinity (mg/l $CaCO_3$)	279 - 469
Dissolved oxygen (mg/l)	8.84 - 12.9

Diet performance evaluation

The diet performance was evaluated according to Olvera-Novoa *et al* (18) as follows:

Weight gain (%)= (final body weight - initial body weight)/ initial body weight
Specific Growth Rate (SGR%/day)= 100[(log_e final body weight- log_e initial body weight)/time, days
Feed Conversion Ratio (FCR)= dry weight of fish fed (g)/fish weight gain
Protein Efficiency Ratio (PER)= fish weight gain (g)/protein fed (g)
Protein Productive Value (PPV)= 100 x (protein gain/ protein fed)

Statistical analysis

All data obtained were subjected to one-way analysis of variance (ANOVA) test (P< 0.05). When ANOVA revealed significant differences, Duncan's multiple-range test (17) was applied to characterize and quantify the differences between treatments using Statgraphics 5 Plus package for Windows (Manugistics Inc. and Statistical Graphics Corp, Maryland, US.).

Results and discussion

Table 1 presents the nutrient composition of the diets. The proximate composition of the dietary protein ingredients of the five meals is shown in table 2. The crude protein content ranged between 20.6 and 81%. The fish responded very well to the experimental diets. Fish survival remained very high throughout the experimental period.
Water quality conditions were similar in all the tanks with the different dietary treatments (Table 3) throughout the trial and were all within the recommended optimum for *C. gariepinus* (19). The water temperature ranged from 25.8 to 32.9 ^{O}C, while the dissolved oxygen was between 8.84 and 12.9 mg/l.
Table 4 presents the performance characteristics of the experimental fish. Feed intake was not affected by treatments (P> 0.05).The mean final weight ranged from 77.03 to 83.36 with the least value recorded from diet AM2. The percentage weight gain ranged from 3.07 to 3.48, with diet AM1 contributing the highest value. The feed conversion ratio (FCR) was high ranging from 2.64 to 2.75 with diet AM1 contributing the highest value. Similarly the protein efficiency ratio (PER) was between 1.76 and 1.55 with the highest value obtained from diet AM1, the fish meal diet. Observations of the growth performance of the individual fish shows that for *C. gariepinus*, diet AM1 had significantly better weight gain (ADG, 0.93), specific growth rate (SGR, 0.93), and (PER, 1.76) compared to other diets. This was followed by diet AM3 (blood meal) which gave an average daily growth (ADG) of 0.89 and FCR of 2.65. The lowest average daily growth (0.83) and SGR of 0.87 were obtained from diet AM2 (shrimp meal). This proves and confirms the major concern of fish nutritionists with shrimp meal diets, which has been attributed to the high level of chitin that forms part of the protein complex. This has been found to have low digestibility for both ruminant and fish (12). As a result of poor absorption of the chitin, the energy value becomes low (9). However, preparing artificial feeds using shrimp processing wastes through fermentation was found to reduce the ash and chitin content of shrimp heads (5). The mean final weight of the experimental fish for both diets AM2 and AM4 (shrimp and raw tilapia meal respectively) were low compared to the other three diets. These two diets however showed very high values of FCR, 2.73 and 2.74 respectively when compared to others diets. This probably is suggesting that large quantities of these replacers will be required when used as replacement for fish meal. The protein productive values of the test diets fortified

Table 4
Growth response and feed utilization of *Clarias gariepinus* fed varying diets fortified with rendered animal protein meals after 70 days

	Diets					
Parameters	AM1	AM2	AM3	AM4	AM5	±SEM[b]
Initial mean body weight (g)	18.6	18.9	18.9	19.0	18.7	
Final mean body weight (g)	83.36[a]	77.03[a]	81.11[b]	78.60[a]	82.21[b]	1.55
% Weight gain	3.48[a]	3.07[a]	3.29[a]	3.14[a]	3.40[a]	0.09
Average daily growth (g/fish/d)	0.93[a]	0.83[a]	0.89[ab]	0.85[a]	0.91[a]	0.05
Feed conversion ratio	2.75[a]	2.73[a]	2.65[a]	2.74[ab]	2.64[a]	0.07
Specific growth rate (%/d)	0.93[a]	0.87[a]	0.90[a]	0.88[a]	0.91[a]	0.03
Feed intake (g)	166.24[ab]	162.19[a]	164.73[a]	163.10[a]	167.38[a]	4.04
Protein efficiency ratio	1.76[a]	1.56[a]	1.59[a]	1.55[a]	1.75[a]	0.02
Protein productivity value (%)	40.76[a]	42.00[a]	40.04[a]	39.82[a]	40.30[a]	0.01
Survival (%)	89	91	89	87	87	0.00

[a] Values in the same row having the same letter are not significantly different (P> 0.05)
[b] ± SEM denotes standard error of the pooled means

Table 5
Carcass composition of *C. gariepinus* fed varying artificial diets fortified with animal protein meals after 70 days

Carcass composition (%)	Initial	AM1	AM2	AM3	AM4	AM5	±SEM[b]
Moisture	68.58	69.32	68.43	68.67	68.87	68.49	NS
Protein	13.99	14.89	15.64	15.33	15.28	15.87	NS
Lipid	4.66	4.88	4.68	4.76	4.66	4.72	NS
Ash	1.33	1.99	1.73	1.45	1.45	1.32	NS

with shrimp and blood meals gave mean values of 42% and 40% respectively. These values are however very low when compared to other values obtained from similar animal-based diets used by Fagbenro (6). It could be responsible for the low final weight obtained from diets AM2 and AM4. When compared to the values obtained by Fagbenro (4), when *C. gariepinus* fingerlings, were fed amphibian meals, it was observed that the present study had greater daily growth and better protein utilization.

There was appreciable increase in the protein and lipid contents of the carcass composition of the experimental fish at the end of the study. This trend agrees with similar work done by Fashakin (7). The highest cost of producing 1 kilogram of feed was obtained from Diet AM1 (N85.4), followed by diet AM2 (N75.9), while the least was diet AM3 (N63.1). [N= Nigerian currency, 1 US$= N130]. The most cost-effective diet in terms of cost per unit gain in weight of fish was obtained from diet AM5 followed by diet AM1 and lastly diet AM2.

The results of this study showed that the utilization of maggot meal is the most cost effective (even though it did not give the highest final weight gain) when compared to other diets. Fish meal had the highest cost implication, even though it gave the highest mean weight gain. The use of fish meal in fish culture has been the cause of high cost of feed procurement in aquaculture. In order to enhance better and optimum utilization, it is suggested that further processing of the major ingredients (shrimp, blood, tilapia and maggot) of diets AM2, 3, 4 and 5 be carried. In addition, cost reduction in fish feed can be implemented by replacing fish meal with a combination of two or three of the major protein ingredients such as blood, shrimp and maggot meals in a compounded ration.

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