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Original Research Article

Poultry offal meal as a substitute for fishmeal in diets for mudcatfish *Heterobranchus longifilis* juveniles

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A B S T R A C T

Four practical diets containing varying protein levels of 35% with fishmeal (FM), 30%, 35% and 40% with poultry offal meal (POM) were fed to *Heterobranchus longifilis* juveniles weighing 77.26±1.18-94.59±1.76g in plastic aquaria for 10weeks. This was to determine the effect of POM as 100% replacer of fishmeal in diets. Fishmeal diet of 35% crude protein (CP) recorded the best percent weight gain of 29.56%, specific growth rate (SGR) 0.68±0.02%day^{-1}, feed conversion ratio (FCR) 1.94±0.65, protein efficiency ratio (PER) 2.37±0.35 and apparent net protein utilization (15.36) which were significantly different ($P<0.05$) from other treatments. Best performing POM diet at 40% CP had 9.60% (%weight gain), 0.18±0.02% day^{-1}(SGR), 5.23±1.13 (FCR) and PER (0.68±0.12). The POM diets had higher fat (13.56-16.48%) and digestible energy (3921.7-4048.0Kcal/kg) than the FM diet and this reflected on the body fat (4.54-6.42%) of fish. Fish survival was 100% for all treatments due to the conducive environmental conditions and hardy nature of test fish. POM diets were more economical to produce. The high energy level in POM diets coupled with deficiency in 1 or more essential amino acids probably influenced reduction in feed consumption, nutrient utilization and limited growth. Although POM at 40% CP has potentials in aqua feeds for *H. longifilis* juveniles, the results suggest future studies for partial FM replacement and fortification with amino acids to reduce dietary fat and improve feed intake for fish growth.

Keywords

Protein; substitution; growth; survival; *Heterobranchus longifilis.*

Introduction

The genus *Heterobranchus* is of the Clariidae family and is commonly distributed in West Africa (Daget and Iltis, 1965). The juveniles are found in tributary rivers and flood plains during the rainy season. *Heterobranchus longifilis* is an indigenous species of significance in Nigeria (Eyo, 1999). Grow-out trials confirmed the great potential value of *H. longifilis* (Oteme et al., 1996). This fish is an omnivorous scavenger (Teugel et al., 1990) and because of the increasing importance of catfish culture in Nigeria, it has become necessary to provide complete and cost effective rations for this industry. FAO (2009) reported that aquaculture is gaining considerable importance as a means of improving world fish production. Therefore mass scale fish production would depend heavily on the amplification of proper feeding protocols to satisfy nutritional requirements of cultured species (Ismat et al., 2013).

An essential consideration for *H. longifilis* is protein in the feed necessary to obtain satisfactory growth and conversion values. Weight gain of fish is essentially linear with protein content in the feed and directly proportional to dietary protein content at a range of 20 to 40% (Dupree and Huner, 1984). Protein is usually the most expensive component in the diet of cultured fish; hence dietary protein levels directly affect production cost (Lazo et al., 1998). Fishmeal is a quality protein source commonly added to fish diets (Turker et al., 2005). It is a rich source of essential amino and fatty acids, energy and minerals, highly digestible and very palatable to most fish. The increasing cost of fishmeal together with decrease in its quality have necessitated the search for less expensive plant or animal protein sources as partial or total replacements for fishmeal in aqua feeds.

Poultry by-product meals (PBM) are valuable alternative protein sources for carnivorous fish and had been tested in diets for channel catfish (Lochmann and Phillips, 1995) and Juvenile Pacific white shrimp, *Litopenaeus vannamei* (Cheng et al., 2002). Yu (2004) reported that high quality PBM can replace fishmeal totally in trout feed without harming the performance provided crystalline lysine and methionine are supplemented to meet the requirements. Also, PBM has a nutritional composition and feeding value similar to that of fishmeal for shrimp, tilapia and trout although feed utilization may be reduced slightly by about 5% at high use rate. Poultry offal, a by-product of the broiler processing plant and processors in local markets is sufficiently available to be recycled as animal protein source for use in fish feeds. Faturoti (2000) reported that local chicken offal (cooked and dried) contained 61.6% crude protein (CP), 16.5% crude lipid, 3.5% crude fibre, 9.0% ash and 8.3% moisture. This worker in a growth response studies observed best gross profit and profit index at 75% and 100% inclusions of chicken offal in the diet of *Clarias gariepinus*. Hence, this study attempts to investigate the effect of complete substitution of fishmeal with poultry offal meal protein source in diet of *H. longifilis* juveniles.

Materials and Methods

Experimental diets

Four practical diets containing varying levels of protein using fishmeal (FM) and poultry offal meal (POM) were formulated and produced. The FM control diet had 35% CP as optimal for growth of *Heterobranchus bidorsalis* and *Clarias gariepinus* juveniles according to Faturoti (2003) while others contained 30%, 35% and 40% CP with POM protein source. Gross composition of experimental diets is presented in Table 1. Each diet was prepared separately to form dough and each dough extruded through a meat mincer to produce long strands of feed. The strands were cut into smaller units of 3-5mm size pellets and dried over a heated aluminium sheet for 30minutes, cooled and packaged separately in small labeled polythene bags. The feeds were stored in a refrigerator until required for the feeding experiment.

Table.1 Gross composition of experimental diets fed to *Heterobranchus longifilis* juveniles for 70 days

Feed ingredient	Diets			
	FM-35	POM-30	POM-35	POM-40
Tilapia fishmeal (64.25%CP)	44.43			
Poultry offal meal (67.80%CP)		33.05	41.80	50.50
Corn	33.87	45.35	36.60	27.90
Wheat bran	15.0	15.0	15.0	15.0
Vitamin/Mineral premix	0.50	0.50	0.50	0.50
Ascorbic acid	0.10	0.10	0.10	0.10
Table salt	0.20	0.20	0.20	0.20
Red palm oil	2.80	2.80	2.80	2.80
Starch (Binder)	3.0	3.0	3.0	3.0
Total	100	100	100	100
Proximate composition (%Dry matter):				
Moisture	5.73	5.64	5.44	5.41
Crude protein	35.25	31.00	36.25	40.75
Ether extract	9.42	16.48	13.56	15.76
Crude fibre	5.86	3.44	2.86	3.42
Ash	14.25	7.95	7.66	6.78
Nitrogen free extract	29.49	35.49	34.23	27.88
Digestible energy (calculated), Kcal/kg	3327.1	3921.7	3862.4	4048.0

Digestible energy calculated as 3.0, 4.25, 3.8 and 8.0 Kcal/g of carbohydrate (non-legume), protein (animal), protein (plant) and Fats (New, 1987). FM=Fishmeal, POM=Poultry offal meal; 30, 35, 40=protein levels.

Experimental fish

Twenty *Heterobranchus longifilis* juveniles (weight 77.26±1.18-94.59±1.76g, length 223.27±0.92-246.44±1.33mm) were obtained locally, acclimatized and fed with a commercial diet containing 30% protein and devoid of POM for 7days. Prior to the start of the experiment, 5 fish from stock, 2 fish from each treatment at the end of experiment and samples of experimental diets were analyzed for proximate composition using AOAC (1990) procedures. The digestible energy (DE) was calculated for each diet according to New (1987).

Experimental system

Twelve rectangular plastic aquaria (46x38x28cm^3) were filled with clean and aerated tap water to the 40-litre mark. Continuous oxygen supply was by Tecas Air Pump (Model AP 1500) connected with air tubes and air stones. Each aquarium was then stocked randomly with 1 fish in triplicate per treatment. The aquaria were covered with synthetic netting material in order to prevent fish from jumping out. Weight and length measurements of fish in each aquarium were carried out using a beam balance

(Model MB 2610) and metal metre rule at the commencement of the experiment and on weekly basis.

Fish were fed daily with prepared diets according to treatment at 5% total fresh body weight. Daily rations were divided into two halves and fed to fish at 1000 and 1600 hours local time. At biweekly intervals, fish in each aquarium was weighed and amount of ration adjusted based on weight increment. Water replacement was 50% daily removal and re-filled to 40-L mark in aquaria. Accumulated undigested food particles and waste products at bottom of aquaria were siphoned out daily with a rubber hose. Total water replacement and cleaning of aquaria were carried out every other day throughout the experimental period. Each aquarium was monitored for fish survival rate. Water temperature was measured daily with a laboratory mercury-in-glass thermometer (0-100^{o}C) in the morning and evening. The pH was measured using a pH meter (Model Jenway 3150), dissolved oxygen determined by Winkler's method and unionized ammonia by Nesslerization (Boyd, 1979) on a bi-weekly basis.

Wet samples of fish from each test diet were taken at the end of experiment, their abdomen dissected open to observe condition of liver and abdominal content. The economy of feed was also calculated. This experiment was conducted for 70days from July to September, 2002 at the Fisheries Department Laboratory, Rivers State University of Science and Technology, Port Harcourt in Nigeria.

Data computation and analysis

The weight gain (g), percent weight gain (%), specific growth rate (%day^{-1}), condition factor (K), and fish survival (%) were calculated. Hepatosomatic index as liver weight (g) x 100/wet body weight (g) of fish (Htun-han, 1978), economy of feed as financial cost of feed (₦)/body weight gain of fish (g) (New, 1989). Feed conversion ratio (FCR), protein efficiency ratio (PER) and apparent net protein utilization (ANPU) were also calculated.

Data were analyzed for statistical significance by analysis of variance (ANOVA) using Statistical Analysis System (SAS) User's Guide, SAS/STAT Version (2003). Duncan's Multiple Range Test (Duncan, 1955) procedures were used to identify significant differences between treatments at 0.05level of significance.

Results and Discussion

Experimental diet and fish body

The biochemical assay showed that dietary protein for fishmeal diet was 35.25% and ranged 31.00-40.75% for POM diets. These values were within intended inclusion levels. Lipid was least (9.42%) in FM diet but much higher in poultry offal meal diets (13.56-16.48%). The fibre and ash levels were about the same in the POM diets but lower in FM diet. The moisture levels were about the same for all diets (5.41-5.73%). The digestive energy in FM diet was 3327.1Kcal/kg while in POM diets, energy values were higher and ranged 3862.4-4048.0Kcal/kg.

The initial and final body nutrient compositions for test fish are expressed as percent wet weight in Table 2. The fish carcass protein in all the dietary treatments was higher than the initial fish carcass protein. This suggests that fish growth was not due to increase in weight gain per se, but is associated with synthesis of tissue protein (Fuller, 1969). Carcass protein was significantly higher in fish fed the control diet (FM-35), (P<0.05) while the body fat in fish fed POM diets were much higher (4.54-6.42%) and differed significantly (P<0.05) from fish fed FM-35 diet (2.27%). Values of fish carcass ash were about the same in all dietary treatments. The results in this study indicated that POM fed fish accumulated more fat in the body than FM fed fish.

Fish growth

Table 3 shows the growth responses of the test fish to the different diets. Fish survival was 100% for all diets during this experiment. The water quality parameters were within the acceptable tolerant limits for fresh water fish culture (Boyd, 1982). Temperature ranged 26.5-28.0^{o}C, pH varied from 6.5-7.4, dissolved oxygen was 4.30-5.5mg/l and ammonia-nitrogen, 0.01-0.08mg/l. The good growth and survival rate of fish could be attributed to the maintenance of good water quality the weight gain (23.30±4.30g) and percent weight gain (29.56%) of fish fed FM-35 diet were significantly higher than those fed POM diets (4.36±0.80-9.08±1.76, 5.39-9.60%). The condition of FM and POM-40 fed fish were similar. The hepatosomatic index (HSI) was higher for POM fish than FM-35 fed fish (Table 3). The condition and HSI of fish as indicative of well-being increased with dietary protein level in POM fed fish. The increase in weight gain in experimental fish showed that the diets supported growth and survival to various extents.

The best growth performing diet contained fish meal at 35% CP. This performance was superior to those of POM fed fish possibly due to feed quality and higher acceptability of the FM diet. Webster et al. (2001) in their studies with juvenile sunshine bass *Morone chrysops* x *M. saxatilis* stated that diet consumption may be a growth limiting factor. The digestible energy in the diet showed that the order of increase was POM>FM diets. Excess energy relative to protein content in the diet resulted in high lipid deposition in the body of fish fed POM diets in this study. This observation corroborated the report of ICAR (2006) that diets containing excess energy lead to fatty fish and may also inhibit optimal utilization of other dietary components (Winfree and Stickney, 1981). Since fish feed to meet their energy requirement, POM diets with higher energy levels resulted in decreased feed intake and reduced weight gain when FM was totally substituted as a protein source.

The diets were not optimally consumed and the fixed quantity of diet fed daily (5% body weight) was probably too much as some of it could have been wasted in the culture medium. Brown and Gratzek (1980) explained that too much energy in relation to the percentage protein in the ration can prevent fish from consuming enough protein to meet their daily need for optimum growth rate even though the fish are allowed to eat as much as they will consume.

The amount of fat observed in the abdomen and liver of *H. longifilis* juveniles in this study increased as POM protein level increased in diets. This observation corroborated the report of Gouveia (1992) who observed increase of body lipid in rainbow trout fed poultry by-product meal. High levels of dietary fat can cause fatty infiltration of the liver. Fatty infiltrated livers are swollen, pale yellow and of a greasy texture (Piper et al., 1982). This condition was observed in the livers of the experimental fish fed POM diets in all the protein levels.

Table.2 Proximate body composition (%wet weight) of *Heterobranchus longifilis* juveniles before and after feeding graded dietary protein levels.

Diet	Moisture (%)	Crude Protein (%)	Ether extract (%)	Ash (%)
Fish at start of experiment	72.52	17.37	2.96	4.48
FM-35 (Control)	70.65	21.10	2.27	4.08
POM-30	71.20	18.74	4.54	4.07
POM-35	70.06	17.86	5.90	4.42
POM-40	70.45	17.55	6.42	4.32

Table.3 Effect of protein sources at different levels on growth of *Heterobranchus longifilis* juveniles.

Parameter	Fish meal	Poultry offer meal		
	35%	30%	35%	40%
Initial weight of fish (g)	78.82± 4.30^c	80.82± 0.80^b	77.26± 1.18^c	94.59± 1.76^a
Weight gain (g)	23.30± 4.30^a	4.36± 0.80^d	5.63± 1.18^c	9.08± 1.76^b
Total length of fish (mm)	223.27± 3.09^d	240.15± 0.94^b	233.26± 0.92^c	246.44± 1.33^a
Percent weight gain (%)	29.56	5.39	7.29	9.60
Specific growth rate (%day^{-1})	0.68 ± 0.02^a	0.08± 0.007^c	0.12± 0.006^b	0.18± 0.02^b
Condition factor (K)	0.65 ± 0.006	0.57 ± 0.003	0.59 ± 0.001	0.61± 0.004
Hepatosomatic index (HSI)	1.344	1.404	1.257	1.565
Percent survival (%)	100.0	100.0	100.0	100.0
Feed conversion ratio	1.94± 0.65^d	10.01± 2.53^a	7.85± 2.07^b	5.23± 1.13^c
Protein efficiency ratio	2.37± 0.35^a	0.51± 0.09^b	0.59± 0.11^b	0.68± 0.12^b
Apparent net protein utilization	15.36	3.26	1.88	1.12
Economy of feed (₦/g.wt.gain)	7.79	4.58	4.09	4.99

Mean with same letter for a given parameter in same horizontal row are not significantly different (P>0.05).

Nutrient utilization

Table 3 gives the nutrient utilization indices. The FCR of the FM fed fish (1.94±0.65) was superior to those fed POM diets which ranged 5.23±1.13-10.01±2.53. Feed conversion ratio is used to compare the ability of the different diets to support weight gain (Hardy, 1989) thus indicating that FM diet was a better diet to support growth of *H. longifilis* juveniles in this study. Higher FCR with POM indicated that feed utilization was less efficient as reported by De Silva et al. (1989).

Diet performance was therefore in the order of FM-35 (control) >POM-40>POM-35>POM-30. The PER and ANPU of FM fed fish were better than POM fed fish. This showed better protein quality and utilization for the FM diet than POM containing diets. The implication of lower PER values for POM diets was the observed reduced growth in the test fish as protein required for maintenance consumed a greater part of the protein intake (Turker et al., 2005). The ANPU in POM diets decreased as dietary protein increased. This trend was similar to reports of Omoniyi and Fagade (2003) in hybrid tilapia *Oreochromis niloticus* x *Sarotherodon galilae*us fry and Copeland et al. (2002) in Black seabass *Cenropristis striata*.

Fishmeal has a higher biological value (Adikwu and Haruna, 1999) and its amino acid profile closely marched the requirement of fish (Tacon and Jackson, 1985), hence the only FM containing diet performed best in this study. In the contrary, POM is limiting in two essential amino acids, lysine and methionine (NRC, 1993; Yu, 2004). This is in addition to higher amount of dietary fat which eventually contributed to inadequate utilization of POM diets by the fish. These fish could not obtain adequate protein in the diet, resulting in growth retardation, poor live weight and length increases and feed efficiency. The nutritional value of a protein source is a function of its digestibility and amino acid make up to influence feed utilization and growth (Otisi and Ufodike, 1986).

A deficiency of 1 or more indispensable amino acid in POM probably resulted in poor utilization of its protein at 100% substitution of FM. Viola and Zohar (1984) reported that up to 50% of FM could be replaced successfully within Tilapia feeds by poultry product. However, the contrary was the case in chinook salmon where growth reduced at similar replacement level (Webster et al., 2000). It is probable that *H. longifilis* juveniles could tolerate only partial replacement of FM as it is with some fish species and not complete substitution in this study. The POM diets were economical with ₦ 4.09-4.99/g.wt.gain than the FM-35 diet with ₦7.79/g.wt.gain. Although the FM-35 diet appeared superior in quality and supported highest growth, it was not necessary the most economical feed to produce.

Poultry offal meal is a potential animal protein source with some economic advantage in aqua feeds for catfish. At dietary 40%CP, it showed 38.97% performance in weight gain, similar in fish condition, survival and appreciable FCR (5.23) compared to the control, FM-35 at 100% replacement. The results suggest future trials in fishmeal replacement with POM to reduce dietary fat content and a supplementation with limiting amino acids in order to improve the biological performance and make POM a valuable dietary ingredient.

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