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USE OF SESAME SEED CAKE AS REPLACEMENT FOR FISHMEAL IN DIETS FOR CATFISH, *CLARIAS GARIEPINUS* (BURCHELL 1822)

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Abstract

A 6-week feeding trial was conducted in glass tanks with juvenile Clarias gariepinus to examine the effects of partial and total replacement of fishmeal with sesame seed cake protein. Five semi-purified isonitrogenous diets (I, II, III, IV, V containing 40% protein) and isocaloric (3.9 Kcal gross energy/g of dry diet) were formulated to contain varying percentage of 0%, 25%, 50%, 75% and 100% solvent extracted sesame seed cake in replacement for fishmeal. Diet I (0% sesame seed cake protein) was the control. Specific growth rate (SGR), food conversion ratio (FCR) and protein efficiency ratio (PER) were not significantly different (P > 0.05) from diets I, II, III, IV in weight gain, SGR, FCR and PER. The results of this study suggest that sesame seed cake cannot totally replace fishmeal in diets for Clarias gariepinus. However, a 25% replacement of fishmeal by sesame seed cake will give similar SGR, FCR and PER when compared to an all fishmeal diet, but was found to be richer in methionine and arginine.

Keywords: Sesame seed cake, *Clarias gariepinus*, replacement value, fishmeal.

Introduction

Fishmeal is an essential component of the feeds of most cultured fish species. Fish feed constitutes about 60% of the input required for high fish production in an aquacultural system. Unfortunately, fishmeal is very expensive in Nigeria because Nigeria is not a fish producing country (FAO, 1992). A ton of fishmeal in 1995 cost ₦120,000 ($1,500), hence there is need to seek for alternatives to reduce the cost of fish feed production or seek substitutes. Plant protein feedstuffs such as cottonseed, soybean, groundnut and sunflower cakes have been incorporated into fish diets to replace the fishmeal components (Gropp *et al.*, 1976; Robinson *et al.*, 1981; Winfree and Stickney, 1981; Balogun and Ologhobo, 1989; Hossain and Jauncey, 1989). Soybean meal is the most widely used primary plant protein source in many fish diets (Lovell, 1988). However, fish growth was reduced when diets containing soybean meal (totally replacing fishmeal) were fed to tilapia, *Oreochromis mossambicus* (Jackson *et al.*, 1982). One possible reason for this decreased growth is the activity of protease inhibitors in crude soybean meal and amino acid imbalance (Dabrowski and Kozak, 1979; Wilson and Poe, 1985).

Common plant protein feedstuffs have recently become expensive and scarce due to their high demand in animal feed and insufficent production level. However, sesame seed cake is not commonly used as animal feed ingredients and has nutritive potentials as a feedstuff in diets for warm water fish species (Hossain and Jauncey, 1989). Sesame seed cake is known to be rich in methionine, an amino acid lacking in most plant protein feedstuff and its incorporation in fish diets has been little investigated. This study was therefore designed to investigate the partial and total replacement of fishmeal with sesame seed cake in the diets of *Clarias gariepinus* juveniles.

Materials and Methods

Experimental diets

The fishmeal used was the brown menhaden type donated by Paulo's Agricultural Enterprises of Hull, England. The solvent-extracted sesame seed cake was prepared by running 500 ml of petroleum ether

(B.P. 60-65° C) through 2 kg of pre-pressed sesame seed in several stages. The residual solvent was removed by drying the flour in conventional oven at 60° C for one hour.

Five semi-purified isonitrogenous diets were formulated to contain varying levels of solvent-extracted sesame seed cake (SSC) as replacement for fishmeal (FM) at 0%, 25%, 50%, 75% and 100% (Table 1). In preparing the diets, dry ingredients were first milled to small particle size and passed through a 250 mm mesh sieve. Ingredients were thorougly mixed with the addition of near boiling water (90° C) to form a homogenous dough. The mixtures were passed through a mincer with 0.8 mm diameter die to produce "spaghetti-like" strands which were steamed for 15 minutes and dried at 60° C for 4 hr in a Gallenkamp conventional oven. The products were broken up into smaller pellets and packed in polythene bags, and immediately stored in a deep freezer (-18° C) until fed.

Table 1. Feed formulation (g/100g) and proximate compositon of experimental diets.

Diets	I	II	III	IV	V	Mean	± S.E.
Ingredients							
Fishmeal	51.60	42.71	28.47	14.24	-		
Solvent extracted sesame cake	-	14.24	28.47	42.71	63.52		
Cod liver oil	-	1.00	2.50	4.00	5.00		
Corn oil	5.00	4.00	2.50	1.00	-		
Mineral premix	4.00	4.00	4.00	4.00	4.00		
Vitamin premix	2.00	2.00	2.00	2.00	2.00		
CMC	2.50	2.50	2.50	2.50	2.50		
Chromic oxide	0.50	0.50	0.50	0.50	0.50		
Dextrin	22.93	19.37	19.37	19.37	14.99		
a-Cellulose	11.47	9.69	9.69	9.69	7.49		
Nutrient content (dry matter)							
Dry matter	89.70	92.31	87.62	92.06	88.15	89.89	0.34
Protein (%)	42.91^{a}	41.05^{b}	40.81^{b}	39.39^{b}	37.87^{c}	40.41	2.02
Lipid (%)	10.13	10.40	9.60	15.20	16.00	12.27	0.07
D.E.	3.70^{a}	3.90^{b}	4.01^{b}	4.15^{c}	3.94^{b}	3.94	0.20
P.E. Ratio	115.97	105.26	101.77	94.92	96.12	102.81	
Chromic oxide (%)	0.47	0.51	0.46	0.48	0.46	0.46	
Ash (%)	13.77	10.98	9.62	8.80	8.83	10.34	
Crude fibre (%)	6.00	4.00	2.00	6.00	12.00	6.00	
NFE (%)	26.72	33.06	37.81	30.13	24.84	30.51	

CMC = Carboxyl methyl cellulose (Binder)

Protein contents of the diets were determiend by the micro-Kjeldahl method (A.O.A.C, 1991). Crude lipid was determiend by Bligh and Dyer technique as modified by Hanson and Olley (1963). Digestible energy (DE) was estimated from the dietary ingredients as established for channel catfish (NRC, 1983) which is a related species.

Experimental tanks and fish

The feeding trial was conducted in 40.5 litre glass tanks (30 x 30 x 45 cm) filled with water. Undergravel filters were installed in each of the tanks to remove the particulate materials. Continuous aeration was provided by a central air compressor through air stones and 90% of water in the aquaria was exchanged every week and replaced with pre-heated water at an ambient temperature of 28 ± 2° C. Chloride levels were maintained at approximately 500 mg/l by the addition of 10 g food-grade sodium chloride (NaCl) per tank to minimize the effects of nitrite to fish health. The tanks were cleaned once a week. Black polythene plastic bags were used to cover the tanks between 0900-1700 hr to give 16:8 hr per daylight to dark cycle. Water temperatures were regulated to give 28 ± 2° C using underwater heaters; pH was 7.50 ± 0.5; ammonia was 0.25 ± 0.15mg/l; dissolved oxygen was 8.50 ± 1.50mg/l; water hardness was 200 ± 50 ppm and alkalinity was 240 ± 60 ppm.

Six juveniles of *Clarias gariepinus* with mean weight of 78.37 ± 0.59 g and 128.22 ± 2.58 mm length with four replicated per treatment were used. The catfish were fed at 3% of their body weight twice daily for 42 days. Weekly batch-weighing of catfish per tank was done and feeds were adjusted accordingly after weighing. At the start and termination of the feeding trial, four fish per treament were sacrificed by decapitation. The fish flesh were homogenized with 30 ml of deionised water and kept in the freezer at -18° C until analysed. Faecal samples were collected during the last week of experiment by siphoning with a 5 mm tubing, pooled from each treatment and freeze-dried in liquid nitrogen for digestibility studies.

Amino acid analysis

Amino acid compostion of the diets were determined (Table 2) by hydrolysis using 6M hydrochloric acid (HCl) in a Kontron Chromakon 500 amino acid analyzer in Hull, England.

Growth performance

Growth performance and feed utilization were determined in terms of daily weight gain (g), specific growth rate (SGR); % day), feed conversion ratio (FCR) and weight gain (%). Growth response parameters were calculated as follows

SGR (% day) = $\log_e Wt - \log_e W_1/T$) X 100;

Where W_t is the weight of fish at time (t_1), W_1 is the weight of fish at time = 0, and T is the culture period in days.

FCR = total dry feed fed (g)/total wet weight gain (g).

PER = Live weight gain (g) / Crude protein intake (g)

Statistical analysis

Data obtained were subjected to analysis of variance (ANOVA) (SAS, 1987). Duncan's multiple range test (Duncan, 1955) was used to compare differences among individual means.

Results

The growth and nutrient utilization indices are presented in Table 3. SGR, FCR and PER were not significantly different (P > 0.05) among *C. gariepinus* juveniles receiving diets containing 0% and 25% SSC (Table 3). Fish fed diets containing 50% and 75% SSC were not significantly different (P > 0.05) from each other. However, the fish fed 100% sesame seed cake protein was significnalty (P < 0.05) different from the other treatments. Fish survival was highest in diets I and II and lowest in diet V (83.33%) which was significantly (P < 0.05) lower than those of other diets (Table 3).

Carcass proximate composition at the conclusion of feeding trial resulted in significnat differencces (P < 0.05) in crude protein content of fish carcass between fish fed diets I and V, but no significant differences (P > 0.05) occurred between fish fed diets III and IV (Table 4). Moisture, crude lipid and ash followed a similar trend as crude protein except for diets III and IV. However, ash content of diet I was not significantly different (P < 0.05) from that of diet V.

Discussion

The present study indicated that a 25% replacement of fishmeal with solvent-extracted SSC was similar to the control diet containing 100% fishmeal protein inclusion in terms of SGR, FCR and PER.

Table 2. Amino-acid composition of SESSC-supplemented experimental diets.

Diets	I	II	III	IV	V
Amino acid types					
Aspartic acid	3.88	3.85	3.28	2.94	3.06
Threonine	1.80	1.78	1.51	1.34	1.38
Serine	1.91	2.00	1.77	1.63	1.82
Glutamic acid	5.31	5.93	5.61	5.47	6.47
Proline	2.13	2.21	1.96	1.51	1.71
Glycine	2.63	2.59	2.09	1.74	1.75
Alanine	3.02	2.95	2.38	1.97	1.96
Cystine	0.13	0.15	0.16	0.18	0.23
Valine	2.52	2.42	2.12	1.69	1.75
**Methionine	1.31	1.98	1.79	1.57	1.51
Isoleucine	2.16	2.01	1.67	1.51	1.63
Leucine	3.46	3.34	2.81	2.45	2.71
Tyrosine	1.47	1.38	1.21	1.18	1.63
Phenylalanine	1.82	1.74	1.53	1.47	1.71
ammonia	2.91	2.87	2.45	2.36	2.76
**Lysine	3.84	2.97	2.12	1.52	1.03
Histidine	0.95	1.03	0.85	0.81	0.87
**Arginine	2.48	3.03	3.15	3.45	4.64
Tryptophan					

** = Limiting amino acids for channel catfish

A total replacement of fishmeal by solvent-extracted SSC as in diet V led to a high FCR (5.98), the lowest daily weight gain (0.45), poor SGR (0.39), PER (0.17), survival (83.33%), and a protein digestibility of 54.90%. However, a partial replacement, even as low as 25% (diet II) improved considerably the methionine content of all the plant protein based diets (diets, II, III, IV and V) (Table 2).

For several decades, the use of plant protein sources to partially or totally replace fishmeal in diets has been of interest to fish nutritionists. Soybean meal has been the most widely used. The result of most researchers had been reduced growth as the level of soybean is increased. Sena *et al.* (1989) fed *Phaseolus aureus* (a legume) to *Oreochromis niloticus* at different levels and observed that percentage average daily weight gain and FCR were better at 25% incorporation level of plant ingredient. The reduction in weight gain in the present study is in agreement with Sena *et al.* (1989) and Hossain and Jauncey (1989). The latter worked with carp, *Cyprinus carpio* fingerlings using fishmeal, mustard oil cake, linseed and sesame seed meal. Balogun and Ologhobo (1989) did not observe significant differences in growth performances of fingerlings of *C. gariepinus* fed 100% fishmeal diet and those fingerlings on 100% cooked soybean meal. Olukunle (1996) reported that incorporating boiled or roasted sesame seed in the diets of *C. gariepinus* at 100% crude protein level gave a growth response poorer than the control (100% fishmeal protein). The observation of the latter work was probably due to the presence of anti-nutritional factor, particularly phytic acid (1.17 ± 0.11g/100g) in the undehulled seeds. Phytic acid binds bivalent ions such as zinc thus making them unavailable. An unusual feature of undehulled sesame seed is the presence of 1-2% oxalic acid and

Table 3. Growth and feed utilization of *C. gariepinus* fed diets of varying % FM replaced by SESSC.

Diets	I	II	III	IV	V	Mean	±S.E
Ingredients							
Initial wt. (g)*	78.46[a]	78.01[a]	78.50[a]	78.72[a]	78.15[a]	78.37	0.59
Final wt. (g)	146.40[a]	135.33[b]	115.77[c]	111.70[d]	97.10[e]	121.26	1.96
Daily wt. Gain (g)	1.46[a]	1.36[b]	0.89[c]	0.79[c]	0.45[d]	0.99	0.22
Weight gain (%)	84.96[a]	73.48[b]	51.29[c]	45.22[d]	16.04[e]	54.19	1.62
Specific growth rate (%)	1.36[a]	1.31[a]	0.99[b]	0.89[c]	0.39[d]	0.99	0.05
Total wt. of feed fed (g)	96.16	87.93	77.99	75.10	113.36	90.12	
Total wt. gained (g)	67.94	57.32	37.27	32.98	18.95		
Food Conversion Ratio	1.35[a]	1.53[a]	2.09[b]	2.28[b]	5.98[c]	2.65	0.88
Protein Efficiency Ratio	0.78[a]	0.65[a]	0.48[b]	0.44[b]	0.17[c]	0.50	0.16
% Protein Productive Vallue	19.93[a]	18.93[b]	18.60[c]	18.50[c]	14.88[d]	18.17	0.38
App. Protein Digestibility (%)	88.18[a]	91.26[b]	91.26[c]	91.07[d]	88.55[a]	90.20	0.47
Total Protein Digestibility (%)	86.72[a]	85.00[b]	80.40[c]	81.25[d]	54.90[e]	77.65	0.44
Initial av. Length (mm)	136.00	123.59	127.89	130.12	123.60	128.22	2.58
Final av. length (mm)	159.90	147.63	140.92	148.83	158.00	151.06	2.70
Survival (%)	100	100	91.67	87.50	83.33		

*Average of 4 replicates

Note: Figures in the same row having the same superscripts are not significantly different ($P < 0.05$).

Table 4. Proximate carcass composition (% dry matter basis) of the fish sample at the start and end of the trial.

Diets	Initial	I	II	III	IV	V	Mean	± S.E.
Moisture	77.39	78.98[a]	78.08[b]	81.68[c]	81.90[c]	79.65	79.65	0.34
Crude protein	8.27	16.24[a]	15.84[b]	15.71[c]	15.67[c]	14.22[d]	15.54	0.14
Crude Lipid	3.34	1.60[a]	2.40[b]	2.52[c]	2.60[c]	3.20[d]	2.06	0.11
Ash	4.00	1.00[a]	1.50[c]	0.50[b]	0.50[b]	1.00[a]	1.00	0.07

associated with it, is the calcium oxalate 2-3% which might have depressed fish growth even after roasting or boiling.

Solvent extraction attempted to reduce the levels of oxalic and phytic acids. In the present studies, the phytic acid level was reduced from 1.70 ± 0.02/100g in pre-pressed sesame seed cake to 0.09 ± 0.06g/100g in the solvent-extracted cake. However, Spinelli *et al.* (1983) suggested that the level of phytic acid should be reduced to below 0.5% prior to inclusion in fish diets.

The results of the present study indicated that a diet with 25% sesame seed cake incorporation will support weight gains in *Clarias gariepinus* similar to diets with 100% fishmeal and will supply a higher methionine and arginine content. Since fishmeal protein component represent 60% of the cost of ingredients in the complete diet (Person, Comm.), the use of less expensive plant protein sources to supply limiting amino acids (methionine and arginine) would reduce the cost of diet formulation and increase the profit to fish farmers.

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