Growth performance of *Oreochromis niloticus* fed diets in which cooked soybean replaced fish meal

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Abstract

Five experimental diets were formulated. In the control diet fishmeal was used as the sole source of dietary protein. The protein of the fishmeal in the control diet was replaced with varying levels of dehulled and cooked soybean meals at 0%, 25%, 50%, 75% and 90% levels to supply 30% crude protein as required by *Oreochromis niloticus*. All diets were maintained iso-nitrogenous (30% crude protein) and isocaloric (285 Kcal/100g DE, 428.89 ± 2.31 Kcal/100g GE) by varying the amount of corn. In a 56 days feeding experiment *Oreochromis niloticus* fingerlings were fed the diets. The feeding trial was conducted in glass aquaria. Evaluation of growth parameters and nutrient utilization of the fish was based on weight gain, feed conversion ratio, specific growth rate, and protein efficiency ratio and protein productive value. Best growth and nutrient utilization was obtained in fish fed the control diet and it decreased as the soybean level increased in the diet. Cost of diets reduced with inclusion of soybean meal. However, the cost of 1kg gain in body weight of *Oreochromis niloticus* was lowest on the control diet due to lower feed conversion ratio. Statistic analysis revealed that the soybean inclusion levels in diet is negatively correlated to weight gain and protein gain but has a strong positive correlation with lipid content of the fish carcass.

Keywords: *Oreochromis niloticus*, soyabean, performance

Introduction

The quality and quantity of proteins are the factors that influence the yield of fish in an intensive culture system (Lovell, 1984). Feed has been estimated to account for about 60-80% of the total cost of production of fish depending on species and environment (Pillay, 1993). Effective reduction of feed cost, especially the protein constituent, with no doubt enhances fish production. Fishmeal has been the major protein source in fish feed diet (Martinez – Palacios *et al*, 1988). However its high cost and sometimes-poor quality as a result of processing have limited

its use in commercial fish diet (Rumsey, 1993). Due to the short supply of fish meal and the corresponding increased cost, the use of other sources of animal and vegetable proteins have been extensively studied either as partial or complete substitute (Webster *et al*, 1995). Fishmeal has been found to have some factors that are important in palatability and also affect growth in fish. Hence it has been recommended (Wilson, 1991) that fishmeal should contribute at least 10% of the dietary protein percentage. Of all the plant protein feedstuffs, soybean meal is considered to be the most nutritious and is

used as the major protein source in many feeds (Lovell, 1984). However growth reduction was observed with the total replacement of fishmeal in the diet. The reasons for the decreased growth rate are due to the activity of the trypsin inhibitor in raw or inadequately heated soybean meal, sub-optimal amino acid balance of soybean and the digestible energy of soybean meal being lower than that of fishmeal in diets for fish (Webster *et al.*, 1995).

Due to the limitations in the use of raw or inadequately processed soybean in fish diets, further processing to improve the nutritional quality becomes empirical. Heat treatment seems to be the best (Rumsey, 1993). Balogun and Ologhobo (1989) processed soybean by pressure-cooking for 45 minutes before feeding it to *Clarias gariepinus*. Tilapia, *Oreochromis niloticus* is a suitable fish for culture because it has rapid growth rate, high tolerance to low oxygen content, efficient food conversion, ease of spawning, resistance to diseases and it is also socially acceptable (Pillay, 1993).

The objectives of this study were to evaluate growth of and nutrient utilization of *Oreochromis niloticus* fed cooked soybean meal as a partial substitute for fishmeal and compare the cost benefit of using cooked soybean in place of fishmeal.

Materials and Methods

Preparation of Experimental Diets

Soybeans were soaked in water for 18 hours and then rubbed between the palms to remove the seed coat washed in water to remove the testa, and then poured in boiling water at 100°C and cooked for 60 minutes according to the recommendation of Lof, 1995. The soybeans were drained in a Gallenkamp oven with mounted fan for a period of 3 days at 55°C, ground to meal and store in a freezer until needed.

Experimental feeds were formulated to contain 30% crude protein in the soybean meal replaced fishmeal at 0, 25, 50, 75 and 90% (Table 1). These constitute the treatments. Other ingredients for each diet were weighed and hand mixed in a bowl. Each of the diets was further thoroughly mixed using the mixing bowl of Hobart A – 200T. 250ml of warm water was evenly sprinkled on 500g feed to obtain a homogenous mass and gelatinized starch was added to get a dough-like paste fat diet mixture was extruded through a 3mm diameter size mincer of Hobart A-200T pelleting machine to form pellets which were broken and fed to *Oreochromis niloticus* fingerlings. The pelleted diet was kept in labeled cellophane bags and stored in a cool and dry condition.

Fish feeding and experimental tank management

Three hundred and seventy five (375) of average weight 5.28 ± 0.05 g were divided into 5 groups representing the treatments. Each group was again divided into 3 to give a total of 15 replicates containing 25 fingerlings per replicate. Each group of 25 fingerlings were stocked in 45 litres aquarium. There were 15 45L aquaria in all each representing a replicate. The fish were fed 5% of their body weight. 2.5% was fed at 08:00 – 09:00 hours and another 2.5% at 17:00 and 18:00 hours daily. Three hours after feeding the leftover feed was siphoned out of the tank, dried at 50° in the oven and weighed. Faeces were collected four hours after feeding to reduce pollution. The water in each tank was replaced on alternate days. Feeding of fish lasted for 56 days during which weight were taken and recorded on weekly basis.

Proximate Analyses

The proximate analysis of the raw and cooked soybeans, experimental diets and the experimental fish were carried out according to AOAC (1990).

Table 1: Composition of experimental diets (% dry weight)

Ingredients	DIETS				
	A 0%	B 25%	C 50%	D 75%	E 100%
Fishmeal	44.74	33.56	22.37	11.19	4.50
Soybean meal	-	17.31	34.62	51.93	62.31
Corn	38.71	32.58	26.46	20.33	16.64
Starch	1.00	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50	0.50
Fat	6.05	6.05	6.05	6.05	6.05
Bone meal	3.00	3.00	3.00	3.00	3.00
Vit. Min					
Premix	3.00	3.00	3.00	3.00	3.00
Rice bran	1.00	1.00	1.00	1.00	1.00
Proximate analysis of diets (dry matter basis)					
Crude Protein	30.41	30.37	30.21	30.17	30.31
Crude lipid	15.25	15.90	15.20	15.76	15.24
Ash	9.16	9.90	9.64	9.69	9.36
Crude fibre	6.09	5.61	5.19	5.63	5.58
NFE	39.10	38.22	39.76	38.72	39.51
*Gross energy	428.18	426.63	428.00	430.11	432.12
Cost/Kg Feed	98.16	91.77	86.98	78.15	71.33

*Calculated based on *fishmeal 4.5, *full-fat soybean 5.33, *corn 4.06 kcal/g. and **vegetable fat 8.83

*Cho, *et al.*, 1982 ** Paperna, 1982

Data collection and Statistical Analysis

The following water quality parameters: temperature: dissolved oxygen and pH were recorded daily using a Y.S.I model 57 oxygen meter (Yellow spring, Ohio) and electronic pH meter (Jenway, England).

The fish feed intake, body weight were monitored on weekly basis. The specific growth rate, feed conversion ratio (FCR), protein efficiency ratio (PER) and the protein productive value (PPV) were calculated from the data obtained as indicated below:

$$\text{i. Weight gain (\%)} = \frac{100 (\text{Final body weight} - \text{initial body weight})}{\text{initial body weight}}$$

$$\text{ii. Specific growth rate (SGR\% day)} = \frac{100 (\text{Final body weight} - \text{initial body weight})}{\text{Time duration / days}}$$

$$\text{iii. Feed conversion Ratio (FCR)} = \frac{\text{Dry weight of feed fed (g)}}{\text{Fish weight gain (g)}}$$

$$\text{iv. Protein Efficiency Ratio (PER)} = \frac{\text{Fish weight gain (g)}}{\text{*Protein intake}}$$

$$\text{v. Protein productive value (PPV)} = \frac{100 \times (\text{Protein gain})}{(\text{Protein})}$$

*Protein intake was calculated as the difference between the quantity feed fed and the leftover on dry matter basis.

Statistical analysis of the growth performance data was made using one-way analysis of variance (ANOVA) using the statistical package on Microsoft Excel, Microsoft Word 2000. Differences between means were separated using Duncan Multiple Range Test (Duncan, 1955). Cost of feed was calculated based on current prices of ingredients and the quantity used.

Results

The results of the proximate composition of the raw and cooked soybean (*Glycine max*) seeds are shown in Table 2 while that of the diets are presented on Table 1. The means of the water quality parameters were temperature 25.87°C, dissolved oxygen 6.42mg/litre and pH 7.48. The cost of the experimental diets is shown in Table 1. The cost/kg of feed was highest on the control diet while the least was on diet 4. The cost of producing soybean-based diets was lower in other diets compared with the control diet due to the ease and cheap availability of soybean as compared to the more expensive fishmeal. However, the cost of 1kg gain in weight of fish was cheapest in fish fed the control diet, which has the lowest feed conversion ratio.

Growth performance and nutrient utilization of experimental fish

The growth response of the *Oreochromis niloticus* fingerlings is shown in Table 3. The mean initial weight of fish was 5.28 ± 0.05 while the mean final weight was 13.51 ± 1.78 . Figure 1 gives the graphical representation of the weekly weight increase for the period of 8 weeks. The highest growth response in terms of mean weight gain, specific growth rate were recorded with the fish fed with the control diet while the least specific growth rate, protein efficiency ratio and feed conversion ratio were from those fed on

Table 2: Proximate composition of raw and cooked soybean (dry matter %)

	Raw soybean	Cooked soybean
Crude protein %	42.52	42.72
Ether extract %	16.47	17.37
Crude fibre %	6.23	2.07
Ash %	3.27	4.43
N.F.E. %	31.51	33.41

Table 3: Growth Performance and nutrient utilization *Oreochromis niloticus* (dry matter %)

	A	B	C	D	E	SEM	
Mortality (%)	2.50±0.17 ^a	4.50±0.71 ^a	7.00±1.4 ^{ab}	8.00±1.14 ^b	12.50±0.71 ^b	0.17	
Mean Final Weight (g)	16.13±0.042	14.22±0.014 ^a	13.32±0.014 ^a	12.28±0.057 ^a	11.59±0.005 ^a	0.79	
Mean Initial Weight (g)	5.32±0.134	5.20±0.00	5.32±0.035	5.28±0.007	5.28±0.000	0.02	
Mean Weight Gain (g)	10.81±0.41 ^a	9.02±0.028 ^a	8.00±0.028 ^a	7.00±0.028 ^a	6.31±0.031 ^a	0.79	
Daily Weight Gain (units)	0.19±0.02 ^a	0.16±0.01 ^b	0.14±0.00 ^c		0.13±0.02 ^d	0.11±0.01 ^d	0.01
Feed Conversion Ratio	1.56±0.028 ^d	1.71±0.28 ^{cd}	1.86±0.085 ^{bc}	2.01±0.014 ^{ab}	2.14±0.014 ^a	0.10	
Specific Growth rate (%/day)	1.98±0.13 ^a	1.80±0.14 ^{ab}	1.64±0.14 ^{bc}	1.51±0.15 ^{cd}	1.40±0.14 ^d	0.10	
Protein Productive Value	43.86±0.14 ^{ab}	46.80±0.14 ^a	37.49±0.16 ^b	17.87±0.14 ^c	14.59±0.14 ^c	6.68	
Protein Efficiency Ratio	2.11±0.006	1.94±0.000 ^a	1.79±0.076 ^b	1.65±0.000 ^{bc}	1.54±0.006 ^c	0.10	
*Cost/Kg Fish (₦/kg)	153.13	156.93	161.78	157.15	152.65		

*Cost is based on the feed conversion ratio of fish on each diet.

Table 4: Proximate composition of experimental fish (% dry weight basis)

	Initial	A	B	C	D	E
Protein	60.64	62.89	62.56	62.23	61.44	61.32
Lipid	8.28	9.42	9.82	9.87	9.95	9.99
Ash	9.69	11.40	11.46	11.47	11.55	11.99
N.F.E.	21.39	15.29	16.09	16.40	17.08	16.77

Fig. 1: Weekly Weight (g) of *Oreochromis niloticus* fed the test diets

90% inclusion of soybean in the diet. The weight gain decreased as the soybean inclusion levels increased improvement. The nutrient utilization based on the protein efficiency ratio and protein productive value is given in Table 5. There were significant differences ($P < 0.05$) in protein efficiency ratio and protein productive value of fish on the different diets. The mean protein efficiency ratio value was 1.81 ± 0.23 while mean

protein productive value was 32.12 ± 4.94 . The highest protein efficiency ratio and protein productive value was recorded in fish fed control diet i.e. diet A while the lowest was recorded in fish fed diet E.

The best feed conversion ratio was obtained in fish fed diet A, this increased progressively as soybean inclusion in the diet increased with the highest value on fish fed diet E. The protein efficiency ratio reduced with increasing soybean inclusion. The highest value was in fish fed diet A while the least was in fish fed diet E.

Proximate composition of carcass of the experimental fish

Table 4 shows the carcass proximate composition of *Oreochromis niloticus* at the beginning and end of the growth trial. The fish fed with the control and cooked soybean meal diet inclusion had higher carcass protein and lipid contents than when they were at the fingerlings stage, however the ash content also increased. The crude protein content decreased as the level of replacement of cooked soybean increased while the lipid and ash values increased. There were no significant differences ($P > 0.05$) in both the protein and lipid content of the carcass but significant difference ($P < 0.05$) occurred in ash and NFE of carcass.

Table 5: Correlation and regression analysis of soybean inclusion level against carcass weight, protein and lipid gain

Subject	A	B	R	Prediction equation
Fish Lipid / Soybean inclusion	12.84	+9.63	+0.74	$Y = 12.84x + 9.63$
Weight Gain / Soybean inclusion	24.37	-11.61	-0.8	$Y = 24.37x - 11.61$
Protein Gain / Soybean inclusion	20.89	-2.99	-0.65	$Y = 20.89x - 2.99$

Correlation and regression analysis of weight, protein and lipid gain against soybean inclusion levels

Correlation between the soybean level in each of the diets with the fish carcass lipid, weight gain and protein gain are presented in Table 5. There was a weak but positive correlation between the soybean inclusion level in the diet and the carcass lipid. A strong but negative correlation existed between weight gain and soybean inclusion level in the diets. There was also a negative correlation between the soybean inclusion level and the protein gain of fish.

Discussion

The values of the water parameters in this study are similar to that recommended by Wilson (1991) for *Oreochromis niloticus* fed varying levels of soybean diet. This shows that the water parameters could not have adversely affected the growth and nutrient utilization of the experimental fish. The result of the proximate analysis of soybean used in feeding trial was similar to the values reported by FAO (1996) for soybean. There is little variation in the proximate composition of the raw and cooked soybean.

The mean initial weight was 5.28 ± 0.05 while the final weight was 13.51 ± 1.78 . The mean weight gain was 8.23 ± 1.77 with the control diet having

the highest weight gain of 10.8 ± 0.41 . The weight gain decreased as the soybean inclusion increased. This could be due to the higher quality of fishmeal in the control diet. Although cheaper and a highly accepted plant-protein, soybean does not have the same quantity and quality of essential amino acid as fishmeal. But the weight gain of *Oreochromis niloticus* in this study compare favourably that reported by Osman *et al.* (1996).

Also, the specific growth rate decreased as the level of soybean increased. These show that the soybean diets did not support growth as much as the control diet. But the specific growth rate of *Oreochromis niloticus* in this study was higher than the 0.6 reported by Macintosh and De Silva, (1984).

The nutrient utilization in terms of protein efficiency ratio and protein productive value was better in the control diet and decreased as the soybean inclusion level increases. The better performance of the fish fed the control diet in both growth responses and nutrient utilization could have been due to available and/or better balance of essential amino acids of fish meal as compared to that of soybean. Since soybean was soaked before cooking reduction in growth could not be attributed to anti-nutrient factors. The strong but negative correlation that existed

between weight gain, protein gain and soybean inclusion level in the diets shows that as the soybean inclusion level increased fish weight gain and protein gain reduced. These trend shows that it would take a longer time for fish fed on soybean diet to attain market size.

The results from this study shows that when well processed soybean could be used to partially replace fishmeal up to 25% of diet without compromising the gains. In this study soybean was included up to 62.31% of the diet this could have led to the progressive decrease in the fish performance. According to Viola and Arieli, (1983) decrease in fish growth with increasing level of full fat soybean meal could be due to deficiency of full fat soybean in lysine and methionine and also the poor binding properties of the pellets which lead to decrease in digestibility of the diets.

The significant increase in protein levels of fish shows that the fish was able to utilize the nutrient present in the feed. The crude lipid value of the carcass increased as the soybean level increased. This is in agreement with the work of Reinitz *et al*, (1978) who reported that percentage body fat was higher in fish fed full fat soybean than in those fed the standard diet. Newton *et al*, (1980) also reported increased level of body fat in cage-cultured channel catfish full-fat soybean meal diet. This could be an advantage in fish farming where the focus is on table size. Positive correlation between the soybean inclusion level in the diet and the carcass lipid could have been due to the increasing fat content in the diets as a result of the fat content of the full fat soybean meal which was higher than in the fishmeal

Reduction in cost of diet as the soybean inclusion level increased was due to the cheaper cost of soybean as compared to the more expensive fishmeal. This advantage was

reduced when the cheaper soybean diet gave high feed conversion ratio thereby increasing the unit cost of producing a kilogram fish.

Conclusion

This study shows that cooked soybean diet produced good result when partially substituted up to 25% of total diet for fishmeal in the diets of *Oreochromis niloticus*.

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