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Effects of Dietary Soybeans (*Glycine max* (L.) Merr.) on Growth and Body Composition of African Catfish (*Clarias gariepinus*, Burchell) Fingerlings

O.O. Fafioye[1,*], S. O. Fagade[2], A.A. Adebisi, Jenyo-Oni[3], G.A.K. Omoyinmi[4]
[1] Department of Biological sciences, Olabisi Onabanjo University, P.M.B. 2002, Ago-Iwoye, Ogun State, Nigeria.
[2] Department of Zoology, University of Ibadan, Ibadan, Nigeria.
[3] Department of Wildlife and Fisheries, University of Ibadan, Nigeria.
[4] Department of Agricultural Science, Federal College of Education, Osiele, Abeokuta, Ogun State, Nigeria.

* Corresponding Author: Tel.: +234 5454871; Fax: -
E-mail: ofafioye@yahoo.com

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Abstract

The effect of feeding *Clarias geriepinus* fingerlings with diets supplemented with soybeans was studied for 56 days. Two of the soybeans were heat treated for 30 and 60 minutes, the third was toasted (for 10 minutes) and the fourth was raw soybean (control). Fish of an initial mean body weight of 2.36±0.67g were grown to a final mean body weight of 6.18±0.94g at a temperature of 25.0±1.23°C, pH 6.18±0.73 and dissolved oxygen 5.5±2.54g. The diets used additionally contained blood meal, cassava flour, red palm oil, vitamin/mineral premix and chromic oxide. Fish fed diets that were heat treated for 60 minutes had the highest percentage of weight gain, feed conversion ration, protein efficiency ratio, specific growth rate, apparent protein utilisation and digestibility. The fish carcass protein in all dietary treatments ($diet_1$ = 58.59, $diet_2$ = 58.63, $diet_3$ = 57.98 and $diet_4$ = 57.92) was higher than the initial carcass protein (56.75), thereby confirming the potential of incorporating soybeans in fish feed formulation.

Key Words: dietary, soybeans, growth, body composition, *C. gariepinus*

Introduction

Fish are one of the cheapest sources of animal protein in Nigeria and constitute about 40% animal protein intake by average Nigerian (Afolabi *et al*., 1984; Sadiku and Oladimeji, 1991). However, the average protein intake by an average Nigerian was estimated to be about 63.24g/caput/day, which is below 70g/caput/day FAO minimum recommendation (Falaye and Akinyemi, 1985).

Fresh water fish constitute 69.6% of the total fish supply available to Nigeria (FOS, 1990). Rest of this amount is mudfish, *Clarias gariepinus* Burch, family Clariidae, which marketing trends predict an increase in consumer demands, because most of its production comes from artisanal fisheries.

Fish production takes into account the fish nutrition for efficient growth in an aqua- cultural system. And thus, fish should feed at a quantity, which is not exceeding the dietary requirements, but fish feed amounts to over two-thirds of the variable cost of a fish culture in an intensive management system (Eyo, 1990).

High costs, increasing demand and uncertain availability of fishmeal, plus risk factors associated with diseases from animal protein sources resulted in nutritionists studying alternative sources for inclusion into the diets of fresh water and marine species (Nyirenda *et al*., 2002). The most promising source is soybean, which has high nutritive and commercial value (Boonyaratpalin *et al*., 1998).

Soybeans, *Glycine max* (L.) Merr., are grain legumes and the seeds are used for human consumption, or as a concentrate for farm animals. It is used as protein (35%) supplement and it constitutes the major fraction of the crude protein, with relatively high amount of lysine and essential amino acids and vitamins (i.e. thiamine, niacin, B-complex and carotene) (Martin and Ruberte, 1980).

This study presents the results of an experiment concerning the effects of dietary soybeans on the growth and body composition of African catfish, *Clarias gariepinus* fingerlings.

Material and Methods

Rearing and sampling: The study was conducted at the Research Laboratory, Department of Biological Sciences, Olabisi Onabanjo University, Ago Iwoye, Nigeria. One hundred and fifty fingerlings of *Clarias gariepinus* (mean body weight: 2.36 ± 0.67g) were obtained from Guizy Fish Farms, Ibadan, Nigeria and transported to the laboratory in two aerated PVC bags. They were held in two circular plastic tanks (50 L) for two weeks and fed with commercial diet at 3% body weight. The tanks were half-filled with tap water, which was allowed to stand for 24 hours in order to allow for dechlorination. After acclimation period (14 days), the fish were divided into the groups of 10 fish per tank (to avoid overcrowding) to 12 rectangular glass tanks of 45-litre each, three tanks per treatment (FAO, 1986). Each tank was supplied with 30 litres of dechlorinated water and aerated continuously by an air compressor, so that oxygen levels were kept close to saturation. Some water quality parameters (temperature, pH and dissolved oxygen) were monitored throughout the feeding trails. Faecal matter and food remains were siphoned out and fresh water was added daily. Fish were fed experimental diets by hand three times per day, 7 day a week at 4% biomass of fish. Every 15 days, fish were weighed in groups of five (to avoid stress) to the nearest 0.01g using a digital scale. The experiment lasted for 56 days (June-July), which was ideal for standardized routine laboratory test (FAO, 1986).

At the end of the experiment, all fish from each tank were individually weighed and their livers removed and weighed for hepatosomatic index determination. Tissues were stored at -4°C to measure whole body composition and fat and glycogen contents of livers.

Diets: Four diets were prepared having the same formula composition (Table 2) and proximate composition (Table 3) using standard methods of AOAC (1995). Soybeans (G. max) used in preparing the experimental diets were purchased from Oba market, Ago-Iwoye. The dry seeds were exposed to heat processing methods as follows:

Diet 1 was oven heated for 30 minutes, diet 2 was heated for 60 minutes, diet 3 was toasted in frying pan for 10 minutes and diet 4 was raw soybean used as control. Both the heat processed and raw soybean seeds were separately ground into fine powders, using electric blender to obtain soybean meal. Each meal was mixed with cassava flour as binder and energy source, blood meal as supplementary animal protein, palm oil as fatty acids, chromic oxide as indicator for digestibility test and vitamin/mineral premix. Diets were prepared in the laboratory after thoroughly blending all the dietary ingredients, then moistening and cold pelleting by using large injection syringe (20ml). The empty injection syringe was packed full with moistened dietary ingredients and later pressed out through the front opening into pellets. Pellets were dried with forced air circulation at room temperature, crumbled to the required size, packed in nylon and stored in the refrigerator at -4°C until used.

Analyses: weight gain was calculated as the difference between the initial and final body weight of fish.

The growth rate (GR) was determined using linear regression:

$$Y_i = a+b\ x_1$$

Table 1. Values of physio-chemical parameters of water during feeding trials of *Clarias gariepinus*

	Diet			
	1	2	3	4
Temperature (°C)	24-26	24-26	24-26	24-26
Mean ± S.D.	25±1.23	25±1.23	25±1.23	25±1.23
Dissolved oxygen (mg /l)	3.8-7.1	4.0-6.8	4.0-69	4.2-6.8
Mean ± S.D.	5.5±1.96	5.5±2.54	5.5±2.54	5.5±2.56
PH	6.2-7.3	6.4-7.3	6.4-7.4	6.5-7.2
Mean ± S.D.	6.8±0.71	6.9±0.65	6.9±0.71	6.9±0.92

Table 2. Composition of basic experimental diets

Raw materials	Percentage in diet
Soybean	64
Cassava flour	20
Blood meal	11
Red palm oil	2.0
Chromic oxide	0.5
Vitamin/mineral premix	2.5

Table 3. Proximate analysis of experimental diets

Composition	Diet			
	1	2	3	4
Dry matter	94.42	94.40	94.41	94.43
Crude protein	50.01	50.12	50.04	49.83
Crude fibre	3.95	3.87	3.92	3.72
Lipid	5.72	5.46	5.83	5.10
Ash	10.26	9.87	10.14	9.53
Moisture	4.34	4.34	4.28	4.65
Subtotal	74.28	73.66	74.21	72.83

Where Y_i is total weight (g) of fish at time t.
a = average weight (g) of fish at the start of the experiment
b = growth rate in g/day.
x_1 = the number of days at time t.

Specific growth rate (SGR):

$$SGR (\%) = \{[\ln (Wt_2)-\ln (Wt_1)] /(t_2 - t_1)\} * (100/1)$$

where Wt_1 and Wt_2 are weights at respective time t_1 and t_2 and the difference of t_2-t_1 is the time duration (in days) considered between W_2 and W_1.

Hepatosomatic index (HI) was calculated as liver weight (g), divided by fish whole body weight (g), and multiplied by 100.

e.g. HI (%) = (liver weight / fish whole body weight) * (100/1)

Feed conversion ratio (FCR) was determined as described by Hepher (1988).

FCR = Weight gained by fish / Wt of feed consumed

Protein efficiency ratio (PER) was determined as described by Mazid *et al*. (1972).

PER = Weight gained / Protein fed

Where protein fed = [(% protein in diet * total diet consumed) / 100]

Digestibility of each diet was determined using the methods described by Furukawa and Tsukahara (1966).

$$\%\ \text{digestibility of nutrient} = 100-\frac{(100x\ (Cr\%)\ \text{fed})\ x\ (\%\text{nut. in faeces})}{(\%Cr_2O_3\ \text{in faeces})\ (\%\ \text{nut. in feed})}$$

Data were subjected to one-way analysis of variance at 5% probability level.

Carcass analysis was made as follows: *C gariepinus* was minced and a portion was removed for moisture and ash content. Moisture was determined by drying pre-weighed samples in porcelain cups at 104°C for 24-h. Then, ash was obtained by incinerating the dried samples at 500°C for 12-h. The rest was lyophilised and used for crude protein and fat analyses. The Kjaldahl method of protein analysis (AOAC, 1984) was used in order to determine protein content, while soxhlet extraction with petroleum ethers was used for fat. All analyses were performed in triplicate.

Results

The physico-chemical parameters of water used for this study are shown in Table 1. Water temperature ranged between 24 and 26°C, dissolved oxygen between 3.8 and 7.1 mg/l and pH between 6.2 and 7.4.

Composition and proximate analysis of experimental diets fed to *C. gariepinus* (Table 2 and 3, respectively) contained 50% crude protein. No

Table 4. Growth performance factors of *C. gariepinus* fed different experimental diets

Parameter	Diet				
	1	2	3	4	P>0.05
Initial mean wt (g)	2.36±0.67	2.36±0.69	2.4±0.05	2.38±0.11	NS
Final mean wt (g)	6.09±0.95	6.16±0.62	6.18±0.94	6.13±0.77	NS
Weight gained (g)	3.73	3.80	3.78	3.75	"
Weight gain %	158.05	161.02	157.50	157.60	"
SGR	0.83	0.85	0.84	0.84	"
FCR	18.46	20.12	18.34	18.45	"
PER	0.42	0.50	0.43	0.40	"
APU	82.34	87.05	83.71	83.68	"
Digestibility %	78.46	82.13	81.68	80.66	NS

SGR= specific growth rate; FCR= food conversion ratio; PER= protein efficiency ratio;
APU= Apparent protein utilisation; NS = Not significant (P>0.05).

Table 5. Effect of dietary treatment on body composition of carcass of *Clarias gariepinus*

Component body (%)	Diet				
	Initial	1	2	3	4
Protein	56.75	58.59	57.92	58.63	57.98
Ash	15.35	13.78	14.03	14.09	13.96
Fat	11.74	10.35	10.27	10.64	10.10
Moisture	16.16	17.28	17.78	16.64	17.96
Hepatosomatic index (%)	1.0	1.3	1.3	1.1	1.1

significant difference (P>0.05) was identified in the values of ash, lipid, moisture and crude fibre of the four diets. There were no differences observed in growth or nutrient utilisation values among fish fed different diets. Generally, values for all the performance factors examined were high (Table 4).

Fish carcass composition is shown in Table 5. Whole body composition showed no differences among the groups of *C. gariepinus* fed different diets, the only exception being the diet 2, where higher protein content (58.63%) was measured compared to the remaining diets. Body fat and ash contents (10.64% and 14.09%, respectively) were also slightly higher in fish fed diet 2 at the expense of moisture, which indicated the lowest values. Differences for these parameters (protein, ash and fat) with those of other diets (diets 1, 3 and 4) were not significant (P>0.05). Hepatosomatic index ranged between 1.3 for the diet 1 and 1.1 for the diet 4 without any statistically significant differences among the groups (Table 5).

Discussion

The physico-chemical parameters of water were within the range for culturing African catfish, *C. gariepinus* (Viveen *et al.,* 1977). *Clarias gariepinus* fingerlings in this study showed appreciable growth response to the inclusion of soybean in their diet. The percentage increase in body weight of fish fed processed soybean over fish fed raw soybean conferred an additional nutritional advantage. In an experiment with juvenile salmon, Smith (1977) found a rapid growth response to dietary supplementation with soybean. Lovell (1989) observed that heating soybean improved the digestibility of the polysaccharides and metabolisable energy in addition to the inactivation of trypsin inhibitors. However, reduced growth performance and protein digestibility in fish were attributed to trypsin inhibitory factors (Eyo, 1994), which was also present in soybeans (Boonyaratpalin, *et al*., 1998). Therefore, high digestibility recorded in fish fed processed soybean could be attributed to heat processing method employed. Banyigyi, *et al*. (2001) obtained similar results on feed utilisation and growth of juvenile catfish (*Clarias gariepinus*) fed heat-treated; 'bambara' groundnut (*Vigna subterranes*, Verde (L)) meal.

The high value recorded for all performance factors examined could be attributed to high protein content of the diets (approximately 50%), which is within the range of recommended dietary requirements for fish (Faturoti *et al*., 1986; Maluwa *et al*., 1975; Parpoura and Alexis, 2002). However, the daily water changes might have affected fish growth performance as observed by Absalom and Omenaihe (2002) in Nile tilapia, *Oreochromis niloticus*, but because of the hardy nature of *C. gariepinus* coupled with its bimordial respiration, the effect of daily water change in fish growth might be lesser (insignificant), compared with *O. niloticus.*

Fish carcass composition recorded higher protein content in all the diets than the traditionally toasted and raw soybean. This indicates that there was protein synthesis and increased tissue production in treated *C. gariepinus* and that fish growth was not due to the increase in weight alone (Koven *et al*., 2001; Fountoulaki *et al*., 2003). The moderately high level of carcass fat in diets 1-4 indicated an enhanced production of lipids in the fish. Fountoulaki *et al*. (2003) observed in gilthead bream fingerlings that lipid was associated with increase efficiency of metabolism.

In conclusion, this study shown that both heat-treated and raw soybeans might enhance better growth performance and feed utilisation by *C. gariepinus* fingerlings. The high digestibility of the diets suggests that soybeans have the potential of replacing or competing with animal protein in fish feed formulation. The results also indicate that protein synthesis occurred when fish were fed with soybean.

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