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Effect of Replacing Fishmeal with Soybean Meal on Growth, Feed Conversion and Carcass Composition of Fingerling *Oreochromis niloticus* (Nile Tilapia)

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Abstract

A feeding trial was conducted to replace the Fish Meal (FM) protein by Soybean Meal (SBM) protein in the feeds for fingerling *Oreochromis niloticus* (0.57±0.05g; 3.54±0.18 cm) Six practical diets (35% crude protein; 16.28 kJ g^{-1} gross energy) replacing 0, 20, 40, 60, 80 and 100% fish meal protein by soybean meal protein were prepared. The diets were fed to triplicate groups of fish near to satiation for 6 weeks. The live weight gain (LWG, 308.77-608.77%), protein retention efficiency (4.03-25.74%), specific growth rate (1.75-4.11%/day), feed conversion ratio (1.54-3.47), and protein efficiency ratio (0.82-1.86), in fish fed diets with 0, 20 and 40% replacement of fish meal with SBM did not show any significant differences. However, further replacement of fish meal by soybean meal beyond 40% resulted in significant fall in above parameters indicating that fish meal could be replace by soybean meal up to 40%, which would be useful in formulating cost-effective commercial feeds for the intensive culture of this fish.

Key words: Growth performance, Soybean Meal, Requirment and *Orechromis niloticus*

Introduction

Progressive growth in the aquaculture industry and the intensification of fish production have led to the increasing demand for fishmeal (FM) to provide aquafeed for fish species (Hardy, 2010). The above-mentioned challenges have resulted in the inflation of FM price and an uncertainty in its supply. Thus, introducing economic and eco-friendly alternative protein sources with local availability and high nutritional value is pivotal for the sustainable aquaculture progression (Gatlin et al., 2007; Hardy, 2010; Zeynali et al., 2020).

Therefore, the development of costeffective feeds using inexpensive and locally available plant and animal protein sources will contribute to sustainable aquaculture development for the future (Mazid et al., 1997; Nguyen, 2007; Mzengereza et al., 2014; Yakubu et al., 2014; Pai et al., 2016; Jewel et al., 2018; Limbu, 2019; Yousif 2019a,b; Mohammed et al., 2020). Tilapia are freshwater fish belonging to the family Cichlidae. They are native to Africa, but were introduced into many tropical, subtropical and temperate regions of the world during the second half of the 20th century (Pillay, 1990). Tilapia are currently known as "aquatic chicken" due to their fast growth, adaptability to a wide range of environmental conditions, disease resistance, high flesh quality, ability to grow and reproduce in captivity and feed on low trophic levels (El-Sayed, 2006; Nguyen, 2007; Bhujel, 2014; Chirapongsatonkul *et al*., 2019). Fish meal is the most attractive protein source for aquaculture diets because of its high protein content, well balanced amino acid and fatty acid composition, high digestibility and palatability, however, the high cost of FM and lack of availability are making it impracticable to use in all aquafeeds. In recent years, a decline in fish stocks on which FM production depends and the increased consumption of fish has promoted the search for alternative protein sources (Akiyama *et al*., 1995; Yıldırım et al., 2014). Plant proteins are almost similar to FM in terms of the protein content and protein and amino acid digestibility (Hardy, 1996). However, their amino acid profile does not match the amino acid requirement of some fish species as FM does (Hardy, 1996; Mohammed et al., 2020). Plant is the vital protein source for the sustainable production in aquaculture (Gatlin *et al*., 2007), which includes soybean meal, ground nut cake, wheat middlings etc. Among those different ingredients, soybean meal is the most important alternative for fishmeal in aquafeed as it has high-protein content, relatively favourable amino acid profiles, high digestibility, reasonable price and easy availability (Bonaldo et al., 2008; Gatlin *et al*., 2007; Li *et al*., 2020). This study was conducted to replace the fishmeal protein by soybean meal protein for Nile tilapia so that cost-effective nutritionally-balanced feeds could be prepared for tilapia intensive culture.

Materials and Methods

Experimental System and Animals

Fingerling *Oreochromis niloticus* were procured from Centeral Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal-India. These were transported in oxygen filled polythene bags, to the wet laboratory Department of Zoology, Aligarh Muslim University, Aligarh, India, and given a prophylactic dip in $KMnO_4$ solution (1:3000) and stocked in indoor cylindrical aqua-blue coloured, plastic lined (Plastic Crafts Corp, Mumbai, India, 1.22m in diameter 0.91m in height) fish tanks (water volume 600 L) for a fortnight. During this period, the fish were fed to apparent satiation by feeding diet consisting of mustard oil cake, soybean meal and wheat middling in the form of soft cake twice a day at 0900 and 1730 h. For conducting the experiment, *Oreochromis niloticus* fingerlings (0.57±0.05g; 3.54±0.18 cm) were sorted out from the above acclimated lot and stocked in triplicate groups in 70-L circular polyvinyl tanks (water volume 55 L) fitted with a continuous water flow-through (1-1.5 L min^{-1}) system at the rate of 20 fish per tank for each dietary treatment. Fish were fed test diets in the form of soft cake to apparent satiation twice daily at 0900 and 1600h. No feed was offered to the fish on the day they were weighed. Initial and weekly weights were recorded on a top-loading balance (Precisa 120A; 0.1 mg sensitivity, Oerlikon AG, Zurich, Switzerland). The feeding trial lasted for 6 weeks. Faecal matter and unconsumed feed, if any, were siphoned off before every feeding. The unconsumed feed was filtered on a screen soon after active feeding, dried and weighed to measure the amount of feed consumed. External deficiency signs and mortality if any, were examined and recorded.

Diet Formulation and Preparation

The soybean used as protein sources in this study was collected from Aligarh market, India commercial sources. These are; soybean (*Glycine* spp) meal (solvent extracted), groundnut (*Arach is hypogaea* L.) meal and cottonseed (*Gossypium* spp.)

cake (mechanically extracted). All the ingredients (which came as one batch) procured from local market and subjected to proximate analysis. Proximate composition was analyzed before any diet formulation to check the nutritional quality. Control diet containing 35% CP and 16.28 $kJ.g^{-1}$ GE was prepared. These levels are based on requirements for Nile tilapia fingerlings Anderson et al. (1991). Feasibility of replacing fishmeal with soybean meal for Nile tilapia *O. niloticus* fingerling were find out by preparing six diets replacing 0% D1, 20% D2, 40% D3, 60% D4, 80% D5, 100% D6 fish meal protein by soybean meal protein (Table 1). Six isonitrogenous (35% CP) and isocaloric (16.28 $kJ.g^{-1}$) diets were formulated using fish meal, soybean meal, ground nut cake, mustard oil cake and wheat middling. Crude protein content in the diet was fixed at 35% on the basis of earlier available information (Abdelghany, 2000; Niamat and Jafri, 1984). All the ingredients were weighed and blended in a Hobart electric mixer (A-200T Mixier Bench Model unit; Ottawa, Canada) thoroughly. These were then steam cooked at 80°C in a volume of hot water. Oil, mineral and (vitamin premixes were perpared as per Halver (2002), were added to the lukewarm bowl one by one with constant mixing at 60°C. The final diet with bread dough consistency, and then pellets were produced by manual meat grinder with 0.6 mm diameter and later were dried for 24 hrs and subsequently broken into crumbled form and each diet was packed in a plastic bag and stored until used. The proximate composition of the experimental diets used in this experiment were analyzed and are given in Table 1. Amino acid content of experimental diets was analysed using Amino Acid Analyzer (Hitachi L-8800; Tokyo, Japan). Recovery hydrolysis for analysis of tryptophan was performed in 4 N methanesulfonic acid and for sulphur amino acids in performic acid (Table 2). The fatty acid profiles of the experimental diets were analyzed gas liquid chromatography (GLC® Shimadzu GLC Ltd, Japan) and are given in Table 3.

Water quality parameters

Water temperature, dissolved oxygen, free carbon dioxide, pH, and total alkalinity during the feeding trial were recorded following standard methods (APHA, 1992). The average water temperature, dissolved oxygen, free carbon dioxide, pH, and total alkalinity over the 6-weeks feeding trial, based on daily measurements, were 25.6-27.7 ºC, 6.6-7.5 mg L^{-1}, 7.1-9.2 mg L^{-1}, 7.2-7.6 and 71-81.7 mg L^{-1}, respectively.

Proximate composition analyses

At the begining of experiment, 10 fish were euthanized at stocking and frozen (<-15 ºC) for initial whole-body composition analysis, and at the termination of the six weeks feeding trail, all fish were counted and weighted, and 10 fish per trough were ranndomly selected for analysis of whole-body composition. Assessment of proximate composition of ingredients, diets and carcass was made using standard techniques (AOAC 2005). Briefly, crude protein (N x 6.25) was determined (Kejeltec Tecator™ Technology 2300, Sweden), dry matter was determined after drying in a oven at 105 ºC, ash content was determined by incineration in a muffle furnace at 550 ºC for 8 hrs, crude fat (solven extraction with petroleum ether B.P 40-60ºC for 2-4 h Socs Plus, SCS 4, Pleican Equipments, Chennai, India).

Growth Parameters

The effects of replacing fish meal with soybean meal in diets on growth and conversion efficiency of fingerling *Oreochromis niloticus* during the present experiment was evaluated using following indices:

Absolute weight gain (g $fish^{-1}$) = Final individual body weight-Initial individual body weight

Live weight gain (LWG; %) = Final individual body weight-Initial individual body weight/Initial individual body weight × 100

Feed conversion ratio (FCR) = Dry feed fed/Wet weight gain

Protein efficiency ratio (PER) = Weight gain/Protein fed

Protein Retention Efficiency= (Final body weight x Final protein)-(Initial body weight x Initial protein)/ Initial Protein * 100

Specific growth rate (SGR; % day^{-1}) = Ln Final body weight-Ln Initial body weight/No. of days × 100

Per cent survival (SR;%) = (Final number of fish/Initial number of fish) × 100

Statistical analysis

All growth data were subjected to one-way analysis of variance (Sokal and Rohlf, 1981). When a significant treatment effect was observed, Tukey's honest significant difference test was used for multiple mean comparisons at a P<0.05 level of significance. Statistical analyses were done using Origin (version 6.1; Origin Software, San Clemente, CA).

Results

Over the 6 weeks feeding trial. replacement of fish meal by soybean meal on protein to protein basis was found to be feasible up to 40% as evident by insignificant differences among the live weight gain (600.18-608.77%), feed conversion ratio (1.54-1.63), protein efficiency ratio (1.74-1.86), specific growth rate (3.86-4.11%) and protein gain (0.43-0.48 g/fish) of fish fed diets D1, D2 and D3 where in 0, 20 and 40% fish meal protein was replaced by soybean meal protein (Table 4). However, further replacement of fish meal by soybean meal protein (beyond 40%) resulted in a significant decrease in growth and conversion efficiencies. Significantly (P>0.05) poorest LWG (308.77%), FCR (3.47), low PER (0.82), SGR (1.75%) and PG (0.09) were detected in fish fed diet D6 where in 100% fish meal protein is replaced with soybean meal protein. The amino acid and fatty acids composition of experimental diets was also affected by the substitution of fish meal by soybean meal (Table 2 and 3). Amino acid composition of the experimental diets was not significantly affected among the varying replacement groups. The fatty acid composition of the test diets was also not affected significantly except eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA) and docosapentaenoic acid (DPA) which were found to decrease in D4, D5 and D6 significantly (p>0.05) where in 60, 80 and 100% fish meal protein.

Body composition of the fish was significantly altered by the different replacement levels of soybean meal (Table 5). No remarkable differences in moisture content were evident in fish fed diets D1, D2 and D3. However, remarkable variations in body moisture were detected in fish fed diets D4, D5 and D6 compared to that of D1, D2 and D3. Ash content differed insignificantly among the groups. No significant differences amongst the body protein of the fish fed diets of D1, D2 and D3 replacing 0, 20 and 40% fish meal protein were evident. Whereas in fish fed diet D6 replacing 100% fish meal showed a sharp decline in body protein.

Discussion

The findings of the current study revealed that the improvement of feed and protein efficiencies attributed to the better growth performance in fish fed. Aquaculture feed industries are facing a serious problem of scarcity of its finite protein source such as fish meal. Successful replacement of fish meal by economical protein sources, even in minor quantities from a feed formulation, is desirable as it will obviously reduce the feed cost as well as farm production costs (Lovell, 1989; Amaya et al., 2007; NRC, 2011; Yıldırım et al., 2014). Nutrition is critical because feed typically represents approximately 50 percent of the variable production cost. Fish nutrition has advanced dramatically in recent years with the development of new, balanced commercial diets that promote optimal fish growth and health (Sidhu and Sidhu, 2020). Nutrition forms 70% of the total cost of animal or fish production thus making feed efficiency an important parameter for a successful business (Craig et al., 2017). In the absence of fishmeal, it is important to evaluate the nutritional value of alternative ingredients and formulate diets based on a mixture of ingredients which can collectively replace fishmeal in the diet of fish. Among the many protein sources available for animal feeds, plant proteins appear to be the most appropriate alternatives to fishmeal in fish diets. Partial replacement of fishmeal by plant proteins has been accomplished in many carnivorous cultured fish (Gomes et al., 1995; Kaushik et al., 1995, 2004; Robaina et al., 1995; Masumoto et al., 1996; Fagbenro, 1999, 2001; El-saidy and Gaber, 1997, 2002; Abeer et al., 2019), but total replacement has met with success in only a few cases (Kaushik et al., 1995; Regost et al., 1999). In view of this, a number of plant and animal protein sources have been used for the replacement of fish meal (Yue and Zhou, 2008; Ju et al., 2012; Macias-Sancho et al., 2014; Ding et al., 2015; Shiu et al., 2015; Sharawy et al., 2016; Yousif et al., 2019 a,b; Shao et al., 2019). In this experiment, replacement of fishmeal by soybean meal on protein to protein basis was found to be feasible up to 40% without compromising growth and feed conversion. However, further replacement of fishmeal by soybean meal beyond 40% resulted in a marked decrease in growth parameters. This reduction in growth may be because of the poor amino acid and fatty acid profile of the experiment diet due to lower amount of fish meal in this diet. This reduction may also be related to poor palatability of soybean meal and the high level of anti-nutritional factor in the soybean meal. The negative effects at high inclusion levels of plant protein sources are well documented from earlier work on trout (Gomes et al., 2004; Torstensen et al., 2008; Sanz et al., 1994; Barnes et al., 2014) and other species (Wang et al., 2012; Liu et al., 2012; Walker et al., 2010; Refstie et al., 2001; Opstvedt et al., 2003; Mundheim et al., 2004; Yousif et al., 2019 a,b).

In this study, reduced growth performance and higher feed conversion ratio were recorded in fish fed diets D4, D5, and D 6 with 60, 80 and 100% replacement value. This indicates that soybean meal cannot be used as a high level protein source for *Oreochromis niloticus.* These results are similar to that observed for Eyo and Olatunde (1998) mudfish *C. auguillaris* fingerlings; El-saidy and Gaber (2002) using SBM to replace FM for *Oreochromis niloticus* and their results showed that 55% can totally replace fish meal without adverse effect on fish performance; Li et al. (2020) in juvenile of *Nibea diacanthus* using fermented soybean meal, their results showed that replaced up to 31.57% of the fish meal diet with soybean meal without negative effects on growth performance; Muzini et al. (2004) fish meal and shrimp meal can be totally replaced with soybean meal in diets for juvenile red claw crayfish (*Cherax quadricarinatus*); Song et al. (2014) in juvenile starry flounder (*Platichthys stellatus*) replacing up to 70% of dietary FMP with SPH did not hamper growth or reduce feed efficiency of juvenile starry flounder, optimal replacement level restricted to 38.32%, successfully replaced 40% of the fish meal diet with soybean meal for Nile tilapia without negative effects on growth performance.

Conclusion

Result from the present experiments indicates that 40% of fish meal protein could be replaced by soybean meal without altering the growth, conversion efficiencies and body composition of fingerling *Orochromis. niloticus*, respectively. Thus, enabling formulation of cost-effective artificial feeds for the intensive culture of this fish.

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Table 1. Ingredients composition of experimental diets (35% C.P)

Ingredients (g/ 100 g dry diet)	D 1 (0%)	D 2 (20%)	D 3 (40%)	D 4 (60%)	D 5 (80%)	D6 (100%)
Fish meal[1]	14.71	11.76	8.82	5.88	2.94	0.00
Soybean meal[2]	0.00	4.44	8.89	13.33	17.78	22.22
Groundnut cake[3]	32.69	32.69	32.69	32.69	32.69	32.69
Mustard oil cake[4]	13.51	13.51	13.51	13.51	13.51	13.51
Wheat middling[5]	14.29	14.29	14.29	14.29	14.29	14.29
Cottonseed meal[6]	2.63	2.63	2.63	2.63	2.63	2.63
Mineral premix[7]	2.0	2.0	2.0	2.0	2.0	2.0
Vitamin premix[8]	3.0	3.0	3.0	3.0	3.0	3.0
Sunflower oil	5.0	5.0	5.0	5.0	5.0	5.0
Cod Liver oil	2.0	2.0	2.0	2.0	2.0	2.0
Alpha cellulose	10.17	8.67	7.16	5.66	4.16	2.65
Total	100	100	100	100	100	100
Proximate composition of the diet						
Protein (%)	35±0.08	35±0.27	35±0.18	35±0.48	35±0.05	35±0.34
Ether Extract%	7.21±0.04	7.37±0.15	7.48±0.61	7.32±0.28	7.22±0.36	7.52±0.41
Ash (%)	7.25±0.21	7.33±0.25	7.18±0.62	7.13±0.29	6.56±0.23	6.78±0.25
Fiber content (%)	6.63±0.3	6.32±0.5	6.38±0.4	6.43±0.4	6.36±0.2	6.33±0.1
Calculated gross energy (kJ g^{-1}, dry diet)	16.2±0.14	16.25±0.01	16.28±0.03	16.21±0.05	16.36±0.12	16.35±0.02

[1]Fishmeal 68% CP; [2]Soybean meal 45% CP; [3]Ground nut meal 52%; [4]Mustard Oil Cake 37; [5]Wheat Middling 14% CP and [6]Cottonseed meal 38%.[7]Mineral mixture (g/100g dry diet) calcium biphosphate 13.57; calcium lactate 32.69; ferric citrate 02.97; magnesium sulphate 13.20; potassium phosphate (dibasic) 23.98; sodium biphosphate 08.72; sodium chloride 04.35; almunium chloride.6H_2O 0.0154; potassium iodide 0.015; cuprous chloride 0.010; mangnous sulphate H_20 0.080; cobalt chloride. 6H_2O 0.100; zinc sulphate. 7H_2O 0.40 (Halver, 2002). [8]Vitamin mixture (g/100 dry diet) choline chloride 0.500;inositol 0.200; ascorbic acid 0.100; niacin 0.075; calcium pantothenate 0.05; riboflavin 0.02; menadione 0.004; pyridoxine hydrochloride 0.005; thiamin hydrochloride 0.005; folic acid 0.0015; biotin 0.0005; alpha-tocopherol 0.04; vitamin B_{12} 0.00001; Loba Chemie, India (Halver, 2002).

Table 2. Amino acid composition (% dry matter) of the experimental diets.

	Experimental Diets					
	D 1 (0%)	**D 2 (20%)**	**D 3 (40%)**	**D 4 (60%)**	**D 5 (80%)**	**D6 (100%)**
Arginine, %	2.66±0.01	2.61±0.03	2.55±0.05	2.49±0.01	2.43±0.03	2.38±0.02
Histidine, %	0.89±0.02[a]	0.87±0.04[ab]	0.85±0.02[b]	0.83±0.03[bc]	0.81±0.01[c]	0.79±0.01[d]
Isoleucine %	1.21±0.02[a]	1.18±0.02[a]	1.15±0.03[ab]	1.11±0.01[b]	1.08±0.02[c]	1.05±0.04[d]
Leucine %	2.26±0.03[a]	2.20±0.02[ab]	2.14±0.01[b]	2.08±0.04[c]	2.02±0.3[d]	1.96±0.02[e]
Lysine %	2.11±0.04[a]	2.02±0.05[a]	1.93±0.02[b]	1.84±0.04[c]	1.75±0.02[d]	1.65±0.05[e]
Methionine %	0.69±0.04[a]	0.63±0.02[b]	0.57±0.05[c]	0.51±0.01[d]	0.45±0.02[e]	0.38±0.03[e]
Cystine %	0.21±0.01[c]	0.24±0.02[b]	0.27±0.03[b]	0.30±0.01[ab]	0.33±0.02[a]	0.37±0.02[a]
Phenylalnine %	1.32±0.02[a]	1.29±0.01[a]	1.26±0.05[b]	1.23±0.03[c]	1.20±0.01[d]	1.17±0.3[e]
Tyrosine %	1.15±0.3[a]	1.12±0.02[ab]	1.09±0.02[b]	1.05±0.02[c]	1.02±0.04[cd]	0.99±0.01[d]
Threonine %	1.27±0.02[a]	1.23±0.03[ab]	1.18±0.02[b]	1.13±0.03[bc]	1.09±0.04[c]	1.04±0.05[d]
Tryptophan %	0.14±0.03[d]	0.17±0.02[c]	0.20±0.02[b]	0.22±0.03[b]	0.25±0.01[ab]	0.28±0.03[a]
Valine %	1.71±0.02[a]	1.67±0.03[a]	1.63±0.01[bc]	1.59±0.01[c]	1.54±0.02[c]	1.50±0.02[d]

[1]Mean values of 3 replicates±SEM; [2]Not statistically significant (P>0.05)

Table 3. Fatty acids Profile of the experimental diets

		Experimental Diets					
Fatty acid Profile		**D 1 (0%)**	**D 2 (20%)**	**D 3 (40%)**	**D 4 (60%)**	**D 5 (80%)**	**D6 (100%)**
Sat							
Myristic	14:0	$0.85±0.01^{a}$	$0.71±0.02^{b}$	$0.57±0.03^{c}$	$0.57±0.03^{c}$	$0.28±0.01^{d}$	$0.14±0.01^{e}$
Palmitic acid	16:0	$6.39±0.2^{d}$	$6.44±0.3^{c}$	$6.49±0.2^{b}$	$6.49±0.4^{b}$	$6.58±0.2^{a}$	$6.62±0.3^{a}$
Stearic acid	18:0	$1.64±0.2^{c}$	$1.70±0.3^{bc}$	$1.76±0.4^{b}$	$1.76±0.6^{b}$	$1.87±0.4^{a}$	$1.93±0.7^{a}$
Mon							
Palmitoleic acid	16:1 n-7	$1.31±0.02^{a}$	$1.11±0.03^{a}$	$0.92±0.01^{b}$	$0.92±0.03^{b}$	$0.53±0.01^{c}$	$0.34±0.01^{d}$
Oleic acid	18:1 n-9	$19.86±0.4^{c}$	$20.24±0.6^{bc}$	$20.62±0.2^{b}$	$20.62±0.2^{b}$	$21.38±0.8^{a}$	$21.76±0.4^{a}$
Gadoleic acid	20:1 n-11	$1.63±0.05^{a}$	$1.43±0.03^{b}$	$1.23±0.1^{c}$	$1.23±0.2^{c}$	$0.82±0.1^{d}$	$0.62±01^{e}$
Erucic acid	22:1 n-9	$1.07±0.02^{a}$	$0.88±0.01^{b}$	$0.68±0.02^{c}$	$0.68±0.01^{c}$	$0.30±0.01^{d}$	$0.10±0.01^{e}$
n-3 LC-PUFA							
Linoleic acid (LA)	18:2 n-6	$16.27±0.4^{d}$	$18.36±0.7^{c}$	$20.45±0.3^{b}$	$20.45±0.3^{b}$	$24.63±0.5^{a}$	$26.72±0.2^{a}$
Gamma-Linolenic acid (GLA)	18:3 n-6	0.03±0.01	0.02±0.01	0.02±0.01	0.02±0.00	0.02±0.00	0.01±0.00
Arachidonic acid	20:4 n-6	$0.13±0.01^{a}$	$0.11±0.02^{b}$	$0.09±0.03^{c}$	$0.09±0.01^{c}$	$0.05±0.02^{d}$	$0.03±0.01^{e}$
Alpha-Linolenic acid (ALA)	18:3 n-3	$0.25±0.2^{e}$	$0.51±0.1^{d}$	$0.76±0.3^{c}$	$0.76±0.2^{c}$	$1.27±0.1^{b}$	$1.53±0.4^{a}$
Stearidonic acid	18:4 n-3	$0.30±0.01^{a}$	$0.25±0.02^{ab}$	$0.20±0.01^{b}$	$0.20±0.02^{b}$	$0.10±0.01^{c}$	$0.05±0.01^{d}$
Eicosapentaenoic acid (EPA)	20:5 n-3	$1.36±0.02^{a}$	$1.13±0.01^{a}$	$0.90±0.02^{b}$	$0.90±0.03^{b}$	$0.45±0.02^{c}$	$0.22±0.01^{d}$
Docosapentaenoic acid (DPA)	22:5 n-3	$0.52±0.01^{a}$	$0.42±0.01^{b}$	$0.33±0.01^{c}$	$0.33±0.04^{c}$	$0.14±0.01^{d}$	$0.05±0.02^{e}$
Docosahexaenoic acid (DHA)	22:6 n-3	$1.80±0.02^{a}$	$1.51±0.02^{ab}$	$1.22±0.02^{b}$	$1.22±0.03^{b}$	$0.65±0.01^{c}$	$0.36±0.02^{d}$

[1]Mean values of 3 replicates±SEM; [2]Not statistically significant (P>0.05)

Table 4. Growth, conversion efficiencies, survival and carcass composition of fingerling *Oreochromis niloticus* fed soybean meal based diet

	Varying replacement levels of fish meal by soybean meal (%)					
	D 1 (0%)	**D 2 (20%)**	**D 3 (40%)**	**D 4 (60%)**	**D 5 (80%)**	**D6 (100%)**
Initial weight (g/fish)[1,2]	0.57±0.01	0.57±0.03	0.57±0.01	0.57±0.02	0.57±0.02	0.57±0.01
Final weight (g/fish)[1,2]	2.90±0.01[a]	2.93±0.02[a]	3.20±0.04[a]	2.27±0.05[b]	1.69±0.02[c]	1.19±0.03[d]
Absolute weight gain (g/fish)[1,2]	3.47±0.03[a]	3.51±0.02[a]	3.42±0.01[a]	2.84±0.02[b]	2.26±0.01[c]	1.76±0.01[d]
Live weight gain (%)[,2]	608.77±0.9[a]	605.17±0.5[a]	600.18±0.4[a]	498.25±0.7[b]	396.49±0.3[c]	308.77±0.5[d]
Protein retention efficiency (%)[1,2]	21.62±0.2[b]	21.61±0.4[b]	25.74±0.1[a]	14.58±0.1[c]	8.27±0.3[d]	4.03±0.2[e]
Protein gain (g/fish)	0.43±0.02[a]	0.43±0.01[a]	0.48±0.03[a]	0.29±0.01[b]	0.17±0.02[c]	0.09±0.01[d]
Specific growth rate (%/day)	3.87±0.02[a]	3.86±0.03[a]	4.11±0.03[a]	3.29±0.05[b]	2.59±0.01[c]	1.75±0.02[d]
Feed conversion ratio	1.63±0.01[d]	1.62±0.03[d]	1.54±0.02[e]	1.98±0.03[c]	2.65±0.02[b]	3.47±0.02[a]
Feed intake (mg $fish^{-1}$ day^{-1})	5.69±0.01	5.69±0.04	5.27±0.02	5.62±0.04	5.99±0.01	6.11±0.02
Protein efficiency ratio	1.74±0.02[b]	1.76±0.02[b]	1.86±0.01[a]	1.44±0.03[c]	1.08±0.01[d]	0.82±0.03[e]

[1]Mean values of 3 replicates ± SEM.
[2]Mean values sharing the same superscripts are insignificantly different (P > 0.05).

Table 5. Carcass composition (%wet basis) and survival of fingerling *Oreochromis niloticus* fed diets containing varying replacement levels of fish meal by soybean meal [1,2]

	Varying replacement levels of fish meal by ground nut cake (%)						
	Initial	**D 1 (0%)**	**D 2 (20%)**	**D 3 (40%)**	**D 4 (60%)**	**D 5 (80%)**	**D 6 (100%)**
Moisture (%)	74.68±0.22	78.18±0.34[a]	78.20±0.56[a]	78.21±0.27[a]	76.24±0.22[b]	74.45±0.86[c]	73.13±0.19[d]
Crude protein (%)	12.86±0.23	16.48±0.23[a]	16.47±0.13[a]	16.87±0.14[a]	14.28±0.32[b]	12.15±0.25[c]	11.67±0.11[d]
Crude fat (%)	3.58±0.43	3.67±0.18[c]	3.66±0.14[c]	3.65±0.23[c]	4.25±0.28[b]	4.82±0.22[b]	5.21±0.12[a]
Ash (%)	2.36±0.22	2.22±0.01	2.21±0.02	2.22±0.02	2.19±0.03	2.17±0.01	2.15±0.01
Survival (%)	-	100	100	100	98	95	90

[1] Mean values of 3 replicates±SEM; [2]Not statistically significant (P>0.05).

أثر إستبدال مسحوق الأسماك بمسحوق فول الصويا على النمو . معدل التحول الغذائي والتركيب الكيميائي لأصبعيات أسماك البلطي النيلي

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المستخلص

أجريت هذه التجربة لإستبدال مسحوق الاسماك بمسحوق فول الصويا لعليقة لاصبعيات أسماك البلطي النيلي *Oreochromis niloticus* (0.57±0.05 جم 3.54±0.18 سم) لستة علائق (35% بروتين خام و 16.28 كيلوجول / جرام طاقة نمو) بمعدل احلال 0 , 20 , 40 , 60 , 80 و 100% مسحوق سمك بمسحوق فول الصويا. وتم توزيع العلائق علي الثلاثة مكررات إلى حد الأشباع لمدة 6 اسابيع. حيث كان الوزن الحي المكتسب (308,77-608,77%) , معدل كفاءة البروتين (4,03-25,74%) , معدل النمو النوعي (1,75 -4,11 % اليوم) , معدل التحول الغذائي (1,54-3,47) و معدل كفاءة البروتين (0,82 -1,86) للاسماك التي تمت تغذيتها بعليقة 0 , 20 و 40% احلال لمسحوق السمك بمسحوق فول الصويا لاتوجد اي فروق معنوية. وبالتالي معدل احلال مسحوق السمك بمسحوق فول الصويا بنسبة 40%. لاتوجد فروق معنوية, وعليه يمكن تركيب علائق اقتصادية للاسماك المستزرعة في النظام المكثف.