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EFFECT OF PARTIAL AND TOTAL REPLACEMENT OF FISH MEAL BY SOYBEAN MEAL ON GROWTH AND PROXIMATE ANALYSIS OF NILE TILAPIA

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SUMMARY

A 16 week feeding trial was conducted in aquaria with all-male sex-reversed Nile tilapia *Oreochromis niloticus* (2.79±0.5 g). Five isonitrogenous (25% protein) and isocaloric (288 Kcal metabolizable energy/100g) diets were formulated to replace 0, 25, 50, 75 and 100% of fish meal protein with soybean meal protein. The experimental diets were tested in two replicates to evaluate the effects of replacing fish meal protein (FMP) with soybean meal protein (SMP) on growth, feed utilization, carcass traits and proximate analysis of all-male sex-revered Nile tilapia *O. niloticus*. After 16 weeks, fish fed a diet with 100% FMP had a significant ($P<0.001$ and $P<0.05$) higher individual body weight and body length than fish fed any of the other diets. No significant differences ($P>0.05$) were found in condition factor (K), feed conversion ratio (FCR) and protein efficiency ratio (PER). Daily weight gain (DWG) decreased significantly ($P<0.001$) with each increase of soybean meal level in formulated diets. Percentages of dressing, flesh, viscera, bone and by-products were not significantly ($P>0.05$) affected by inclusion levels of SMP and FMP in tilapia diets. Proximate analysis of whole fish body indicated that, the inclusion levels of SMP and FMP had significant effects ($P<0.001$) on protein, fat and ash contents where fish fed the diet D1(0% SMP) showed higher percentages of protein and fat and the lower percentage of ash. Proximate analysis of flesh indicated that, inclusion levels of SMP and FMP did not significantly affected moisture, protein and ash but fat content decreased significantly ($P<0.001$) with increasing SMP in the diet. These results support the use of soybean meal as important replacement protein sources for fish meal in practical feeds for tilapia fish.

Key words: *Nile tilapia, growth performance, body composition, fish meal, soybean meal*

INTRODUCTION

Fish meal is one of the most expensive ingredients in fish diets. Fish nutritionists have tried to use less expensive plant protein sources to partially or totally replace fish meal. 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 fish diets (Lovell, 1988). Kaushik *et al*., (1995)

were able to achieve total substitution of fish meal by soy protein concentrate in the diet of rainbow trout, *Oncorhynchus mykiss*. However, growth has tended to be reduced in fish fed diets with soybean replacing all the fish meal (Mohsen and Lovell, 1990; Shiau *et al.,* 1990; Webster *et al*., 1992; Shouqi *et al*., 1998; Carter and Hauler, 2000; Elangovan and Shim, 2000 and Floreto *et al*., 2000) and the lower growth rate may be due to reduced amino acid availability in diets with a high percentage (>50%) of soybean meal (Darbowsky *et al*., 1989). Reasons for this decreased growth is due to the activity of protease (trypsin) inhibitors in crude or inadequantly heated soybean meal (Willson and Pope, 1985). Although, soybean protein has a well-balanced amino acid profile for fish, it is low in methionine (Storebakken *et al*., 2000). The energy content of soybean meal is lower than that of fish meal in diets for fish (Hilton and Slinger, 1986). As reviewed by Storebakken *et al*., (2000), toasting (steam-cooking) of meals inactivates proteinase inhibitors and agglutinating lectins.

Further extraction with ethanol and/or acidic water produce soy protein concentrates which typically contain 50-70% crude protein (Lusas and Riaz, 1995). This additional extraction removes water-soluble carbohydrates, soybean isoflavones, antigenic storage proteins and factor(s) inducing distal enteritis, but not phytic acid (reviewed by Storebakken *et al*., 2000). Viola *et al*., (1983) reported that heating soybean meal at 105°C for 30-90 min destroyed most of the trypsin inhibitors present. However, excessive heating may cause loss of essential amino acids (Plakas *et al*., 1985). Soaking in tape water and in normal saline (0.9%), gamma irradiation and treatment under pressure completely destroyed the trypsin inhibitor and the hemagglutinin activity in soybean (Eman, 2001). Results of studies conducted to evaluate the potential of different soybean products (soybean meal, full-fat soybeans, soy isolates and concentrates) however, show much variability. This is attributed mostly to processing technologies involved and to the presence of various anti-nutritional factors such as lectins, protease inhibitors, antigenic or estrogenic factors, oligosaccharides, ect. (Liener, 1989). Hence the objective of this study was to evaluate the replacement (partially or totally) of fish meal by soybean meal in tilapia diets on growth, carcass and proximate analysis of all male sex-reversed Nile tilapia, *O. niloticus*.

MATERIALS AND METHODS

The present experiment was carried out at the Central Laboratory for Aquaculture Research at Abbassa, Sharkia Governorate, Egypt. The experiment started on the 4th August 2000 and continued to the end of November of the same year. A total number of 500 *O. niloticus* fry (2.79±0.05 g). were obtained from Kafr El-Sheikh hatchery, and randomly distributed into ten rectangular aquaria (100×50×40cm) representing 5 treatments (with 2 replicates) and each aquarium was stocked with 50 fish.

Tested diets were formulated to contain 25% crude protein and 288 Kcl/100g ME. The composition of the experimental dies are illustrated in table (1). Fish were given 10% of total biomass per day until the end of the 8th week and then decreased to 5% until the end of the experimental period (16 weeks) and fish were fed the prepared diets at a rate mentioned above 6 days/week (twice daily at 10 a.m and 2 p.m). A biweekly fish sample (15 fish) were randomly chosen from each aquarium and

weighed and the amount of feed was adjusted according to the changes in body weight throughout the experimental period.

Growth performance and feed efficiency parameters:

Records of live body weight (g) and body length (cm) of individual fish were measured in 15 fish for each aquarium and repeated every two weeks. The other growth performance and feed efficiency parameters were measured by using the following equations:

Condition factor (K)=100 [W/L^3], where W=weight of fish in grams and L = Total length of fish in cm.

Specific Growth Rate (SGR)= $100(LnW_2-LnW_1)/T_2-T_1$, where W_2 is the weight at T_2 and W_1 is the weight at T_1 and Ln is the natural log.

Daily weight gain = total weight gained (g)/period (days).

Feed conversion ratio (FCR) = dry feed ingested (g)/weight gain (g).

Protein efficiency ratio (PER) = weight gain (g)/protein ingested (g)

Carcass and proximate analysis:

At the end of the experiment, five fish were randomly chosen from each aquarium and weighed and slaughtered and carcass traits were carried out according to Lovell (1981). Another five fish were used for the proximate analysis of the whole fish body. Proximate analysis for feed, whole fish and fillet was carried out according to the methods of AOAC (1990).

Statistical analysis:

The statistical analysis of data was carried out by using the computer program, SAS (1996) by adopting the following fixed model.

$$Y_{ijk} = \mu + \alpha_i + \beta_j + e_{ijk}$$

Where: Y_{ijk} = observation of the ijk^{th} fish, μ = overall mean, α_i = fixed effect of the i^{th} replicate, β_j = fixed effect of the j^{th} diet and e_{ijk} = random error assumed to be independently and randomly distributed (0, $\delta^2 e$).

RESULTS AND DISCUSSION

Growth performance:

As presented in table (2) fish initial body weight ranged between 2.77 to 2.87 g with insignificant differences among the fish groups fed the experimental diets indicating the complete randomization of fish dividing among the experimental fish groups at the start. After 16 weeks from the experimental start average body weights for fish fed the different tested diets D1(0%SMP), D2(25%SMP), D3(50%SMP), D4(75%SMP) and D5(100%SMP) were 58.80, 52.83, 51.90, 47.42 and 45.18 g, respectively. Statistical evaluation of these results indicated that, live body weight decreased significantly ($P<0.001$) with each increase in replacing level of FMP by SMP. Viola and Arieli (1983) indicated that, soybean meal could be used to replace up to half of the fish meal in tilapia feeds containing 25% protein while, Shiau *et al*., (1990) found that, defatted soybean meal or full-fat soybean meal can be used to replace 30% fish meal protein in a diet for *O. niloticus* × *O. aureus* fingerling hybrids when protein level is low (24%).

With other fish species, Webster *et al*., (1992) found that, after 12 weeks, final body weights of blue catfish (*Ictalurus furcatus*), were decreased as replacing percentage of fish meal with soybean which increased form 48% to 69%. Carter and Hauler (2000) replaced 25 and 33% of fish meal by soybean meal or protein concentrates made from narrow-leafed lupine or field pea in diets for Atlantic salmon, *Salmo salar* and found insignificant differences in body weight between the control and diets containing the plant protein. Elangovan and Shim (2000) indicated that, soybean meal could be replace up to 50% of fish meal in the diet without any significant effect on body weight of tin foil barb*, Barbodes altus*.

As presented in table (2) averages of initial body length ranged between 5.28 to 5.49 cm with insignificant differences among the fish groups fed the experimental diets. After 16 weeks from the experimental start, results indicated that, fish body length decreased with each increase in replacing levels of FMP by SMP and the longest bodies were recorded in D1(0%SMP) group followed in a decreasing order by D2(25%SMP), D3(50%SMP), D4(75%SMP) and D5(100%SMP) group. Statistical analysis of these results indicated that, the differences between body lengths for fish fed D1 and each of the other four experimental diets were significant ($P<0.05$), but the differences between the other diets (D2, D3, D4 and D5) were insignificant. These results are agreed those obtained by Webster *et al*., (1992). They found that, blue catfish (*Ictalurus furcatus*) fed the control diet (48% soybean meal and 13% fish meal) were significantly longer than fish fed the diet with 55% soybean meal and 9% fish meal and also than the diet with 62% soybean meal and 4% fish meal.

Average values of condition factor (K) ranged between 1.74 and 2.00 at start and between 1.61 and 1.65 at the end of experiment with insignificant differences between the different diets tested for condition factor (K) at start and end of the experiment (Table 2). These results are in partial agreement with those of Eid and Magouz (1995). They reported that, K values ranged between 2.20 to 2.33 for Nile tilapia fed diets containing different protein sources (fish meal, soybean meal, linseed meal, corn gluten, tomato waste, clover leafs, duck weed, poultry by-products meal, bone and meat meal) and the differences were not significant.

Specific growth rate (SGR) values during the whole experimental period i.e. (0-16 weeks) were 2.73, 2.61, 2.62, 2.54 and 2.48% (Table 2) for the tested diets D1, D2, D3, D4 and D5, respectively with significant differences ($P<0.001$) between these values where SGR decreased with each increase in replacing level of FMP by SMP and these results are in agreement with studies reported on tilapia, *O. niloticus*×*O. aureus* (Shiau *et al*., 1990), rainbow trout, *Oncorhynchus mykiss* (Reinitz, 1980), common carp, *Cyprinus carpio* (Nandesha *et al*., 1989); channel catfish, *Ictalurus punctatus* (Moshen and Lovell, 1990) blue catfish *Ictalurus furcatus* (Webster *et al*., 1992); African catfish, *Clarias gariepinus* (Van-Weerd *et al*., 1999); bream, *Megalobrama skolkovii*, (Haiqing and Xiqin, 1994); Chinese longsnout catfish, *Leiocassis longirostris* (Shouqi *et al*., 1998) and Atlantic salmon, *Salmo salar* (Carter and Hauler, 2000). Also, Escaffre *et al*., (1997) found that, incorporation of soybean concentrate levels of up to 40% in diets did not adversely affect growth of common carp larvae, but at levels of 60 or 70%, growth retardation was observed which was not improved by sulfur amino acids supplementation.

On the other hand, Vielma *et al*., (2000) indicated that, rainbow trout, *Oncorhynchus mykiss* fed the diet supplying 69% of protein from soybean ingredients

grew significantly faster and weighed significantly more than fish fed diets with fish meal as a source of protein alone.

As shown in table (2), averages daily weight gain (DWG) during the whole experimental period were 0.50, 0.45, 0.44, 0.40 and 0.38 g for the tested diets listed above and the differences between these values were significant ($P<0.001$). These results indicate that, increased inclusion level of SMP significantly decrease DWG of Nile tilapia. Elangovan and Shim (2000) found that tin foil barb, *Barbodes altus* fed the diet containing FM/SM ratio of 1:1 had significantly ($P<0.05$) lower gain than fish fed the other diets containing FM/SM ratios of 3:1 and 2:1.

On the other hand, Floreto *et al*., (2000) show that SM levels of not more 50% of dietary protein significantly resulted in higher body weight gains than the higher SM levels in diets of the American lobster, *Homarus Americans*. Shiau *et al*., (1990) found that weight gain of tilapia fish *O. niloticus* × *O. aureus* fed diets in which 30% of fish meal protein was replaced by defatted soybean meal or by full-fat soybean meal were not significantly ($P>0.05$) different from those of fish fed the control diet (fish meal).

Feed utilization:

Feed conversion ratio (FCR) during the whole experimental period (0-16 weeks) were 3.02, 3.02, 3.02, 3.00 and 3.14 (Table 2) for the experimental diets D1(0%SMP), D2(25%SMP), D3(50%SMP), D4(75%SMP) and D5(100%SMP), respectively with insignificant differences between these values indicating the possibility of complete replacement of FMP by SMP in tilapia diets without any adverse effect on the feed conversion ratio and these results are in agreement with those of tilapia *O. niloticus* × *O. aureus* (Shiau *et al*., 1990), blue catfish *Ictalurus furcatus* (Webster *et al*., 1992) rainbow trout, *Oncorhynchus mykiss* (Kaushik *et al*., 1995); Atlantic salmon, *Salmo salar* (Carter and Hauler, 2000). On the other hand, Shouqi et al., (1998) found that, FCR for Chinese longsnout catfish, *Leiocassis longirostris* decreased significantly when fish meal was replaced by soybean meal. Similar results obtained with tin foil barb, *Barbodes altus (*Elangovan and Shim, 2000).

During the whole experiment period protein efficiency ratio (PER) for the tested diets was relatively equal to 1.34 (Table 2) and this refers to the possibility of complete replacement of FMP by SMP without any adverse effect on protein efficiency ratio in order to reduce the feeding costs for this fish specie. Shiau *et al*., (1990) found that PER for *O. niloticus* × *O. aureus* fed diets in which 30% of fish meal protein was replaced by defatted soybean meal or by full-fat soybean meal were not significantly ($P>0.05$) different from those fed the control diet (fish meal only) and the same results were obtained for blue catfish *Ictalurus furcatus* (Webster *et al*., 1992); rainbow trout, *Oncorhynchus mykiss* (Kaushik *et al*., 1995). In a recent study, Carter and Hauler (2000) replaced 25 and 33% of fish meal with soybean meal or narrow-leafed lupin or field pea in diets of Atlantic salmon, *Salmo salar* they found that, the increased inclusion of soybean meal or field pes from 25% to 33% had no significant effect on PER but there were significant reductions when narrow-leafed lupin was included at 33%.

Carcass traits:

Results of dressing percentage (table 3) show that, the higher dressing percentage obtained with the diet D2(25% SMP) and decreased gradually with each increase of soybean meal protein in the diet. The higher flesh percentage (37.64%) obtained with

D3(50%SMP) followed by D2(25%SMP), and D1(0%SMP), and the lowest percentage (34.40%) recorded with D5(100%SMP) and the differences were not significant. Table (3) also indicated that, the increase in replacing level of FMP with SMP increased flesh percentage until the inclusion level 50% i.e. D3(50%SMP) and decreased gradually to 35.2% for D4(75%SMP) and 34.4% for D5(100%SMP).

With respect to head percentage recorded, the higher values were obtained in carcasses of fish fed D5(100%SMP) and the differences between D5 and each of the other diets were significant but the differences between the other treatments D1, D2 and D3 were not significant. Percentage of viscera ranged between 3.16 to 4.10% with insignificant differences between viscera percentage as affected by the inclusion level of FMP and FMP and the same trend was also observed for the percentages of scales. With regard to the total by-products (head+viscera+bone+scales+fins) results of table (3) show that, increasing the replacing level of FMP with SMP followed by increase the percentage of by-products from 52.47 and 52.32% for D1(0%SMP) and D2(25%SMP) to 56.74 and 55.88% for D3(50%SMP) and D4(75%SMP) and for 58.30% for D5(100%SMP), respectively and the differences between these total by-products percentages were not significant (P>0.05).

Proximate analysis of fish:

Proximate analysis, the measurements of the amounts of moisture, protein, lipid and ash is routinely conducted on experimental fish at the end of feeding trials. Knowledge of the proximate composition of the fish allows assessment of fish health, determination of efficiency of transfer of nutrients from the feed to the fish and make it possible to predictably modify carcass composition (Shearer, 1994)

a. Proximate analysis of whole fish:

Results in table (4) indicated that averages moisture content of whole fish were 79.23, 77.43, 80.55, 76.09 and 77.40% for D1, D2, D3, D4 and D5, respectively with insignificant differences between these averages. Webster ***et al***., (1992) and Haiqing and Xiqin (1994) found that, moisture content of blue catfish, *Ictalurus furcatus* and bream, *Megalobrama skolkovii* did not significantly different with increasing percentage of SM as a replacement for FM in fish diets.

The higher protein percentage (64.44%) was obtained for fish fed the diet D1 (0% SMP) and the increase in inclusion levels of SMP to 25% or 50% in diets did not significantly affect the protein content of whole fish, but when the inclusion levels of SMP reached to 75% or 100%, protein content of whole fish decreased significantly (P<0.001) to 61.97 and 61.70%, respectively. Eglal Omar and Nour (1986) found that, the protein content in common carp *Cyprinus carpio* fed on fish meal containing diets was higher than in diets containing a mixture of plant and animal proteins or plant protein alone. Also, Elangovan and Shim (2000), found that, body protein content of tin foil barb*, Barbodes altus* did not significantly differ when fish meal replaced up to 50% with soybean meal.

Fat percentage in whole fish decreased significantly (P<0.001) as inclusion levels of SMP increased (table 4). Similar results were obtained by Mohsen and Lovell (1990), they found that, fat percentage of channel catfish, *Ictalurus punctatus* increased with each addition of fish meal to the diet. Elangovan and Shim (2000) demonstrated that, fat content of tin foil barb*, Barbodes altus* significantly decreased as FM/SM decreased from 3:1 to 2:1 and 1:1.

The higher ash percentage (32.43%) was estimated for fish fed the diet D3 (50% SMP) and the lowest one (27.84%) was obtained by fish fed the diet D1 (0% SMP). Fish fed the diet D3 had a significant ($P<0.001$) higher body ash content than fish fed the other diets, although the body ash content among fish fed D1, D2, D4 and D5 did not significant different.

The present results indicate that, ash content of whole fish increased as fish meal level increased up to the level of 50% and the higher levels of SMP (75 and 100%) decreased the ash content of the whole fish. These results had the opposite trend obtained by Elangovan and Shim (2000) with tin foil barb*, Barbodes altus*.

b. Proximate analysis of fillet:

As described in table (4), moisture content of fish fillet increased as the replacing level of FMP by SMP increased up to 50% and the higher levels (75 and 100%) of replacing of FMP by SMP followed by decrease in the moisture content of fillet and the opposite trend was observed for the fat percentage in fish fillet where fat percentages in fish fillet decreased significantly ($P<0.001$) with the increase of SMP level in the diets. An obvious trend in fillet protein and ash did not occur where the differences in protein and ash content of fish fillet were not significant ($P>0.05$) and these results are in accordance with those obtained by Webster *et al*., (1997).

CONCLUSION

The obtained results show some variability, but do not reject the use of soybean as an important replacement protein source for fish meal in practical diets in order to reduce the feeding costs. Soybean could be replace up to 25% of fish meal with slight decrease on growth performance of Nile tilapia and we can overcome the adverse effect of this replacement by rearing fish for longer time because results of the present study demonstrated that the complete replacement of fish meal by soybean mead did not significantly affected the feed conversion ratio and protein efficiency ratio.

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Table (1): Formulation and proximate analysis of experimental diets.

Item	Experimental diets				
	D1	D2	D3	D4	D5
Feed Ingredient					
Fish meal	22	16.5	11	5.5	0
Soybean meal	0	8.8	17.76	26.6	35.5
Yellow corn	30	34	35	34	35.3
Wheat flour	15.2	9	6.44	7.1	4.3
Shrimp meal	8	9.9	12	13.4	15.3
Corn oil	5	5	5	5	5
Bran	17	14	10	5.6	1.8
Bone meal	2	2	2	2	2
Vitamins & Minerals mixture[1]	0.5	0.5	0.5	0.5	0.5
Ascorbic acid	0.3	0.3	0.3	0.3	0.3
Sum	100	100	100	100	100
Metab. energy (Kcal/100g)[2]	287.96	287.95	287.82	288.00	287.97
Proximate analysis, %					
Moisture	11.46	12.48	13.31	12.22	14.13
Protein	24.75	24.82	24.87	24.88	24.82
Crude fat	6.97	7.24	6.78	7.53	7.25
Ash	11.61	13.25	11.8	12.64	11.12

1- Vitamin and mineral premix per kilogram feed: Vitamin D, 5000 IU; A, 100 IU; E, 20 mg; Riboflavin, 25 mg; Niacin, 100 mg; Choline chloride, 2 g; Pantothenic acid, 50 mg; Pyrodoxine, 2g; B12, 0.05 mg; Mn, 25 mg; Zn, 55 mg; Fe, 0.25 g; Cu, 7.8 mg; I, 2.9 mg and Co, 4.8 mg.

2- Estimated based on values of the diet ingredients (NRC, 1983)

Table (2): Effect of increasing percentage of soybean meal protein and decreasing fish meal protein on growth and feed utilization of Nile tilapia, *O. niloticus*.

	Diets					*P*
	D1(0%SM)	**D2(25%SM)**	**D3(50%SM)**	**D4 (75%SM)**	**D5(100%SM)**	
Body weight (g)						
Initial	2.87±0.11	2.82±0.11	2.82±0.11	2.77±0.11	2.80±0.11	NS
Final	58.80±0.92a	52.83±0.92 b	51.90±0.92 b	47.42±0.92 c	45.18±0.92 c	<0.001
Body length (cm)						
Initial	5.49±0.13	5.31±0.13	5.31±0.13	5.31±0.13	5.28±0.13	NS
Final	16.43±0.6 a	14.77±0.60 b	14.73±0.60 b	14.33±0.60 b	14.14±0.60 b	<0.05
Condition factor (K)						
Initial	1.74±0.09	2.00±0.09	1.90±0.09	1.88±0.09	1.93±0.09	NS
Final	1.65±0.03	1.65±0.03	1.63±0.03	1.61±0.03	1.63±0.03	NS
SGR	2.73±0.02 a	2.61±0.02 b	2.62±0.02 b	2.54±0.02 c	2.48±0.02 c	<0.01
DWG	0.50±0.01 a	0.45±0.01 b	0.44±0.01 b	0.40±0.01 c	0.38±0.01 d	<0.001
FCR	3.02±0.48	3.02±0.48	3.02±0.48	3.00±0.48	3.14±0.48	NS
PER	1.34±0.02	1.34±0.02	1.34±0.02	1.34±0.02	1.28±0.02	NS

Means within each row having different letters were significantly different (P<0.05).
NS = non-significant

Table (3): Effect of increasing percentage of soybean meal protein and decreasing fish meal protein in experimental diets on carcass traits of Nile tilapia, *O. niloticus*.

	Diets					
Item	**D1(0%SM)**	**D2(25%SM)**	**D3(50%SM)**	**D4(75%SM)**	**D5(100%SM)**	***P***
Dressing (%)	51.72±1.50	53.07±1.50	52.67±1.50	51.50±1.50	49.43±1.50	NS
Flesh (%)	35.73±1.22	36.69±1.22	37.64±1.22	35.20±1.22	34.40±1.22	NS
Head (%)	28.36±1.16 b	28.40±1.16 b	29.58±1.16 b	30.05±1.16 ab	33.44±1.16 a	<0.05
Viscera (%)	4.10±0.37	3.24±0.37	3.84±0.37	4.05±0.37	3.16±0.37	NS
Bone (%)	12.86±0.58	12.37±0.58	12.21±0.58	11.86±0.58	11.44±0.58	NS
Scales (%)	4.27±0.28	4.04±0.28	3.97±0.28	4.76±0.28	4.19±0.28	NS
Fins (%)	3.96±0.22 bc	4.15±0.22 bc	3.70±0.22 c	4.42±0.22 ab	4.91±0.22 a	<0.01
By-products (%)	52.47±1.84	52.32±1.84	56.74±1.84	55.88±1.84	58.30±1.84	NS

Means within each row having different letters were significantly different (P<0.05).
NS = non-significant

Table (4):Effect of increasing percentage of soybean meal protein and decreasing fish meal protein in experimental diets on proximate composition of Nile tilapia.

Item	Experimental diets					*P*
	D1(0%SM)	D2(25%SM)	D3(50%SM)	D4(75%SM)	D5(100%SM)	
Whole fish						
Moisture%	79.23±1.29	77.43±1.29	80.55±1.29	76.09±1.29	77.40±1.29	NS
Protein%	64.44±0.42 a	63.28±0.42 a	63.59±0.42 a	61.97±0.42 b	61.70±0.42 b	<0.001
Fat%	7.73±0.18 a	6.65±0.18 b	6.20±0.18 bc	5.84±0.18 cd	5.50±0.18 d	<0.001
Ash%	27.84±0.58 b	28.93±0.58 b	32.43±0.58 a	28.69±0.58 b	28.95±0.58 b	<0.001
Fillet						
Moisture%	79.51±0.75	80.35±0.75	81.44±0.75	81.03±0.75	78.89±0.75	NS
Protein%	87.60±3.80	83.78±3.80	85.22±3.80	77.31±3.80	83.41±3.80	NS
Fat%	5.70±0.32 a	5.52±0.23 a	4.73±0.23 b	4.14±0.23 b	4.21±0.23 b	<0.001
Ash%	7.75±0.49	8.07±0.49	7.91±0.49	7.28±0.49	7.98±0.49	NS

Each values is the means±SE of 10 fish (5 fish per each replicate).
Protein, fat and ash were determined based on dry weight.
Means within each row having different letters were significantly different (P<0.05).
NS = non-significant

الملخص العربى

تأثير الإحلال الجزئى والكلى لمسحوق السمك بفول الصويا على النمو وتركيب الجسم فى أسماك البلطى النيلى

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أجريت هذه التجربة بغرض دراسة تأثير إحلال فول الصويا محل مسحوق السمك فى علائق أسماك البلطى النيلى التى ربيت فى أحواض زجاجية طول فترة التجربة. وقد أستخدمت فى هذه زريعة بلطى نيلى وحيد الجنس متوسط وزنه ٢٫٨ جرام. وفى بداية التجربة تم تكوين خمسة علائق متساوية فى محتواها من البروتين (٢٥% بروتين خام) والطاقة (٢٨٨ كيلو كالورى طاقة ممثلة/١٠٠ جرام عليقه) وتم إحلال بروتين مسحوق السمك ببروتين فول الصويا بنسب مقدارها صفر، ٢٥%، ٥٠%، ٧٥%، ١٠٠% فى العلائق الخمسة ودرس تأثير كل عليقة من العلائق الخمسة على النمو والإستفادة من الغذاء والتحليل الكيميائى لأسماك البلطى التى وزعت على عشرة أحواض (مكررين لكل معاملة) وكان من أهم النتائج المتحصل عليها مايلى:

عند نهاية التجربة والتى أستمرت ١٦ أسبوع وجد أن وزن وطول الجسم للأسماك التى غذيت على العليقة الأولى (١٠٠% مسحوق سمك) كان أكبر معنوياً من تلك التى غذيت على العلائق الأربعة الأخرى بينما كانت الفروق غير معنوية بين المعاملات الخمسة وذلك بالنسبة لمعامل الحالة ، ومعدل تحويل الغذاء وكذلك كفاءة تحويل البروتين. أما متوسط الزيادة اليومية فى وزن الجسم قد أنخفضت تدريجياً بزيادة نسبة إحلال بروتين مسحوق السمك ببروتين فول الصويا.

لم يكن للعلائق الخمسة تأثير معنوى على نسب معظم مكونات الذبيحة فى الأسماك مثل نسبة التصافى ونسبة اللحم ونسبة الأحشاء وكذلك نسبة العظام أما نسبة المخلفات فقد تأثرت معنوياً حيث أعطت العليقة الأولى (١٠٠% مسحوق سمك) أقل نسبة لهذه المكونات بينما أعطت العليقة الخامسة (١٠٠% فول صويا) أعلى نسبة للمخلفات (الأجزاء الغير مأكولة).

أظهرت نتائج التحليل الكيميائى للأسماك (السمكة بأكملها) أن عملية إحلال بروتين مسحوق السمك ببروتين فول الصويا قد أثرت معنوياً على نسبة الرطوبة والبروتين والدهن والرماد حيث اعطت الأسماك التى غذيت على العليقة الأولى (١٠٠% مسحوق سمك) أعلى نسبة من البروتين والدهن وأقل نسبة للرماد. أما بالنسبة للتحليل الكيميائى للحم فقط فقد أظهرت نتائج التحليل الكيميائى أن الفروق بين المعاملات الغذائية الخمسة فروقاً غير معنوية وذلك بالنسبة للبروتين والرماد بينما إنخفضت نسبة الدهن معنوياً بزيادة نسبة إحلال بروتين فول الصويا محل بروتين مسحوق السمك فى العلائق. وبناءً على هذه النتائج يمكن أن ننصح بإستخدام فول الصويا كبديل جزئى لمسحوق السمك فى علائق أسماك البلطى بحيث لاتزيد نسبة الإحلال هذه عن ٢٥% لتقليل تكاليف الإنتاج بقدرالإمكان.