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EVALUATION OF SESAME MEAL AS A DIETARY PROTEIN SOURCE FOR NILE TILAPIA (*Orecohromis niloticus*) FINGERLINGS

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ABSTRACT

A laboratory growth trial, carcass composition and muscular size were conducted to evaluate the suitability of sesame meal as dietary protein sources for Nile tilapia fingerlings. Four experimental diets were formulated to substitute different levels of soybean meal protein (0, 10, 20 and 30%) with sesame meal protein. All diets were isonitrogenous (26% protein) and isocaloric (4500 kcal GE/kg DM) and offered for 10 weeks. The results showed that there was no significant (P>0.05) variation in the observed growth responses and feed conversion rations between fish group fed on the control diet and those fed on the diet containing 10% sesame meal. Fish muscular size was significantly affected by the source of dietary protein as well as the level of its inclusion. Dietary sesame meal inclusion led to earlier sexual ripeness and bigger fry.

Keywords: Tilapia, Sesame meal, Performance, Feed utilization, Organs indices, Muscular area.

INTRODUCTION

Nile tilapia (*Oreochromis niloticus*) is an important tropical edible fish, that readily takes prepared feed from fry stage to adult size. Lack of nutritionally adequate and low-cost feeds has always been one of the constraints to the successful practice of fish culture in many developing countries. Coche (1979) observed that cost of feeding in intensive cage culture can account for more than 50% of the production cost. In order to mass-produce fish in cage culture system in Egypt, there is a need to formulate practical diets using agricultural and industrial wastes that may be acceptable to fish. The efficiency of various alternative protein sources as partial dietary replacements for fish meal or soybean meal has been evaluated in fish diets, such as poultry by-products meal (Higgs *et al.*, 1979), poultry offal meal (Hassan and Das, 1993) rapeseed meal (Higgs *et al.*, 1979) and single cell protein (Atack *et al.*, 1979). Hassan (1991) evaluated mustard, linseed and sesame oil cakes as dietary protein source for the common carp fingerlings. Nevertheless, many of these ingredients have been used as dietary protein sources for other fish species, i.e., linseed mustard and sesame. This study was undertaken to determine the usefulness of sesame meal fed to Nile tilapia fingerllings on growth performance, body composition, organs weight and muscular size.

MATERIALS AND METHODS

The present work was carried out at the Wet. Lab. of the Department of Animal and Fish Production, Faculty of Agriculture Kafr El-Sheikh, Tanta University during year 2004.

1. Rearing of fish:

A number of 80 fingerlings of *Oreochromis niloticus* with an average initial body weight of 10 g were used in this study. The fish were taken from the stock of Almoasasa farms. The fish were divided into 8 similar groups in glass aquaria (60 x 35 x 40 cm). Aquaria containing 70 liter of water were stocked with 10 fish in each. The groups were distributed into the experimental treatments in duplicate. Four air pumps and 8 air stones were used for aeration (one air pump for each two aquarium). Dechlorinated tap water was used to change one third of the water in each aquarium every day. Water was airated before be used for about 24 hours to remove chlorine. Samples of water were taken weekly from each aquarium(before the daily water changing) to determine water quality parameters (Abdelhamid, 1996) including temperature (via a thermometer), pH (using Orient Research Model 201-pH meter) and dissolved oxygen (means an Oxygen-meter Model 9070). Analyses of NO_2, NO_3 and Hardness were done by commercial kits (Hach International Co., Cairo, Egypt) and analysis of PO_4 and alkalinity using commercial kits (LaMotte International Co., Cairo, Egypt). Light was controlled by a timer to provide 14-h light: 10 h dark as a daily photoperiod.

Table (1): Proximate composition and essential amino acid composition of sesame and soybean meals.

Composition %	Sasame meal	Soybean meal
DM%	88	89
CP%	40	44
EE%	13.51	1.1
Ash%	14.55	6.3
CF%	5.35	7.3
NFE%	26.59	41.3
Ca^{++}%	0.42	0.26
P^{+++}%	0.67	0.64
Mg^{++}%	0.21	0.30
Calculated values:		
GE (kcal/kg)[b]	4605.4	4261.14
DE (kcal/kg)[c]	3454.05	3195.85
Amino acid con.	According to Robert (2002)	(NRC, 1993)
Arginine	4.61	3.39
Histidine	1.18	1.19
Isoleucine	1.71	2.03
Leucine	3.00	3.49
Lysine	1.29	2.85
Methionine	0.64	0.57
Cystine	2.14	0.70
Phenylalanine	2.14	2.22
Threonine	1.71	1.78
Tryptophane	2.15	2.02
Valine	2.36	2.02
Glysine	4.29	2.68

a)NFE = 100 - (CP% + EE %+ CF% + Ash%).

b)GE = Gross energy was calculated by using multiplication the factors 4.1, 5.6 and 9.44 kcal GE/g DM for carbohydrate, protein and fat impactively (Joblin, 1983).

c)DE was calculated as 75% of the gross energy (Jobling, 1983).

The fingerlings were acclimatized to the aquarium conditions and feeding regime for one week followed by 10 weeks experimental period.

2. Diet formulation:

The sesame meal was obtained from a private mill at El-Mahala city. The proximate composition and amino acid analysis of sesame meal comparing with those of soybean meal are given in Table 1. Sesame meal was added in the experimental diets to replace 0, 10, 20 and 30% of soybean meal protein. These diets were designated as diet 1, 2, 3 and 4, respectively. Four isonitrogenous (26% crude protein) and isocaloric (4500 kcal GE/kg DM) feed mixtures, from indigenous ingredients and imported herring meal were used. Chemical analysis of the ingredients used in the mixed diets are presented in Table 2. Fish were weighed weekly and the amount of feed quality was adjusted accordingly. The daily ration was introduced at 2 equal meals at 8 am and 2 pm.

Table (2): Composition and chemical analysis of the experimental diets.

Ingredients (%)	Diets No. (% sesame meal protein replacement)			
	T1 (control) (0%)	T2 (10%)	T3 (20%)	T4 (30%)
Fish meal (72%)	10	10	10	10
Soybean meal (44%)	34	30.6	27.2	23.8
Yellow corn	39	38.75	38.5	38.25
Wheat bran	10.7	10.7	10.7	10
Sun flower	6	6	6	6
Vit. & min. mixture (1)	0.3	0.3	0.3	0.3
sesame meal (40)	-	3.65	7.3	10.95
Determined values (%):				
Dry matter	89.57	89.93	89.63	90.69
CP	26.36	26.32	26.25	26.17
EE	7.09	8.62	8.92	8.96
CF	5.34	5.05	4.93	5.30
Ash	5.52	6.06	6.66	6.27
NFE	55.69	53.95	53.24	53.30
Calculated values:				
GE kcal /kg (2)	4446.18	4517.93	4513.36	4515.1
DE kcal/kg (3)	3388.44	3388.44	3385.02	3386.32
ME kcal/100 g (4)	380.07	380.07	379.82	380.01
P/E ratio (5)	59.28	58.25	58.16	57.96

(1) Vitamin and mineral mixture (product of HEPOMIX). Each 2.5 kg contains: 12.000.000 IU Vit. A ; 2.000.000 IU Vit. D_3 ; 10 g Vit. E ; 2 g Vit. K_3 ; 1 g Vit. B_1 ; 5 g Vit. B_2 ; 1.5 g Vit. B_6 ; 10 mg Vit. B_{12} ; 30 g Nicotinic acid ; 10 g Pantothenic acid ; 1 g Folic acid ; 50 mg Biotion ; 250 g Choline chloride 50% ; 30 g Iron ; 10 g Copper ; 50 g Zinc ; 60 g Manganese ; 1 g Iodine ; 0.1 g Selenium and 0.1 g Cobalt.

(2) GE (gross energy) calculated by the values 4.1, 5.6 and 9.44 kcal GE/g DM of carbohydrate, protein and fat, respectively (Jobling, 1983).

(3) ME was calculated as 75% of the gross energy (Jobling, 1983).

(4) P/E ratio = protein to energy ratio mg crude protein /kcal GE.

(5) ME (Metabolizable energy) calculated using the value of 3.49, 8.1 and 4.5 kcal/g for carbohydrate, fat and protein, respectively, according to Pantha (1982).

3. Physical and Biochemical analysis:

Fish samples (4-5 fishes) from each group were obtained at the end of the experiment for chemical analysis and measuring areas of muscular and abdominal cavity (infiltration/muscular areas) using Echo scan (Hs/s) ultrasonic, diagnostic instrument, Budapest, Romeny Co., according to (Salem, 2003). Chemical analysis for dry matter (DM), crude protein (CP), ether extract (EE) and ash in the diets used and in fish body (in addition to crude fiber (CF) in the diet) was carried out according to A.O.A.O. (1980).

4. Performance parameters:

Average weight gain (AWG), average daily gain (ADG), specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER) protein productive value (PPV) and survival rate (SR) were calculated according to the following equations:

1- AWG (g/fish) = [Average final weight (g) - average initial weight (g)]
2- ADG (g/fish/day) = [AWG (g) / experimental period (d)]
3- SGR (%/day) = Ln final weight (g) - Ln initial weight (g) x 100 / experimental period (d)
4- FCR = Feed intake, dry weight (g) / live weight gain (g)
5- PER = Live weight gain (g) / protein intake (g)
6- PPV = 100 [final fish body protein (g) - initial fish body protein (g) / crude protein intake (g)]
7- Survival rate (SR) = Total number of fish at the end of the experiment x 100 / total number of fish at the start of the experiment

5. Organs' indices:

All fish were killed and soon the abdominal cavity was opened to remove liver, kidney gonads and spleen and weighed at once individually. Liver (HSI), kidney (KSI), gonads (GSI), and spleen (SSI) indices were calculated as follow:

- HSI (Hepato Somatic Index) = Liver weight x 100 / Gutted fish weight (Jangaard *et al.*, 1967).
- KSI (Kidney Somatic Index) = Kidneys weight x 100 / fish weight (Abdelhamid *et al.*, 2004-a).
- GSI (Gonado Somatic Index) = Gonads weight x 100 /fish weight (Tseng and Chan, 1982).
- SSI (Spleeno Somatic Index) = Spleen weight x 100 / fish weight (Abdelhamid *et al.*, 2004-a).

6. Statistical analysis:

The obtained numerical data were statistically analyzed using SPSS (1997) for one-way analysis of variance. When F-test was significant, least significant differences was calculated (Duncan, 1955).

RESULTS

1. Water quality parameters:

The most important physico-chemical parameters of the rearing water used in the experiment are shown in Table 3. Data in this table

indicated that the values obtained lie in the acceptable range required for normal growth of tilapia.

Table (3): Ranges of some important measured physico-chemical parameters of water usd for fish rearing.

Temperature (°C)	pH value	DO_2 ppm	Alkalinity mg/L	Hardness mg/L	PO_4 mg/L	NO_2 mg/L	NO_3 mg/L
26-27	7.5-8.5	5.5-6	160-165	300-350	0.1-0.2	0.14-0.15	1.5-2.5

2. Growth performance:

Data concerning average weight gain (AWG), average daily gain (ADG), specific growth rate (SGR) and survival rate (SR) are presented in Table (4). The results revealed that the differences in AWG between diets 1 and 2 or diets 3 and 4 were not significant. Yet, diets 1 and 2 were responsible for significantly higher AWG than diets 3 and 4. Also, 10% sesame meal protein (diet 2) did not differ significantly in ADG or SGR than the control (diet 1). But increasing sesame meal level (diets 3 and 4) led to a significant reduction in either ADG and SGR. However, sesame meal inclusion did not affect SR, except at the highest level (30%, diet 4) which reduced SR ($P<0.05$).

Table (4): Effect of different dietary concentrations of sesame meal on growth and survival rates of *Tilapia niloticus* (means ± SE).

Diets No.	AWG (g/fish)	ADG (g/fish/day)	SGR (%/day)	SR (%)
1	28.30^{a} ±0.40	0.41^{a} ±0.005	1.90^{a} ±0.002	100^{a} ±0.001
2	27.40^{a} ±0.01	0.40^{a} ±0.002	1.88^{a} ±0.001	100^{a} ±0.001
3	25.30^{b} ±0.90	0.36^{b} ±0.01	1.77^{b} ±0.003	100^{a} ±0.001
4	23.60^{b} ±0.01	0.34^{c} ±0.005	1.69^{c} ±0.01	95.0^{b} ±0.005

a, b and c means in the same column bearing the same letter do not differ significantly at 0.05 level.

3. Feed conversion and protein utilization:

Feed and protein utilization expressed as feed conversion ratio (FCR), protein efficiency ratio (PER) and protein productive value (PPV) for *Tilapia niloticus* are given in Table (5). The data indicated that FCR, PER and PPV were poorer in fish groups grown on the highest sesame meal level (30%), diet 4 compared with the control and the other levels (10 and 20%) of sesame meal.

Table (5): Effect of different dietary concentration of sesame meal on feed conversion ratio, protein efficiency ratio and protein productive value (means ± SE) by Nile tilapia.

Diet No.	FCR	PER	PPV
1	1.63^{b} ±0.045	2.33^{a} ±0.06	21.34^{a} ±0.005
2	1.75^{ab} ±0.07	2.18^{ab} ±0.09	21.63^{a} ±0.006
3	1.82^{ab} ±0.06	2.10^{ab} ±0.06	20.67^{b} ±0.005
4	1.91^{a} ±0.03	2.00^{b} ±0.03	19.59^{c} ±0.001

a, b and c means in the same column bearing the same letter do not differ significantly at 0.05 level.

4. Body composition:

Values of dry matter (DM), crude protein (CP), ether extract (EE) and ash of the fish body are summarized in Table (6). The 10 percent sesame meal protein (diet 2) was similar in its effect on DM and EE percentage to the control. Yet, all levels of dietary sesame inclusion reduced CP% and increased ash % in the fish body.

Table (6): Means±standard errors of chemical composition of the whole fish body (% on dry matter basis) as affected by dietary inclusion of sesame meal.

Diets No.	DM	CP	EE	Ash
1	26.22^{a} ±0.001	60.93^{a} ±0.13	16.90^{a} ±0.05	22.17^{c} ±0.0
2	26.30^{a} ±0.04	58.79^{b} ±0.14	16.95^{b} ±0.05	24.22^{b} ±0.09
3	25.55^{b} ±0.07	57.86^{c} ±0.61	17.10^{a} ±0.06	25.33^{a} ±0.60
4	25.60^{b} ±0.02	57.40^{a} ±0.15	16.95^{b} ±0.05	25.65^{a} ±0.31

a, b and c means in the same column bearing the same letter do not differ significantly at 0.05 level.

5. Organs' indices:

Table 7 illustrates calculations of the internal organs indices as affected by dietary sesame meal inclusion. Most of the tested indices (HSI, KSI and SSI) reflected remarkable and gradual decreases proportional to the dietary level of sesame meal, but gonadosomatic index for female and male was increased significantly by inclusion of sesame meal in the diet, without significancy among diets 2, 3 and 4. Therefore, the fish fed on diets 2, 3 and 4 (including sesame meal) were sexually riped and spawned earlier than the control fish (fed without sesame meal).

Table (7): Effect of dietary inclusion of sesame meal on organs indices of Nile tilapia fish (means ±SE)

Diet No.	HSI	GSI (female)	GSI (male)	KSI	SSI
1	2.74^{a} ±0.08	4.22^{b} ±0.11	0.60^{b} ±0.005	0.11^{a} ±0.005	0.28^{a} ±0.00
2	2.82^{a} ±0.01	4.70^{a} ±0.11	1.62^{a} ±0.20	0.09^{ab}±0.005	0.25^{b} ±0.00
3	2.26^{b} ±0.03	4.56^{a} ±0.06	1.56^{a} ±0.06	0.06^{b} ±0.01	0.24^{c} ±0.00
4	1.89^{c} ±0.08	4.52^{a} ±0.07	1.39^{a} ±0.019	0.07^{b} ±0.02	0.06^{d} ±0.00

a, b, c and d means in the same column had different letters significantly (P<0.05) differ.

Moreover, feeding on diets No. 2, 3 and 4 led to larger (size and weight) fry from the first spawning than those produced from the control.

6. Infiltration/ muscular areas:

The fish were examined for infiltration/ muscular areas using Echoscan HS/S ultrasonic, diagnostic instrument (Budapest, Remeny Co.). This test presented the variation among the tested groups as illustrated in Figures (1-4), where zm; the number of the actually zoom (zoom 2 to 8 am), st: the number of the actually displayed memory as shown, PR: automatically identifies the type of connected probe (e.g., is MHz liner probe), Ng: indicates the measure of actual near gain in a range of 1-16, FG : indicates the measure of the actual acoustic power, DP: active only with sector probe and

indicates the measure of damping of piezo crystals of the pro, PA ; picture averaging, pp; post-processing, DIR ; direction of scanning, FR; fast or slow scanning, HI ; high scanning rate, F; the various measurements can be selected, N; not active and ID ; identifying characters. Figures (1-4) presented the control (Fig. 1) and 10% level of sesame meal (Fig. 2) with larger muscular (white) area than in Figures 3 and 4 of fish fed on sesame meal levels at 20 and 30%, respectively.

7. Economic study:

The economic parameters of the tested diets are presented in Table (8), where price/ton of fish meal 4000 LE, soybean meal 1500 LE, yellow corn 900 LE, oil 3000 LE, vit. & min. mixture 12000 LE, wheat bran 600 LE and sesame meal 800 LE.The calculation depends on the average price of dietary ingredients at year 2003. The calculated figures showed that the cost of one ton feed mixture reduced gradually at all levels of protein substitutions. Moreover, increasing of sesame meal level led to reduce feed intake and hence total gain also. Therefore, increasing level of dietary sesame meal slightly increased feed cost/kg gain of fish.

Table (8): Feed cost per kg gain of fish as affected by gradual levels of dietary sesame meal.

Diets No.	Feed intake (g/fish)	Cost (LE) of one ton feed	Reduction in feed cost (LE)	Total gain (g/fish)	Feed cost/kg gain (LE)*
1	470.8	1597	-	285	2.64
2	470.3	1572.9	24.1	275	2.69
3	439.4	1548.9	48.1	253	2.69
4	415.4	1524.8	72.2	234	2.71

*** Feed cost /kg gain (LE) = feed intake x cost (LE) of ton feed x 100/total gain**

DISCUSSION

Mean values of the physico-chemical parameters measured for the fish rearing water were evaluated as good and suitable for tilapia culture according to the judging scales given by Abo-Salem *et al.* (1992), Abd El-Hakim *et al.* (2002) and Abdelhamid (2003).

The normal effects of 10% sesame meal diet (similar to the control diet without sesame meal) on fish growth, survival rate, FCR, PER, PPV EE content, HSI, KSI, muscular area and feed cost/kg fish gain are similar to those found by Abd Elmonem *et al.* (2004). They fed red tilapia fry on 0, 10, 20 and 30% sesame hulls by-product as a partial substitution (non-conventional feedstuff) of soybean meal. They reported no significant effects on fish growth, FCR, PER, body composition, survival, HSI, and GSI but there was some profit of using sesame meal. They mentioned that sesame meal accelerated ripening of males but it caused oocyte atersia. However, the present results proved that sesame meal has positive sexual effects; since it significantly increased GSI for both sexes and accelerated sexual maturity as well as size of the produced fry.

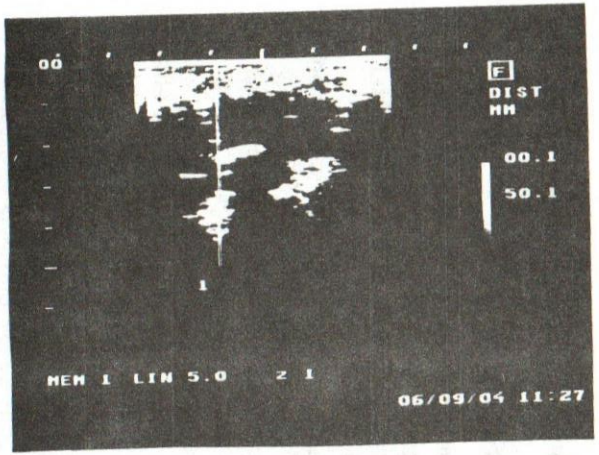

Fig. 1: The control fish

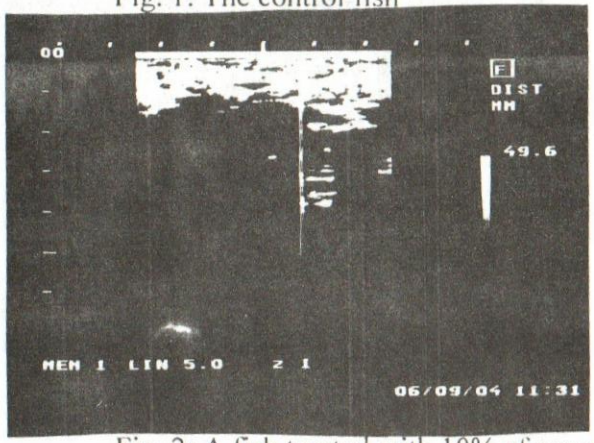

Fig. 2: A fish treated with 10% of sesame meal

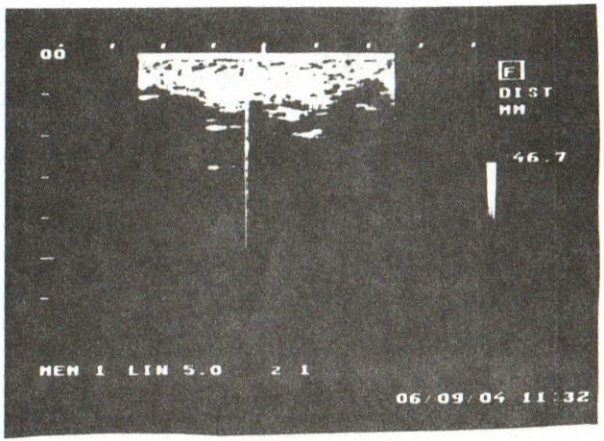

Fig. 3: A fish treated with 20% of sesame meal

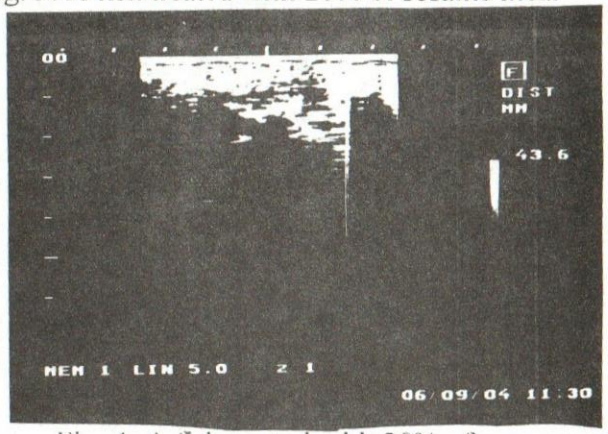

Fig. 4: A fish treated with 30% of sesame meal

Sesame (*Sesamum indicum L., pedaliaceae*) is an important annual oil seed crop in Egypt. It has high content of edible oil and protein (Abou-Gharbia, 1997). It is rich in phytosteroid, protein, essential amino acids and omega three fatty acids (Beckston-Sternberg and Duke, 1994). It has also an antioxidant hepatoprotective activity (Morris, 2002). So, its meal (as a by-product of its oil extraction) may also contain such materials which may be responsible for the reproductive improvements.

However, fish cultures in Egypt produced 50% of the whole fish production of year 2004 (Nasr El-Din, 2004). Aquaculture depends mainly on artificial feeding. Therefore, it has to search for unconventional feed resources to avoid fish out of competition on the conventional feeds with the other animal species. Hence, black seed meal, roquette seed meal (Abd Elmonem *et al.*, 2002), fig jam by-product (El-Dakar *et al.*, 2003), dried drooping dates (Srour *et al.*, 2002), licorice roots (Shalaby *et al.*, 2003), mallow meal (Abdelhamid *et al.*, 2004-b), olive pulp by-products (Abd Elmonem, 2004), faba bean middling (Shalaby *et al.*, 2004), fennel seed meal (El-Dakar *et al.*, 2004) and others were evaluated as new feed sources or additives for tilapia fish. So sesame meal could be used in tilapia diets at a levels of 3.65% (or to substitute 10% of soybean meal protein in the fish diet) without adverse effects on growth and feed utilization but even may improve reproductive performance of the brood stock.

CONCLUSION

The results suggest using sesame meal to replace up to 10% soybean meal protein without affecting growth performance and feed and protein utilization, but it may enhance reproduction of fish.

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تقيم كسب السمسم كمصدر بروتينى فى علائق اصبعيات أسماك البلطى النيلى

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**المعمل المركزى لبحوث الثروة السمكية – وحدة بحوث الثروة السمكية بسخا

صممت هذه التجربة لدراسة تأثير الاستبدال الجزئى لبروتين كسب فول الصويا ببروتين كسب السمسم بمعدلات (صفر ، ١٠ ، ٢٠ ، ٣٠%) فى علائق اصبعيات البلطى النيلى بمتوسط وزن ابتدائى ١٠ جم ، وكانت نسبة البروتين فى العلائق التجريبية حوالى ٢٦% واستمرت التجربة ١٠ اسابيع . أظهرت النتائج أن معدلات النمو كانت متقاربة بين مجموعة الكنترول والمجاميع التى استبدل فيها نسبة من بروتين كسب فول الصويا ببروتين كسب السمسم بمعدلات ١٠ ، ٢٠% . وأيضا حدث تقارب لمعدلات التحويل الغذائى والاستفادة من البروتين ، ومن ناحية التحليل الكيماوى لجسم الأسماك وجد تقارب فى نسبة البروتين ، بينما زادت نسبة الدهن فى علائق كسب السمسم ، وجد أن المناسل زادت فى الوزن بمعدل أكبر فى مجموعات الاستبدال بكسب السمسم عن وزن مناسل أسماك مجموعة الكنترول ، وقد انعكس ذلك على ميعاد وكمية أول تفريخة للأمهات ، حيث تم إنتاج أول تفريخة فى الأسماك المعاملة بكسب السمسم مبكراً عن مجموعة الكنترول. ووجد أن مساحة العضلات فى المعاملة ١٠% استبدال متقاربة من مساحة عضلات الكنترول ، ويليهما المعاملة ٢٠% ثم المعاملة ٣٠% استبدال. ولم يوجد فرق كبير فى تكاليف التغذية لإنتاج كيلو زيادة فى وزن الأسماك بين المعاملات المختلفة.

ويمكن أن نستخلص من هذا البحث أن الاستبدال الجزئى لبروتين كسب فول الصويا ببروتين كسب السمسم بنسبة ١٠% هو المستوى الذى يمكن التوصية به فى علائق اصبعيات أسماك البلطى النيلى.