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RESPONSE OF NILE TILAPIA, *Oreochromis niloticus*, FINGERLINGS TO DIETS SUPPLEMENTED WITH DIFFERENT LEVELS OF FENUGREEK SEEDS (HULBA)

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ABSTRACT

Five experimental isonitrogenous (30% crude protein) and isoenergitic diets (446 kcal gross energy /100g dry feed) were formulated to contain 0, 2, 4, 6 and 8 % of fenugreek seeds meal (FSM), aiming to study the effects of different levels of FSM on growth performance, feed and nutrients utilization, body composition, levels of plasma glucose, total plasma lipids (TPL) and total plasma proteins (TPP), activity of liver enzymes and cost-benefit analysis of Nile tilapia fingerlings. Ten glass aquaria, with the dimensions of 70x30x 40 cm, were used to stock 10 fish (averaging 6 g/fish)/each. Fish fed 3-5 % of the body weight daily at three meals, six days a week for 77 days. Fish were weighed biweekly and feed amounts were adjusted on the basis of the new weight.

Results showed that fish fed diets containing 2% FSM had significantly higher ($P<0.05$) body weight, weight gain, SGR, FCR and PER than those fed the control diet and other supplemented fenugreek seed levels. However, FSM levels of 6 and 8% gave significantly ($P<0.05$) lower growth performance parameters, FCR, PER, PPV% and ER% than the control diet. No significant differences ($P> 0.05$) were observed in moisture, crude protein, ether extract, ash and energy content of Nile tilapia fed diets containing various levels of FSM. However, plasma glucose, total protein and total lipid concentrations were decreased as FSM levels increased in the experimental diets. Cost-benefit analysis indicated that the 2% FSM level was more economically than other fenugreek seed supplemented levels.

Keywords: Nile tilapia, Feed additives, Fenugreek seeds, Growth, Chemical composition

INTRODUCTION

Feed additives are important for improving feed utilization and animal performance. However, some of them may cause unfavorable side effects. Moreover, there is evidence indicating that these products could be considered as pollutants for human on the long run (Stickney, 1994). Adding of liquid krill, *Euphasia Pacifica* to the diet of rainbow trout, *Oncorhynchus mykiss*, before pelleting or coated on the pellets increased feed intake and decreased feed waste (Oikawa and March, 1996; Sakr, 2003 and El-Dakar *et al.*, 2004). Recently, there is increasing interest to use natural spices as feed additives rather than classical ones. Several studies in animal nutrition showed that adding some spices or medicinal and aromatic plants to diets of sheep, goats, rabbits, chicken, cows and buffaloes had favorable effects on live weight gain, feed intake, feed efficiency and nutrient digestibility (Hanafy, 1995; Karaly, 1995; Gaber *et al.*, 1996; Mir *et al.*, 1998; Youssef *et al.*, 1998; Abol-Fotouh *et al.*, 1999; Allam et al ., 1999; El- Ayek *et al.*, 1999 and El-Saadany *et al.*, 1999). The most recently studies showed successful use of spices and natural herbs in fish nutrition including marjoram, basil, licorice

roots, black seed, peppermint (Abd El-Maksoud *et al.*, 2002; Abd El-moneim *et al.*, 2002; Sakr 2003;Shalaby *et al.*, 2003 and El-Dakar *et al.*, 2004).

Fenugreek, *Trigonella foenoum* graecum, is one of the medicinal spices that may serve as feed additives in fish diets. Egyptian use fenugreek seeds for medicinal purposes or roast the seeds and use them as coffee. In various areas of North Africa, the seeds (ground into a paste) in combination with sugar (molasses) and olive oil were traditionally eaten by women to gain weight. Fenugreek is also an important source of diosgenin, which is widely used in the production of steroids (which probably accounts for the weight gain), sex hormones, oral contraceptives and veterinary medicines (Mazur *et al.*, 1998). Fenugreek is considered to be a good source of crude protein, crude fat, and total carbohydrates (Abd El-Aal and Rahma, 1986). Fenugreek contains phytoestrogens such as daidzeim, genistein and secoisolari ciresinal (Mazur *et al.*, 1998). Morsy (1995) reported that significant improvement in body weight gain and dressing percentage with broiler chicks fed diets containing 500g fenugreek per ton diet. There is a lack information about the use of fenugreek seeds in fish nutrition. The present study therefore was conducted to study the effect of different levels of FSM as a feed additive on growth performance, feed conversion, nutrient utilization, body composition, hematology, liver enzymes and benefit analysis of Nile tilapia, *Oreochromis niloticus,* fingerlings.

MATERIALS AND METHODS

Experimental facilities:-

This work was carried out at the Fish Nutrition Lab., Aquaculture Division National Institute of Oceanography and Fisheries (NIOF), Alexandria, Egypt. Ten glass aquaria with dimensions of 70 x 30 x 40 cm, total net volume for each aquarium was 70 L, were used in this study. All aquaria were filled with dechlorinated tap water stored 24 hours before use. Fingerlings of Nile tilapia, *O. niloticus* were obtained from Maryot Fish Farming Co, Alexandria Governorate, Egypt. Fish were transported in fiberglass tanks (300 L). After arrival, all fish were kept for one week to alleviate stresses and to be adapted to the new conditions. Ten fish in the same initial weight (6 g/fish) were selected and randomly allotted into each experimental aquarium. Fish were fed the control diet for two weeks, during this period, healthy fish of the same weight replaced the dead one.

Experimental diets:-

Five experimental diets were formulated to contain 0, 2, 4, 6 and 8% of fenugreek seeds meal (FSM) as feed additive. Each diet was fed to two randomly assigned (duplicate) aquariums. Ingredients composition of the experimental diets is presented in Table (1). Fishmeal was home made by collecting small fish and non-saled fish locally named "Wazafa" from fish market to dry in oven at 60 °C for 48 hours. Then dry fish were grounded and sieved prior to keep at –20 °C until use as an animal protein source. Soybean meal (44%) was used as a plant protein source. While yellow corn, wheat bran, wheat milling by-product and sunflower oil were served as energy sources. The experimental diets were prepared by mixing ground dry

ingredients with water and pelleted using meat mincer with 1-mm diameter holes. The pellets were air dried and stored at -20° C until use. Fish fed 5, 4 and 3 % of the body weight daily for the 1-4, 5-8 and 9-11weeks, respectively. The feed amount was given at three times a day (9 00, 1200 and 1500) in equal proportions. Feeding was performed for six consecutive days a week, for 77days. Fish were weighed biweekly and feed amounts were adjusted on the basis of the new weight of fish.

Table 1: Ingredients composition (%) of the experimental diets

Ingredient	Diets No.				
	1	2	3	4	5
Fish meal	15	15	15	15	15
Soybean meal	34	33	32	31	30
Yellow corn	5	5	5	5	5
Fenugreek seeds meal	0	2	4	6	8
Wheat milling by-product	34	33	32	31	30
Wheat bran	5	5	5	5	5
Sunflower oil	5.0	5.0	5.0	5.0	5.0
Vitamin mix.[1]	0.875	0.875	0.875	0.875	0.875
Ascorbic acid	0.125	0.125	0.125	0.125	0.125
Mineral mix.[2]	1.0	1.0	1.0	1.0	1.0
Total	100	100	100	100	100

1-vitamin premix contained 12000IU, 2000000IU, 10g, 2g, 1g, 4g, 1.5g, 10g, 20g, 10g, 1g, 50 mg and 500 mg per kg of vitamin A, D3, E, K, B1, B2, B6, B12, nicotinic acid, pantothonic acid, folic acid, biotin and colin, respectively.

2-Minerals premix contained 13.4, 33.4, 3.2, 13.4, 23.2, 8.4, 0.6, 4.2, 0.6, 0.6, 0.6 and 897.4 g/Kg of calcium dihydrogen phosphate, calcium lactate, ferric citrate, magnesium sulfate, dipotassium phosphate, sodiumhydrogen phosphate, aluminum chloride, zinc sulfate, cupper sulfate, manganese sulfate, cobalt chloride and wheat, respectively.

Environmental conditions:-

Fish were reared in water at 27±2 °C temperature and 8.8±0.2 pH. Third of the aquaria water volume was exchanged daily, except the weighing days ,where about two thirds of the water volume were changed.

Analytical methods:-

Diets and fish samples were chemically analyzed according to AOAC (1990). Gross energy values were calculated by using factors of 5.65, 9.45 and 4.2 kcal/g of protein, lipid and carbohydrate, respectively (NRC, 1993)

Blood analysis:-

Blood was collected using heparinized syringes from the caudal vein of all the experimental fish at the termination of the experiment. Blood samples were centrifuged at 3000 rpm for 15 minutes to allow separation of plasma which was subjected to determine plasma total proteins (Armstrong and Carr, 1969), total lipids (Frings *et al.*, 1972) and glucose (Trinder, 1969). The activities of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were determined colorimetrically by using commercial kits (Quimica Clinica Aplicada, S.A., Aspain) according to the method of Reitman and Frankel (1957).

Cost-benefit analysis:-

To evaluate cost-benefit analysis of FSM supplemented diets of Nile tilapia fingerlings, incidence cost (IC) and profit index (PI) were calculated according to New (1985).

Statistical analysis:-

Analysis of variance (ANOVA) was carried out according to Snedecor and Cochran (1982) using a completely randomized design (CRD). Differences were subjected to Duncan's Multiple Range-Test (Duncan, 1955) at a significance level of 0.05. Program of MSTAT-C was used to compute the statistical analysis (MSTAT-C, 1988).

RESULTS AND DISCUSSION

Diets:-

Results indicated that FSM was rich in nitrogen free extract and crude protein, it contained 56.4 and 28.21%, respectively. However it was poor in ether extract and ash. While it had a moderate crude fiber (Table 2). Similar results were obtained by Abd El-Aal and Rahma, (1986). All the experimental diets were isonitrogenous and isocaloric, P/E ratio was in the same range for all the diets.

Table 2: Chemical analysis of the experimental diets.

Item	Fenugreek seeds	Diet No.				
		1	2	3	4	5
Dry matter %	95.95	94.41	94.1	93.99	94.12	94.23
% on the DM basis:-						
Crude protein	28.21	30.42	30.39	30.35	30.32	30.29
Ether extract	2.15	9.7	9.68	9.67	9.66	9.65
Crude fiber	9.91	2.89	3.04	3.19	3.34	3.49
NFE	56.40	46.2	46.19	46.18	46.16	46.14
Ash	3.33	10.79	10.7	10.61	10.52	10.43
Gross energy ,kcal/100 g diet	418	459	458	458	457	457
P/E ratio mg/kcal	–	77.21	77.33	77.23	77.15	77.07

Growth performance:-

Data in Table (3) show the growth performance and feed and nutrient efficiencies of Nile tilapia fingerlings fed diets containing different levels of FSM. Results showed that fish fed diets containing 2% FSM had significantly higher ($P<0.05$) body weight, weight gain and SGR than those fed the control diet. However, FSM levels of 6 and 8% gave significantly ($P<0.05$) lower growth performance parameters than the control diet. These results agreed generally with those reported by Morsy (1995) who found that there was a significant improvement in body weight and gain of broiler chicks fed 500g fenugreek seeds/ton diet. However, the addition of 1000g FSM/ton was insignificant comparing with the control diet at 7 weeks of age. El-Husseiny *et al.* (2002) used various levels of fenugreek seeds (1, 1.5, and 2%) at different levels of metabolizable energy (3200, 3000, and 2800 kcal/kg diet for broiler chicks). They reported that chick fed fenugreek diets had significantly ($P<0.01$) less body weight and higher feed intake than those fed the control diet. The differences between these studies may be due to different animals' species and environmental conditions.

Table 3: Growth, survival rate, feed and nutrient efficiency utilization of Nile tilapia fingerlings fed diets containing different levels of fenugreek seeds.

Item		Supplemented FSM level (%)					MSE[1]
		0	2	4	6	8	
Initial weight	g/fish	6.06	6.05	6.03	6.07	6.08	0.01
Final weight	g/fish	33.1^{b}	35.76^{a}	33.95^{b}	28.65^{c}	28.55^{c}	0.98
Gain[2]	g/fish	27.04^{b}	29.71^{a}	27.92^{b}	22.59^{c}	22.47^{c}	0.98
SGR[3]	% /day	2.21^{b}	2.31^{a}	2.25^{ab}	2.02^{c}	2.01^{c}	0.04
Survival rate	%	100	100	100	95	95	0.001
Feed intake	g/fish	42.61	45.04	44.1	42.18	42.8	0.44
FCR[4]		1.49^{b}	1.43^{a}	1.49^{b}	1.76^{c}	1.8^{d}	0.05
Feed efficiency[5]	%	67^{b}	70^{a}	67^{b}	57^{c}	56^{d}	1.92
PER[6]		2.21^{b}	2.31^{a}	2.22^{b}	1.88^{c}	1.84^{d}	0.06
PPV[7]	%	40.97^{a}	38.79^{a}	36.55^{a}	30.04^{b}	30.17^{b}	1.55
ER[8]	%	27.81^{a}	26.61^{a}	24.21^{a}	19.95^{b}	18.91^{b}	1.23

*Values in the row having a common superscript letter are not significantly different (P>0.05).

1. Standard error of the means derived from the analysis of variance
2. Gain = (final weight - Initial weight).
3. Specific growth rate = 100(Ln final weight - Ln initial weight)/ day).
4. Feed conversion ratio = DM intake/weight gain.
5. Feed efficiency % = 100 (gain/feed intake).
6. Protein efficiency ratio = weight gain/protein intake.
7. Productive protein value = 100(protein gain / protein intake).
8. Energy retention % = 100 x (gross energy gain / gross energy intake).

Improvement of performance of Nile tilapia fed 2% FSM in their diets may be due to its effects on carbohydrate metabolic enzymes. Devi *et al.* (2003) found that fenugreek improved body weight and liver glycogen, they also showed significant effect on key carbohydrate metabolic enzymes in diabetic rats. The same effect may be obtained with other spices (Abd El-Maksoud *et al*., 2002; Abd Elmonem *et al.*, 2002; Sakr 2003; Shalaby *et al.*, 2003 and El-Dakar *et al.*, 2004). According to Henry and Emery (1986) the metabolic rate increased by 25% when chili sauce and mustard sauce were added to a meal. Certainly, the carbohydrate oxidation rate was gradually increased after feeding the meal containing red pepper and there was a significant difference between the red pepper diet and the control diet (Yoshioka *et al.*, 1995). The activity of beta-glucuronidase significantly increased in the colon, intestine and liver of rat fed fenugreek seed powder at 2-g/kg-body weight when compared to an untreated control group. Therefore, supplementation of fenugreek seeds in the diet inhibits colon carcinogensis by modulating the activities of beta-glucuronidase and mucinase group (Devasena and Menon, 2003). The present study showed significantly ($P<0.05$) lower body weight, gain and SGR among the fish groups fed diets supplemented with 6 and 8% FSM than the control group. Similar results were obtained by Udayasekhara and Sharma (1987) who found that the growth of animals receiving different levels of fenugreek seeds (5, 10 and 20%) was significantly lower than that of the control animals.

Feed intake and feed utilization:-

Feed intake (Table 3) was insignificantly (P>0.05) different among all fish groups fed FSM levels. It ranged between 42.18 and 45.04 g/fish. There were significant differences (P<0.05) in FCR among the fish fed graded levels of FSM. The 2% FSM was the best-supplemented level for FCR and PER in comparison to the control and other test fenugreek levels. These results are in agreement with those of Sakr (2003) and El-Dakar *et al.* (2004) who showed similar results with different spices e.g. marjoram, basil, peppermint and anise for tilapia sp. However, El-Husseiny *et al.* (2002) found no significant difference in FCR between chicks fed fenugreek and the control diet. Moreover, Udayasekhara and Sharma (1987) indicated that the replacement of casein diet up to 20% by fenugreek seeds (extracted) did not produce any deleterious effect on feed intake, while the feed intake of rats receiving fenugreek seeds alone was significantly lower than that of the control animals.

Increasing FSM level resulted in a decrease in productive protein value and energy retention efficiency. Yet, there were no significant differences (P> 0.05) among fish fed diets containing (0, 2 and 4% FSM) in PPV% and ER%. Different spice plants gave similar results (Sakr 2003; Shalaby *et al.*, 2003 and El-Dakar *et al.*, 2004). Hybrid tilapia, *O. niloticus* X *O. auraus*, fed different levels of dried marjoram (El-Dakar *et al.*, 2004) or peppermint (Sakr, 2003) leaves had insignificant differences in protein and energy utilization.

Survival rate:-

Survival rate of the experimental fish groups was within the normal range. It recorded 100% for all fish groups except those fed diets containing 6 and 8% FSM levels which gave 95% survival rate for both (Table 3). Muralidhara *et al.* (1999) found that fenugreek seeds powder fed to weaning rats at dietary doses of 0, 1, 5 and 10% in a pure diet had no toxicity.

Body composition:-

Results in Table (4) showed no significant differences (P> 0.05) in moisture, crude protein, ether extract, ash and energy content of Nile tilapia fed diets containing various levels of FSM. This data is in agreement with those published by Abd El-Maksoud (2002), Abd Elmonem *et al.* (2002) and Shalaby *et al.* (2003) for other spices. But in the present study, ether extract content of fish decreased by increasing of FSM levels in the experimental diets. These results confirm previous findings by El-Dakar *et al.* (2004) who found that deposit lipid decreased when hybrid tilapia fed graded levels (0, 0.5, 1.0 and 2%) of dried marjoram leaves. Sakr (2003) obtained similar results with dried peppermint leaves. In this connection, several investigators have reported that ground seeds of fenugreek have hypoglycemic and hypocholesterolemic effect (Madar and Shomer, 1990; Matsuo *et al.*, 1996 Rashwan, 1998 and Saito *et al.*, 1999)

Table 4: Body composition of Nile tilapia fed different levels of fenugreek seeds[ns].

Diets	Initial fish	Supplemented FSM level (%)					SEM*
		0	2	4	6	8	
Moisture	76.83	69.91	71.57	72.22	72.93	72.97	0.47
Crude protein	13.24	17.58	16.21	15.9	15.43	15.88	0.30
Ether extract	5.81	8.41	7.91	7.28	7.05	6.37	0.28
Ash	3.79	4.11	4.3	4.42	4.37	4.66	0.09
Energy kcal/100 g	130	179	166	159	154	150	3.97

ns means are not significant
* Standard error of the means derived from the analysis of variance.

Blood parameters:-

Data in Table (5) indicated that plasma glucose, total protein and total lipid concentrations were decreased as FSM levels increased in the experimental diets. These results are in agreement with those of Rashwan (1998) who reported that serum total protein decreased significantly ($P<0.05$) with fenugreek seeds addition to rabbit's diet. In addition, El-Husseiny *et al.* (2002) found that blood total lipid, cholesterol and glucose levels chicks fed hot pepper and fenugreek seeds were significantly ($P<0.05$) lower than those of the control group. Ravikumar and Anuradha (1999) demonstrated that supplementation of fenugreek seeds in the diet lowered lipid peroxidation. In the present study, aspartate aminotransferase (AST) and alanine aminotransferase (ALT) activities seemed not significantly ($P>0.05$) affected for fish fed FSM levels until 4%, but dramatically elevated at 6 and 8% FSM.

Table 5: Blood parameters of Nile tilapia fed different levels of fenugreek seeds.

Item		Supplemented FSM level (%)					SEM*
		0	2	4	6	8	
Glucose mg/dl		57.64^{a}	43.75^{b}	38.13^{c}	35.42^{bc}	30.04^{c}	3.72
Total protein g/dl		5.23^{a}	5.18^{a}	3.60^{b}	3.61^{b}	3.04^{c}	0.24
Total lipid g/dl		4.46^{a}	4.19^{b}	3.83^{bc}	$3.87b^{c}$	3.40^{c}	0.19
AST[1]	u/dL	107^{c}	104^{c}	103^{c}	124^{b}	180^{a}	9.78
ALT2	u/dL	47	41	40	53	64	3.57

* Values in the row having a common superscript letter are not significantly different ($P>0.05$).
Standard error of the means derived from the analysis of variance
1. Aspartate aminotransferase.
2. Alanine aminotransferase.

Muralidhara *et al.* (1999) indicated that fenugreek powder does not produce any effect GOT and GPT activity. However, Nakhla *et al.* (1991) reported that GOT activity was elevated by fenugreek crude seed saponins diets for broiler chicks.

Organs indices:-

Table (6) shows the effect of different levels of FSM on gutted weight percent and hepatosomatic and gonadosomatic indies of Nile tilapia

fingerlings. Results indicated that GW% of males was slightly higher than females fish. However, GSI for females fed FSM was higher in comparison with the males. It recorded 4.16 *vs* 2.54% for females and males, respectively. At the same time, GSI was affected by FSM levels in tilapia diets. Values of GSI decreased in males and increased in females by increasing of FSM levels. While HSI seemed to be similar in both sexes of fish and it was not affected by fenugreek levels.

Table 6: Organs indices[1] of Nile tilapia fed different levels of fenugreek seeds.

FSM %	Male			Female		
	GW[2] %	HSI[3]	GSI[4]	GW[2] %	HSI[3]	GSI[4]
0	89.52[a]	2.51[b]	3.89[a]	87.37[a]	3.28[a]	3.83[b]
2	85.03[b]	2.34[b]	3.56[a]	82.40[c]	2.69[b]	3.98[b]
4	88.98ab	2.77[a]	2.14[b]	86.57[b]	2.80[b]	4.03[b]
6	88.79[a]b	2.85[a]	1.97[b]	86.43[b]	3.01[a]	4.49[a]
8	89.11[a]	2.10[c]	1.06[c]	88.16[a]	2.98[b]	4.46[a]
Average	88.29	2.51	2.52	86.19	2.80	4.19

**Values in the column having a common superscript letter are not significantly different (P>0.05).*

1. **Five fish were taken as a randomly sample from each replicate.**
2. **Gutted weight % = 100 (body weight without viscera weight/body weight)**
3. **Hepatosomatic index = 100 (liver weight/ body weight).**
4. **Gonadosomatic index = 100 (Gonad weight/ body weight).**

Cost-benefit analysis:-

Data in Table (7) show the effect of different levels of FSM as feed additives in Nile tilapia diets. Results indicated that cost per one-kilogram diet ranged between 3.50 and 4.42 LE. Incidence cost (represents the feed cost to produce one kilogram fish gain) of fish fed diet containing 2% FSM decreased by 3% than those fed the control diet. Then it increased with increasing FSM levels in the Nile tilapia diets. In contrast, profit index of fish group fed 2% FSM increased to 104 than the control fish group. However, higher levels of FSM resulted in a decreased profit index. Previous studies showed that the use of spices in small amounts gave lower incidence cost and higher profit index of fish species (Abd Elmonem *et al.*, 2002; Sakr, 2003; Shalaby *et al.*, 2003 and El-Dakar *et al.*, 2004). Improvement of economic efficiency of fish fed spices or medical and aromatic plants as feed additives may be due to their ability to reduce feed waste and organic matter in the culture environment which results in a good water quality (Mendoza *et al.*, 1997; Sakr, 2003 and El-Dakar *et al.*, 2004).

Generally, the present study could recommend the safely and economically use fenugreek seeds meal at 2 % level in tilapia diets.

Table 7: Cost-benefit analysis of Nile tilapia fed different levels of fenugreek seeds.

Supplemented FSM level (%)	0	2	4	6	8
Cost / kg feed	2.30	2.31	2.31	2.32	2.32
Incidence cost[1]	3.62	3.50	3.65	4.33	4..42
Change %	100	97	101	120	122
Profit index[2]	1.66	1.72	1.64	1.39	1.37
Change %	100	104	99	84	83

1- Incidence cost = feed cost to produce one kilogram fish.
2- Profit index = value of fish /cost of feed consumed, 1 kg fresh fish equals 6 LE
3- Kilogram cost of fishmeal, soybean meal, yellow corn, fenugreek seeds, wheat milling by-product, wheat bran, corn starch, sunflower oil, vitamin premix, ascorbic acid and minerals premix were 5, 2.5, 0.8, 1.9, 0.8, 0.8, 3,10, 10 and 10 LE, respectively.

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استجابة إصبعيات أسماك البلطى النيلى للعلائق المحتوية على مستويات مختلفة من بذور الحلبة

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فى تجربة غذائية أجريت لدراسة تأثير إضافة مستويات مختلفة من مسحوق بذور الحلبة على النمو والاستفادة من الغذاء والعناصر الغذائية وعلى مستويات الجلوكوز والدهون الكلية والبروتينات الكلية للبلازما والتركيب الكيماوى لجسم الأسماك وتحليل التكلفة/ الربح لأسماك البلطى النيلى، استخدمت عشرة أحواض زجاجية بأبعاد ٧٠ X ٣٠X ٤٠سم لتخزين عشرة أسماك بمتوسط وزن ٦جم/سمكة تم تركيب خمسة علائق تجريبية متزنة فى البروتين و الطاقة لتحتوى على صفر ، ٢ ، ٤ ، ٦ ، ٨ % من مسحوق بذور الحلبة. قدمت العلائق ثلاثة مرات يوميا فى ستة أيام كل أسبوع لمدة ٧٧ يوما. وكانت الأسماك توزن كل أسبوعين وتعدل على أساسها كميات الغذاء.

وقد أشارت النتائج أن الأسماك المغذاه على عليقه تحتوى على ٢% مسحوق بذور الحلبة سجلت زيادة معنوية فى كل من وزن الجسم والزيادة الوزنية ومعدل النمو النوعى ومعدل التحويل الغذائى وكفاءة الاستفادة من البروتين والطاقة مقارنة بالعلائق المحتوية على المستويات الأخرى من الحلبة والكنترول ،فى حين أن العلائق المحتوية على ٦ أو ٨% من مسحوق بذور الحلبة سجلت انخفاضا معنويا فى كل من كفاءة النمو والقياسات الغذائية الأخرى بالمقارنة بالعليقة الكنترول.

كما أظهرت النتائج انه لا توجد اختلافات معنوية فى تركيب الجسم (الماء والبروتين والمستخلص الأثيري والرماد والطاقة) للأسماك التى تغذت على مستويات مختلفة من مسحوق بذور الحلبة، فى حين أن الجلوكوز والبروتينات الكلية والدهون الكلية للبلازما كانت تتناقص بزيادة مستوى الحلبة فى العلائق. أوضح تحليل التكلفة / الربح أن ٢%من مسحوق بذور الحلبة كان أفضل مستويات الإضافة من الناحية الاقتصادية.