EVALUATION OF LINSEED MEAL AS FEED INGREDIENT IN DIETS OF GROWING NILE TILAPIA (*OREOCHROMIS NILOTICUS*)

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ABSTRACT

A laboratory growth experiment was conducted to evaluate the suitability of various levels of linseed meal as a dietary protein source for Nile tilapia. Five experimental diets were formulated containing different levels of linseed meal to substitute soybean meal protein at rates of 0%, 25%, 50%, 75%,and 100 %. All diets were isocaloric and isonitrogenous and contained about 30% crude protein. The diets were evaluated on the basis of fish survival, growth, feed conversion, protein efficiency ratio, protein productive value, body composition and internal organs indices. Significantly ($P<0.05$) variations were observed in growth responses and feed conversion ratios among the control diet and the diet containing (25 %) linseed meal. The diets containing 50, 75, and 100% linseed meal showed the poorest performance. Similai trends were also observed in protein efficiency ratio and protein productive value, all diets except that containing (50,75,and 100% linseed meal) which showed the poorest value. The carcass composition of experimental fish was relatively effected by different dietary treatments. Cost benefit analysis showed that low profit index and high incidence cost were obtained by the control diet.

Keywords: Nile tilapia, linseed meal, performance.

INTRODUCTION

The increased intensification of fish culture in recent years depends mainly on complete rations to cover the nutrient requirements of fish. Sufficient level of dietary protein is needed for rapid growth. Protein is the most expensive component in artificial diets for fish (EL-Ebiary, 2002).Also a shortage of inexpensive and readily feed is a constraint for the development of aquaculture .On the other hand, as in most aquaculture endeavors, reducing feed cost is a persistent concern because feed cost significantly impacts production cost . High cost of protein from conventional feedstuffs has forced fish nutritionalists to consider ultimate sources of protein. One approach for reducing feed cost is to substitute lower cost feed ingredients, such as plant, herbs and by-products, for more expensive ingredients such as fishmeal and soybean meal. Jackson et al (1982) reported that copra, groundnut, sunflower, rapeseed and cottonseed meals at low inclusion levels promoted growth rate of tilapia. The efficiency of various alternative protein diet, e.g. poultry by-product meal and rapeseed meal was reported (Higgs et al; 1979). However, there is a paucity of information on the efficiency of mustard, linseed, sesame, groundnut and copra oil cakes or meals as alternative protein sources in feeds of tilapia. Hossain and Jauncey (1989) evaluated mustard, linseed and sesame oil cakes as dietary protein sources for the common carp fingerlings. However, there is no information for common carp fry nevertheless, many of these ingredients have been used as dietary protein sources for other fish species, i.e. groundnut meal (Wu and Jan, 1977; Cruz and Laudencia , 1978 and Jackson et al ; 1982) linseed , mustard and sesame (Hasan et al.,1991). This study was undertaken to determine the possibility of replacement of linseed meal instead of soybean meal in the form of compounded pelleted diets fed to tilapia, which would probably decrease the artificial feeding costs.

MATERIALS AND METHODS

The present work was carried out at the wet lab. in department of Animal and Fish Production, Faculty of Agriculture Kafr EL-Sheikh , Tanta University during year 2005 .

1. Rearing of fish:

Hundred fingerlings of *Oreochromis niloticus* with an average initial body weight of 10 g were used in this study. The fish were purchased from the stock of Moasaset EL-sharaky , Kafer EL-Sheikh . The fish were divided into 10 similar groups in glass aquaria (60 x 35 x 40 cm). Each aquarium contained 70 liter of water and stocked with 10 fish. The fish were distributed into the experimental treatments in duplicate aquaria. Five air pumps and 10 air stones were used for aeration (one air pump and 2 air stones for each two aquaria) . Dechlorinated tap water was used to change one third of the water in each aquarium every day. Water was aerated before use for about 24 hours to remove chlorine. Samples of water were taken weekly from each aquarium (before changing the water) 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). Analysis of NO2, NO3 and hardness were done by commercial kits from Hach International Co; Cairo, Egypt, and analysis of PO4 and alkalinity were carried out using commercial kits from LaMotte International Co; Cairo, Egypt. Light was controlled by a timer to provide 14 h light: 10 h dark as a daily photoperiod. The fingerlings were acclimatized to the wet lab. conditions and feeding regime for one week followed by 10 weeks experimental period .

2. Diet formulation:

The linseed meal was obtained from Shaheen Oil Co., Kafr El – Sheikh. The proximate composition and amino acid analysis of linseed meal compared with those of soybean meal are given in Table (1). Linseed meal was added to the experimental diets to replace 0, 25, 50, 75, and 100 % of soybean meal protein. These diets were designated as diets No. 1, 2, 3, 4 and 5, respectively. Five isonitrogenours (30 % crude protein) and isocaloric (19.03 MJ GE/ kg DM) feed mixtures from indigenous ingredients and imported herring meal were used composition and chemical analysis of the experimental diets is presented in Table (2) . During the experimental period fish were fed on experimental diet at a rate of 3% of the live body weight daily. Fish were weighed weekly and the amount of feed was adjusted accordingly. The daily ration was introduced at 2 equal portions at 8 am and 2 pm.

Table (1): Proximate composition and essential amino acids composition (% dry matter basis).

COMPOSITION	LINSEED MEAL	SOYBEAN MEAL
Determined values :		
DM%	90.00	89.0
CP%	33.00	44.0
EE%	8.27	1.1
ASH%	11.65	6.3
CF%	8.00	7.3
NFE% (a)	39.08	41.3
Calculated values:		
GE (MJ/kg) (b)	17.68	17.81
ME(MJ/kg) ©	14.70	14.67
Amino acid content:		
Glysine	1.80 %	1.50 %
Arginine	3.16 %	3.39 %
Histidine	0.71 %	1.19 %
Isoleucine	1.66 %	2.03 %
Leucine	2.11 %	3.49 %
Lysine	1.21 %	2.85 %
Methionine	1.68 %	0.57 %
Cystine	0.61 %	0.70 %
Phenylalanin	1.68 %	2.22 %
Threonine	1.32 %	1.78 %
Tryptophane	0.57 %	0.64 %
Valine	2.02 %	2.02 %
Tyrosine	1.01 %	1.03 %
	According to NRC (1993).	According to Robert,(2002).

a)NFE = 100 – (CP% + EE% + CF% + ASH%)

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

c)ME(metabolizable energy) calculated using the value of 3.49,8.1 an4.5kcal/g for carbohydrate , fat and protein , respectively, according to pantha(1982).

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

Ingredients (%)	Diets No. (% linseed meal protein replacement)				
	D1 (control) (0%)	D2 (25%)	D3 (50%)	D4 (75%)	D5 (100%)
Fish meal (72%)	10	10	10	10	10
Soybean meal (44%)	45	33.75	22.5	11.25	--
Yellow corn	27.7	23.95	20.2	16.45	12.7
Wheat bran	6	6	6	6	6
Rice bran	6	6	6	6	6
Sun flower oil	5	5	5	5	5
Vit. & min.(1)	0.3	0.3	0.3	0.3	0.3
Linseed meal (33%)	--	15	30	45	60
Total	100	100	100	100	100
Determined values (%):					
Dry matter	89.50	88.9	89.30	90.60	90.30
CP	29.61	29.50	29.35	29.20	28.90
EE	8.55	8.70	8.80	9.10	10.11
CF	5.30	5.25	4.90	5.20	4.50
Ash	4.70	5.30	6.50	6.30	6.40
NFE	51.84	51.25	50.45	50.20	50.09
Calculated values:					
GE MJ/ kg (2)	19.18	19.12	18.98	18.96	19.33
ME MJ / kg (3)	16.00	16.00	15.80	15.80	16.10
MgP/KJGE (4)	15.43	15.40	15.45	15.40	14.94

(1) Vitamin and mineral mixture (product of HEPOMIX Cairo) each 2.5 kg contain: 12.000.000IU Vit.A; 2.000.000 IU Vit.D3 ; 10 g Vit. E ; 2 g Vit.K3 ; 1g Vit. B1 ; 5g Vit. B2 ; 1.5 g Vit. B6; 10 g Vit. B12 ; 30 g Nicotinic acid ; 10 g pantothenic acid ; 1 g folic acid ; 50 g biotien ; 250g choline chloride 50 % ; 30g iron ;10g copper ; 50 g zinc ; 60 g manganese ; 1g iodine ; 0.1 g selenium and cobalt 0.1 g .

(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 (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).

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

3. Biochemical analysis :

Fish samples (5-6 fishes) from each group were obtained at the end of the experiment for chemical analysis for dry matter

(DM) , crude protein (CP), ether extract(EE) ,and ash in the diets used and in fish whole body (besides crude fiber , CF in the diet) 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- SR = 100[Total No of fish at the end of the experiment/total No. of fish at the start of the experiment].

5. Organs indices:

All fish were killed and soon abdominal cavity was opened to remove liver , kidney, gonads and spleen which were weighed individually. Liver (HIS) , 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 (Alabaster and Lioyd , 1982).
- 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 ; 2004a) .

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 difference was calculated according to (Duncan, 1955).

RESULTS

1- Water quality parameters:

The most important physical-chemical parameters of tap water used in the experiment are shown in Table (3) . Data in this Table indicate that the values obtained lie in the acceptable ranges required for normal growth of tilapia (AbdEl-Hakim et al., 2002 and Abdelhamid,2003)

Table (3): Averages Some important measured physical-chemical parameters of water.

Temperature (ċ)	pH value	DO2 ppm	Alkalinity mg/l	Hardness mg/l	PO4 mg/l	NO2 mg/l	NO3 mg/l
25-27	6.5-8	5-6	145-150	250-300	0.1-0.2	0.12-0.13	1-2

2- Growth performance:

Results concerning average body weight , average daily gain , specific growth rate and survival rate showed a significant ($p < 0.05$) decrease with increasing linseed meal level instead of soybean meal (Table 4) except with 50% linseed meal in tilapia diet (diet 3) which showed no significant difference in specific growth rate as compared with the control diet . The results clearly showed that the diet containing 25% linseed meal was slightly better in average weight gain and average daily gain than the control diet .Results of table (4) also clearly showed that the diets, containing 75% and 100% linseed meal were slightly lower than (in all tested parameters)than the control diet . The specific growth rate and survival rate clearly showed that the diet containing 25%

and 50% linseed meal were better than those containing 75% and 100% linseed meal.

Table (4) Growth performance parameters of Nile tilapia fed on the experimental diets containing different levels of linseed meal.

Treatment No. (linseed meal%)	AWG g/fish	ADG g/fish/day	SGR (%/day)	SR (%)
1- Control (%)	18.65(b)±0.85	0.27(b)±0.01	2.19(a)±0.06	100(a)±0.00
2- (25%)	23.12(a)±0.22	0.33(a)±0.01	2.38(a)±0.01	100(a)±0.00
3- (50%)	19.10(b)±0.90	0.27(b)±0.01	2.22(a)±0.05	100(a)±0.00
4- (75%)	16.70(c)±0.15	0.24(c)±0.01	2.00(a)±0.07	90(b)±0.00
5- (100%)	15.96(c)±0.15	0.23(c)±0.01	1.49(b)±0.03	90 (b)±0.00

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

3- Feed and protein utilization:

Results concerning feed conversion ratio and protein efficiency ratio of experimental groups fed the .diets No.2 and 3 (25%and50% linseed meal) were significantly better compared with the control . The results of FCR , PER and PPV (Table 5) clearly showed that the diets containing 25 % and 50 % linseed meal were slightly better than the other treatment groups (diets No. 4 and 5) .

Table (5): Feed and nutrient utilization of Nile tilapia fed on the experimental diets containing different levels of linseed meal .

Treatments No. (%linseed meal)	FCR	PER	PPV
1- Control (0%)	1.23 (c) ± 0.04	2.70 (a) ± 0.11	23.31 (a) ± 0.18
2- (25%)	1.11 (c) ± 0.03	2.99 (a) ± 0.06	23.46 (a) ± 0.66
3- (50%)	1.18 (c) ± 0.07	2.82 (a) ± 0.18	22.60 (ab) ± 0.20
4- (75%)	1.36 (a) ± 0.04	2.66 (a) ± 0.27	21.30 (bc) ± 0.40
5- (100%)	1.38 (a) ± 0.02	2.10 (b) ± 0.02	18.53 (d) ± 0.23

a , b and c mean 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 whole fish bodies are summarized in Table (6) .The results of carcass composition of Nile tilapia showed no significance differences (p>0.05) differences in crude protein between fish groups fed the control and those fed the diet No.2 (25% linseed meal) , but diet No.2 showed a significant (p<0.05) increase in ether extract and a significant decrease in ash ,compared with the control . Significant (p<0.05) increase in dry matter % was recorded in fish groups fed on the diets containing 25% and 50% linseed meal compared with those fed the control diet.

Table (6): carcass chemical composition (%) of Nile tilapia fed on the experimental diets containing different level of linseed meal .

Treatments No. (%linseed meal)	DM	CP	EE	Ash
1- Control (0%)	25.96(b)±0.16	60.13(a)±0.01	15.88(c)±0.03	25.00(a)±0.02
2- (25%)	26.00(a)±0.10	60.12(a)±0.01	16.75(a)±0.05	23.12(b)±0.05
3- (50%)	26.00(a)±0.10	59.93(b)±0.03	16.80(a)±0.05	23.33(b)±0.03
4- (75%)	25.78(b)±0.03	59.69(b)±0.05	16.60(ab)±0.05	23.45(b)±0.06
5- (100%)	25.71(b)±0.14	59.45(c)±0.05	16.55(ab)±0.01	24.00(a)±0.01

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

5- Internal organs indices :

The main effects of dietary linseed meal inclusion on fish organs indices (Table7) were found to be on HSI, KSI, and SSI, but there were no significant differences between diet 1 [control] and diet 2 (25% linseed meal). The results of table 7 clearly showed significant (p<0.05) differences between diets1 and diet2 on one side and the other treatments on the other side concerning HSI, KSI and SSI.

Table (7): Effect of dietary linseed meal level on organs indices of the experimental fish.

Treatment (% linseed)	HSI	GSI FEMAL	GSI MALE	KSI	SSP
1- control (0%)	2.63(a)±0.08	3.48(ab)±0.02	0.064(c)±0.06	0.14(a)±0.01	0.29(a)±0.002
2- (25%)	2.70(a)±0.01	3.95(a)±0.03	1.46(a)±0.02	0.11(a)±0.02	0.27(a)±0.004
3- (50%)	2.28(b)±0.03	2.29(b)±0.01	1.12(b)±0.02	0.05(b)±0.002	0.28(a)±0.008
4- (75%)	2.13(b)±0.02	2.91(b)±0.02	1.10(b)±0.02	0.05(b)±0.002	0.20(b)±0.003
5- (100%)	1.94(c)±0.05	2.95(b)±0.01	0.88(c)±0.08	0.04(c)±0.005	0.021(b)±0.001

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

6- Economic efficiency :

The economic parameters of the tested diets are presented in Table (8). The calculation depends on the average price of dietary ingredients at year (2005) where local market price/ton of fish meal 4000 LE , soybean meal 2000 LE , yellow corn 1000 LE , oil 3000 LE , Vit.&Min. 12000 LE and linseed meal 1500 LE. The calculated figures showed lower cost of one ton of all diets containing linseed meal . However , the control diet recorded the highest price being 1835 LE / ton .

Table (8): Data of the economical efficiency due to feeding fish on graded level of linseed meal.

Treatment (%) Linseed meal	Feed intake g/fish	Cost (LE) of one ton diet	Decrease in feed cost (LE)	Total gain g/fish	Feed cost* / kg gain (LE)
1-control (0%)	22.90	1835.0	0.00	18.65	2.25
2- 25%	24.80	1797.5	37.5	23.12	1.89
3- 50%	22.54	1760.0	75.0	19.10	2.07
4- 75%	21.56	1722.5	112.5	16.70	2.22
5- 100%	19.80	1685.0	150.0	15.96	2.09

*Feed cost / kg gain (LE) = Feed intake x cost (LE) of one ton feed /1000 x total gain

The diets containing (75% and 100% linseed meal) showed the lowest fish gain comparing with the other linseed meal levels (25% and 50%) and the control diet. Therefore, diets No. 4 and 5 showed high feed cost / kg gain but the levels of 25 and 50% linseed meal gave the lowest feed cost / kg gain being (1.89 and 2.07LE).

DISCUSSION

Nile tilapia fish are diversified feeders (El-Sayed and Teshima, (1991) , so that they can utilize many plant originated materials as protein sources , e.g. cottonseed meal (Jackson et al ., 1982),soybean meal (Tacon et al., and Viola and Arieli , 1983), leucaena leaf meal (Wee and Wang , 1987 and Santiago et al ., 1988), tomato pulp silage (Hassanen et al ., 1993), oilseed meal , single cell proteins , legumes (El-sayed , 1999), azolla (Tharwat , 1999 and El-Ebiary(2002), black seed and Coquette seed meals (Abd Elmonem et al ., 2002),tomato by-product meal (Soltan , 2003), sweet lupin (Osman ,2003), sesame meal (Abdelhamid et al.,2004a), mallow(Abdelhamid et al ., 2004b) , sesame hulls (Abd Elmonem et al ,.2004), plant protein concentrates (El- Ebiary et al .,2004), and kochia (Srour et al .,2004).

Using such unconventional sources became a must for the developing countries (Greenhalgh , 1985), the area is designated as "the South" where the food shortages and multiple deaths from famines ; therefore there is need for a continuing and growing place for the development of novel sources of food , although the problem is a complex one and the development of novel sources of food will not be an easy task (Howat , 1985) . Additionally , Spinelli (2003) reported that the rapid world-wide expansion of aquaculture strongly indicates that a crisis will be precipitated in the aqua feed industry in the near future .

The results of the present investigation indicate that linseed, meal at low inclusion levels (25 and 50% as replaced of soybean meal protein) is a good dietary protein source for Nile tilapia . Imbalance of limiting essential amino acids in the diets containing higher levels of plant protein sources was mentioned (Jauncy and Ross,1982) . Although the linseed meal used in the present study was deficient in lysine, methionine and thereonine, the prepared diet did not have any deficiency because of the amino acid profile was covered the fish meal . The performance of Nile tilapia fed 25% and 50% linseed meal protein was significantly not different from the control diet . However , the significantly poorer growth response of Nile tilapia at high level of linseed meal may be due to the presence of anti-nutritional or growth inhibitory substances .Since Immature linseed meal contains a small amount of the cyanogenetic glycoside .So, unprocessed linseed meal or processed under low temperature can be toxic to animals, especially if wetted before being fed (Gohl, 1981 and McDonald et al .,1981). However, normal processing involving high temperature treatment .The results of the present study support the finding of Hasan et al .(1989) . Where no significant reduction in growth and feed conversion was observed when fish were fed on diets containing up to 50% linseed meal . The carcass protein content of Nile tilapia fed different diets did not show large variations , although some of the values were statistically different. However, the carcass moisture and lipid contents showed large fluctuations, since carcass moisture and lipid contents of fish always tend to show greater fluctuations than other carcass components and they appear to be inversely related (Atack et al.,1979 ; Hasan et al., 1990 and Hasan and Macintosh ,1993).

CONCLUSION

As potential partial substitute for soybean meal , linseed meal at 25-50% inclusion levels gave the most promising results . Therefore , the use of linseed meal , which are locally available and relatively inexpensive in many developing countries , as alternative dietary protein sources for Nile tilapia could reduce the feeding cost considerably . Therefore,the results suggest the useful useness of linseed meal to replace up to 50% of soybean meal protein in tilapia fish diets.

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الملخص العربى

تقيم كسب بذرة الكتان كمكون غذائى فى علائق أسماك البلطي النيلى النامية

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صممت هذه التجربة لدراسة تأثير الاستبدال النسبي لبروتين كسب فول الصويا بكسب الكتان بمعدلات (صفر ،٢٥، ٥٠، ٧٥، ١٠٠%) و استخدمت اصبعيات من البلطي النيلى بمتوسط وزن ابتدائي ١٠ جم وكانت نسبة البروتين في العلائق التجريبية حوالي ٣٠% واستمرت التجربة ١٠أسابيع . ووجد أن معدلات النمو أعلي في العلائق التي بها نسبة استبدال ٢٥%كسب كتان بكسب فول الصويا من علائق الكنترول، وتساوى النمـــــــو على نسبة الاستبدال ٥٠% مع علائق الكنترول، وأيضا حدث تحسن في معدلات التحويل الغذائي ومعدلات الاستفادة من البروتين على نسب الاستبدال ٢٥% ،٥٠% ومن ناحية التحليل الكيماوي لجسم الأسماك وجد أن النسبة بين البروتين والدهون والرماد متقاربة بين المعاملات المختلفة ، وان كانت نسب البروتين زادت علي معدلات الاستبدال ٢٥، ٥٠%، وأيضا لم توجد فروق معنوية بين الوزن النسبي للمناسل فى المعـــــــــــــاملات المختلفة . أما بالنسبة للعائد الاقتصادي لعملية الاستبدال فكان واضحا أن هناك انخفاض في تكاليف

التغذية لإنتاج كيلو زيادة في وزن الاسماك في المعدلات المنخفضة لاستبدال كسب فول الصويا بكسب الكتان ومن هنا يمكننا خفض تكلفة إنتاجية طن ألعليقه وبالتالي يمكن التقليل من مشكلة الارتفاع الكبير في أسعار العلائق.