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EVALUATION OF JOJOBA SEED MEAL (*SIMMONDSIA CHINENSIS)* AS PARTIAL AND TOTAL REPLACEMENT OF FISHMEAL IN NILE TILAPIA, *OREOCHROMIS NILOTICUS (L.),* FINGERLINGS DIETS

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ABSTRACT: *The suitability of treated jojoba seeds meal (Simmondsia chinensis) (JSM) as a partial and total substitute for dietary fish meal protein in the diets of fingerlings Nile tilapia was evaluated. Five experimental diets were formulated with JSM replacing 0.0, 25, 50, 75 and 100 % of fish meal protein (diets A, B, C, D and E, respectively). The control diet was prepared with fish meal as the sole source of protein. All the diets were isonitrogenous with 30.3% protein and isocaloric with 4.0 kcal/g of diet. Experimental diets were fed to two replicate groups of Nile tilapia with initial average body weight of 3.3 $\pm$ 0.01g. The feeding trial was conducted under laboratory conditions for a period of 16-week. The results of the present study revealed that, the fish fed diet B which contained 25% JSM had significantly ($P \leq 0.01$) the best average body weight, gain in weight (g/fish), gain in weight %, specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER) and feed consumed (g/fish) compared with those of fish fed control diet A (100% FM) and all other diets. Survival rate % of the fish fed experimental diets B and C were not significantly different ($P > 0.05$) from those of fish fed the control diet A. Chemical composition of fish flesh crude protein and crude fat (dry basis %) and apparent digestibility coefficient of crude protein and crude fat of the fish fed experimental diets B and C did not differ significantly ($P > 0.05$) from those of fish fed the control diet A. From the above results and the economic evaluation of the study it can be concluded that, up to 25 % of fish meal protein can be replaced by jojoba seed meal protein in fingerlings Nile tilapia diets without decreasing the growth performance and feed utilization parameters. More scientific research is needed to maximize the commercial benefit from JSM by other fish species.*

Key words: *Jojoba meal- fishmeal- plant protein source- Nile tilapia.*

INTRODUCTION

The shortage in global fish meal (FM) production coupled with increased demand and competition for its use in livestock and poultry feeds has further increased FM prices. It is evident, on the long-run, that many developing countries will be unable to depend on FM as a major protein source in aqua feeds. Therefore, several attempts have been made to partially or totally replace FM with less expensive, locally available protein sources (El- Sayed, 1999).

Jojoba *(Simmondsia chinesis)* as a dioecious desert shrub that grows on arid or semi-arid regions is being cultivated to provide a renewable source of a unique high-quality oil (Sabien *et al*., 1997). Several advantages are favoring jojoba seeds to be grown in Egypt such as limited water requirements, high seed yield in new reclaimed soils and relatively high oil content, (50%) (Wisniak, 1987). The meal remaining after the oil extraction, contains high protein level (approximately 30%) and therefore should be of interest for livestock producers as a feed supplement. Motawe (2005) demonstrates that up to 25% JSM could be used to replace fish meal as a protein source in the diet of tilapia without affecting growth performance of fish. Beyond that level growth was depressed and the fish population experienced mortality when fed 100% JSM diet. Wu *et al.* (1995) indicated that 40% protein diet for tilapia achieved the best feed conversion ratio and is suitable to examine alternative protein sources.

The present study was carried out to evaluate partial or total replacement of fish meal by treated jojoba meal *S. chinensis* (as a new plant protein source in Egyp) as alternative protein source, after being supplemented with 0.50 % methionine and 0.50 % lysine and the effect of replacement on growth performance, feed and nutrients utilization, carcass composition and apparent nutrient digestibility of Nile tilapia, *O. niloticus* fingerlings.

MATERIALS AND METHODS

Culture condition:

Juveniles Nile tilapia, *Oreochromis niloticus*, were obtained from a local fish farm (Foka Hatchery, Kalubia Governorate, Egypt). Fish were acclimatized to laboratory condition for four weeks in fiberglass tanks (water volume 1000 L). At the beginning of the experiment, 10 glass aquaria 80L each were stocked with 10 fish/aquarium with an average weight of 3.3 ± 0.01 g. The aquaria were supplied with fresh water (free of chlorine) at a rate of 250 ml $min.^{-1}$ with supplemental aeration. The aquria were illuminated by over head fluorescent lighting set on a 14 h light: 10 h dark cycle.

Jojoba Preparation:

Jojoba residual of seed squeezing in the Egyptian Natural Oil was jojoba meal seeds *(Simmondsia chinensis)*, exposed earn jojoba for hot water vapor at temperatures of 120 ° c for half an hour to get rid of toxic *simondsin* and that cause multiple adverse effects on fish from anorexia (as a new plant protein source) .

Diets and feeding regime:

Proximate composition of jojoba seeds meal and fish meal (% dry matter) used in the present study is presented in Table 1. The experimental diets (Table 2) were formulated with the same macronutrient composition and therefore were isonitrogetic and isoenergetic in terms of crude protein (30.0%) and gross energy (4.0 kcal/g diet). The energy value of each diet was calculated using the gross energy values for the macronutrients (5.6 kcal/g protein, 9.5 kcal / g fat and 4.1 kcal / g carbohydrate, fiber was not included in calculation). Fish meal (FM) provided the only animal protein source in the control diet (Diet1). Diets (2-5) had different percentages (25%, 50 %, 75 % and100%) of jojoba seeds meal protein as a fish meal protein replacement. The experimental diets were pelleted, dried and stored at -20ºC until used as described in a previous work (El-Saidy and Gaber 2001). The calculated essential amino acid concentrations (Table 3) in the experimental diets met or exceeded those recommended by Santiago and Lovell (1988). For digestibility tests 0.5 % chromic oxide was included in the diets as an inert indicator (Cho and Kaushik, 1990). Each diet was given to two replicate groups of fish. The feeding rates ranged from 5 % of fish weight at the beginning to 3 % at the end of the feeding trial (NRC 1993). The fish were fed twice daily, six days per week for 16 weeks feeding trial. Feed intake was recorded daily and calculated at the end of the trial as average total amount consumed (g/fish).

Each group of fish was weighed at the beginning and every two weeks of the experimental period. Feces were collected with a modified fecal collection system after 16 weeks of the feeding trial (Yamamoto *et al*. 1998). From week 16 of the feeding trial, fish were fed the 0.5 % chromic oxide diets to facilitate the digestibility test. After 16 weeks of feeding trial, two groups of 10 fish per diet treatment were transferred to two 50L collection tanks having a steep conical bottom connected to a feces collection chamber. Water flowed to the top and out at the bottom of the conical tanks at a rate of less than 0.4L / min. Fish were prevented from stirring the feces by a circular net placed at the base of the tank. To test the apparent nutrient digestibilitie of the five experimental diets, the fish were fed their last respective meal at 2000 hours, and the feces were collected the next day at 0800 hours. The collected feces were immediately frozen at -20 ^{o}C until analyzed. These samples of feces were used to determine the apparent digestibility coefficient. The apparent digestibility coefficients (ADC) for nutrients were calculated using the following formula:

$ADC_{nutrient}$ = {1 - (% dietary Cr_2O_3 / % fecal Cr_2O_3 x % fecal nutrient / % dietary nutrient)} x 100, according to Maynard and Loosli (1969).

Growth study:

At the beginning of the growth study, 15 fish were sampled and stored at -20 ^{o}C for analysis of whole body composition. At the end of the feeding trial (16 weeks), five fish per tank were withdrawn for analyses. Sample of fish from each group were frozen at - 20 C. Growth performances were determined according to Cho and Kaushik (1985) as following:

SGR (specific growth rate) = (Ln final weight - Ln initial weight / No of days experiment).

FER (feed efficiency ratio) = wet weight gain (g) / dry feed intake (g).

FCR (feed conversion ratio) = dry feed intake (g)/wet weight gain (g).

PER (protein efficiency ratio) = weight gain (g) / protein intake (g).

Water quality:

Water temperature and dissolved oxygen were measured every other day using aYSI Model 58 oxygen meter. Total ammonia and nitrite were measured twice weekly using a DREL, 2000 spectrophotometer. Total alkalinity and chloride were monitored twice weekly using the titration method; pH was monitored twice weekly using an electronic pH meter (pH pen; Fisher Scientific, Cincinnati, OH). During the 16-weeks feeding trial, the water-quality parameters averaged (± SD) water temperature, 26.8 ± 0.9°C: dissolved oxygen, 5.6 ± 0.7 mg /l: total ammonia, 0.19 ± 0.12 mg /l nitrite, 0.07 ± 0.03 mg / l: total alkalinity, 178 ± 42 mg /l: chlorides, 570 ± 152 mg / l: pH, 8.4 ± 0.3.

Analytical methods:

Analyses of samples were made as follows: dry matter after desiccation in an oven (105°C for 24 h), ash (incineration at 550°C for 12 h), crude protein (micro kjeldahl, N x 6.25), crude fat (ether extraction by soxlhet method), and crude fiber by AOAC, (2000). Gross energy of feces and whole body was determined by a diabetic bomb calorimeter. The chromic oxide in diets and feces was determined by Furukawa and Tsukahara (1966).

Statistical analysis:

The data were analyzed by one-way analysis of variance (SAS, Institute Inc, 1993). Duncan's multiple rang test (Duncan, 1955) was used to compare differences among individual means. Treatment effect were considered significant at $p \leq 0.05$. All percentage and ratio were transformed to arcsin values before analysis (Zar, 1984).

Table 1: Chemical analysis (%) of used ingredients in the experimental diets (on DM basis).

Ingredient	DM (%)	CP (%)	EE (%)	CF (%)	Ash (%)	NFE (%)	GE (kcal/100 g DM)
Fish meal	93.10	60.20	10.90	0.62	17.28	0.00	504.46
Jojoba meal	91.40	24.00	6.89	3.12	3.88	57.11	463.32
Soybean meal	90.70	44.00	1.73	5.83	6.82	41.50	435.74

Table 2: Formulation and proximate analysis (%) of experimental diets (on DM basis).

Ingredients	Diets[1]				
	A	B	C	D	E
	Control	JSM 25%	JSM 50%	JSM 75%	JSM 100%
Menhaden fish meal (60%CP)	20.0	15.0	10.0	5.0	0.0
Jojoba seed meal (24%CP)	0.0	12.5	25.0	37,5	50.0
Soybean meal (44% CP)	40.0	40.0	40.0	40.0	40.0
Corn starch	30	22.5	15	7.5	0.0
Vegetable oil	4.0	4.0	4.0	4.0	4.0
Vit& Min Premix[2]	2.0	2.0	2.0	2.0	2.0
Vitamin C[3]	1.0	1.0	1.0	1.0	1.0
Molasses	2.0	2.0	2.0	2.0	2.0
L.Methionine	0.5	0.5	0.5	0.5	0.5
L.Lycine	0.5	0.5	0.5	0.5	0.5
Total (%)	100	100	100	100	100
Chromium oxide (Cr_2O_3)	0.5	0.5	0.5	0.5	0.5
Proximate composition (%)[4]					
Dry matter	88.36	88.43	88.50	88.50	88.64
Crude Protein	30.3	30.3	30.3	30.3	30.3
Ether extract	5.41	5.53	5.66	5.61	5.61
Crude fiber	3.91	4.48	5.05	5.6	6.18
Nitrogen Free Extract[6]	42.23	41.68	41.21	41.02	41.53
Crude ash	8.23	8.57	8.91	8.91	9.59
GE (Kcal/kg) [5]	4110.07	4104.78	4099.9	4098.29	4088.57

1 Diets A, B, C, D and E contained 0%, 25%, 50%,, 75% and100% Jojoba meal instead of fish meal, respectively.
2 Premix supplied according to Xie, et al. (1997).
3 Phospitan C (Mg-L-ascorbyl-2-phosphate); Showa Denko K. K., Tokyo, Jap
4 Values represent the mean of three sample replicates.
5 Gross energy calculated according to Sanz, et al. (1994).
6 Nitrogen free extract = 100 - (% moisture + % protein + % fat + % fiber + % ash).

Table 3: Calculated amino acid composition of diets used in the study (g per 100 g diet).

	Diets					
Indispensable amino acids	A	B	C	D	E	Required
Arginine	2.08	2.44	2.86	3.29	3.63	1.33
Histidine	0.84	0.96	0.98	1.06	1.13	0.54
Isoleucine	1.59	1.62	1.91	2.08	2.24	0.99
Leucine	2.73	2.68	2.61	2.54	2.48	1.09
Lysine	2.48	3.01	2.43	2.17	1.90	1.63
Methionine	1.05	1.36	1.28	1.20	1.11	1.02
Phenylalanine	1.42	1.45	1.48	1.51	1.53	1.82
Threonine	1.40	1.42	1.46	1.50	1.54	1.15
Tryptophan	0.37	0.41	0.47	0.53	0.58	0.32
Valine	1.81	1.83	1.90	1.96	2.01	1.09

Data obtained from the National Research Council (1993).
From Santiago and Lovell (1988).

Results

Growth performance:

The initial body weight (IBW) of all fish in all treatments were 3.3g per fish of Nile tilapia (*Oreochromis niloticus*) and the final body weight of the five experimental diets are shown in Table (4). After sixteen week of trial feed the results indicate that the final body weight of the treatment 1(Control) (JSM 0%), treatment B (JSM 25%) were 25.0±4.7 and 25.65±0.9 g/fish, respectively and there were no significant differences (*P > 0.05*) between them. But the treatment 3 (JSM 50%), treatment 4 (JSM 75%) and 5(JSM 100%) were 17.4±0.0[b], 11.75±2.5 and 6.80±0.20, respectively and they were significantly differs (*P ≤ 0.01*) from the control diet and other experimental diets. The gain in weight (Table 4) of the treatment A (Control) and treatment B (JSM 25%) were 21.7±3.5 and 24±0 22.4±0.9g, respectively and there were no significantly differences (P > 0.05) among them. But the treatment C (JSM 50%), treatment D (JSM 75%) and treatment 5 (JSM 100%) were 14.1±0.05, 8.50±2.60 and 3.50±0.30, respectively and there were significant differs (P ≤ 0.01) among jojoba diet. The percentage of weight gain in diet 1(Control) and diet B (JSM 25%) were 655.5±16 and 694.2±32, respectively of the initial body weight (3.3 g) and there were no significant difference (P > 0.05) among them, however diet C (JSM 50%) , diet D (JSM 75%) and diet E (JSM 100%) were 425.8±9 , 257.8±89 and 103.6±9 , respectively of the initial body weight (3.3 g) which mean that were significant difference (P ≤ 0.01) between them and diet 1 (control). The specific growth rate (% /day) (Table 4) of the treatment A (control) and treatment B (JSM 25%) were 2.1±0.2 and 2.2±0.04, respectively and there were no significant differences (*P > 0.05*) among them. But the treatment C (JSM 50%) treatment D (CSM 75%) and treatment E (JSM 100%) were 1.7±0.01, 1.3±0.3 and 0.7±0.04, respectively and there were significantly differences (*P ≤ 0.01*) between them and the control diet.

Table 4. Initial weight, final weight, weight gain, weight gain percentage and specific growth rate (SGR) of Nile tilapia (*Oreochromis niloticus*) fingerlings fed five experimental diets.

	Diets [1, 2]				
Items	A (100% FM)	B (25% JSM)	C (50% JSM)	D (75% JSM)	E (100% JSM)
Initial weight g/fish	3.3±0.01	3.3±0.01	3.3±0.01	3.3±0.01	3.3±0.01
Final weight g/fish	25.0±4.7[a]	25.65±0.9[a]	17.40±0.00[b]	11.75±2.50[bc]	6.80±0.20[c]
Gain in weight g/fish	21.7±3.5[a]	22.4±0.9[a]	14.1±0.05[b]	8.50±2.60[bc]	3.50±0.30[c]
Weight gain %	655.5±16[a]	694.2±32[a]	425.8±9[b]	257.8±89[bc]	103.6±9[c]
SGR (% day $^{-1}$)	2.1±0.2[ab]	2.2±0.04[a]	1.7±0.01[b]	1.3±0.3[c]	0.7±0.04[d]
Survival rate (%)	90±0.0[a]	100±0.0[a]	100±0.0[a]	90±14.1[a]	70±0.0[b]

1 Values are means ± SE of three replications.
2 Means in the same row, having different superscript letters, are significantly different (P≤ 0.01).

Feed utilization:

Feed utilization, feed conversion ratio (FCR), feed efficiency ratio (FER), protein efficiency ratio (PER) and feed consumed (g/fish) of Nile tilapia (*Oreochromis niloticus*) fingerlings fed five experimental diets are shown in Table (5). The best value of feed conversion ratio (FCR) of 1.5±0.07 was recorded with groups of fish fed diet B and followed by treatment A (control diet) which was 1.7±00.1 then followed by treatment C of 1.8±0.00 and followed by treatment 4 which had FCR of 1.8±0.1. There were no significant differences (*P > 0.05*) among the four treatments. The highest value of feed conversion ratio was found in treatment E it was 2.6± 0.04[a] and it differ significantly (P ≤ 0.01) from treatment 1 (control) and other diets.

The best value of feed efficiency ratio (FER) (Table 5), of the five experimental diets were treatment A (control), and C there were 0.5± 0.05, 0.6 ± 0.2 and 0.5± 0.0, respectively. There were no significant differences (P > 0.05) among the three treatments. The lowest value of feed efficiency ratio was found in treatment D and E there were 0.3 ± 0.06 and 0.2± 0.007 it differences significantly (*P ≤ 0.01*) from treatment 1 (control) and other test diets. The best value of protein efficiency ratio (PER) (Table 5) of the five experimental diets was treatment B it was 1.9± 0.1 followed by treatment A (control) it was 1.7± 0.2 then followed by treatment C it was 1.5± 0.007 and followed by the last good PER was found in treatment D it was1.1± 0.2. There were no significant differences (P > 0.05) among the four treatments. But the lowest value of protein efficiency ratio was found in treatment E it was 0.6± 0.03 and it differences significantly (*P ≤ 0.01*) from treatment A (control) and other diets. The best value of feed consumed (g/fish) (Table 5) of the five experimental diets was treatment 1 (control) it was 41.4 ±5 followed by treatment B the highest value it was 39.3± 0.6. There were no significant differences (P> 0.05) among the tow treatments. Treatment C, D and E which had feed consumed (g/fish) of 31.5± 0.04[b], 25.1± 3.3 and 17.8± 0.2 , respectively, and there were no significant differences (*P > 0.05*) between them but they are differ significantly (*P ≤ 0.01*) from treatment A (control) and other diets.

Table 5. Feed utilization, feed conversion ratio (FCR), feed efficiency ratio (FER), protein efficiency ratio (PER) and Feed consumed (g/fish) of Nile tilapia (*Oreochromis niloticus*) fingerlings fed five experimental diets.

	Diets [1, 2]				
Items	A (100% FM)	B (25% JSM)	C (50% JSM)	D (75% JSM)	E (100% JSM)
FCR	1.7±00.1[cd]	1.5±0.07[d]	1.8±0.00[c]	1.8±0.1[b]	2.6±00.04[a]
FER	0.5±0.05[ab]	0.6 ± 0.2[a]	0.5± 0.0[b]	0.3 ± 0.06[c]	0.2± 0.007[d]
PER	1.7± 0.2[ab]	1.9± 0.1[a]	1.5± 0.007[b]	1.1± 0.2[c]	0.6± 0.03[d]
Feed consumed g/fish	41.4 ±5[a]	39.3± 0.6[a]	31.5± 0.04[b]	25.1± 3.3[b]	17.8±0.2[c]

[1]Values are means ± SE of three replications
[2]Means in the same row, having different superscrip letters, are significantly different ($P \leq 0.01$).

Chemical composition of fish flesh (dry basis %):

Chemical composition of fish flesh (dry basis %) at the end of the experiment are presented in Table (6). It is evident from this table that, the highest value of crude protein content was recorded with fish fed diet B. It was 67.79±0.78 then diet A (control) it was 64.69±0.28 and then followed by diet E it was 63.74±0.02. Diet B had significantly ($P \leq 0.05$) the highest crude protein content compared with diet A (control) and other diets. The lowest value of crude protein was recorded with fish fed diets C and D. It was 62.68±0.00 and 62.34±0.47, respectively, they were significantly ($P \leq 0.05$) different from the control and other diets. The highest value of crude fat was recorded with fish fed diet C. It was 21.99±0.15 then fish fed diet D it was 21.75±0.49. They were no significant difference ($P > 0.05$) between them. Crude fat content of fish fed diet A (control) was 18.95±0.78 and diet E was 20.90±1.27 they were no significant difference ($P > 0.05$) between them. The lowest value of fat content (15.60±0.85) was recorded with fish fed diet B and it differ significantly ($P \leq 0.05$) from control and other diets. The ash content of groups of fish fed diets A, B, C, D and E were 16.36±0.50, 16.61 ± 0.08,15.32 ± 0.15, 15.32±0.15 and 15.37 ± 1.29, respectively. The dry matter content of fish fed diets A, B, C, D and E were 28.88±1.10, 29.94±0.88, 28.08±0.53, 28.24±0.43 and 31.14±0.94, respectively. Incorporation of jojoba seed meal in Nile tilapia diets as partial and complete replacement of fish meal did not significantly affect the dry matter and ash contents of fish flesh at the end of the experiment.

Apparent digestibility coefficients (ADC):

Apparent digestibility coefficients for Nile tilapia fingerlings fed five experimental diets containing different dietary Jojoba meal protein replacement, data are presented in Table (7). The highest value of 90.54±0.38 for (ADC) of crude protein was recorded with diet B, followed by87.37±0.57for diet A (control). There were no significant differences ($P > 0.05$) between them. The (ADC) of crude protein for diet C was 85.45±0.64[b]and there were no significant difference ($P > 0.05$) between it and control diet1. Diets D and E had the lowest values of (ADC) of crude protein it was79.98±1.52and 68.93±2.62 respectively. They were difference significantly ($P \leq 0.01$) from diet 1 (control). The highest value of

90.28±0.58 for (ADC) of crude fat was recorded with groups of fish fed diet 1 (control). The values of (ADC) for diets B, C and D were 89.91±0.76, 89.31±0.92 and 88.11±1.42, respectively. There were no significant differences between them and control diet A. The lowest value of 85.94±1.26 for (ADC) of crude fat was recorded with groups of fish fed diet E and it difference significantly from the control and other diets. The highest value of 77.95±0.10[a] for (ADC) of dry matter was recorded with groups of fish fed diet 2, followed by76.91±0.28 for diet A (control)There were no significant differences (*P > 0.05*) between them. The values of (ADC) for diets C, D and E were 75.29±0.54, 75.18±0.73, and 74.71±0.46, respectively. There were difference significantly from the control and diet C.

Table 6. Effect of different dietary jojoba seed meal protein level in Nile tilapia diets on chemical composition of fish flesh (dry basis %). Values are means ± SE.[1, 2]

Diets	Jojoba meal Replacement (%)	Protein (%)	Fat (%)	Ash (%)	Dry matter (%)
At the start		61.88	12.71	22.41	24.47
At the end					
A (control)	0	64.69±0.28[b]	18.95±0.78[b]	16.36±0.50	28.88±1.10[b]
B	25	67.79±0.78[a]	15.60±0.85[c]	16.61±0.08	29.94±0.88[ab]
C	50	62.68±0.00[cd]	21.99±0.15[a]	15.32±0.15	28.08±0.53[b]
D	75	62.34±0.47[d]	21.75±0.49[a]	15.32±0.15	28.24±0.43[b]
E	100	63.74±0.02[bc]	20.90±1.27a[b]	15.37±1.29	31.14±0.94[a]

[1]a,b,c,d, means in the same column bearing different letter differ significantly at 0.05 level.

Table 7. Apparent nutrients digestibility coefficients for Nile tilapia fingerlings fed diets containing different dietary jojoba seed meal (JSM) protein replacement.

Apparent Digestibility Coefficients

Diets [1, 2]	Jojoba meal replacement (%)	Crude protein	Crude fat	Dry matter
A (control)	0	87.37±0.57[b]	90.28±0.58[a]	76.91±0.28[b]
B	25	90.54±0.38[a]	89.91±0.76[ab]	77.95±0.10[a]
C	50	85.45±0.64[b]	89.31±0.92[ab]	75.29±0.54[c]
D	75	79.98±1.52[c]	88.11±1.42[b]	75.18±0.73[c]
E	100	68.93±2.62[d]	85.94±1.26c	74.71±0.46[c]

[1]Values represent the means of three samples.
[2]a, b,c, means in the same column bearing different letter differ significantly at ($P \leq 0.01$) level.

Economic Efficiency:

Feeding costs in fish production represent about 70% of the running production under the recent experimental conditions all other costs are constant. The feeding costs to produce one Kg gain in weight could be used for the comparison among treatments. The price lists experimental ingredients used in jojoba seed meal experiment are shown in Table (8). The cost of Kg mixed feed and cost of producing Kg fish gain in LE in the dietary treatments are presented in Table (9). The present data show that the lowest cost of 1Kg diet in this study was obtained by T_5 (5.58LE) followed by T4, T3 and T2 (8.92LE) whereas the highest cost of 1Kg diet was recorded with T1 (10.03LE). The lowest consumed feed (Kg) to produce 1(Kg) fish was obtained by B (1.5) then A (1.7) while the highest value of consumed feed 1(Kg) to produce 1(Kg) fish obtained by D (2.6). The lowest cost of producing (Kg) fish gain was obtained when fish were reared on D (12.04 LE\kg gain), however, the highest cost was recorded by A (17.05 LE\Kg gain) the increasing in price of feed is considered one of the most important factors limiting profitability in fish culture. The high cost of fish feed mainly related to the cost of fish meal and soybean meal and therefore finding a relatively lower cost alternative ingredient has been an ongoing research goal (FAO, 2006 Hernandez *et al,* 2007). The use of plant derived protein sources cheaper than soybean meal could be explored to further reduce the cost of fish feeds.

Discussion

Jojoba Chemical Analysis:

In comparison to previous studies El-Anany (2007), Swingle (1985) and Vermauti (1998) ether extract was high (6.89%) while crude fiber was low (3.12%) in the present study. These results may be attributed to inefficient extraction of jojoba oil and/or squeezing technique. On the other hand, crude protein analysis in jojoba meal (24%) is in agreement with different studies Fernanda (2007) and Audu (2008).

Table 8. The price lists experimental ingredients used in Jojoba seed meal experiment.

Ingredient	Price/ ton LE	Price /kg LE
Fish meal (60%)	17000	17
Jojoba meal (24%)	1500	1.50
Soybean meal (44%)	3500	3.50
Corn starch	6000	6.00
Vegetable oil	10000	10.00
Vit& Min Premix[1]	85000	85.00
Vitamin C	65000	65.00
Molasses	6000	6.00
Methionine	95000	95.00
Lycine	95000	95.00

Table 9. Effect of treatment on economical efficiency.

Treatments	Cost of 1 ton diet (L.E)	Cost of 1 Kg diet (L.E)	FCR	Cost of Kg Fish gain (L.E)	Cost of Kg fish Based on Control diet
A	10030	10.03	1.7	17.05	100
B	8920	8.92	1.5	13.38	78.48
C	7810	7.81	1.8	14.06	82.46
D	6290	6.29	1.8	12.04	70.62
E	5580	5.58	2.6	14.5	85.04

Growth Performance and Survival (%):

Results of the present study illustrated that using 25% JSM to replace FM in T2 improved significantly (P ≤ 0.05) fish final weight, weight gain, while, SGR % and survival did not affected significantly (P ≥ 0.05). On the other hand, all growth performance parameters significantly (P ≤ 0.05) decreased with increasing replacement percentage of JSM, more than 25%, instead of FM in Nile tilapia (*O. niloticus*) diets. In agreement with the present results, Vermauti *et al* (1998) on poultry and Khalil *et al.* (2009) on tilapia reported that the negative effects on growth performance associated with increasing level of JSM instead of FM may be attributed to the increase in glycosides (namely simmondsin) existing in Jojoba meal. In addition, potential use of jojoba meal as a waste product for animal feed Flo *et al*. (1997), Jones and Lewis (1999), Jones and Lewis (2001), Cokelaere *et al.* (1996), Motawe (2006) and tilapia feed was Khalil *et al* (2009) demonstrated. Furthermore, Khalil *et al* (2009) concluded that increasing JSM instead of FM in tilapia diets led to significant (P ≤ 0.05) decrease in growth performance, all organs indices and liver functions enzymes were significantly affected.

Feed Utilization:

Partial replacement (25%) of FM with JSM in the experimental diets does not affect fingerlings feed intake significantly (P ≥ 0.05). On the other hand, partial (50% and 75%) and total (100%) replacement of FM have inhibited feed intake of fingerlings. On the contrary, Khalil *et al*; (2009) found that there were no significant differences (P ≥ 0.05) in feed intake and feed conversion ratio of tilapia when different levels (0%, 25%, 50%, 75% and 100%) of JSM to replace FM in that respect, the anti-nutritional factor found in jojoba meal (*simmondsine*), has been identified as the most responsible food intake inhibition and appetite suppression to rodents, rats, dogs, and chickens Lievens *et al*. (2003). Consequently, it was discovered that *simmondsin* acted as a hunger satiation ingredient and rather than being toxic, jojoba satisfied the animals' hunger, causing the decline in feed intake Vermauti, *et al* (1997). Moreover, Vermauti *et al* (1997) demonstrated that the anorexic effect of defatted jojoba meal in chickens is due mainly to some palatability factors, possibly tannins and saponins; whereas in rats, Cokelaere *et al* (1996) concluded that it reduces feed intake solely by its satiating effect, which results mainly from *simmondsin* and related cyanomethylene glycosides.

Furthermore, Wiseman and Price (1987) found that feeding birds on jojoba meal have decreased body weights marginally and attributed it to antinutritional factors present in jojoba meal, such as tannins, phytic acid, and trypsin inhibitors. Finally, Fernanda *et al* (2007) recommended that *simmondsin* should be previously eliminated from the residual jojoba cake after oil squeeze.

Carcass Composition of Fish:

In the present study, replacement FM with JSM up to 25% achieved the higher values for dry matter, protein percentage and content (29.94%, and 67.79%, respectively) in carcass of fish fed the diet B. In contrast, Omar and Nour (1986) found that common carp *(Cyprinus carpio L.)* fed fishmeal included diets was higher than that fed diets containing mixture of plant and animal protein or plant protein alone. In addition, Elangovan and Shim (2000) found that protein content of tin foil barb (*Barbodes altus*) did not differ significantly ($P \geq 0.05$) when fish meal replaced up to 50% with soybean meal. Moreover, Khalil *et al*. (2009) found no significant differences ($P \geq 0.05$) in crude protein, ether extract, ash and energy content in whole body carcass of Nile tilapia *O. niloticus* with increasing JSM replacement level up to 100%. On the other hand, ether extract (%) in whole fish increased significantly ($P \leq 0.05$) as inclusion levels of JSM increased in the present study which disagree with the findings of Mohsen and Lovell (1990) who found that ether extract (%) of channel catfish increased with each addition of fish meal to the diet.

Economic Evaluation:

Replacement of fishmeal with cheaper ingredients of either vegetable or animal origin in fish feed is necessary because of rising cost and uncertain availability of fishmeal. In Higgs (1995) spite of being preferred to include feedstuffs with relatively high levels of carbohydrate in formulated fish feed in view of its protein-sparing effect that may make the diet more cost effective Hidalgo (1993) replacement plant protein sources instead of fishmeal becomes a must owing to its limited supply and high cost. In the present study, the cost of diet required to produce one kilogram of fish flesh decreased with increasing JSM replacement level for FM in the experimental diets. Taking into consideration feed conversion ratio, diet B realized the best value which improved with partial replacement (25%) of FM and then reduced with continue increasing replacement level up to 100%.

On the other hand, diet B realized the best growth performance and feed utilization especially FCR in spite of being not significant ($P \geq 0.05$) between treatments. Consequently, the cost of diet B required to produce one kilogram of fish flesh was the optimal between treatments taking into account FCR, feed cost/kg diet and weight gain. In agreement with our results Khalil *et al* (2009) recommended using 25% JSM to replace FM in Nile tilapia (*O. niloticus*) diet reduced costs of aqua-feeds without any adverse effects on the fish.

Conclusion:

Owing to the limited supply and high cost of fishmeal and other marine protein sources, nutritionists had turned the attention to search for total or partial alternatives of plant protein sources. Jojoba seed meal is promising new animal feed that contains high crude protein as well as high carbohydrate and low fiber. Because of containing four anti-nutritional compounds that have an adverse effects on animal feed intake and appetite, jojoba seed meal (*Simmondsia chinensis*) have to subject to more investigations to 1) eliminate anti-nutritional compounds (*simmondsin*) found in residual cakes, 2) give added value to the sub-product (Jojoba press-cake) to convert these products into raw material suitable for animal feed preparation and decrease the negative impact on palatability and animal feed intake. Accordingly, in order to use jojoba seed meal as an ingredient for fish feed, it is necessary to characterize their proximal composition of protein and anti-nutritional compounds to detoxify it using bacterium fermentation of sweet (acidophilus) milk currently seems to be the most effective, where the bacterium grows well on jojoba seed meal and after three weeks, at room temperature, converts it to a palatable and nutritious feed. In addition, before jojoba meal can be accepted as fish feed, it must be shown that hazardous compounds cannot be transmitted to fish flesh. It could be concluded that jojoba seed meal could be recommended to substitute fishmeal up to 25% as safe dietary ingredient without any adverse effects on growth performance, feed utilization and economical diet cost of Nile tilapia (*O. niloticus*) fingerlin

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تقييم كسب بذور الجوجوبا كبديل جزئى أو كلى لمسحوق السمك فى إعداد علائق إصبعيات أسماك البلطى النيلى

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الملخص العربى

أجريت هذه الدراسة لمدة 16 أسبوع على أسماك البلطى النيلى لدراسة إمكانية استخدام بروتين كسب بذور الهوهوبا المعامل حراريا بالتعرض للبخار على درجة حرارة 120 درجة مئوية لمدة نصف ساعة كبديل جزئى أو كلى لبروتين مسحوق السمك فى إعداد علائق إصبعيات أسماك البلطى النيلى وعلى ذلك تم تكوين خمسة علائق تجريبية. العليقة الاولى تحتوى على مسحوق السمك بمعدل20% كمصدر وحيد للبروتين الحيوانى وذلك لإستخدامها كعليقة للمقارنة (كنترول). تم إستبدال بروتين مسحوق السمك بنسبة 25 %، 50 %، 75 % و 100% ببروتين كسب بذور الجوجوبا للعلائق من 2 الى 5 على التوالى وكانت العلائق كلها متماثلة فى الطاقة والبروتين. أجريت التجربة فى عشرة أحواض زجاجية سعة كل منها 80 لتر مياة وقسمت الأسماك إلى عشرة مجموعات متساوية كل مجموعة عشر سمكات متوسط وزن إبتدائى 3.3 + 0.01 جم / سمكة - وزعت الأعشوائيا علىالعلائق (مجموعتان/ عليقة) غذيت الأسماك بهذه العلائق بمعدل 5 % من وزن الجسم الحى يوميا وخفضت تدريجيا الى 3 % من وزن الجسم الحى فى اليوم. أوضحت النتائج أن مجاميع الأسماك التى غذيت على العليقة 2 والتى تحتوى على 25 % بروتين كسب بذورالجوجوبا كبديل لبروتين مسحوق السمك لا تختلف معنويا عند مستوى 0.01 عن الأسماك التى غذيت على العليقة الكنترول (100% بروتين من مسحوق السمك) فى متوسط وزن الجسم و الزيادة النسبية فى وزن الجسم و معدل النمو النسبى ومعامل التحول الغذائى ومعدل إستهلاك الغذاء وكفاءة إستخدام البروتين بينما كان هناك إنخفاض معنوى فى كل مقاييس الأداء والأستفادة من الغذاء للأسماك بزيادة مستوى كسب بذور الجوجوبا إلى 50 % و 75% و 100% بالعلائق 3 و4 و5على التوالى. لم يتأثرمعدل البقاء للأسماك للعلائق 1و 2و 3 باضافة كسب الهوهوبا الى العلائق حيث كان 100 % لكل منها. وجد أن معامل الهضم الظاهرى للبروتين الخام والدهن الخام والمادة الجافة للعلائق إنخفض معنويا عند مستوى معنوية 0.01 بزيادة مستوى كسب بذور الجوجوبا بالعلائق. كذلك وجد أن مكونات الجسم للأسماك من البروتين الخام والدهن الخام والرماد الخام والمادة الجافة تاثرت معنويا بزيادة مستوي كسب بذور الجوجوبا بالعلائق. من نتائج الدراسة والتقييم الاقتصادى يتضح أنه من الممكن إستبدال بروتين مسحوق السمك جزئيا حتى 25% بإستخدام بروتين كسب بذور الجوجوبا المستخلص والمعامل حراريا بالبخار على درجة حرارة 120 درجة مئوية لمدة نصف ساعة فى إعداد علائق إصبعيات أسماك البلطى النيلى دون أى تأثيرات عكسية على النمو والأداء والإستفادة من الغذاء ومكونات الجسم للأسماك ومعامل الهضم الظاهرى للعلائق.