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THE INFLUENCES OF ω6/ω3 DIETARY FATTY ACID RATIO ON GROWTH PERFORMANCE AND BODY FATTY ACID COMPOSITION OF NILE TILAPIA *(OREOCHROMIS NILOTICUS)*

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SUMMARY

The effect of different dietary fatty acid sources (Fish oil (PUFA), Soybean oil (ω6) , linseed oil (ω3)) on growth performance of Nile tilapia (Oreochromis niloticus) and body fatty acids composition was investigated. Tilapia fed diet containing 4.2 (6/ ω3 ratio (3% soybean oil) had higher significant ($P \leq 0.05$) differences in the final body weight, average body weight gain and specific growth rate than other treatments. Feed conversion ratio being better with diet content 4.20ω 6 / ω3 ratio (3% soybean oil) compared to other treatments. Body lipid content of tilapia fed diet content of 0.45 ; 1.2 and 4.6 dietary ω6/ω3 ratio (5 % lipid level) had the highest significant ($P \leq 0.05$) values than fish fed 0.6 ; 1.40 and 4.20 dietary ω6/ω3 ratio (3% lipid level),irrespective of the dietary lipid sources.

The whole body (F.A.) 18: 1ω9 concentration was higher in tilapia fed diet containing 0.45 ω6 / ω3 ratio (5 % linseed oil) , whereas 18: 2ω6 was more concentrated in the whole body lipid of fish fed diet containing 4.20 and 4.6 ω6 /ω3 ratios (3% and 5% soy bean oil ,respectively) . The highest concentration of 18: 3ω3 was found for fish fed 0.45 and /or 0.60 ω6 /ω3 ratio (5% and 3% linseed oil),respectively . The results of total blood serum lipid followed the same tendency. The highest fish production (Kg / pond)(8.32) and profits (L.E / Pond) (26.98) were recorded for tilapia fed 4.2 ω6 / ω3 ratio (5%soybean oil).

The results revealed that, among dietary sources of fatty acid, vegetable oils have certain advantages to fish oils. They are cheaper, available in large quantities and less subject to oxidation than non-hydrogenated fish oil. Moreover, they permit reasonable growth and feed conversion as the fish

oils.

Key word: dietary ω 6 / ω3, fatty acids, Nile tilapia, *Oreochromis niloticus*, feed conversion.

INTRODUCTION

Nile tilapia (*Oreochromis niloticus*) is an economically important cultured species in several areas of the world, particularly in Egypt. It was the 6th most cultured finfish species in the world (El-Sayed 1999). In Tilapia and other fishes culture, nutrition obviously plays an important role in the maintenance of a healthy and marketable product. Lipids are an important component of diet, both as an energy producer and essential fatty acids sources, which are essential for basic functions, including growth and maintenance of healthy tissues.

Guillou *et al.,* (1995) revealed that in freshwater fish dietary linoleic acid (18:2ω6) and linolenic acid (18:3ω3) or both fatty acids, are liable to be elongated and desaturated. The former fatty acid may be converted to arechidonic acid (20:4ω6) and the latter to docosahexaenoic (22: 6ω3) in phospholipid fraction of fish, whereas, in triglyceride fraction these fatty acids are deposited unaltered, when increasing the concentration of 18 : 2ω6 and 18 : 3ω3.

Tilapia has a requirement for ω3 and ω 6 fatty acids. Millikin (1982) stated that *Tilapia zillii* performs better when fed 1% linoleic acid (18: 2ω6) or 1% arechidonic acid (20: 4ω6) rather than (3 series fatty acids. Takeuchi *et al.,* (1983) reported that neither arechidonic acid (20: 4ω6) nor ω3 PUFA are essential fatty acids for Nile tilapia (*Oreochromis niloticus*). The growth enhancing effect of 18: 3ω3 was found to be inferior to linoleic acid (18: 2ω6), and the dietary requirement of Nile tilapia (*Oreochromis niloticus*) for linoleic acid tilapia was suggested to be 0.5%.

Deering *et at.,* (1997) reported that freshwater fish have higher levels of ω6 fatty acids than the marine species. Fatty acid composition of body lipids clearly reflected the dietary lipids. The ω6 / ω3 ratio of the fish lipids is greatly affected by the ω6/ω3 ratio of the dietary lipids. Halver (1979) reported that the ratio of ω6 and ω3 fatty acids are an important determinant of growth in fish. The average ω3 /ω6 ratios are 0.37 ± 0.1 and 0.16 ± 0.1 for freshwater and marine fish, respectively. Recently, Sargent *et al.,* (1997) reported that, understanding the dietary and tissue relationships between docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA) and arachidonic acid (AA) is as essential for optimizing fish diets as for illuminating the complex interactions between nutrition, behavior and environmental stress. No such data are available in tilapia fish.

The aim of the present study was to elucidate the actual role of dietary fatty acid ratio on growth performance and fatty acid composition of tilapia.

MATERIALS AND METHODS

This study was carried out in the Fish Research Station at El-Kanater El-Khayria, which is belonging to the National Institute of Oceanography and Fisheries, Egypt. The experimental fish were healthy, negative to parasites with an average body weight of 21.45 ± 0.31 gram. The experimental fish were carefully transferred to experimental ponds and were kept for acclimatization for 14 days, thereafter, the actual experimental period extended for 120 days.

A total number of 144 Nile tilapia fingerlings was stocked and equally divided to 6 concrete pond (2x4m each) of 24 fish each. Six experimental ω6/ω3 ratio diets were formulated using three different sources of fatty acid (fish oil (PUFA) , soybean oil (ω6) and linseed oil (ω3) at two dietary inclusion levels (3 and 5%)) (Table ,1). The dietary fatty acids composition are shown in Table (2) .The diets were isocaloric of 21.09 MJ / ME/Kg and isonitrogenous of 30% crude protein according to NRC (1993). Fish were fed at a level of 3% of body weight twice a day at 9 a.m. and 11 a.m.

Ten fish at the beginning and ten fish at the end of the experimental period, were randomly taken from each experimental treatments for body chemical analysis. Crude protein (N x 6.25), ether extract, ash and moisture contents were determined in all experimental diets and fish bodies according to A.O.A.C (1980). The gross energy was calculated according to Hepher *et al.*, (1983). The body fatty acids contents were analysis by Gas liquid chromatography in the Center Laboratory, Faculty of Agriculture, Cairo University.

Two-way ANOVA was made according to the procedure reported by Steel and Torrie (1980). Duncan`s test was applied whenever possible to test mean difference (Duncan, 1955).

RESULTS AND DISCUSSION

In several fish species, it is known that supplying additional fat to the diet improves feed utilization and increases body fat content (Yamamoto *et al.*, 2000). In present study the data showed that Nile tilapia (*O. niloticus*) fed diet containing 4.2 ω6/ ω3 ratio (3% soybean oil) had higher significant (P ≥ 0.05) differences in the final body weight, average body weight gain and specific growth rate than other treatments (Table , 3) .

Feed conversion ratio or feed efficiency was improved by adding ω6 (soybean oil) than other sources of fatty acid, being better with diet containing 4.20 ω6 / ω3 ratio (3% soybean oil) compared to other treatments. Takeuchi *et al.*, (1983) found that body weight gain and feed efficiency of *O. niloticus* were improved when fed on diet containing soybean oil. Lovell (1989) mentioned that supplementation of tilapia diets with vegetable oil rich in linoleic acid (18: 2ω 6) generally gave better performance than supplementing with fish oil high in ω3 fatty acids. In this connection reports of Viola and Arieli (1983); and Chou and Shiau (1996) revealed that dietary oil supplementation does not produce better gain in weight and food utilization of tilapia, in contrast to other fishes. These authors noted that this difference has various implication for the practical nutrition of tilapia, including the warring that energy estimates of foodstuffs for carp, trout or catfish should not be applied to tilapia and that high lipid, high energy feed stuffs such as fish meal, when used for tilapia, may have been reevaluated on a protein basis alone and may be replaceable by vegetable protein sources which do not contain as much fat. However, as lipid are a poor source of

Table (1): Ingredient and chemical composition of the experimental diets.

ω6 / ω3 ratio	Experimental treatments					
	0.45	0.6	1.2	1.4	4.2	4.6
Ingredients (%)						
Wheat bran	22.0	22.0	22.0	22.0	22.0	22.0
Yellow corn	25.0	27.0	25.0	27.0	27.0	25.0
Soybean meal	25.0	25.0	25.0	25.0	25.0	25.0
Fish meal	20.0	20.0	20.0	20.0	20.0	20.0
Linseed oil	5.0	3.0	-	-	-	-
Fish oil	-	-	5.0	3.0	-	-
Soybean oil	-	-	-	-	3.0	5.0
Vit. and min. premix.(1)	3.0	3.0	3.0	3.0	3.0	3.0
Nutrient Composition (DM basis).						
Crude protein, %	29.65	29.80	29.65	29.80	29.80	29.65
Ether extract, %	8.75	6.80	8.75	6.80	6.80	8.75
Total carbohydrate, %	56.40	56.35	56.40	56.35	56.35	56.40
Ash, %	5.20	7.05	5.20	7.05	7.05	5.20
Protein/Energy ratio, (P/E ratio)	20.80	21.40	20.80	21.40	21.40	20.80
Gross energy (MJ/Kg)(2)	20.35	20.15	20.35	20.15	20.15	20.35
Digestible energy (Mj/Kg)(3)	15.25	14.95	15.25	14.95	14.95	15.25
Metabolizable energy (MJ/Kg)(4)	14.25	13.95	14.25	13.95	13.95	14.25

(1)- <u>Vitamin and mineral mixture each 1 kg of mixture contains:</u> 4.8m. I. U. Vit. A., 0.8m. I. U. Vit D3 , 4.0g. Vit E., 0.8 g. Vit K., 4.0g. Vit B12., 4.0g. vit B2., 0.6g. Vit B6., 4.0 g. Vit Pantothenic acid., 8.0 g Vit Nicotinic acid., 400 mg. Vit Folic acid., 20 mg. Vit Biotin, 200 g. Choline, 4 g. Copper., 0.4 g. Iodine., 12 g. Iron., 22 g. Manganese, 22 g. Zinc., 0.04 g. Selenium.

(2)- GE was calculated using values 5.65 Kcal/g protein, 4.2 Kcal/g carbohydrate and 9.45 Kcall/g fat according to Hepher *et al.*, (1983).

(3)- DE was calculated from gross energy as 75% as reported by Hepher *et al.*, (1983).

(4) -ME was calculated from gross energy as 70% as reported by Hepher *et al.*, (1983).

energy for tilapia and their ability to utilize carbohydrates is also restricted, as in other warmwater fish, which are considered to be more or less diabetic (Anderson *et al.*, 1984), the proteins are the only remaining source of energy. Therefore, tilapia feeds should contain higher levels of protein compared to feeds for catfish or carp. Moreover, oils should not be used to balance the energy content of isocaloric diets in nutritional studies with tilapia, otherwise ways should be chosen, therefore, results of studies in the past, when widely different oil levels were used should be reassessed.

Table (2): The fatty acid composition (% dietary fat) of different experimental diets.

ω6 / ω3 ratio	Experimental treatments						
	0.45	0.6	1.2	1.4	4.2	4.6	SE±
Saturates:							
14:0	1.59	2.15	5.85	5.41	10.15	9.60	0.27
16:0	8.27	9.24	13.11	13.02	11.78	11.54	0.30
18:0	3.25	2.93	1.19	1.24	2.75	3.07	0.21
Monounsaturated:							
16:1ω 9	2.13	2.87	7.96	7.31	2.05	2.32	0.38
18:1ω 9	19.96	19.54	15.25	15.93	20.92	21.71	0.34
20:1 ω9	3.45	4.66	12.75	11.98	4.84	3.60	0.56
22:1ω 9	5.04	6.81	18.73	17.67	6.81	5.06	0.81
Diounsaturates:							
18:2ω 6	16.36	17.78	9.94	13.04	31.26	42.26	0.02
20:4ω 6	0.14	0.18	0.27	0.18	0.18	0.14	0.01
20:6 ω6	1.06	1.43	4.33	4.02	1.44	1.07	0.18
Polyunsaturated:							
18:3 ω3	35.99	28.68	3.37	3.99	4.09	4.88	2.42
18:4ω 3	0.40	0.54	1.52	1.50	0.54	0.40	0.06
20:5 ω3 (EPA)	2.13	2.87	6.56	5.98	2.87	2.13	0.36
22:5ω 3	0.27	0.36	0.73	0.70	0.36	0.27	0.05
Profile variables:							
Total saturated	13.11	14.32	20.15	19.67	24.68	24.21	0.41
Total polyunsaturated	40.15	33.88	16.51	16.19	9.29	8.75	1.70
Total unsaturated/ Total saturated ratio	6.63	5.98	3.96	4.08	3.10	3.10	0.19
Total ω 9	30.56	33.86	54.67	52.88	35.61	32.67	1.44
Total ω 6	17.56	19.39	14.54	17.24	32.88	35.47	1.47
Total ω3	39.09	32.45	12.18	12.17	7.85	7.68	1.88
Total ω 3/ ω 6	2.01	1.56	0.74	0.65	0.2	0.18	0.14

The whole body composition of tilapia fed different dietary fatty acid level and sources are tabulated in Table (4). Body dry matter and crude fat contents were significantly ($P \geq 0.05$) difference among dietary ω6/ω3 ratios. Body dry matter content was highest in fish fed the diets containing 4.6 dietary ω6/ω3 ratio (5% soybean oil) ; 0.6 dietary ω6/ω3 ratio (3% linseed oil) and 4.2 dietary ω6/ω3 ratio (3% soybean oil) in decreasing order , than the other treatments .Body lipid content of tilapia fed diet content of 0.45 ; 1.2 and 4.6 dietary ω6/ω3 ratio (5 % oil level) had significantly ($P \geq 0.05$) highest value than fish fed 0.6 ; 1.40 and 4.20 dietary ω6/ω3 ratio (3% lipid level), irrespective of dietary lipid sources . The data revealed that when dietary lipid is supplied in excess of tilapia requirement, proportion of this lipid is deposited as body fat .The data agreed with the finding of Chou and Shiau (1996) who reported that the source of dietary lipids and their profile of fatty acids composition are the limiting factors influence lipid efficiency and digestibility by fish and they found the positive correlation between body lipid content and dietary lipid, as already reported in most of the fish species investigated (Tibaldi *et al.*, 1996).

Table (3): The Nile tilapia growth performance of different experimental treatments.

ω6 / ω3 ratio	Initial body weight (gm)	Final body weight (gm)	Average body daily gain (g/day)^{1}	Specific growth rate (%day)^{2}	Feed conversion ratio^{3}	Feed efficiency (%)^{4}	Feed consumption per fish (g/120day)
0.45	21.41	187.2^{c}	1.39^{bc}	1.81^{b}	2.12^{b}	47.26^{b}	350.94
0.60	21.39	190.8^{bc}	1.92^{bc}	1.83^{c}	2.24^{b}	44.80^{b}	378.16
1.20	21.46	175.1^{d}	1.28^{c}	1.75^{b}	2.37^{b}	42.40^{c}	362.38
1.40	21.39	177.2^{d}	1.30^{bc}	1.76^{b}	2.20^{b}	45.48^{b}	342.59
4.20	21.50	207.8^{a}	1.55^{a}	1.90^{a}	1.62^{a}	61.96^{a}	300.67
4.60	21.53	193.8^{b}	1.44^{b}	1.84^{ab}	2.06^{b}	49.10^{b}	350.97
SE±	0.55	4.75	0.04	0.03	0.28	3.88	-

(1) Average daily gain (ADG)= [Final weight - Initial weight)/ period (days)].
(2) Specific growth rate (SGR) = 100 [(In final weight - In initial weight0 / Time (days)].
(3) Feed conversion ratio (FCR) = Dry weight of feed fed (g) / weight gain (g).
(4) Feed efficiency (%) = (weight gain (g) / Dry weight of feed fed (g)) X 100.
SE, standard error. Calculated from residual mean square in the analysis of variance.
a,b.......... etc. mean in the same raw with different superscripts are different (P(0.05).

Table (4): The chemical composition of tilapia whole body fed the different experiment diets.

ω6 / ω3 ratio	Dry matter %	Crude protein %	Ether extract %	Ash %	Gross energy MJ/Kg
Initial	21.86	64.26	8.99	26.75	18.50
0.45	22.70[b]	55.19	25.23[a]	19.59	23.01
0.60	23.58[a]	56.29	19.55[c]	19.16	23.00
1.20	18.88[c]	56.79	24.25[a]	19.10	22.95
1.40	21.48[b]	59.42	22.94[b]	17.65	23.11
4.20	23.30[a]	58.74	22.93[b]	18.32	22.97
4.60	23.78[a]	56.18	24.53[a]	19.29	22.95
SE±	3.12	1.92	2.45	0.74	1.92

The fatty acid composition of the experiment diets (Table, 2) reflected that of the different supplementary oils. The fatty acids of the ω-9 series was the principal represented in the fish oil diets (52.88 and 54.67 %), whereas ω-6 and ω-3 series were the major fatty acids in the soybean oil diet (32.88 and 35.47 %) and linseed oil diet (32.45 and 39.09 %), respectively .The data revealed that the increase in certain fatty acids in the whole tilapia body lipid (Table ,5) were a function of their respective concentration in the experimental diets .This were particularly evident for 16: 1ω9, 18: 1ω9 , 18:2 ω6 and 18: 3ω3. The whole body 18: 1ω9 concentration was higher in tilapia fed the diet content 0.45 ω6 /ω3 ratio (21.11 %) (5 % linseed oil), whereas 18: 2ω6 was more concentrated in the whole body lipid of fish fed the diet containing 4.20 (12.16 %) and 4.6 (11.28 %) ω6 /ω3 ratios (3% and 5% soy bean oil), respectively . The highest concentration of 18: 3ω3 was found for fish fed 0.45 (4.66%)and / or 0.60 (3.24 %) ω6 /ω3 ratio (5% and 3% linseed oil), respectively . The data fully agreed with the finding of Ibeas *et al.*, (1996) who reported that when tissues lipid contain high levels of fatty acids 16:0 and 18 : 1ω9, this indicates that these fatty acids are not only the main source of energy in these tissues , but that they are also , together with ω-3 (PUFA) , the primary fatty acids selectively incorporated into membrane phospholipids .However ,Guillou *et al* ., (1995) reported that freshwater fish generally have a better capacity to desaturate and elongate 18 :1ω9, 18 : 2ω6 and 18 : 3ω3 fatty acids than marine fish . In this connection. Isike *et al.*, (1999) reported that the increased docosahexaenoic acid (22: 6 ω3) in whole body lipid of *Tilapia zillii* larvae indicating that both dietary linoleic and linolenic fatty acid were converted efficiently to docosahexaenoic (22: 6ω3).The data reported herein followed the same tendency . Moreover, the data indicated that the transformation of linoleic acid to docosahexaenoic acid is consistent with previous finding such that the presences of ω6 fatty acids in diets of various tilapia species were required. Kanazawa *et al.*, (1980) reported that *Tilapia zillii* required about 1 % ω6 fatty acids. Similar results were observed in Nile tilapia by Takeuchi *et al.*, (1983) . Stickney and Hardy (1989) reported that even higher amount of ω-6 fatty acids were needed when *O. aureus* fingerlings were reared with various diets , but they also observed that this requirement could be reduced when ω-3 fatty acids were present .

Table (5): The fatty acid composition of whole body fish (% dietary lipid) of different experimental treatments.

ω6 / ω3 ratio	Experimental treatments						
	0.45	0.6	1.2	1.4	4.2	4.6	SE±
Saturates:							
<10c	2.84[ab]	2.47[b]	11.40[a]	1.56[b]	2.01[b]	5.52[ab]	2.21
12:0	3.08[b]	4.25[b]	12.15[ab]	15.52[a]	9.34[ab]	6.51[ab]	1.23
14:0	14.69[b]	14.88[b]	5.04[c]	1.86[c]	10.14[bc]	23.86[a]	2.76
16:0	0.73[b]	0.84[b]	5.16[ab]	9.13[a]	1.29[b]	0.59[b]	1.14
18:0	0.01[b]	0.01[b]	0.01[b]	0.14[b]	0.54[ab]	1.42[a]	0.02
20:0	0.84[b]	0.46[b]	1.57[b]	0.33[b]	5.46[a]	3.68[ab]	0.65
22:0	3.38[ab]	4.19[ab]	1.80[bc]	0.01[c]	7.27[a]	5.35[ab]	0.81
Monounsaturated:							
16:1ω 9	0.75[b]	1.01[b]	23.84[a]	26.25[a]	0.33[b]	0.25[b]	0.53
18:1ω 9	21.11[a]	17.19[ab]	18.95[ab]	8.48[b]	16.30[ab]	17.32[ab]	1.55
22:1ω 9	4.48[a]	0.41[b]	0.43[b]	0.54[b]	0.34[b]	0.49[b]	2.55
Diounsaturates:							
18:2ω 6	38.87[a]	36.14[a]	16.75[b]	0.01[c]	24.66[ab]	13.64[b]	4.24
18:2ω 6	6.97[b]	9.83[b]	9.40[b]	5.01[b]	12.16[a]	11.28[a]	1.00
20:2 ω6	0.56[b]	1.42[b]	0.92[b]	0.01[c]	2.01[a]	2.10[a]	0.30
Polyunsaturated:							
18:3 ω3	4.66[a]	3.24[ab]	0.13[c]	0.01[c]	2.10[b]	2.75[b]	0.53
22:6ω 3	1.34[b]	3.57[b]	12.31[a]	5.89[ab]	5.31[ab]	4.64[b]	1.18

The results in Table (6) indicated that the changes in the whole body saturated fatty acid composition was more (25.3 to 47.61 %) than that found in the experimental diets (13.11 to 24.68) (Table.2), whereas ,the relative concentrations of the whole body polyunsaturated fatty acids was less varied (6.19 to 21.0 %) than that found in the experimental diets (8.75 40.15 %) . The whole body ω6/ω3 ratios increased in relation to the tilapia fed diet containing linseed oil (0.45 and 0.60 ω6/ω3 ratios), while when the ω6/ω3 diet ratio was high (4.2 and 4.6 % for soybean oil diets) the whole body ω6/ω3 ratios were lowered than the values of the diets .The whole body ω6/ω3 ratios for tilapia fed diet containing fish oil were lowest value among all ratios of different whole body tilapia treatments . The data fully agreed with the finding of Deering *et al.*, (1997) who reported that the ω6 / ω3 ratio of the fish lipids is greatly affected by the ω6/ω3 ratio of the dietary lipids. When the dietary ratio is very high in ω6 fatty acids (using vegetable oils), there is a tendency for fish to alter the ratio of PUFA incorporated in favor of ω3 fatty acids. When the dietary oil is a fish oil high in ω3 fatty acids, there is little change in the ω6 / ω3 ratio of lipids incorporated into the fish .

Table (6): The profile variables of whole body fish fatty acids series (% total dietary lipid) for different experimental treatments.

ω6 / ω3 ratio	Experimental treatments						
	0.45	0.6	1.2	1.4	4.2	4.6	SE±
Total saturated	25.3[c]	27.73[c]	26.83[c]	34.62[b]	47.61[a]	37.19[b]	2.80
Total unsat./Total sat.	2.96[a]	2.62[ab]	2.77[ab]	1.95[ab]	1.69[bc]	1.22[c]	0.33
Total polyunsaturates	13.53[b]	18.05[b]	18.04[b]	6.19[c]	21.00[a]	20.68[a]	2.16
Total ω 9	41.21[bc]	54.63[a]	54.36[a]	59.21[a]	41.71[bc]	31.73[c]	3.49
Total ω 6	7.53[b]	11.25[ab]	10.58[ab]	5.00[b]	14.26[a]	12.62[a]	1.29
Total ω 3	6.00[b]	6.81[b]	12.31[a]	5.89[b]	6.74[b]	8.19[b]	0.90
Total ω 3/ ω 6	0.81[bc]	0.63[c]	1.16[ab]	1.28[a]	0.47[c]	0.72[bc]	0.09
Total ω 6/ ω 3	1.26[b]	1.65[b]	0.86[c]	0.85[c]	2.12[a]	1.54[b]	0.21

A standard serum chemistry of Nile tilapia (*O. niloticus*) fed different experimental diets included measuring total serum lipid (TSL) ; total serum protein (TSP) ; total serum albumin (TSA) ;total serum globulin (TSG) and albumin/ globulin ratio (A/G ratio) presented in Table (7) .The results indicated that the diet containing 0.6 (586.02) and 4.6 (584.12) ω6 / ω3 ratios had the highest values of TSL than the other treatments. The results of total serum protein (TSP) and total serum albumen (TSA) indicated that the significantly (P ≥ 0.05) higher values of TSP and TSA for Nile tilapia (*O. niloticus*) were observed for fish fed 0.45 ; 4.2 ω6 / ω3 ratios, respectively. The highest value of TSG was observed for fish fed either 0.45 or 4.6 ω6 / ω3 ratio, whereas, the highest value of A/G ratio was recorded for fish fed 1.2 ω6 / ω3 ratio .It could be noticed that the decline in serum protein would be accompanied with a decline in serum immunoglobullin as was reported before by Greshwin *et al.*, (1985) .

Economic evaluation

The enterprise budgets for production in pond stocked with Nile tilapia (*O. niloticus*) fed different ω6 / ω3 ratios for 120 day grow out are shown in Table (8) . The results indicated that the highest fish production (Kg / pond) (8.32) and profits (L.E / Pond) (26.98) were observed for tilapia fed 4.2 ω6 / ω3 ratio (5%soybean oil) ,while the lower values were obtained for tilapia fed 1.2 ω6 / ω3 ratio (5% fish oil) (7.01 and -60 ,respectively). Concerning the cost of feed consumption (L .E/pond), the highest values were observed for *O. niloticus* fed diet 1.2 ω6 / ω3 ratio (5% fish oil)(93.43 and 98.32 ,respectively) ,while, the lowest values were obtained for Nile tilapia (*O. niloticus*) fed 4.2 ω6 / ω3 ratio (5% soybean oil) (17.26 and 22.15 , respectively).

Table (7):The total serum lipid , total serum protein , albumin (A) , globulin (G) and A/B ratio of tilapia fed the different experiment diets.

ω6 / ω3 ratio	Total serum lipid	Total serum protein	Total serum albumin	Total serum globulin	A/G ratio
0.45	529.85^{b}	4.96^{a}	2.60^{c}	2.37^{a}	1.10^{c}
0.60	586.02^{a}	3.96^{c}	1.97^{d}	1.99^{b}	1.04^{c}
1.20	529.84^{b}	3.98^{c}	2.97^{b}	1.01^{c}	2.97^{a}
1.40	546.21^{b}	3.72^{c}	2.58^{c}	1.14^{c}	2.29^{b}
4.20	557.34^{b}	4.81^{b}	3.00^{a}	1.81^{b}	1.66^{bc}
4.60	584.12^{a}	4.87^{b}	2.78^{c}	2.04^{a}	1.36^{bc}
SE±	58.04	0.23	0.18	0.16	0.23

Table (8): Economic evaluation of Nile tilapia culture fed different experimental diets for 120 days.

ω6 / ω3 ratio	Experimental treatments					
	0.45	0.60	1.20	1.40	4.20	4.6
Mean initial weight (g.)	21.41	21.39	21.46	21.39	21.50	21.53
Mean final weight (g.)	187.25	190.80	175.10	177.20	207.80	193.85
Mean harvest weight (Kg/pond)	7.49	7.63	7.01	7.09	8.32	7.76
Adult.	6.49	6.73	4.94	5.59	8.06	7.11
Unmarketable size	1.00	0.90	2.07	1.50	0.26	0.65
Cost of Kg. diet, L. T.	1.54	1.47	6.35	4.35	1.44	1.49
Cost of feed pond (120 day, L. E)	21.53	22.21	93.43	58.98	17.26	20.98
Cost of fingerlings stocking in initial period/pond, L. E.	2.0	2.0	2.0	2.0	2.0	2.0
Cost of production fish pond L. E	26.42	27.10	98.32	63.87	22.15	25.87
Adult	38.94	40.38	29.64	33.51	48.36	42.66
Unmarketable size	3.00	2.70	6.20	4.52	0.77	1.94
Fuel, L. E (60 l/120 day)	0.60	0.60	0.60	0.60	0.60	0.60
Regular labor cost, L. E	2.29	2.29	2.29	2.29	2.29	2.29
Total cost of fish sale	41.94	43.08	35.84	38.03	49.13	44.60
Profits, L. E	20.42	20.88	-60.00	-25.85	26.98	18.73

- 1 Kg grade N1 = 8.5 L. E - 1 Kg grade N2 = 6.5 L. E - 1 Kg grade N3= 2.5 L. E

From the nutritional point of view, among dietary sources of lipid, vegetable oils have certain advantages to fish oils .They are cheaper, available in large quantities and less subject to oxidation than non-hydrogenated fish oil (Watanabe,1982 ; Nawar and Hultin , 1988). Moreover, they permit a growth and a feed conversion that is as efficient as the fish oils without significantly affecting the flesh organoleptic qualities. However, to raise tilapia as a supplementary dietary attraction for consumers, the fish oils are more advantageous than lipids from vegetable sources because in common with tilapia fish, the humans, have limited capacities for elongation and desaturation of 18: 3ω3 into EPA and DHA (Polvi and Ackman, 1992; Guillou *et al.*, 1995). Meanwhile, the replacement of fish oil fraction with vegetable oils rich in 18:3ω3 (linseed oil) would probably decrease the feed costs and maximize the accumulation of the total ω3 fatty acids in the flesh of farmed tilapia .

Finally, the following could be concluded: -

1-The supplementation of tilapia diets with vegetable oil rich in linoline acid (18:2ω6) gave generally better performance than supplementation with fish oil higher in (PUFA) or linseed oil rich in ω3 .

2-The source of dietary lipids and their profile of fatty acid composition are the limiting factors that influence lipid efficiency.

3-The 18: 2 ω6 was more concentrated in whole body tilapia when fed the diet containing high ω6/ ω3 ratios (4.20 and 4.6), while the highest concentration of whole body 18 : 3 ω3 was found in Nile tilapia when fed lower dietary ω6/ ω3 ratio (0.45 and 0.6).

4-The whole ω6/ω3 ratio of the fish lipid are greatly affected by the ω6/ω3 ratios of the dietary lipid.

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