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Effect of Replacing Dietary Fish Oil with Different Plant Oils on Growth Performance of Nile Tilapia *Oreochromis Niloticus*

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ABSTRACT

This experiment was carried out to study the effect of replacement dietary fish oil by different plant oils on growth performance and feed utilization of Nile tilapia (*Oreochromis niloticus*). Seven isocaloric diets (4.35 kcal/g diet) containing 30% crude protein, with different sources of dietary oils were used. Treatments were: fish oil, FO; linseed oil, LO, corn oil, CO; soya oil, SO; mixture of 50% linseed oil, 25% corn oil and 25% soya oil, ML; mixture of 50% corn oil, 25% linseed oil and 25% soya oil, MC; and mixture of 50% soya oil, 25% linseed oil and 25% corn oil, MS. Results showed that fish fed diet containing FO or ML were significantly higher ($P<0.05$) in growth performance values than fish fed on other diets. Survival rate did not differ significantly among treatments. The highest significant ($P<0.05$) values of feed utilization parameters were obtained with the fish maintained at FO or ML diets. These results suggest that fish oil could be replaced by a mixture of plant oils in Nile tilapia diet without any adversely affect on growth performance or feed efficiency ratio. Moreover, its efficiency economic, available and sharply reduced fish feed cost.

Keywords: growth performance, Fish oil, plant oil, Nile tilapia.

INTRODUCTION

Lipids are very important component in fish diets. They are added to provide energy needed for growth and development of cells, tissues and facilitates the absorption of fat-soluble dietary components such as vitamins. Lipids and oils are also important sources of essential fatty acids (EFA). In addition, they are provide transport of fat-soluble nutrients and are involved in the synthesis of metabolically active compounds (Weirich and Reigh, 2001). Moreover, there is evidence that dietary lipids and their constituent fatty acids influence immune response and disease resistance in fish. A deficiency or excess of n-3 fatty acids can suppress immune function and increase the susceptibility of fish to infectious pathogens (Lim *et al*., 2008). Inter specific variation in the ability of different species to utilize lipid as a source of energy is prevalent. Several studies have shown that providing adequate energy with dietary lipids can minimize the use of more costly protein as an energy source (Kim and Lee, 2005; Ishikawa, 2007).

Fish oil, rich in high unsaturated fatty acid HUFA, is the main dietary lipid source for aqua feeds (Ng *et al*. 2004). Their price and production figures are dependent upon the wild catch of these oil-yielding species. The utilization of alternative dietary oils in aquaculture feeds without diminishing favorable growth traits is important. Steady production and raising prices of fish oil encourage the inclusion of vegetable oils in fish feeds (Montero *et al*., 2003). However, it is also necessary that the oils used in diets provide adequate levels of EFAs needed by fish to sustain adequate growth rates as well as alter the fatty acid profile of the fillet in a way that is beneficial to the consumer (O'Neal and Kohler, 2008). Reduction of fish oil inputs in feed is one of the prioritized goals for the aquaculture industry not only to increase profits, but also to minimize phosphorus loading to the environment (Gatlin and Hardy, 2002). Izquierdo *et al*., (2005) reported that substitution by vegetable oils of up to 60% fish oil in diets for gilthead seabream does not affect growth and feed utilization even after a long feeding period. Moreover, it is possible to substitute dietary fish oil by mixture of vegetable oils even up to 100% in bigger fish. Also, Piedecausa *et al*., (2007) showed that the replacement of fish oil with soybean or linseed oil in seabream diets does not affect growth or feed utilization. However, Ishikawa (2007) stated that studies on fish oil replacement are still limited compared to those on fishmeal replacement.

Nile tilapia, *Oreochromis niloticus* is one of the most important species within the tilapias because of its rapid growth, good quality flesh, disease resistance, adaptability to a wide range of environmental conditions and good survival in high density culture. Therefore, it has become an excellent choice for aquaculture, especially in tropical and subtropical environments (El-Sayed, 2006). Subsequently, the improving of a practical diet for Nile tilapia is necessary. This experiment goal to evaluate the effect and the ability of replace fish oil by different plant oils treatments in fish diets on growth performance, feed efficiency and body composition of Nile tilapia (*Oreochromis niloticus*).

MATERIALS AND METHODS

The Experimental Fish

Nile tilapia fry (*Oreochromis niloticus*) with an average initial body weight of 1.2 ± 0.02 g were obtained from the fish hatchery ponds, Central Laboratory for Aquaculture Research (CLAR) Abbassa, Abu-Hammad, Sharkiya governorate, Egypt. Fish were kept in indoor tank for 2 weeks as an acclimation period to the laboratory conditions. Fish were divided into 7 groups (3 replicates per treatment) each containing 20 fish/ aquarium. Each subgroup of fish was transferred at random into a 100 L glass aquarium. Aquaria were supplemented with continuous aeration; water was exchanged partially every day by stocked dechlorinated tap water. Fish were fed twice daily at 09:00 and 14:00h to apparent satiation and aquaria were cleaned every day before feeding. Fish feeding was carried out 6 days/week. Fish were weighed at the beginning of the experiment and then biweekly for 10 weeks experimental period.

Diet formulation and Preparation

Seven experimental diets were used in this study containing both animal and plant protein sources. The composition and chemical analysis of the experimental diets are presented in Table 1. Diets were formulated from commercial ingredients to achieve 30% dietary protein level with gross energy level 4.35 kcal/g diet based on feedstuff values reported by NRC (1993). Seven different treatments of dietary oils were used in this study: Treatments were: fish oil, FO; linseed oil, LO; corn oil, CO; soya oil, SO; mixture of 50% linseed oil, 25% corn oil and 25% soya oil ML; mixture of 50% corn oil, 25% linseed oil and 25% soya oil, MC and finally mixture of 50% soya oil, 25% linseed oil and 25% corn oil, MS. Oils was added with the rate of 5.0% with equal amount of water using 0.7% phosphatediyl choline (lecithin, manufactor) according to El-Dahhar and El-Shazly (1993) few drops at the time of mixing. Dry ingredients were passed through a sieve (0.6 mm diameter hole) before mixing into the diets. Mixtures were homogenized in a feed grinder mixer. Warm water was then blended into the mixture at the ratio of 50% for pelleting. Diets were pelleted using meat grinder with a 1.0 mm diameter. The pellets were dried in a drying oven model (Fisher oven 13–261–28A) for 24 hours on 65°C and stored in plastic bags which were kept dry until used.

Table 1: Feed ingredients and proximate chemical analysis of experimental diets

Ingredients	Oil treatments						
	FO	**LO**	**CO**	**SO**	**ML**	**MC**	**MS**
Herring fish meal	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Soybean meal	38.5	38.5	38.5	38.5	38.5	38.5	38.5
Corn meal	27.0	27.0	27.0	27.0	27.0	27.0	27.0
Wheat bran	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Starch	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cod liver oil	5.0	0.0	0.0	0.0	0.0	0.0	0.0
Linseed oil	0.0	5.0	0.0	0.0	2.5	1.25	1.25
Corn oil	0.0	0.0	5.0	0.0	1.25	2.5	1.25
Soya oil	0.0	0.0	0.0	5.0	1.25	1.25	2.5
Vit. premix [1]	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Min. premix [2]	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Proximate analysis:							
Dry Matter %	90.47	90.49	90.50	90.45	90.47	90.48	90.47
Protein %	29.85	29.87	29.81	29.78	29.80	29.87	29.79
Fat %	8.65	8.62	8.59	8.64	8.61	8.58	8.64
NFE % [3]	45.11	45.10	45.23	45.24	45.28	45.12	45.20
Fiber %	6.15	6.16	6.15	6.14	6.13	6.17	6.13
Ash %	10.24	10.25	10.22	10.20	10.18	10.26	10.24
GE (kcal/100g)	435.8	435.6	435.5	435.8	435.7	435.3	435.7

1- Vitamins premix (per kg of premix): thiamine, 2.5 g; riboflavin, 2.5 g; pyridoxine, 2.0 g; inositol, 100.0 g; biotin, 0.3 g; pantothenic acid, 100.0 g; folic acid, 0.75 g; para-aminobenzoic acid, 2.5 g; choline, 200.0 g; nicotinic acid, 10.0 g; cyanocobalamine, 0.005 g; α-tocopherol acetate, 20.1g; menadione, 2.0 g; retinol palmitate, 100,000 IU; cholecalciferol, 500,000 IU.
2- Minerals premix (g/kg of premix): CaHPO4.2H2O, 727.2; MgCO4.7H2O, 127.5; KCl 50.0; NaCl, 60.0; FeC6H5O7.3H2O, 25.0; ZnCO3, 5.5; MnCl2.4H2O, 2.5; Cu(OAc)2.H2O, 0.785; CoCl3..6H2O, 0.477; CaIO3.6H2O, 0.295; CrCl3.6H2O, 0.128; AlCl3. 6H2O, 0.54; Na2SeO3, 0.03.
3- Nitrogen-Free Extract (calculated by difference) = 100 – (protein + lipid + ash + fiber).

Chemical Analysis of Diets and Fish

The tested diets and fish from each treatment were analyzed according to the standard methods of Association of Official Analytical Chemists AOAC (1990) for moisture, protein, fat and ash. Moisture content was estimated by heating samples in an oven at 85ºC until constant weight and calculating weight loss. Nitrogen content was measured using a micro kjeldahl apparatus and crude protein was estimated by multiplying nitrogen content by 6.25. Total lipids content was determined by ether extraction and ash was determined by combusting samples in a muffle furnace at 550ºC for 6 hours. Crude fiber was estimated according to Goering and Van Soest (1970). Gross energy (GE) was calculated according to NRC (1993) as 5.65, 9.45, and 4.11 kcal/g of protein, lipid, and carbohydrates, respectively.

Parameters of Growth Performance

Growth performance and feed efficiency parameters were calculated using the following equations:

Weight gain (WG) = $W1-W0$.

Specific growth rate (SGR%/day) = $[(\ln W1 - \ln W0)/T] \times 100$.

Where, Ln = natural log, W0 = Initial body weight (g), W1= Final body weight (g) and T= Time (day).

Feed conversion ratio (FCR) = feed intake (g)/body weight gain (g).
Protein efficiency ratio (PER) = total weight gain (g)/protein intake (g).
Protein productive value (PPV%) = 100 (protein gain/protein intake).
Energy retention (ER%) = 100 (gross energy gain/gross energy intake).
Survival rate (%) = 100 × (fish No. at the end/ fish No. stocked at the beginning).

Water Quality

Water quality parameters were monitored to ensure that water quality remained well within limits recommended for Nile tilapia culture. Water temperature and dissolved oxygen were measured daily using a YSI Model 58 oxygen meter (Yellow Springs Instrument, Yellow Spring, OH, USA). Total ammonia, nitrite, and nitrate were measured twice weekly using a DREL 2000 spectrophotometer by the method of Golterman *et al*., (1978) pH was monitored daily using an electronic pH meter (pH pen; Fisher Scientific, Cincinnati, OH, USA). Water temperature ranged from 26.0 to 27.0°C, dissolved oxygen from 4.7 to 5.8 mg/L, total ammonia from 0.14 to 0.21 mg/L, pH from 7.3 to 7.9 and alkalinity from 174 to 181 mg/L. There were no significant differences in the water quality parameters among the treatments during the experimental period. All the previous water quality parameters were within the acceptable range for normal growth of Nile tilapia (Boyd, 1984).

Statistical Analysis

The obtained data were subjected to one-way ANOVA. Differences between means were tested at the 5% probability level using Duncan test (1995). All the statistical analyses were done using SPSS program version 10 (SPSS, Richmond, USA) as described by Dytham (1999).

Economical Evaluation

The cost of feed required to produce a unit of fish biomass was estimated using a simple economic analysis. The estimation was based on local retail sale market price of all the dietary ingredients at the time of the study. These prices (in LE/kg) were as follows: herring fish meal, 17; soybean meal, 4.0; corn meal, 2.50; starch 6.0, wheat bran 2.25; fish oil (cod liver oil) 62.0; linseed oil, 16.0; corn oil, 12.0; soya oil 11.0; vitamin premix,10.0 and mineral mixture,8.0 LE/Kg.

RESULTS

Growth Performance

Data of Table (2) show that final body weight (FBW), weight gain (WG), daily weight gain (DWG) specific growth rate (SGR%/day) and survival rate of Nile tilapia (*Oreochromis niloticus*) were significantly (P < 0.05) affected by different dietary lipids sources.

Table 2: Growth performance parameters (Means ± SE) of Nile tilapia *Oreochromis niloticus* fed at different dietary oils sources

Treatments	FBW(g)	WG (g)	DWG (g)	SGR%	Survival
FO	22.53 ± 0.21^{a}	21.33 ±0.2^{a}	0.30 ±0.01^{a}	4.19 ± 0.07^{a}	98.33±1.0
LO	18.60 ± 0.15^{d}	17.40 ±0.3^{d}	0.25 ±0.01^{b}	3.92 ± 0.06^{d}	97.67±2.0
CO	18.38 ± 0.20^{de}	17.18 ±0.2^{de}	0.25 ±0.02^{b}	3.90 ±0.05^{de}	96.66±2.0
SO	17.94 ± 0.32^{e}	16.74 ± 0.3^{e}	0.24 ± 0.01^{b}	3.86 ± 0.07^{e}	95.00±3.0
ML	22.06 ± 0.15^{ab}	20.86 ±0.2^{ab}	0.30 ±0.01^{a}	4.16 ± 0.04^{ab}	97.67±2.0
MC	21.84 ± 0.16^{b}	20.64 ± 0.2^{b}	0.29±0.02^{a}	4.14±0.05 ^{b}	98.33±1.0
MS	21.08 ±0.12^{c}	19.88 ± 0.1^{c}	0.28 ± 0.01^{a}	4.09 ± 0.08^{c}	96.66±2.0

Means in each column followed by different letter are significantly different (P < 0.05).

The highest significant (P < 0.05) values of FBW, WG, DWG and SGR were obtained in fish fed at fish oil diet (FO) and mixed of linseed oil diet (ML) without significant differences between the two treatments, followed by group of fish fed on mixed of corn oil (MC) ; mixed of soya oil (MS); fish fed at linseed oil (LO) ; corn oil (CO) diets and finally the least values of FBW, WG and SGR (P < 0.05) were recorded at fish fed on soya oil diet (SO). Survival rate at the end of the experimental period showed that there were insignificant differences (P >0.05) among treatments, it's ranged between 95.0 and 98.33 %.

Feed Utilization

Values of feed conversion ratio FCR, protein efficiency ratio PER, protein productive value PPV% and energy retention ER % of Nile tilapia (*Oreochromis niloticus*) are shown in Table 3. Data showed that the best values (P <0.05) of FCR were found at fish maintained at FO and ML diets, there were 1.58 and 1.61 respectively, while the worst FCR values (P<0.05) were found at fish maintained at single plant oil diets (CO, SO and LO). With respect to PER data in Table (3) indicated that best PER values (P <0.05) was obtained by fish fed on (FO) and mixed oils diets (ML, MC and MS), values were 2.12, 2.08, 2.08 and 2.07 respectively. While the worst (P < 0.05) PER values were observed by fish fed on single plant oil diets (CO, SO and LO). With respect to PPV results indicated that the best (P<0.05) values were obtained by fish fed on FO, ML and MC diets without significant differences between treatments, followed by fish fed on MS diets, and finally the least values (P<0.05) of PPV were observed by fish fed on single plant oil diets (LO, SO and CO). Data of energy retention ER as shown in Table 3 indicated that fish maintained on mixed oils diets (ML, MC and MS) and FO diet were significantly (P<0.05) the highest values of ER than other treatments, while the fish fed on single plant oil diets (CO, SO and LO) were the lowest (P<0.05) in ER values.

Table 3: Feed and nutrient utilization parameters (Means ± SE) of Nile tilapia *Oreochromis niloticus* fed at different dietary oils sources

Treatments	Feed	FCR	PER	PPV%	ER%
FO	33.79±0.2 [a]	1.58±0.03 [c]	2.12±0.03 [a]	36.33±0.08 [a]	21.85±0.04 [a]
LO	29.32±0.1 [c]	1.69±0.05 [a]	1.99±0.04 [b]	34.32±0.06[cd]	20.95±0.41[bc]
CO	29.43±0.1 [c]	1.71±0.04 [a]	1.95±0.04 [b]	33.26±0.42 [e]	20.41±0.28 [c]
SO	28.55±0.6 [c]	1.70±0.03 [a]	1.97±0.06 [b]	33.73±0.32 [de]	20.37±0.33 [d]
ML	33.54±0.5 [a]	1.61±0.02 [bc]	2.08±0.05 [a]	35.70±0.46[ab]	21.32±0.28[ab]
MC	33.37±0.3 [a]	1.62±0.03 [b]	2.08±0.03 [a]	35.62±0.24 [ab]	22.12±0.16 [a]
MS	32.22±0.2 [d]	1.62±0.04 [b]	2.07±0.05 [a]	35.20±0.17[bc]	22.00±0.19 [a]

Means in each column followed by different letter are significantly different (P < 0.05).

Body Composition

With respect to body composition of Nile tilapia, results in Table (4) observed no significant differences (P >0.05) between treatments in fish body moisture contents, it ranged between 73.23and 74.81%. Similarly, results showed that, there were insignificant differences in protein content of fish body between treatments (P>0.05). On the other hand, results of lipid contents in fish body showed that there were significant differences (P<0.05) among treatments. Fish maintained on mixed plant oils diets (ML, MC and MS) and also, SO and CO diets were significantly (P <0.05) the highest values of lipid contents in fish body without significant differences between them, while fish maintained on fish oil and linseed oil diets were the lowest (P <0.05) in fish body lipid contents values.

Table 4: Body composition (M ±SE) % on dry weight basis of Nile tilapia fed at different oils sources

Treatments	Moisture %	Crude protein %	Lipid %
FO	73.68±0.2	65.64±0.03	17.71±0.03 [b]
LO	73.73±0.1	65.95±0.05	18.46±0.04 [b]
CO	74.81±0.1	65.06±0.04	20.20±0.04 [a]
SO	74.02±0.6	65.63±0.03	19.11±0.06 [a]
ML	73.46±0.5	65.46±0.02	19.50±0.05 [a]
MC	74.21±0.3	65.47±0.03	19.23±0.03 [a]
MS	73.23±0.2	65.11±0.04	20.08±0.05 [a]

Means in each column followed by different letter are significantly different (P < 0.05).

Economic Evaluation

With respect to economic evaluation, results of Table 5 showed that replacement fish oil by single plant oils or mixed of them in fish diet is more economic and sharply reduced the feed cost. The reduction in feed cost to produce one kg fish gain at diet containing plant oils was ranged between 23.53 to 28.86% compared to fish fed at FO diet.

Table 5: Economic efficiency for producing one kg gain of fish fed at different oils sources

Items	Oils Sources						
	FO	LO	CO	SO	ML	MC	MS
Price/ kg feed (P.T)*	8.07	5.77	5.57	5.52	5.66	5.61	5.60
FCR kg feed/kg gain	1.58	1.69	1.71	1.70	1.61	1.62	1.62
Feed cost / kg gain (P.T)	12.75	9.75	9.52	9.38	9.11	9.09	9.07
Reduction cost in kg gain%	0.0	23.53	25.33	26.43	28.55	28.70	28.86

* $ = 7.15 P.T

DISCUSSION

Results of the present study indicated that there is no significant difference between fish fed FO diet and fish fed ML diet in growth performance of Nile tilapia (Table 2). Also, results denoted the higher ability of Nile tilapia to accept vegetable oils in diet. Similar results have been reported in previous studies with different species. Ng *et al*., (2001) found that hybrid tilapia (*Oreochromis niloticus* × *Oreochromis aureus*) fed diets containing vegetable oils as sources of lipid was better in growth performance than fish fed cod liver oil diet. Ng *et al*., (2003); Arslan *et al*., (2008) found the same results with catfish. Bell *et al*. (2005) showed that Atlantic salmon can be cultured, over the whole production cycle, using diets in which 100% of added dietary fish oil can be replaced by a blend of rapeseed and linseed oils without detriment to growth performance. Menoyo *et al*., (2004) indicated that dietary FO can be replaced by linseed or soybean oils at a level of substitution 60% without compromising marketable size sea bream growth. Also, Piedecausa *et al*., (2007) showed that the replacement of fish oil with soybean or linseed oil in (*Sharpsnout seabream*) diets didn't affect growth or feed utilization after three months of feeding. Similar results were obtained by Martino *et al*. (2002), they explained that vegetable oils such as soybean oil, corn oil and linseed oil were readily used by surubim fingerlings and no difference in growth of fish was found. In previous study, El-Tawil and Amer (2010) indicated that fish oil could be replaced by linseed oil in red tilapia diet without any effect on growth performance or feed efficiency ratio. However, Henderson and Tocher (1987); Sargent *et al*., (1995) have indicated that polyunsaturated fatty acids (PUFA), linoleic acid (LA, 18:2n-6) and linolenic acid (LNA, 18:3n-3), which are also essential fatty acids (EFA) for fish, can be converted to these longer chain, more unsaturated, and physiologically important HUFAs by freshwater fish. So, results of the present study suggest that the efficiency of mixed of linseed oils used in diet which contain linoleic acid (LA, 18:2n-6) and linolenic acid (LNA, 18:3n-3) provide adequate levels of essential fatty acids needed by fish to sustain adequate growth rate. Kim *et al*. (2007); Aksoy *et al*., (2009) reported that freshwater fish require dietary sources of polyunsaturated fatty acids of the linoleic and linolenic acid families for optimum growth. Difference between growth performance of fish fed FO, ML diets and fish fed other experimental diets in the present study can be considered a consequence of using different type of lipids in the inclusion of vegetable oils in diets and may be related to dietary lipid class as well as fatty acid composition of the diet itself.

Survival rate in the present study showed that there were insignificant differences among treatments. It ranged between 95 to 98.33 %. This result is nearly similar to what El-Tawil and Amer (2010) had found with red tilapia. They suggested that, the replacement of fish oil with linseed oil in diets did not cause any negative effect on growth performance or survival rate. Lim *et al*. (2008) indicated that there was no significant difference in survival rate of Nile tilapia fed on fish oil or vegetable oils in diet. Also, Arslan *et al*., (2008) found the same with juvenile surubim, there were insignificant differences in survival rate when fish oil replaced by linseed or olive oils in fish diets. Izquierdo *et al*., (2008) reported that good larval survival and growth, both in terms of total length and body weight, were obtained by feeding the larvae of gilthead seabream on vegetable oils (rapeseed, soybean or linseed oils). Moreover, the presence of vegetable oils in the diet increased the levels of fatty acids (20:2n−9 and 20:2n−6, 18:2n−9, 18:3n−6, 20:3n−6 and 20:4n−6) in larvae fed rapeseed and soybean oils in comparison to those fed fish oil.

In the present study values of feed efficiency parameters FCR, PER, PPV and ER of Nile tilapia in Table 3 indicated that best values ($P<0.05$) were obtained by fish fed on FO or ML diets, followed by fish fed on mixed of plant oils diets MC and MS while the lowest values of feed efficiency parameters ($P<0.05$) were observed by fish fed on single plant oil diets CO, SO and LO. These results are pointed to using of mixture of plant oils was more efficiency in fish diets than using of single plant oil, it's may be provide adequate levels of EFAs needed by fish to sustain adequate growth rate which were not included in single plant oil separately. These results are in agreement with Izquierdo *et al*., (2005), they reported that substitute dietary fish oil by mixture of vegetable oils in diets for gilthead seabream does not affect growth or feed utilization even up to 100% in bigger fish even after a long feeding period. Moreover, Montero *et al*. (2003) found that fish oil can be replaced by a blend of different vegetable oils like soybean oil, rapeseed oil or linseed oil without affecting gilthead seabream health for a medium period. Also, These results are in agreement with those reported in previous studies by Aksoy *et al*., (2009); El-Tawil and Amer (2010) which indicate that, fish oil could be at least partially substituted or replacement by plant oils in diets for fish species, being this substitution resulted in good feed utilization and maintenance of fish health. El-Tawil and Amer (2010) observed no significant differences ($P >0.05$) between PER values of red tilapia fed on fish oil or linseed oil diets. Also, Trostensen *et al*., (2005); Xue *et al*., (2006) show that marine fish oils could be replacement up to75% by plant oils or mixtures of them without cause any lower growth. Balance between dietary protein and energy is essential in fish feed formulation. At inadequate energy levels dietary protein will be used as an energy source and more protein is used for energy, the more ammonia is produced and the more energy is lost as heat. But at an adequate energy level, dietary protein will be spared for growth (El-Sayed, 1987).

Fish moisture and protein contents in the present study didn't differ significantly ($P >0.05$) in all treatments. While lipid content in fish maintained on FO and ML diets were lower than other treatments. These results are nearly similar with those reported by Arslan *et al*., (2008). They found that fish moisture contents did not differ significantly among dietary treatments, which were olive and linseed oil LO, cod liver oil (CLO), soy-refined lecithin (LE), at the same time crude protein did not differ significantly among treatments except soy-refined lecithin (LE) diet which was the highest. Lim *et al*., (2008) observed insignificant difference among the moisture, protein and lipid contents of Nile tilapia receiving various dietary lipid sources (fish oil and vegetable oils) diets. El-Tawil and Amer (2010) found the same results with red tilapia where no significant differences were observed in fish body moisture or protein contents when fish fed diets containing fish oil or plant oils.

In terms of economic evaluation, results of present study in Table 5 showed that replacement fish oil by single plant oils or mixed of them in fish diet is more economic and sharply reduced the feed cost without any effect on growth performance or feed utilization. The reduction in feed cost was ranged between 23.53 to 28.86% compared to fish fed at FO diet. These results are nearly similar with those reported by Piedecausa *et al*., (2007) who noted that consumption of vegetable oils reduced feed costs of seabream. Also, El-Tawil and Amer (2010) found the same results in red tilapia where replacement fish oil by linseed oil reduced oil cost in fish feed more than 87% without any effect on growth. Montero *et al*. (2003) reported that fish oils are mostly imported from foreign countries, their price and production figures are dependent upon the wild catch of these oil-yielding species. Steady production and raising prices of fish oil encourage the inclusion of vegetable oils in fish feeds which were more available and economic.

CONCLUSION

In conclusion, the obtained results showed that the replacement of fish oil with mixture of plant oils (50% linseed oil, 25% corn oil and 25% soya oil) in the diet of Nile tilapia (*Oreochromis niloticus*) did not cause any negative effect on growth performance or feed utilization, suggesting the addition of this oils to Nile tilapia feed since it's more efficiency economic, available and sharply reduced the feed cost of Nile tilapia.

REFERENCE

Aksoy, M.Y., C. Lim, R. Shelby, and P. Klesius. 2009. Increasing fish oil levels in commercial diets influences hematological and immunological responses of channel catfish, Ictalurus punctatus. *Journal of the World Aquaculture Society*. 40:76-86.

Arslan, M., J. Rinchard, K. Dabrowskii, and M.S. Portella. 2008. Effects of Different Dietary Lipid Sources on the Survival, Growth, and Fatty Acid Composition of South American Catfish, *Pseudoplatystoma fasciatum*, Surubim, Juveniles. *Journal of the world aquaculture societ*y. 39: 51-61.

Association of Oficial Analytical Chemists (AOAC). 1990. Official Methods of Analysis, AOAC, Arlington, VA, USA, 1141p.

Bell, J.G., F. McGhee, J.R. Dick, and D.R.Tocher. 2005. Dioxin and dioxin-like polychlorinated biphenyls (PCBs) in Scottish farmed salmon (*Salmo salar*): effects of replacement of dietary marine fish oil with vegetable oils. *Aquaculture*. 243: 305– 314.

Boyd, C.E. 1984. Water quality in warm water fishponds. Auburn University, Agriculture experimental station, Auburn, Alabama, USA.

Duncan, D.B. 1995. Multiple range and multiple 'F' test. *Biometrics*. 11: 1– 42.

Dytham, C. 1999. Choosing and using statistics: A biologist's guide. London, UK: Blackwell Science.

El-Dahhar, A.A., and K. El-Shazly. 1993. Effect of essential amino acids (methionine and lysine) and treated oil in fish diet on growth performance and feed utilization of Nile tilapia, Tilapia nilotica (L.) *Aquaculture*. 24: 731-739.

El-Sayed, A.M. 1987. Protein and energy requirements of Tilapia Zillii. Ph.D. Diss., Michigan state university. East lansing MI, USA, 147 p.

El-Sayed, A.M. 2006. Tilapia culture. Wallingford, Oxfordshire, UK: CABI.

El-Tawil N.E., and T.N. Amer. 2010. Effect of different dietary oil sources on fish performance, feed utilization and body composition of Red Tilapia (*Oreochromis sp*.) fry. Abbasa Int. J. Aqua. Spicial Issue. The third scintefic Conference, Al Azhar Univ., Cairo 17-18 October 2010. 161-177.

Gatline, D.M., and R.W. Hardy. 2002. Manipulations of diets and feeding to reduce losses of nutrients in intensive aquaculture. In: Tomasso, J.R. (Ed.), Aquaculture and the Environment in the United States. World Aquaculture Society, Baton Rouge, LA, pp:155– 165.

Goering, H.K., and P.G. Van Soest. 1970. Forage fiber analysis (apparatus, reagent, procedures, and some applications). US Dept. Agric. Handbook, Washington D.C., USA.

Golterman, H.L., R.S. Clymo, and M.A. Ohnstad. 1978. Methods of physical and chemical analysis of fresh water. Blackwell Scientific Publication, Oxford, UK.

Henderson, R.J., and D.R. Tocher. 1987. The lipid composition and biochemistry of freshwater fish. *Progress in Lipid Research*. 26:284–347.

Ishikawa, M. 2007. Lipids. In Dietary supplements for the health and quality of cultured fish. Edited by Nakagawa, H., Sato, S. and. Gatlin III. D. CABI North American Office Cambridge, MA 02139 USA.

Izquierdo, M.S., D. Montero, L. Robaina, M.J. Caballero, G. Rosenlund and R. Ginés. 2005. Alterations in fillet fatty acid profile and flesh quality in gilthead seabream (*Sparus aurata*) fed vegetable oils for a long term period. Recovery of fatty acid profiles by fish oil feeding. *Aquaculture*. 250(1-2):431-444.

Izquierdo, M.S., L. Robaina, E.J. Carrillo, V. Oliva, C.M. Hernández-Cruz, J.M. Afons. 2008. Regulation of growth, fatty acid composition and delta 6 desaturase expression by dietary lipids in gilthead seabream larvae (*Sparus aurata*). *Fish Physiology and Biochemistry*. 34:117-127.

Kim, K.D., S.M. Lee, H. G. Park, S. Bai and Y.H. Lee. 2007. Essentiality of dietary n-3 highly unsaturated fatty acids in juvenile Japanese flounder *paralichthys olivaceus*. *J. of the World Aquaculture Society*. 33: 432 – 440.

Kim, K.D., and S.M. Lee. 2005. Effect of dietary protein and lipid levels on growth and body composition of bagrid catfish, *Pseudobagrus fulvidraco*. *Aquaculture*. 243:323–329.

Lim, C., M.Y. Aksoy, A. Davis, and P. Klesius. 2008. Effects of varied dietary lipid sources tested in tilapia study . Global Aquaculture advocate. June 2008, pp: 67-70.

Martino, R. C., J. E. P. Cyrino, L. Portz, and L. C. Trugo. 2002. Performance and fatty acid composition of surubim (*Pseudoplatystoma coruscans*) fed diets with animal and plant lipids. *Aquaculture*. 209:233–246.

Menoyo, D., M.S. Izquierdo, L. Robaina, R. Gines, C.J.Lopez-Bote, J.M. Bautista. 2004. Adaptation of lipid metabolism, tissue composition and flesh quality in gilthead sea bream (*Sparus aurata*) to the replacement of dietary fish oil by linseed and soybean oils. *British J. Nutrition*. 92:41-52

Montero, D., T. Kalinowski, A. Obach, L. Robaina, L. Tort, M.J. Caballero, and M.S. Izquierdo. 2003. Vegetable lipid sources for gilthead seabream, *Sparus aurata*: effects on fish health. *Aquaculture*. 225:252–370.

National Research Council (NRC). 1993. Nutrient Requirements of warmwater fishes and shellfishes. National Academy Press, Washington, DC, 102p.

Ng, W.K., P.K. Lim, and H. Sidek. 2001. The influence of a dietary lipid source on growth, muscle fatty acid composition and erythrocyte osmotic fragility of hybrid tilapia. *Fish Physiology and Biochemistry*. 25:301–310.

Ng, W.K., P.K. Lim, and P. Boey. 2003. Dietary lipid and palm oil source affects growth, fatty acid composition and muscle a-tocopherol concentration of African catfish, *Clarias gariepinus*. *Aquaculture*. 215: 119–143.

Ng, W.K., Y. Wang, P. Ketchimenin, and K. H. Yuen. 2004. Replacement of dietary fish oil with palm fatty acid distillate elevates tocopherol and tocotrienol concentrations and increases oxidative stability in the muscle of African catfish, *Clarias gariepinus*. *Aquaculture*. 233:423–437.

O'Neal Clifford, C., and C. Kohler Christopher. 2008. Effect of Replacing Menhaden Oil with Catfish Oil on the Fatty Acid Composition of Juvenile Channel Catfish, Ictalurus punctatus. *J. of the World Aquaculture Society*. 39(1).

Piedecausa, M.A., M.J. Mazón, B. García García and M.D. Hernandez. 2007. Effects of total replacement of fish oil by vegetable oils in the diets of sharpsnout seabream (*Diplodus puntazzo*). *Aquaculture*. 263:211-219.

Sargent, J.R., J.G. Bell, M.V. Bell, R.J. Henderson, and D.R. Tocher. 1995. Requirement criteria for essential fatty acids. *J. of Applied Ichthyology*. 11:183–198.

Torstensen, B., J.G. Bell, G. Rosenlund, R.J. Henderson, I. Graff, D.R. Tocher, O. Lie, and J.R. Sargent. 2005. Tailoring of Atlantic salmon (*Salmo salar* L.) flesh lipid composition and sensory quality by replacing fish oil with a vegetable oil blend. *J .of Agric. Food Chemistry*. 53:10166- 10178.

Weirich, C.R. and R.C. Reigh. 2001. Dietary lipids and stress tolerance in larval fish. Pages 301–312 in C. Lim and C. D. Webster, editors. Nutrition and fish health. The Haworth Press, Inc., NY, USA.

Xue, M., L. Luo, X. Wu, Z. Ren, P. Gao, Y. Yu, and G. Pearl. 2006. Effect of six alternative lipid sources on growth and tissue fatty acid composition in Japanese sea bass (*Lateolabrax japonicus*). *Aquaculture.* 260:206-214.