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Effect of Dietary Oil Sources and Levels on Growth, Feed Utilization and Whole-Body Chemical Composition of Common Carp, *Cyprinus carpio* L. Fingerlings

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Abstract: The effect of dietary oil sources and levels on growth, feed utilization and whole-body chemical composition of common carp (*Cyprinus carpio* L.) was studied. Fish (4-5 g) were randomly distributed at a rate of 15 fish/100 L aquarium and fed one of the tested diets for 90 days. The obtained results showed that different growth parameters were affected significantly by dietary lipid sources or lipid levels ($p < 0.05$), but not by their interaction ($p > 0.05$). The fish growth was maximized when fed diets containing oil mixture (1:1 v/v corn oil : fish oil) more than that fed plant oil or fish oil alone. The fish groups fed fish oil exhibited better growth than that fed plant oil. Fish growth increased significantly due to the increase in dietary lipid levels and the maximum growth was obtained when fish fed a mixed oil diet with a level of 6%. Fish survival was not affected significantly due to the variation in lipid sources or lipid levels ($p > 0.05$) and it ranged 98.3-100%. Feed utilization parameters were affected significantly by either lipid sources or levels or their interaction ($p > 0.05$) except feed intake (FI), feed conversion ratio (FCR) and feed efficiency ratio (FER) were not affected by the interaction ($p < 0.05$). FI increased with mixed oil source better than the other oil sources. The feed intake was low and the FCR was high with fish group fed the control diet. The adding of oil mixture or fish oil to fish diet enhanced the FI, FCR and FER values to be better than that fed plant oil source or control diets. The optimum feed utilization was obtained with fish groups fed diets containing mixed oil at the level of 6%. Moisture, crude protein, total lipids and ash contents were affected significantly by oil level only ($p < 0.05$) and no significant changes were observed due to oil source or oil source-oil levels interaction ($p > 0.05$). Moisture and crude protein contents decreased significantly, while total lipids increased significantly with the increase of oil level ($p < 0.05$) irrespective to oil source. It is concluded from this study that mixed oil (1:1 v/v corn oil : fish oil) should be added to the diet for common carp fingerlings at a level of 6% irrespective to the lipid content of the basal ingredients of the diet.

Key words: Dietary lipids, common carp, growth, feed utilization, proximate chemical composition

INTRODUCTION

Dietary lipids play an important role in commercial diets as the source of energy and essential fatty acids for the growth and development of fishes (NRC, 1993). It can also spare dietary protein from use as energy and limit ammonia production (Cho and Kaushik, 1990; De Selva *et al.*, 1991; Arzel *et al.*, 1994; Chou and Shiau, 1996; Kim and Lee, 2005). On the other hand, high dietary lipid content might decrease feed consumption and reduce growth (Ahamad Ali, 2004; Pei *et al.*, 2004; El-Marakby, 2006). Moreover, high dietary lipid can also lead to an increase in lipid deposition in fish body and affect the quality and the nutritional value of fish meat. Therefore, the optimal dietary lipid level have to be carefully evaluated and determined.

Increased dietary lipid levels with high quality fats improve growth, feed conversion and protein utilization, thus reducing nitrogen excretion in farmed fish (Steffens, 1993). In general, the main lipid source employed in fish feeds is fish oil, due to its traditionally good availability and high content in n 3 HUFA (polyunsaturated fatty acids of the n 3 series with 20 or more carbons), which are considered as essential fatty acids for marine fish species (Izquierdo, 1996). Both the increase of this ingredient in aquafeeds and the global growth in aquaculture production have increased the demand for this raw material. The global production of fish oil based on fisheries landing, is static and it is predicted that by 2010 the fish feed industry will require at least to 50% of the total world production of fish oil (Tacon, 1997).

In comparison, the global production of vegetable oils has increased in recent years reaching volumes 100 times that of fish oil; therefore, the price of vegetable oils has been more constant and even decreasing in some markets. For some types of oil, prices below that of fish oil have been noted. Therefore, a successful partial replacement of fish oils by vegetable oils would reduce both the absolute dependence on this ingredient and associated costs.

Partial replacement of fish oils by vegetable oils in fresh water fish species results in good results as far as survival, growth and food conversion rates are concerned. Vegetable oils are (with the exception of some such as coconut and palm oils) rich in fatty acids with 18 carbons and many of them are also rich in linoleic or linolenic acids, essential for freshwater fish species. Therefore, many vegetable oils are a good energy source in diets for freshwater species such as African catfish (*Heterobranchius longifilis*, Legendre *et al.*, 1995) or common carp (*Cyprinus carpio*; Fontagne *et al.*, 1999) with maximum replacement rates being up to 40% of the dietary lipids. In other species such as red drum (*Sciaenops ocellatus*) substitution levels up to 70-80% have been reported with soybean oil (Tucker *et al.*, 1997) or linseed oil (Lochmann and Gatlin, 1993) without growth reduction. Also, in Atlantic salmon (*Salmo salar*) and rainbow trout (*Oncorhynchus mykiss*) at least 50 and 80%, respectively, of the fish oil can be replaced by different vegetable oils without compromising growth, survival or feed utilization (Rosenlund *et al.*, 2000; Caballero *et al.*, 2002; Grisdale-Helland *et al.*, 2002). Some of the vegetable oils studied in diets for seabream and bass are soybean, sunflower, olive, rapeseed and linseed (Alexis, 1997; El-Kerdawy and Salama, 1997; Yildiz and Aener, 1997).

Carp are the 2nd most important fish species for aquaculture all over the world, only after salmonids (FAO, 2004) and represent the species of choice due to their high growth rate, significant tolerance to environmental stresses, easy to reproduce and unquestionable market demands. In Egypt, common carp (*Cyprinus carpio*, L.) is one of the major species used in aquaculture systems. However, the success of intensive carp culture depends to a large extent on supplemental feeding. Therefore, the objective of this study was to investigate the effect of dietary oil sources and levels on the growth performance, feed utilization and whole-body composition of common carp (*Cyprinus carpio* L.).

MATERIALS AND METHODS

The Experimental Design

Healthy fish of common carp, *Cyprinus carpio* L. (4-5 g/fish) were obtained from Abbassa fish hatchery, General Authority for Fish Resources Development, Abbassa, Abo-Hammad, Sharkia, Egypt. Fish were acclimated in indoor tanks for 2 weeks where they were fed a commercial diet containing 30% crude protein. Fifty fish were frozen at -20°C for chemical analyses. The fish were distributed randomly in glass aquaria (75×60×50 cm) containing 100 L of aerated water at a rate of 15 fish/aquarium. Each aquarium was supplied with compressed air via air-stones from air pumps. Well-aerated water supply was provided from a storage fiberglass tank. The temperature range was 26-28°C. Siphoning a half of aquarium's water was done every day for excreta removing and an equal volume of dechlorinated water replaced it.

Table 1: Nutrients contents and proximate chemical composition of the tested diets differed in oil levels.

	Control (0%)	Corn oil (%)			Corn oil: Cod liver oil (1:1) (%)			Cod liver oil (%)		
		3	6	9	3	6	9	3	6	9
Ingredients (%)										
Fish meal	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Soybean meal	46.45	46.45	46.45	46.45	46.45	46.45	46.45	46.45	46.45	46.45
Wheat bran	18.25	18.25	18.25	18.25	18.25	18.25	18.25	18.25	18.25	18.25
Ground corn	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Corn oil	0.0	3.0	6.0	9.0	1.5	3.0	4.5	0.0	0.0	0.0
Cod liver oil	0.0	0.0	0.0	0.0	1.5	3.0	4.5	3.0	6.0	9.0
Mineral mixture*	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Vitamin mixture**	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ascorbic acid	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Carboxymethylcellulose	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Starch	10.72	7.72	4.72	1.72	7.72	4.72	1.72	7.72	4.72	1.72
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Chemical composition (%)										
Dry matter	91.2	91.31	91.21	90.98	90.89	91.11	90.79	90.99	91.21	91.50
Crude protein	30.21	29.98	30.11	30.51	30.15	30.30	30.13	29.99	30.22	30.31
Ether extract	2.61	5.73	8.56	11.69	5.58	8.70	11.70	5.66	8.71	11.58
Crude fiber	4.81	4.52	4.90	5.01	4.53	4.66	4.80	4.89	5.00	4.72
Ash	6.01	5.89	6.21	6.11	6.13	6.22	5.70	6.09	5.99	5.80
NFE ***	56.36	53.88	50.22	46.68	53.61	50.12	47.67	53.37	50.08	47.59
GE (kcal/kg feed) ****	4464.3	4632.6	4771.7	4948.8	4616.9	4781.7	4960.3	4620.2	4790.4	4952.6
P:E ratio	67.67	64.72	63.10	61.65	65.30	63.37	60.74	64.91	63.08	61.20

*Vitamin 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; cyanocobalamin, 0.005 g; α -tocopherol acetate, 20.1 g; menadione, 2.0 g; retinol palmitate, 100,000 IU; cholecalciferol, 500,000 IU.

**Mineral premix (g kg⁻¹ of premix): CaHPO₄·2H₂O, 727.2; MgCO₃·7H₂O, 127.5; KCl 50.0; NaCl, 60.0; FeC₂H₃O₇·3H₂O, 25.0; ZnCO₃, 5.5; MnCl₂·4H₂O, 2.5; Cu (OAc)₂·H₂O, 0.785; CoCl₂·6H₂O, 0.477; CaI₂·6H₂O, 0.295; CrCl₃·6H₂O, 0.128; AlCl₃·6H₂O, 0.54; Na₂SeO₃, 0.03.

***NFE (nitrogen free extract) = 100 - (protein + lipid + ash + fiber).

****GE (gross energy): Calculated after NRC (1993) as 5.64, 9.44 and 4.11 Kcal/g for protein, lipid and NFE, respectively

Fish Diets and Feeding Regime

Fish diets were prepared from purified ingredients and was used to formulate ten identical diets in all the nutrient contents differing in lipid sources and levels (Table 1). The lipid sources were corn oil, cod liver oil or oil mixture of both (1:1 v/v). At each lipid source, three lipid levels were done i.e., 3, 6, or 9%. The control diet was free of external lipid addition and depends on the internal lipid contents of diet ingredients. Three aquaria were randomly assigned for each treatment. Fish were fed frequently at the rate of 4% of live body weight for 6 weeks and the feeding rate was 3% of live body weight for the second 7 weeks. Fish in each aquarium was biweekly weighed and the amount of feed given for each aquarium was subsequently readjusted. Dead fish were removed and recorded daily.

Proximate Analysis of Diet and Fish

The tested diets and whole fish body from each treatment were chemically analyzed according to the standard methods of AOAC (1984) for moisture, protein, total lipids and ash. Moisture content was estimated by heating samples in an oven at 85°C till constant weight. Nitrogen content was measured using a microkjeldahl apparatus and crude protein was estimated by multiplying nitrogen content by 6.25. Total lipids content was determined by ether extraction for 16 h and ash was determined by combusting samples in a muffle furnace at 550°C for 6 h. Gross energy was calculated according to NRC (1993).

Growth Parameters

At the end of the experiment, fish were harvested, counted and weighed. The parameters of growth performance were determined and feed utilization were calculated as following:

Weight gain = final weight - initial weight ;

Daily growth rate = weight gain/T;

Specific Growth rate (SGR) = $100 (\ln W_2 - \ln W_1)/T$; where W_1 and W_2 are the initial and final weight, respectively and T is the number of days in the feeding period;

Feed Conversion Ratio (FCR) = feed intake/weight gain;

Feed Efficiency Ratio (FER) = weight gain/feed intake;

Protein Efficiency Ratio (PER) = weight gain/protein intake;

Protein Productive Value (PPV; %) = $100 \times (\text{protein gain/protein intake})$;

Energy Utilization (EU; %) = $100 \times (\text{protein gain/protein intake})$.

Statistical Analysis

All data were subjected to two-way ANOVA to test the significant effect of lipid sources and levels according to Snedecor and Cochran (1973). The significant differences among means at $p < 0.05$ were done using Duncan's multiple range test (Duncan, 1955).

RESULTS

The effect of dietary lipid sources and levels on fish growth is shown in Fig. 1 and Table 2. The different growth parameters were affected significantly by dietary lipid sources or lipid levels, but not by their interaction. The fish final weight increased significantly due to the increase in dietary lipid

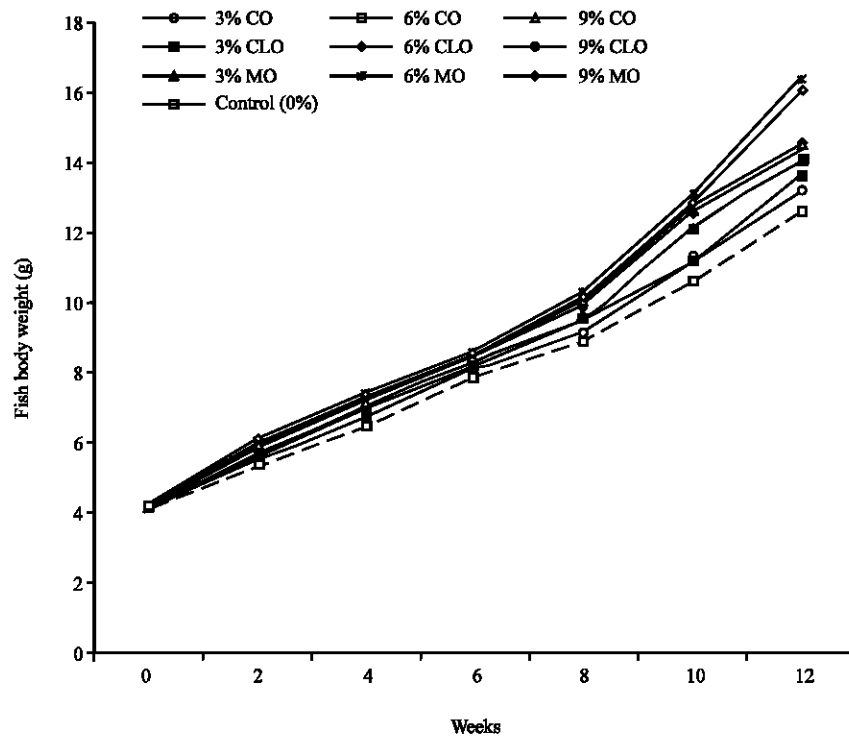


Fig. 1: Changes in live body weight (g/fish) of common carp fed diets containing different dietary lipids sources and levels. CO = Corn oil, CLO = Cod liver oil, MO = Corn oil: cod liver oil (1:1 mixture)

Table 2: Growth performance of common carp in response to different lipid sources and levels in fish diet

Sources	Levels (%)	Initial weight	Final weight	Weight gain	Daily growth rate	SGR	Survival rate
Control		4.1±0.024a	12.6±0.23f	8.5±0.22f	0.094±0.0024e	1.274±0.017e	98.3±1.7a
Plant oil	3	4.2±0.018a	13.2±0.18ef	9.0±0.18ef	0.100±0.0020de	1.272±0.018de	100.0±0.0a
	6	4.2±0.012a	14.0±0.02cd	9.8±0.02cd	0.109±0.0033bc	1.338±0.003bc	100.0±0.0a
	9	4.2±0.038a	14.1±0.13cd	9.9±0.09cd	0.110±0.0010bc	1.346±0.003bc	98.3±1.7a
1:1 mix	3	4.2±0.028a	14.5±0.27c	10.3±0.30c	0.114±0.0033b	1.377±0.028bc	100.0±0.0a
	6	4.1±0.068a	16.4±0.23a	12.3±0.29ab	0.137±0.0032a	1.540±0.033a	100.0±0.0a
	9	4.2±0.042a	16.1±0.22a	11.9±0.25a	0.132±0.0027a	1.493±0.023a	100.0±0.0a
Fish oil	3	4.2±0.006a	13.6±0.31de	9.4±0.32de	0.104±0.0035cd	1.306±0.028cd	100.0±0.0a
	6	4.2±0.012a	15.2±0.16b	11.0±0.16b	0.122±0.0017b	1.420±0.010b	100.0±0.0a
	9	4.2±0.012a	14.5±0.28c	10.3±0.28c	0.114±0.0029b	1.377±0.022bc	98.3±1.7a

Two-Way ANOVA

		Mean square				
Sources	df	Final weight	Weight gain	Daily growth rate	SGR	Survival rate
Levels	2	4.964***	5.76***	4.97E-04***	2.67E-02***	8.333
Source	2	8.340***	8.441***	1.120E-03***	5.363E-02***	2.778
Levels × Sources	4	0.282	0.432	3.606E-05	1.978E-03	2.778

***p<0.01. *Mean values with the same letter(s) are not significantly different

Table 3: Feed utilization by common carp in response to different lipid sources and levels in fish diet

Sources	Levels (%)	Feed intake	FCR	FER	PER	PPV (%)	EU (%)
Control		17.5±0.27f	2.06±0.024a	48.57±0.56d	1.78±0.046d	25.8±0.116f	16.73±0.116h
Plant oil	3	18.4±0.22de	2.04±0.033ab	48.91±0.79cd	1.79±0.035cd	27.4±0.554e	18.11±0.029g
	6	18.9±0.23cd	1.93±0.020bc	51.85±0.54bcd	1.89±0.003bc	29.3±0.41d	19.82±0.508ef
	9	19.0±0.16c	1.93±0.017bc	51.65±0.49bcd	1.88±0.017bcd	31.1±0.035c	21.39±0.225cd
1:1 mix	3	19.5±0.14abc	1.92±0.057c	52.82±1.54bc	1.92±0.055bc	29.5±0.288d	19.70±0.113f
	6	20.0±0.29a	1.63±0.051d	61.15±2.03a	2.23±0.052a	33.5±0.294b	22.58±0.635ab
	9	19.9±0.12ab	1.67±0.042d	59.80±1.53a	2.19±0.046a	35.5±0.277a	23.31±0.111a
Fish oil	3	17.9±0.23ef	1.90±0.071c	52.51±1.87bc	1.92±0.058bc	31.5±0.265c	20.88±0.069cd
	6	19.4±0.23abc	1.76±0.013d	56.70±0.48a	2.06±0.032a	31.8±0.0817c	20.72±0.116de
	9	19.3±0.068bc	1.87±0.052c	53.37±1.41b	1.93±0.050b	31.8±0.0693c	21.79±0.519bc

Two-Way ANOVA

		Mean square					
Sources	df	Feed intake	FCR	FER	PER	PPV	EU
Levels	2	1.918***	8.66E-02***	76.783***	9.827E-02***	25.182***	15.289***
Source	2	3.019***	0.121***	113.216***	0.156***	29.869***	10.127***
Levels × Sources	4	0.305	1.064E-02	11.922	1.627E-02*	6.388***	2.345***

*p<0.05; ***p<0.001. *Mean values with the same letter(s) are not significantly different

levels irrespective to its source, otherwise, fish growth was maximized when fed diets containing oil mixture (1:1 v/v plant oil: fish oil) more than that fed plant oil or fish oil alone. Moreover, fish groups fed fish oil exhibited better growth than that fed plant oil.

The highest final weight was obtained with fish groups fed 6 or 9% (16.4 or 16.1 g, respectively, Fig. 1. Similarly, weight gain, daily growth rate and SGR exhibited the same trends in response to either lipid source or lipid levels (Table 2). Fish survival did not affected significantly due to the variation in lipid source or lipid level (p>0.05). It ranged 98.3-100.0%.

Feed utilization parameters were affected significantly by either lipid source, levels or their interaction except feed intake, FCR and FER were not affected by the interaction (Table 3). Feed intake increased with mixed oil source better than the other oil sources and it was 19.5, 20.0 and 19.9 g feed/fish when fish fed 3, 6 or 9%, respectively. Moreover, the lowest feed intake and the highest FCR were obtained with fish group fed the control diet (17.5 g feed/fish and 2.06, respectively). The adding of oil mixture or fish oil to fish diet enhanced FCR and FER values to be better than that fed plant oil source or control diets. The optimum FCR and FER values were obtained with fish groups fed diets

Table 4: Proximate whole-body composition of common carp in response to different lipid sources and levels in fish diet

Sources	Levels (%)	Moisture	Crude protein	Total lipids	Ash
Control		77.4±0.23a	59.1±0.15a	24.8±0.13d	15.5±0.42sa
Plant oil	3	76.0±0.17b	57.6±0.32b	26.8±0.39c	14.9±0.6ab
	6	75.0±0.22c	56.1±0.43c	28.7±0.04b	13.2±0.13d
	9	73.2±0.03d	55.1±0.07de	30.4±0.21a	13.7±0.27cd
1:1 mix	3	76.0±0.14b	57.9±0.1bb	27.1±0.33c	14.3±0.27bc
	6	74.9±0.32c	55.9±0.52cd	28.5±0.31b	13.9±0.33cd
	9	73.1±0.05d	54.9±0.22e	30.9±0.41a	13.6±0.28cd
Fish oil	3	75.9±0.06b	58.0±0.03b	26.8±0.26c	14.5±0.29bc
	6	74.8±0.13c	56.2±0.41c	29.1±0.23b	13.4±0.37d
	9	73.0±0.03d	54.8±0.36e	30.5±0.24a	13.6±0.17cd

Two-Way ANOVA tests

		Mean square			
Sources	df	Moisture	Crude protein	Total lipids	Ash
Levels	2	19.097***	19.775***	30.473***	3.740***
Source	2	2.867E-02	1.578E-02	9.723E-02	0.106
Levels × Sources	4	2.404E-03	0.114	0.196	0.104

***p<0.001. *Mean values with the same letter(s) are not significantly different

containing mixed oil at the level of 6 or 9% (1.63 and 1.67 and 61.15 and 59.80, respectively; Table 3). Moreover, PER, PPV and EU were enhanced when fish fed diets containing more lipid and the lowest PER, PPV and EU values were obtained with fish group fed the control diet (1.78, 25.8 and 16.73%, respectively). The optimum PER, PPV and EU were obtained with fish groups fed diets containing mixed oil at the level of 6 or 9% (2.23 and 2.19%; 33.5, 35.5%; 22.58 and 23.31%, respectively; Table 3).

Fish body constituents such as moisture, crude protein, total lipids and ash were affected significantly by oil levels only ($p<0.05$) and no significant changes were observed due to oil source or oil source-oil levels interaction ($p>0.05$; Table 4). No significant changes in water content, crude protein, total lipids and ash content are observed due to different oil sources ($p>0.05$). It is noticed that moisture and crude protein contents decreased significantly, while total lipids increased significantly with the increase of oil level ($p<0.05$) irrespective to oil source. Fish fed the control diet exhibited the highest contents of moisture, crude protein and ash and the lowest total lipids (77.4, 59.1, 15.5 and 24.8%, respectively; Table 4).

DISCUSSION

In the present study, the partial replacement of 50% fish oil with corn oil enhanced the growth and feed intake by common carp, however FCR was also optimized. Similar results are obtained by El-Marakby (2006) who found that a mixture of corn oil and cod liver oil (1:1 v/v) gave better growth of Nile tilapia fry than cod liver oil or corn oil alone. Izquierdo *et al.* (2003) studied the effect of partial replacement of fish oil in compound diets for gilthead seabream and seabass, by several vegetable oil sources, on growth, dietary fatty acid utilization and flesh quality. They reported that it is possible to replace up to 60% of the fish oil by soyabean oil, rapeseed oil and linseed oil or a mixture of them, in diets for seabream and seabass, without compromising fish growth and feed utilization. These results differ markedly from those found by several other authors (Alexis, 1997; El-Kerdawy and Salama, 1997; Yildiz and Aener, 1997), where substitutions of 50% the fish oil by vegetable oils reduced growth of the same fish species. Ahamad Ali (2004) evaluated different oil sources named coconut oil, cod liver oil, gingely (sesame seed) oil, sunflower oil, soybean oil and sardine oil individually in the diet of pearlspot (*Etroplus suratensis*). He found that a mixture of coconut oil and sardine oil (1:1 v/v) gave the best growth. Sener and Yildiz (2003) found that there were no significant difference in the growth of rainbow trout (*Oncorhynchus mykiss*) fed either fish oil, soybean oil or sunflower oil.

The partial replacement of 50% fish oil with corn oil increased the protein content in fish body, but not affect the lipid content. In this regard, Izquierdo *et al.* (2003) found that dietary lipid sources did not affect lipid deposition in either liver or muscle of seabass or seabream. Contrarily, El-Marakby (2006) found that the highest moisture and crude protein contents were found in the body of Nile tilapia fry fed mixed oil diet. He also observed no changes in total lipids and ash contents in fish fed different oil sources.

The growth of common carp was maximum when the total lipids in the diet was 8.7% (6% supplementation). This result agreed to some reports that increasing dietary lipid level could improve the growth of fish (Ahmad Ali, 2004; Pei *et al.*, 2004; El-Marakby, 2006). However, the increase up to 9% lipid was not able to promote further growth. Some authors had reported that high dietary lipid level might reduce fish growth (Ahmad Ali, 2004; Pei *et al.*, 2004; El-Marakby, 2006). The growth reduction at high lipid levels could be due to the reduced ability to digest and absorb high lipid, the reduction in feed intake and/or fatty acid imbalance in feed (NRC, 1993).

The present study showed that the increase in dietary lipid level was associated with the increase in feeding rate. It appeared that fish could adjust feed intake to satisfy energy requirements (Kaushik and Médale, 1994). In fed diet containing too high energy, decreased feed intake and growth depression was also reported by El-Sayed and Garling (1988) and Ellis and Reigh (1991). Improved feed conversion ratio and protein efficiency ratio with increasing dietary oil level is in agreement with other studies (Einen and Roem, 1997; Weatherup *et al.*, 1997; Pei *et al.*, 2004). It has been reported that protein utilization can be improved by increasing dietary energy level in many fishes (Beamish and Medland, 1986; Cho and Kaushik, 1990). For common carp in this study, when dietary oil level increased up to 9%, PER and PPV increased. This result indirectly supported that increased dietary lipid level could spare dietary protein (Arzel *et al.*, 1994; Chou and Shiau, 1996; Pei *et al.*, 2004).

The increase of dietary oil levels herein is usually associated with an increase in whole-body lipid content, while crude protein decreased. Positive correlation between dietary lipid levels and body total lipids was also observed in other species (Chou and Shiau, 1996; Ahmad Ali, 2004; Pei *et al.*, 2004). Moreover, Williams and Robinson (1988) reported that there was an apparent decrease in body protein content when fish were fed diets with high lipid levels. Dietary lipid seems to affect ash content slightly.

In conclusion, the present study has shown that it is possible to substitute 50% of the fish oil by corn oil in diets for common carp fingerlings without negative effect on fish performance and feed utilization. However, under the experimental conditions, the diet of common carp fingerlings should contain a mixed oil with a level of 6%.

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