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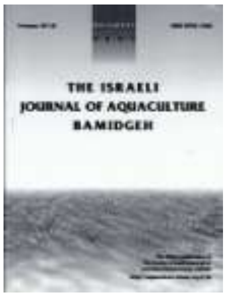

Effects of Partial or Total Replacement of Fish Oil by Unrefined Peanut Oil on Growth and Chemical Composition of Common Carp (*Cyprinus carpio*)

Önder Yıldırım[1]*, Ümit Acar[1], Ali Türker[1], Murat Can Sunar[1], Sevdan Yılmaz[2]

[1] *Department of Aquaculture, Faculty of Fisheries, Muğla Sıtkı Koçman University, Muğla, Turkey*

[2] *Department of Aquaculture, Faculty of Marine Science and Technology, Çanakkale Onsekiz Mart University, Çanakkale, Turkey*

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Abstract

Unrefined peanut oil was evaluated as a partial or total replacement of fish oil in diets for common carp (*Cyprinus carpio*) and growth performance, feed utilization, and biochemical status were examined. Three isonitrogenous (34.5% protein) and isolipidic (12.8% lipid) experimental diets were fed to satiation to triplicate groups of 10 common carp (29.57±0.44 g), each, for 60 days. At the end of the experiment, total replacement of the fish oil by peanut oil did not affect growth, feed utilization, or ash, protein, or moisture content in the carp body. Hepatosomatic and viscerasomatic indices increased as the content of peanut oil increased but did not significantly differ between treatments ($p<0.05$). Serum total protein, globulin, and triglyceride significantly increased as the content of peanut oil increased while glucose decreased. There was no definable trend in cholersterol. In conclusion, replacement of 50% dietary fish oil with unrefined peanut oil had no adverse effect on the growth performance, biochemical parameters, or general health (survival) of common carps.

*Corresponding author. E-mail: onderyildirim@mu.edu.tr

Introduction

Dietary lipids play an important role in growth performance of fishes. Lipids are sources of energy and essential fatty acids. Fish oil is a main lipid source in fish feeds because of the high digestibility of its essential fatty acids (n-3 PUFA). The aquaculture industry uses 80% of the global fish oil production (Jackson, 2011). Unfortunately, the price of fish oil varies depending on the fisheries industry and, with the growth of aquaculture, fish oil production might not be able to supply demands.

To attain sustainability of the aquaculture industry, suitable substitutes for fish oil need be found. Because of their availability and low cost, vegetable oils can replace fish oils. The replacement of fish oil by vegetable oils has shown good results in freshwater fish. At least 40-80% of fish oil can be replaced by vegetable oil without negative effects in Atlantic salmon (Roselund et al., 2001), rainbow trout (Caballero et al., 2002; Karayücel and Dernekbaşı, 2010), and common carp (Fontagne et al., 1999).

Carps are an important freshwater fish species for worldwide aquaculture with an annual global production of 3.4 million tons (FAO, 2012). Peanut oil is one of the world's biggest sources of vegetable oil. Unrefined peanut oil costs about US$1000/ton in contrast to fish oil that costs US$2300/ton. Peanut oil contains high levels of polyunsaturated fatty acids and is cholesterol-free. It is also a source of the antioxidant vitamin E. Therefore, the aim of this study was to evaluate the effects of replacing 50% and 100% fish oil with unrefined peanut oil in common carp diets.

Materials and Methods

Common carp, *Cyprinus carpio* (29.57±0.44 g), were obtained from the Mediterranean Fisheries Research Production and Training Institute in Antalya. Ninety fish were randomly allocated to nine 100-l glass aquaria at 10 fish/aquarium and acclimated for 15 days during which the fish were fed a commercial diet twice a day and the aquaria were aerated by air pumps.

Unrefined peanut oil was obtained from a local factory (Başpınar Fıstık, Osmaniye, Turkey). Three experimental diets (34.5% protein, 12.8% lipid) were prepared, each containing a different level of replacement of fish oil by peanut oil: 0%, 50%, or 100% (Table 1). The dry ingredients were carefully mixed with a laboratory food mixer. The mixtures were primed with water to yield a suitable pulp. Wet diets were made into 2-mm pellets, dried at 40°C in a drying cabinet, and stored at -20°C until use. Proximate analyses of the diets were performed by standard methods (AOAC, 1998).

Fish were hand fed *ad libitum* twice a day (10:00, 17:00) for 60 days. Growth performance and feed utilization were evaluated by relative growth rate (RGR), specific growth rate (SGR), feed conversion ration (FCR), hepatosomatic index (HSI), and viserosomatic index (VSI). At the end of the experiment, all fish from each tank were anesthetized with 20 mg/l clove oil. Blood samples of nine fish per group were drawn by syringe from the caudal veins into biochemistry tubes (BD Microtainer®, UK). Blood serum was separated by centrifugation (4000 × *g* for 10 min), and

Table 1. Formulation and composition of experimental diets for *Cyprinus carpio* (% dry matter).

	Diet (% peanut oil)		
	0 (Control)	*50*	*100*
Ingredient			
Soybean meal	40	40	40
Wheat meal	24	24	24
Fishmeal	22	22	22
Fish oil	10	5	0
Peanut oil	0	5	10
Vitamin mix[1]	2	2	2
Mineral mix[2]	2	2	2
Analytical composition			
Protein	34.3	33.9	34.5
Lipid	12.8	12.8	12.8
Ash	6.86	7.26	6.66
Nitrogen free extract[3]	38.04	38.04	38.04
Energy (kJ/g)[4]	19.62	19.53	19.67

[1] per kg: vitamin A 18000 IU, vitamin D_3 2500 IU, vitamin E 250 mg, vitamin K_3 12 mg, vitamin B_1 25 mg, vitamin B_2 50 mg, vitamin B_3 270 mg, vitamin B_6 20 mg, vitamin B_{12} 0.06 mg, vitamin C 200 mg, folic acid 10 mg, calcium d-pantothenate 50 mg, biotin 1 mg, inositol 120 mg, choline chloride 2000 mg

[2] per kg: Fe 75.3 mg, Cu 12.2 mg, Mn 206 mg, Zn 85 mg, I 3 mg, Se 0.350 mg, Co 1 mg

[3] Dry matter - (crude lipid + crude ash + crude protein)

[4] Calculated according to 23.6 kJ/g protein, 39.5 kJ/g lipid, 17.0 kJ/g NFE

stored at -20°C until use. Glucose, total protein, albumin, globulin, triglyceride, and cholesterol were determined using bioanalytic test kits (Bioanalytic Diagnostic Industry, Co.) and measured with a Shimadzu spectrophotometer (PG Instruments, UK).

Values are expressed as means±standard error of the mean (SE). Statistical significance was determined by one-way analysis of variance (ANOVA). Differences were considered significant at $p<0.05$.

Results

Survival was 100% in all groups. There were no statistical differences between RGR, SGR, FCR, HSI, VSI, or most body components (Table 2). Serum glucose dropped while total protein, globulin, and triglycerides rose with the increasing level of peanut oil. Cholesterol did not show a distinct trend as the peanut oil supplementation increased.

Table 2. Growth, feed efficiency, muscle composition, and blood serum biochemical parameters in common carp fed diets with different levels of fish and peanut oils.

	Diet (% peanut oil)		
	Control	*50*	*100*
Growth and feed efficiency			
RGR (%)[1]	66.71±2.95	59.46±5.02	62.50±2.60
SGR (%/d)[2]	0.84±0.03	0.78±0.06	0.81±0.03
FCR[3]	1.76±0.11	2.01±0.07	1.88±0.03
HSI (%)[4]	0.44±0.07	0.44±0.07	0.49±0.06
VSI (%)[5]	8.00±1.08	8.36±1.70	9.31±1.39
Muscle composition (wet wt basis)			
Ash	0.96±0.06	0.84±0.06	0.92±0.12
Moisture	75.27±1.02	75.63±0.69	74.82±0.45
Protein	20.65±1.54	21.65±1.53	21.10±1.71
Lipid	2.77±0.12[a]	1.48±0.11[c]	2.09±0.00[b]
Blood serum			
Glucose (mg/dl)	85.69±4.34[a]	64.75±5.45[b]	63.19±5.99[b]
Total protein (g/dl)	4.27±0.25[b]	5.82±0.24[a]	5.87±0.27[a]
Albumin (g/dl)	1.51±0.14	2.22±0.32	1.65±0.15
Globulin (g/dl)	2.76±0.34[a]	3.60±0.33[ab]	4.21±0.38[b]
Triglycerides (mg/dl)	47.45±3.70[b]	55.51±3.34[ab]	64.42±5.31[a]
Cholesterol (mg/dl)	46.45±1.95[ab]	39.79±5.47[b]	62.39±6.93[a]

Means in a row with different superscripts significantly differ ($p<0.05$).
[1] Relative growth rate = 100[(final wet wt - initial wet wt)/initial wet wt]
[2] Specific growth rate = 100(ln final fish wt - ln initial fish wt)/days
[3] Feed conversion ratio = feed intake/wt gain
[4] Hepatosomatic index = 100(liver wt/body wt)
[5] Viserosomatic index = 100(carcass wt/body wt)

Discussion

Total replacement of the fish oil with unrefined peanut oil resulted in similar growth performance compared to the control. In a similar study, the best growth performance was obtained with a mixture of corn and cod liver oils (Abbass, 2007). Likewise, growth performance and survival of *Cirrhinus mrigala* were not compromised when fish oil was substituted by palm oil up to 25% (Singh et al., 2012). Fish oil can be replaced by up to 60-75% canola, rapeseed, soybean, or palm oil in rainbow trout, seabass, and gilthead seabream diets without negative effects on growth performance or feed utilization (Caballero et al., 2002; Izquierdo et al., 2003; Fountoulaki et al., 2009; Pettersson et al., 2009; Karayücel and Dernekbaşı, 2010).

Partial or total replacement of fish oil did not affect the ash, moisture, or protein contents in the fish body, similar to results when cottonseed oil replaced fish oil in rainbow trout diets (Güler and Yıldız, 2011). In contrast, replacement of 50% fish oil with corn oil increased the protein content in common carp but did not affect the lipid or ash content (Abbass, 2007). HSI and VSI were highest (but not significantly) in fish fed the 100% peanut oil diet. Similarly, HSI and VSI were highest in rainbow trout fed a diet containing 100% vegetable oil (Güler et al., (2011) and there were no significant differences HSI and VSI in rainbow fed soybean, rapeseed, olive, or palm oils (Caballero et al., 2002).

Biochemical variables are useful indicators of stress in fish (Yılmaz and Ergün, 2012). Increased glucose is a well-known stress indicator in fish (Morgan and Iwama, 1997). In this study, the glucose level decreased as the dosage of peanut oil increased. Nutritional status can affect the glucose response (Martínez-Porchas et al., 2009) and blood glucose is affected by dietary plant oils (Kenari et al., 2011). For example, in *Heterobranchus longifilis* fingerlings fed a basal diet containing 60 g of different oils per kg diet, cod liver oil, shea butter oil, and poultry fat decreased the serum glucose level while palmkernel oil, sunflower oil, and pork lard increased it (Babalola et al., 2009). Changes in the serum glucose level might be caused by a shift of glucose from the tissue to the blood, or by impairment of glucose mobilization (Kenari et al., 2011).

Serum protein, albumin, and globulin levels are thought to be related to a strong innate immune response of fish (Wiegertjes et al., 1996). In this study, total protein and globulin significantly increased with the peanut oil supplemention, suggesting that peanut oil has no adverse effect on the immune system of carp. Similarly, vegetable oils did not lead to immune suppression in grouper (Lin and Shiau, 2003), largemouth bass (Subhadra et al., 2006), or caspian brown trout (Kenari et al., 2011).

Serum total triglyceride was significantly higher in fish fed the 100% peanut oil diet than in fish fed the control diet, indicating that unrefined peanut oil stimulates triglyceride production and secretion while fish oils reduce them (Vegusdal et al., 2005). The low level of n-3 fatty acids in diets with blends of vegetable oils may lead to the increased total triglyceride in fish serum.

Our results indicate that 50% replacement of dietary fish oil with unrefined peanut oil has no adverse effect on feed utilization, growth performance, biochemical parameters, or survival in common carp. Such replacement can help lower feed costs in the aquaculture industry.

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