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RESEARCH ARTICLE

EFFECTS OF DIETARY FISH OIL SUBSTITUTION WITH SUNFLOWER OIL ON THE SURVIVAL, GROWTH PERFORMANCE AND PROXIMATE COMPOSITION OF *CYPRINUS CARPIO* (LINN.)

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Abstract

Lipid is an essential component of fish nutrition and fish oil (FO) is the major source of lipid and is supplemented at very high levels in fish diets. Decreasing global availability coupled with highly variable price of fish oil has forced the aquaculture industry to investigate the possibilities of alternative cheap dietary lipid sources. Therefore, the present study was conducted to evaluate the effects of fish oil replacement with sunflower oil (SFO) on survival and growth parameters of fish and proximate composition of fish flesh in *Cyprinus carpio* (Linn.). Five isonitrogenous and isoenergetic dietary treatments (0%, 25%, 50%, 75% and 100% replacement of fish oil with sunflower oil) were prepared. The diet with 0% SFO was the control. Fish were fed on these diets for a period of 60 days. Significant differences ($P>0.05$) were not detected during 60 day feeding trial on the net weight gain (NWG) and specific growth rate (SGR) of the fish. No statistically significant differences ($P>0.05$) were observed on the survival of fish as well as proximate composition of fish flesh. Hence, the study suggested that the SFO can serve as a good substitute of FO for cost effective feed production and aquaculture

Introduction

Demand for fish is constantly increasing as humans are becoming more and more health conscious. They prefer to consume nutritious food with added health benefits. Fishes possess both these qualities and are, therefore, considered as health or functional food. They have high protein content (15-25%), which is required for maintenance and growth of human body. Fishes are rich in vitamins A, D, E and K and minerals (calcium, phosphorus and iron). Compared to beef and chicken, fish meat is more digestible as it contains much less connective tissue (Calder, 2004). Above all, fishes are the best sources of long-chain (LC) polyunsaturated fatty acids (PUFAs) mainly the n-3 and n-6 PUFAs. The n-3 PUFAs are known to be cardio-protective (Sanderson et al., 2002), anti-atherosclerotic (Givens et al., 2006), antithrombic (Calder, 2004) and anti-arrhythmatic (Givens et al., 2006). The increased demand of fish can be met from aquaculture as the capture fisheries is towards decline.

With an annual increase of ~10% since the 1950s, the aquaculture industry is the fastest growing food producing sector in the world and accounts for nearly 50% of the world's fish consumption today (SOFIA, 2008). Estimates show that the growth will continue over forthcoming decades as the demand increases with the growth in the human population (SOFIA, 2006). One of the main concerns encountered by the aquaculture industry is the great dependence on fish oil (FO) produced from wild fish as sole lipid source in the feeds. Given the estimated growth together with a production of FO that is estimated to be static (SOFIA, 2006), the dependence upon this finite resource could be risky to the aquaculture sector (Tacon, 2004). Consequently, there is a need for sustainable alternatives to FO. In fact, research efforts have been made to identify potential raw lipid materials that could act as substitutes to FO. Efforts to replace fishmeal and fish oil are ongoing and further improvements are expected. In recent years, the percentage of fishmeal and fish oil in compound feeds for aquaculture has shown a clear downward trend while their international prices have increased. At present, and in the near future, fishmeal and fish oil will be widely used as strategic ingredients at lower levels and for specific stages of production, e.g. fry (FAO, 2014). The most successful alternatives have been oils of plant origin due to their global availability and favorable price and the fact that their nutritional properties can satisfy the nutritional requirements of the fish. However, the use comes with certain disadvantages, mainly in terms of altered fatty acid composition in the muscle of fish (Bell et al., 2001; Torstensen et al., 2005; Pettersson et al., 2009).

Dietary lipid requirements of fish are important to ensure the optimum growth and welfare of the fish in culture and also to meet the consumer’s expectations of a healthy product. Therefore, great attention is currently being directed towards suitable mixtures of fish-feed lipids to meet the requirements of the fish. The challenge is to develop diets which fulfill the lipid requirements of the fish and make the fish flesh a healthy product from a consumer’s point of view.

So, the objective of this study is to identify the effect of sunflower oil for complete and partial replacement of fish oil from the feed of common carp without compromising with the growth performance and nutritional quality (proximate composition) of the fish.

Materials and method:

Animals and treatments

Common carp, *Cyprinus carpio* (*Linn.*) fingerlings were procured from a local fish farm. The fish selected for the experiment were acclimatized for 5-6 days to laboratory conditions in plastic tubs of 100 litre capacity. The experiment was run in triplicates for 60 days in plastic tubs of 34 litres capacity fitted with complete aeration and filteration system, with 12 fishes in each of it. Five dietary treatments (0%, 25%, 50%, 75% and 100% replacement of fish oil with sunflower oil) were prepared. The percent contribution of different ingredients to different experimental diets and their proximate composition is shown in Table 1. Different experimental diets prepared were kept in air tight containers. Fishes were fed twice daily @ of 5% of fish biomass.

Water quality parameters

The weekly water quality parameters *viz.* total alkalinity, total hardness, salinity, dissolved oxygen (DO) and ammonia were estimated by the standard methods provided by APHA, 1991. Water temperature was recorded with the help of an ordinary mercury thermometer having the range of 0-50°C and pH was recorded by using a digital pH meter (model ELICO LI120).

Survival and growth performance

Survival (%) was calculated by comparing the live carp recovered at the end of the experiment with the total carp stocked at the start of the experiment.

Growth was estimated in terms of net weight gain (NWG) and specific growth rate (SGR) by using following formulae:

NWG (g) = Final body weight (g) – Initial body weight (g)

$$\text{SGR (\%W/d)} = \frac{L_n \text{ final body weight} - L_n \text{ initial body weight}}{\text{Period of culture}} \times 100$$

Chemical analysis

Proximate analysis was conducted using standard procedures (AOAC, 2000), percentage moisture (2g sample dried at 100±2°C to constant weight), Crude proteins (CP) by Kjeldhal’s method, total lipid content by solvent extraction method, ash by incineration in a muffle furnace. Carbohydrate content was calculated by difference (FAO, 2004):

% Carbohydrate = 100 – (% moisture + % crude proteins + % total lipids + % ash)

Statistical analysis

The data were subjected to the Analysis of Variance (ANOVA) with the help of STATGRAPH and Microsoft Excels statistical packages.

Results and discussion:

Water quality parameters

Water quality monitoring showed no statistically significant differences between different diets, and the observed values indicate that none of the experimental diets affected the quality of water and culture water parameters were within the suitable range. Summary of water quality parameters during the experimentation period is given in the Table 2.

Survival

In the present study, it has been observed that none of the treatments adversely affected their survival rates and no mortality was observed during the experimentation period of 60 days. Similarly, Menoyo et al. (2005) recorded no mortality in atlantic salmon fed 0%, 25%, 50%, 75% and 100% linseed oil diets for 12 weeks. Similarly 100% survival was reported in Caspian great sturgeon and Rainbow trout during experimentation period in which fish oil was replaced with other alternative lipid sources in fish feeds (Bayraktar and Bayir 2012; Hassankiadeh et al., 2013).

Growth performance

The data on the growth performance of common carp fed experimental diets is given in Table 3. Significant differences (P>0.05) were not detected during 60 day feeding trial on the net weight gain (NWG) and specific growth rate (SGR) of the fish. The NWG of fish ranges from 1.26g to 1.37g and SGR ranges from 0.19-0.21 among different treatment groups. Similarly, Bransden et al., 2003 detected no significant differences on the growth performance of Atlantic salmon fed sunflower oil diets for 63 days. Hassankiadeh et al., 2013 also reported no negative influence of fish oil substitution with vegetable oils (canola oil, soybean oil and sunflower oil) on the growth performance of Caspian great sturgeon juveniles. Similarly Wassef et al., 2009 also reported no significant differences in NWG, FBW and SGR of gilthead seabream fed vegetable oil diets: VO1 vegetable oils blend 1 (sunflower:cottonseed:linseed 1:1:1 w/w/w) and VO2 vegetable oils blend 2 (sunflower:cottonseed:linseed 1:1:1 w/w/w) for 20 weeks. The results are also in agreement with findings of other researchers for some teleosts (Martino et al. 2002; Turchini et al. 2003; Mourente et al. 2005; Subhadra et al. 2006; Piedecausa et al. 2007; Almaida-Pagan et al. 2007).

Proximate composition

Proximate composition of fish flesh following 60 days of feeding the experimental diets with SFO are shown in Table 4 and indicated no significant differences in moisture (73.81-74.93%), crude protein (14.28-15.16%), total lipid (3.94-4.13%), ash (1.45-1.53%) and carbohydrate (5.16-5.63%) contents among different dietary treatments. Similarly, Hassankiadeh et al., 2013 also reported non-significant effect of fish oil substitution with vegetable oils (canola oil, soybean oil and sunflower oil) on the proximate composition of Caspian great sturgeon juveniles. Wassef et al., 2009 also reported no significant differences in proximate composition of gilthead seabream fed vegetable oil diets for 20 weeks. Similar results were obtained for white sturgeon, Iranian sturgeon, Nile tilapia, Atlantic salmon, Murray cod and gilt-head sea bream (Xu et al. 1993; Imanpoor et al. 2011; El-Husseiny et al. 2010; Bransden et al. 2003; Francis et al. 2006; Martinez-Lorens et al. 2007).

Table 1: Formulation and proximate composition of experimental diets

Ingredients	Diet1	Diet2	Diet3	Diet4	Diet5
Fish oil	20	15	10	5	20
Poultry fat	-	5	10	15	-
Goat fat	-	-			
Soybean meal	20	20	20	20	20
Groundnut oil cake	20	20	20	20	20
Mustard oil cake	20	20	20	20	20
Wheat flour	5	5	5	5	5
Rice bran	5	5	5	5	5
Corn starch	5	5	5	5	5
Vitamin & mineral mixture	1	1	1	1	1
Molasses	3.5	3.5	3.5	3.5	3.5
Iodized salt	0.5	0.5	0.5	0.5	0.5
Proximate composition (%)					
Moisture	5.21±0.08	5.18±0.12	5.25±0.10	5.08±0.08	5.18±0.12

Crude protein	26.83±0.58	26.83±0.29	26.53±0.78	27.12±0.50	26.54±1.27
Total lipid	19.93±0.13	19.80±0.23	20.20±0.11	20.06±0.13	20.30±0.05
Ash	8.43±0.07	8.25±0.18	8.43±0.07	8.22±0.15	8.43±0.07
Carbohydrate	39.58±0.80	39.93±0.35	39.58±0.83	39.50±0.50	39.54±1.40

Diet 1 = 0% replacement of fish oil, Diet 2 = 25% replacement of fish oil, Diet 3 = 50% replacement of fish oil, Diet 4 = 75% replacement of fish oil and Diet 5 = 100% replacement of fish oil

Table 2: Summary of water quality parameters during the experimentation period

		Temperature (°C)	DO (mgl^{-1})	pH	Alkalinity (mgl^{-1})	Hardness (mgl^{-1})	Ammonia (mgl^{-1})	Salinity (ppt)
Diet 1	**Mean**	31.11	8.97	7.51	112.26	235.00	0.033	0.053
	Max	36.50	9.33	7.67	118.00	244.00	0.037	0.061
	Min	25.00	8.26	7.27	105.33	225.33	0.029	0.043
Diet 2	**Mean**	31.11	9.22	7.53	112.00	231.06	0.034	0.049
	Max	36.50	9.60	7.66	116.67	240.00	0.035	0.056
	Min	25.00	8.80	7.36	106.00	221.33	0.031	0.040
Diet 3	**Mean**	31.11	9.22	7.48	111.33	228.20	0.034	0.054
	Max	36.50	9.45	7.64	116.67	239.33	0.035	0.060
	Min	25.00	8.80	7.30	104.67	218.66	0.031	0.050
Diet 4	**Mean**	31.11	9.34	7.54	111.86	228.46	0.034	0.051
	Max	36.50	9.60	7.72	117.33	237.33	0.036	0.060
	Min	25.00	9.06	7.17	105.33	220.00	0.032	0.040
Diet 5	**Mean**	31.11	9.32	7.57	112.06	230.13	0.033	0.053
	Max	36.50	9.60	7.71	118.00	238.66	0.035	0.060
	Min	25.00	8.93	7.40	103.33	221.33	0.029	0.048

Diet 1 = 0% replacement of fish oil, Diet 2 = 25% replacement of fish oil, Diet 3 = 50% replacement of fish oil, Diet 4 = 75% replacement of fish oil and Diet 5 = 100% replacement of fish oil

Table 3: Survival and growth performance of common carp reared on different experimental diets.

	Diet1	Diet2	Diet3	Diet4	Diet5
MIBW (g)	9.91±0.00	9.91±0.00	9.91±0.00	9.91±0.00	9.91±0.00
MFBW (g)	11.22±0.07	11.18±0.06	11.29±0.12	11.19±0.06	11.24±0.09
NWG (g)	1.30±0.07	1.26±0.06	1.37±0.12	1.27±0.06	1.33±0.09
SGR (%/d)	0.20±0.01	0.19±0.01	0.21±0.02	0.19±0.01	0.20±0.01
Survival (%)	100±0.00	100±0.00	100±0.00	100±0.00	100±0.00

Diet 1 = 0% replacement of fish oil, Diet 2 = 25% replacement of fish oil, Diet 3 = 50% replacement of fish oil, Diet 4 = 75% replacement of fish oil and Diet 5 = 100% replacement of fish oil

Table 4: Proximate composition (%) of *Cyprinus carpio* (Linn.) fed different experimental diets.

	Initial (Zero day)	After 60 days				
		Diet1	**Diet2**	**Diet3**	**Diet4**	**Diet5**
Moisture	76.45±0.13	75.35±0.32	73.88±0.25	74.75±0.69	73.96±0.19	73.91±0.28
Crude protein	13.20±0.43	14.58±0.30	14.58±0.30	14.28±0.58	14.87±0.50	14.95±0.58
Total lipid	2.79±0.04	3.94±0.07	3.90±0.06	3.90±0.07	3.87±0.07	3.95±0.07
Ash	1.51±0.03	1.50±0.03	1.45±0.03	1.43±0.06	1.48±0.06	1.53±0.01
Carbohydrate	6.03±0.53	5.63±0.42	6.18±0.41	5.62±0.80	5.80±0.70	5.64±0.83

Diet 1 = 0% replacement of fish oil, Diet 2 = 25% replacement of fish oil, Diet 3 = 50% replacement of fish oil, Diet 4 = 75% replacement of fish oil and Diet 5 = 100% replacement of fish oil

Conclusion:

The results of the experiment, therefore, suggest that it is possible to replace the fish oil in fish feed either partially and completely with sunflower oil without affecting the survival, growth performance of the fish, the quality of the rearing water and the muscle proximate composition of *Cyprinus carpio* (Linn.). Hence, the study suggested that the SFO can serve as a good substitute of FO for cost effective feed production and aquaculture.

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