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Effect of the Different Oil on Growth Performance and Body Composition of Rainbow Trout (*Oncorhynchus mykiss* W., 1792) Juveniles

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Abstract

Fish oil is the main lipid for energy and essential fatty acid source in commercial fish feeds. The steady production and rising price of fish oil encourage the inclusion of vegetable oils in fish feeds. In order to evaluate the effect of the vegetable oil on growth performance and whole body composition of rainbow trout was researched in this study. Weight gain, feed conversion ratio, specific growth rate, whole body composition and amount of fatty acids of rainbow trout fed the feeds included fish oil; soybean oil and sunflower oil were studied.

Rainbow trout juveniles having approximate initial weight of 5.78±0.09 g were fed by experimental feeds included different kinds of oil during 60 days. As a result of the experiment, weight gain of the fish were found 29.3±0.4 g in the fish oil group, 28.1±0.4 g in the sunflower oil group and 28.8±0.6 g in the soybean oil group. Feed conversion ratios were found 1.05, 1.12 and 1.08 respectively. The fish was fed by a commercial trout feed added different kind of oils with a ratio of 10% and containing approximately 43.5% crude protein, 14.0% crude lipid. At the end of the feeding trials, whole body fat contents were found 6.1% in the fish oil group, 5.3% in the sunflower group and 5.9% in the soybean oil group. There is no big difference among the groups regarding to lipid accumulation in the liver.

Naturally in the groups fed the feeds included vegetable oil, the ratio of n-6 fatty acids were higher than the control group and in the group fed fish oil (control group), n-3 fatty acids ratio were higher than the others. As a result, it is possible to use certain amount of soybean oil and sunflower oil as substitute fish oil in the rainbow trout diets.

Key Words: Trout nutrition, dietary lipids, fatty acid composition.

Introduction

Aquaculture is one of the most rapidly developing sectors in the world. According to the recent data, world aquaculture production is increased to 42.8 million MT by an increase 36.7% between the years 1995-1999 (FAO, 2000). In Turkey, totally rainbow trout production was found 38,570 MT according to the governmental data (Anon., 2000). Aquaculture is now one of the most rapidly developing sectors in the food industry in Turkey and has been greatly influenced by global developments. In the 1980s, farming of Atlantic salmon *Salmo salar* began along the Black Sea; however, it was not successful because the surface water temperature of 20ºC during the summer is marginal for salmon culture. Rainbow trout aquaculture still has great potential for further development in both fresh and marine waters in Turkey (Şener and Yıldız, 2000).

Rainbow trout nutrition is a well known research area and our knowledge about this fish advance to nutrition of other farmed fish. (Barnabe, 1990; NRC, 1981; Watanabe, 1996). Although water temperatures and other environmental factors change to nutrient requirement of rainbow trout, crude protein 38-55%, crude lipid 25% (at least 1% EFA) and carbohydrates as simple sugars 20% in the starter feeds are favorable (Austreng, 1979; Barnabe, 1990; Halver, 1972). In addition, rainbow trout diets have to include 1% 18:3 n-3 fatty acids for normal growth (Barnabe, 1990; Otha and Watanabe, 1996; Emidio *et al.*, 1993).

Rainbow trout also require n-3 and n-6 fatty acids as the other fish and if essential fatty acids are not found their diets, some typical deficiencies symptoms occur in these fish (Goddard, 1996). Fish generally have high level HUFA from n-3 series in their tissue differently from the other farmed animals. Different EFA requirements of the fish are characteristic in freshwater and marine fish species. HUFA from n-3 series are high level in the marine fish and these EFA get better growth performance (Otha and Watanabe, 1996; Yıldız and Şener, 1997).

As the all other fish, rainbow trout require 3 fatty acids: eicosapentaenoic acid (20:5n-3), docosahexaenoic acid (22:6n-3) and arachidonic acid (20:4 n-6) in diets for best growth performance (Kiesling *et al.*, 2001; Koven *et al.*, 1993; Otha, and Watanabe, 1996; Sanz *et al.*, 1994; Sargent *et al.*, 1997). These fatty acids are important for membrane functions, survival and growth performance during the larval period. According to the recent studies, EFAs in the diets are affected to the body composition and total liver fats of the rainbow trout (Emidio *et al.*, 1993; Rouhonen *et al.*, 1998; Reinitz and Yu, 1981). The aim of the present study was to examine the effect of fish oil, sunflower oil and soybean oil on the growth

performance and fatty acid composition of rainbow trout.

Materials and Methods

Feeding trials

Feeding trials of the research was conducted in totally 60 days at the Sapanca Inland Waters Research Center during the time 7 February to 7 April 2001. Rainbow trout, with an average initial weight 5.78 g were randomly allocated to 280 L of water (30 fish per tank) in duplicate fiberglass tanks. One experimental diet was formulated according to the previous results and nutrients requirements of rainbow trout in Istanbul University Sapanca Research Station (NRC, 1981). Sunflover oil and soybean oil were substituted to experimental feeds (Austreng, 1979; Emidio *et al*., 1993). Experimental feeds were produced at the Sapanca Inland Waters Research Center (Sakarya/Turkey) as steam pressured pellets with laboratory type feed mill (KTRON, S-200; K-TRON-SODER –AG, Amandus Kahlnache Hamburg, Germany). Fish oil, sunflover oil or soybean oil was added to the same experimental feed with a ratio of 10%. Daily feed portion was adjusted to 2% of live weight of fish. Three groups of fish were fed twice a day by hand. Fish were not fed in the weighting days. Experimental diet formulation is shown in Table 1.

Table 1. Composition of the diet used for experiments

Ingredients	**%**
Fish meal	50
Soybean meal	20
Sunflower meal	8
Wheat grain	10
Oil *	10
Vitamin and mineral mixture	2
Total	100
Proximate analysis	**% (as dry basis)**
Moisture	8.75±0.05
Crude protein	43.79±0.42
Crude lipid	13.98±0.18
Crude fibre	3.06±0.06
Ash	10.33±0.19
Nitrogen free extract	19.96±0.38
Metabolizable energy KJ/g	13.17±0.32

*= Fish oil, sunflower oil or soybean oil

Chemical analyses

Fish samples collected from three different groups at the initial and end of the feeding trial were stored –20ºC for chemical analyses. Ten fish in the initial and five fish at the end of the feeding trials were killed and sampled in each group to determine whole body composition and fatty acid composition of rainbow trout. Proximate composition of nutrients in the experimental feed and fish samples were analyzed according to the AOAC (1998) methods. Moisture, crude protein, crude lipid, crude cellulose and crude ash in the experimental feed were analyzed and gross and metabolic energy value calculated in respect of Halver (1972). Dry matter, crude protein, crude lipid, crude ash and total fat content of the fish and fish liver were analyzed in the homogenized fish samples (Akyıldız, 1968; AOAC, 1998).

Growth performance

During the feeding trials, water temperature (°C) pH and dissolved oxygen value of the water in the experimental tanks were measured daily. Experimental fish were weighed every two week. Feed conversion ratio (FCR) was calculated according to the equation: FCR = feed intake (dry weight) (g) / live weight gain (g). Specific growth rate (SGR) was calculated according to the equation: SGR = [(ln weight gain) x 100 / days reared]. Condition factor (CF) was determined by the formula: [final body weight (g)/ final total body length (cm)^3 x 100]. Hepatosomatic index (HSI) = [liver weight (g)/final body weight (g) x 100] and viscerosomatic index (VSI) = [viscera weight (g)/body weight (g) x 100] were determined to estimate fat accumulation in whole body and liver of the fish (Ricker, 1979).

Fatty acids analysis

Crude lipid analysis was conducted by ether extraction, and total lipid was extracted after homogenization in chloroform/methanol (2/1 v/v) containing 0.01% butilated hydroxytoluene as antioxidant basically according to the Folch *et al.* (1957). Fatty acid methyl esters were prepared by esterification with 1% sulfuric acid in methanol (Christie, 1993) and the fatty acid analysis of the feed and fish samples were analyzed by capillary gas chromatography (Perkin Elmer Auto System XL capillary gas chromatography, column 30m x 0.25mm, CP-2330 Supelco, Deutschland), flame-ionization detector at 220ºC, Helium was used as the carrier gas, split rate 1/50, oven temperature programmed for rise from 120ºC/2 min. to 220ºC/15min. at a rate 5ºC/min. Injector temperature was 240ºC. Fatty acid methyl esters were identified by reference to known standards (Sigma-Aldrich Chemie GmbH, Deutschland).

Statistical analyses

The difference between the growth performance of groups were tested by one way analyses of variance (ANOVA) and difference between means compared by the Duncan test at a 95% interval of confidence at the end of feeding trials (Sümbüloğlu and Sümbüloğlu, 1998; Zar, 1984).

Results

Water temperature was measured between the ranges of 12-14ºC (13±1ºC), average dissolved oxygen value was found 9.4 mg/l and the pH were measured 7.2-7.8 (7.1±0.7) during the feeding trials. After the feeding trials, data were analyzed and difference between the values of live weight gain, specific growth rate, feed conversion ratio, condition factor and VSI were not statistically significant ($P \geq 0.05$). But HSI was significantly different ($P \leq 0.05$). Growth performance of rainbow trout fed experimental feeds including different kinds of oil is shown in Table 2.

Results of the fatty acid analysis in the experimental feeds are represented in Table 3. As shown on the Table 3, n-3 of the feed includes fish oil is higher than feeds including soybean and sunflower oil. On the contrary, that n-6 of feeds including soybean and sunflower oil is higher than feed including fish oil. Fatty acid composition of the fish samples obtained at the end of feeding trials are presented in Table 4. Dietary fatty acids effected whole body fatty acid composition.

Fatty acid composition of liver of fish samples collected at the initial and end of feeding trials is shown in Table 5. The profile of fatty acid in fish liver was similar to the whole body fatty acid composition and different kind of oil in the experimental feeds affected in the fatty acids in the liver of fish

Discussion and Conclusion

It is well known that lipid source and fatty acids in the diets are affected fatty acid accumulation in the body and liver of fish. In addition to sparing effect of lipid on dietary protein is also well known subject in fish nutrition. Fish oil is a best and conventional energy source for rainbow trout diets for a long time. Moreover fish oil is an excellent source for n-3 fatty acids required by rainbow trout for optimal growth. Some vegetable oil include n-6 such as soybean and sunflower oil were also used some aquaculture diets (Barnabe, 1990; Koven *et al*., 1993; Reinitz and Yu, 1981). Lipids are approved as an energy source and more economical than the other energy source in practical rainbow trout diets at all times (Emidio *et al.*, 1993; Sargent *et al.*, 1997; Sanz *et al.*, 1994).

Lipid content in the aquaculture diets has been increased in recent years after the extruded aquaculture feeds were used widely in the trout farms. Therefore lipids in the fish diets and effects of the lipids on fish body composition are required more research (Austreng, 1978; Emidio *et al.*, 1993; Sanz *et al.*, 1994).

In this study fish oil, soybean oil and sunflower oil added to feeds of rainbow trout are not effected growth performance but total lipid content of the liver of fish fed the feeds included soybean oil and sunflower oil was higher than fish fed the feeds included fish oil. These results are similar to previous studies done in rainbow trout (Watanabe, 1996; Otha and Watanabe, 1996; Emidio *et al.*, 1993; Kiesling *et al.*, 2001; Sanz *et al*., 1994; Rouhonen *et al.*, 1998). According to the fatty acid analysis fatty acid profile was similar to in whole body and fish liver. According to the results rainbow trout can use some vegetable oil including n-6 for energy requirement. (Emidio *et al.*, 1993; Otha and Watanabe, 1996; Rouhonen *et al.*, 1998; Sanz. *et al.*, 1994). In our another recent research, although

Table 2. Growth performance and whole body composition of rainbow trout fed experimental diets[1]

Groups	Initial	Experimental group I (Fish oil)	Experimental group II (Sunflower oil)	Experimental group III (Soybean oil)
Body composition (%)				
Moisture	68.53±0.08	74.95±0.12	75.06±0.14	74.85±0.07
Crude protein	13.24±0.02	13.50±0.01	12.63±0.02	14.48±0.03
Crude lipid	3.80±0.03	6.10±0.05	5.30±0.06	5.50±0.02
Ash	2.32±0.02	2.53±0.01	2.05±0.03	2.48±0.02
Whole liver oil (%)	4.10±0.06	3.10±0.08	3.60±0.05	3.50±0.04
Growth performance				
HSI	2.46± 0.27	1.30±0.29[a]	1.42±0.30[b]	1.54±0.40[c]
VSI	20.58±0.04	18.57±0.08	17.61±0.07	18.91±0.03
CF	1.13±0.06	1.33±0.17	1.29±0.13	1.29±0.09
Live weight (g)	5.78±0.38	35.05±1.12	33.87±0.94	34.54±1.03
Live weight gain (g)	-	29.27±0.84	28.09±0.76	28.76±0.93
FCR	-	1.05±0.11	1.12±0.15	1.08 ± 0.15
SGR	-	1.18±0.04	1.15±0.06	1.16±0.08

[1]: Values ± SEM from 2 replicates with 10 fish for initial and a period of 5 fish/group for body composition, HSI and VSI, 60 fish/group for CF, Live weight, Live weight gain, FCR and SGR. Means within the values of live weight gain, FCR, SGR CF and VSI are not significantly ($P \geq 0.05$) different but difference between the values of HSI are important ($P \leq 0.05$) by ANOVA.

Table 3. Fatty acid composition of experimental feeds (%)

Fatty acids	Experimental group I (Fish oil)	Experimental group II (Sunflower oil)	Experimental group III (Soybean oil)
Saturated			
14:0	5.74	1.86	1.83
15:0	0.68	0.19	0.17
16:0	17.51	9.79	12.88
17:0	1.08	0.41	0.42
18:0	3.87	3.99	3.94
20:0	0.60	0.29	0.65
21:0	1.40	0.49	0.48
23:0	0.55	0.21	0.23
24:0	0.12	0.21	0.17
Unsaturated			
14:1	0.14	-	-
16:1	6.45	1.94	1.82
17:1	0.98	0.39	0.41
n-9			
18:1n-9	17.58	20.78	18.05
22: 1n-9	0.87	0.39	0.40
20:1n-9	1.21	0.59	0.64
24:1n-9	0.67	0.26	0.25
n-6			
18:2n-6	5.00	45.73	40.87
18:3n-6	0.16	-	-
20:3n-6	0.19	0.54	0.39
20:4n-6	0.87	0.24	0.24
n-3			
18:3n-3	1.07	0.47	3.85
20: 3n-3	0.15	-	-
20:5n-3	10.23	3.90	4.02
22:6n-3	14.40	4.03	4.01
Total n-3	25.85	8.40	11.88
Total n-6	6.22	46.51	41.50
Total n-9	20.33	22.02	19.34
DHA/EPA	1.41	1.03	1.00

Table 4. Fatty acid composition of the fish fed different oil added experimental feeds (%)

Fatty acids	Initial	Experimental group I (Fish oil)	Experimental group II (Sunflower oil)	Experimental group III (Soybean oil)
Saturated				
14:0	3.53	4.24	1.87	1.86
15:0	0.34	0.51	0.20	0.20
16:0	17.40	18.85	13.22	15.11
17:0	0.52	0.69	0.37	0.34
18:0	3.67	3.84	4.61	4.18
20:0	0.18	0.26	0.21	0.41
21:0	0.29	0.27	0.26	0.26
23:0	-	-	-	0.02
24:0	0.05	-	0.12	0.11
Unsaturated				
14:1	0.08	0.10	0.03	0.03
16:1	4.82	5.85	2.25	2.30
17:1	0.61	0.81	0.35	0.37
n-9				
18:1n-9	17.45	20.09	20.67	19.04
20:1n-9	3.16	1.50	1.20	1.14
22:1n-9	0.19	0.18	0.13	0.12
24:1n-9	0.27	0.57	0.35	0.33
n-6				
18:2n-6	12.28	6.44	32.68	29.97
18:3n-6	0.25	0.13	0.50	0.44
20:3n-6	0.09	0.09	0.24	0.21
20:4n-6	0.79	0.89	0.54	0.41
n-3				
18:3n-3	1.53	1.04	0.60	2.42
20:3n-3	0.50	0.29	1.34	1.19
20:5n-3	4.99	5.19	1.98	1.96
22:6n-3	14.55	18.32	8.76	8.79
Total n-3	21.57	24.84	12.68	14.36
Total n-6	13.42	7.55	33.96	30.82
Total n-9	20.88	22.34	22.35	20.63

Table 5. Liver fatty acid composition of the fish fed different oil added experimental feeds (%)

Fatty acids	Initial	Experimental group I (Fish oil)	Experimental group II (Sunflower oil)	Experimental group III (Soybean oil)
Saturated				
14:0	2.13	1.78	1.18	1.02
15:0	0.21	0.33	0.13	0.12
16:0	16.37	16.84	17.56	18.33
17:0	0.64	0.87	0.53	0.46
18:0	4.56	6.57	8.56	8.09
20:0	0.11	0.17	-	0.21
21:0	0.19	0.14	-	-
22:0	0.30	-	-	-
23:0	0.66	-	0.32	-
24:0	-	-	-	0.11
Unsaturated				
16:1	3.39	2.31	1.11	1.19
17:1	0.40	0.52	-	0.16
n-9				
18:1n-9	15.53	12.59	12.84	12.59
20:1n-9	2.83	1.16	1.13	0.90
22:1n-9	1.19	0.16	0.24	0.12
24:1n-9	0.52	0.48	0.88	0.52
n-6				
18:2n-6	6.03	2.84	15.83	13.29
18:3n-6	0.11	-	0.26	0.23
20:4n-6	1.43	3.53	2.55	2.32
n-3				
18:3n-3	0.66	0.37	0.16	0.61
20:3n-3	1.28	0.34	3.90	3.56
20:5n—3	3.55	4.38	1.80	2.25
22:6n-3	30.47	36.24	23.83	26.93
Total n-3	35.96	41.33	29.69	33.35
Total n-6	7.57	6.37	22.03	15.84
Total n-9	20.07	14.39	15.09	14.13

saturated/unsaturated fatty acid ratio was moderate, rainbow trout had the lowest percentage of EPA and relatively low percentage content of DHA, but a very high percentage of 18:2n-6, which was up to almost 10 times that of marine fish (Tanakol *et al.*, 1999)

In conclusion fatty acids profiles of cultured fish are acceptable as an indicator for human nutrition. Total n-3, n-6 and DHA/EPA ratio were the best appropriate values in fish fed with fish oil.

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