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EFFECT OF SUNFLOWER AND LINSEED OIL SUPPLEMENTATION IN THE DIET ON THE CHEMICAL AND FATTY ACID COMPOSITION OF RAINBOW TROUT (*ONCORHYNCHUS MYKISS* W.), CULTIVATED IN RECIRCULATING SYSTEM

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Abstract

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The aim of this study was to determine the influence of the dietary linseed and sunflower oil supplementation on the chemical and fatty acid composition in the meat of rainbow trout (*Oncorhynchus mykiss* W.), cultivated in recirculating system. The fish in the experiment received extruded pellets and were divided in control (CG) and two experimental groups – EL and ES. The feed of the rainbow trout of EL group was supplemented with 5% linseed oil and that of the group ES contained additionally 5% sunflower oil. The fish of the control group did not receive any of the above mentioned oils as additives. At the end of the 60 day trial period, four fish of each group were randomly selected for evaluation of the chemical and fatty acid composition in the fillet. Significant influence of the vegetable oils in the diet on the water content of the fillets was found ($P \leq 0.05$) as the group fed linseed oil showed the highest value of this parameter in comparison with the fish of the control group and the group receiving sunflower oil. Supplementation with both oils led to significantly higher protein content in the meat of the two experimental groups, compared to this one of the fish of the control ($P \leq 0.001$), while the value of the dry matter was lower in the fillets of the group with the linseed oil in the diet, compared to this parameter of fish from C and ES ($P \leq 0.05$). The linseed and sunflower oils in the diet of the rainbow trout influenced significantly the contents of C16:0 ($P \leq 0.05$), C18:2 ($P \leq 0.01$) and C18:3 ($P \leq 0.001$) in the fillets. The fish receiving sunflower oil as feed additive displayed highest levels of C18:2, compared to these parameters in the fish of C and EL groups. The group with linseed oil supplementation in the diet had lower content of C16:0 and higher value of C18:3 content than the fish fed pellets supplemented with sunflower oil and the control group. The changes in the individual fatty acids in the fish of experimental groups EL and ES corresponded to those of their total amounts – the content of n-6 PUFA was highest in the group fed with added sunflower oil ($P \leq 0.05$), while the rainbow trout receiving diet, supplemented with linseed oil had highest total content of n-3 PUFA ($P \leq 0.01$). The vegetable oils influenced the values of n-6/n-3 ratio ($P < 0.001$) which were significantly higher in the fish of ES group, when compared to these ones in the fillets from the control and linseed oil groups.

*Key words***:** rainbow trout (*Oncorhynchus mykiss* W.), chemical composition, fatty acid profile, linseed oil, sunflower oil

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Introduction

Nowadays the consumers have developed high demands to their food. It should be healthy, natural, high quality, harmless and easy to cook, as well as attractive and with excellent organoleptic characteristics. Fish meat responds to all these requirements. The fatty acid composition of the lipids in fish meat reflects that of the feed (Shearer, 1994; Jobling, 2003). Fish oil from marine fish is the main source of lipids in the feed used in aquaculture due to the good flavor obtained in the cultivated fish (Lane et al., 2006). The increasing production requires higher quantities of fish oil and meal, traditionally used as components in the feeds for fish (Edwards et al., 2004). Given that the fish cultivation depends on these two products, the growth of the sector will depend on the supply of waste fish („trash fish“), whose catches decrease globally (Sargent and Tacon, 1999; Tidwell and Allan, 2002; Pike and Barlow, 2003; Tacon, 2004; Pike, 2005; Tacon et al., 2006; FAO, 2011). This leads to higher price of fish meal and oil in the world market (Barlow, 2000; Delgado et al., 2003; Mráz, 2012) and therefore the aquaculture feed manufacturers tend to replace these components with more sustainable alternatives (Pickova and Morkore, 2007).

The inclusion of vegetable oils in fish feeds affects the nutritional quality of fish meat (Reinitz and Yu, 1981; Hardy et al., 1987; Arzel et al., 1994; Skonberg et al., 1994). The high contents of eicosapentaenoic (C20:5) and docosahexaenoic acids (C22:6) in fish oil are of great importance as nutrients in feed. The vegetable oils might partially replace C20:5 and C22:6 in feeds for rainbow trout. The oils rich in α-linolenic acid (C18:3n-3) such as linseed oil should be used as a partial replacement of the fish oil in feed. They are much more receptive as a dietary perspective for people, especially given the innate ability of freshwater fish to convert 18:3n-3, C20:5 and C22:6 (Drobná et al., 2006).

The aim of this study was to determine the influence of the dietary linseed and sunflower oil supplementation on the chemical and fatty acid composition in the meat of rainbow trout (*Oncorhynchus mykiss* W.), cultivated in recirculation system.

Material and Methods

The rainbow trout in the three groups were raised in concrete tanks with a capacity of 0.8 m^3, which were part of the recirculation system. The hydrochemical parameters during the experiment were within the normal range for this species. The fish were fed three times per day. They received 6 mm extruded pellets “Aqua UNI“, produced by “Aqua garant”. The feed of the fish of the experimental group EL was supplemented with 5% linseed oil, while the feed of the trout of the group ES contained additionally 5% of sunflower oil. The vegetable oils were sprayed in the pellets 1 h before feeding. The fish of the control group CG did not receive any of the above mentioned vegetable oils with their diet. The nutrient content of the feed of the three groups is presented in Table 1, including the data from the specification of the firm as well as the obtained after our analysis according to AOAC (2012). The fatty acid composition of the feed of the three groups is presented in Table 2.

After 60 days trial period, 4 fish from each group were randomly selected for evaluation of the chemical and fatty acid composition of the fillets. The live weight of the fish was within the range of 323.58 ± 67.77 g – 334.79 ± 67.52 g.

Table 1

Nutrient content in the feed of the rainbow trout (*Oncorhynchus mykiss* W.)

Item	According to the specification of “Aqua garant”	Groups		
		CG	ES	EL
Crude protein, %	42.00	43.00	43.00	43.00
Fat, %	16.00	17.12	22.12	22.12
Fibre, %	2.50	3.31	3.31	3.31
Moisture, %	7.62	7.62	7.62	7.62
Lysine, %	1.68	1.68	1.68	1.68
Methionine + cysteine, %	2.84	2.84	2.84	2.84
Ca, %	1.42	1.42	1.42	1.42
P, %	1.40	2.5	2.5	2.5
Chlorides, %	1.84	1.84	1.84	1.84
ME, MJ/kg	18.20	18.64	20.54	20.54
ME, kcal/kg	4352	4455	4910	4910

* 1 kg feed contains: vitamin A – 10 000 IE; vitamin D_3 – 1500 IE; vitamin – E – 200 mg; vitamin K – 3 mg; thiamin – 10 mg; riboflavin – 15 mg; pyridoxine – 8 mg; vitamin B_{12} – 0.02 mg; nicotinic acid – 40 mg; folic acid – 3 mg; biotin – 0.3 mg.
** 1 kg feed contains: Fe – 145 mg; Mn – 67 mg; Cu – 16 mg; Zn – 68 mg; I – 1.5 mg; Co – 0.5 mg; Se – 0.6 mg.

Table 2

Fatty acid composition of the feed of the rainbow trout (*Oncorhynchus mykiss* W)

Fatty acids, %	Groups		
	CG	ES	EL
C14:0 Myristic	1.99	1.21	0.93
C16:0 Palmitic	13.74	10.86	10.45
C16:1 Palmitoleic	2.02	0.90	1.97
C18:0 Stearic	3.07	3.14	4.69
C18:1 Oleic	49.41	44.03	40.40
C18:2 Linoleic	23.20	36.16	23.79
C18:3n-3 α-linolenic	2.68	1.49	14.94
C20:2 Eicosadienoic	0.47	0.19	0.18
C20:3 Eicosatrienoic	0.18	0.15	0.47
C20:4 Arachidonic	ND[1]	ND	ND
C20:5 Eicosapentaenoic	2.17	1.17	1.35
C22:5 Docosapentaenoic	0.50	0.52	0.47
C22:6 Docosahexaenoic	0.57	0.19	0.36

[1]ND – not detected

Chemical composition

Meat samples were prepared according to AOAC (2006; method 983.18) and subjected to determination of water content using air drying (AOAC, 1997; method 950.46). Crude protein content was calculated by converting the nitrogen content, quantified by Kjeldahl's method, using an automatic Kjeldahl system (Kjeltec 8400, FOSS, Sweden). Lipid content was determined by the method of Soxhlet, using an automatic system (Soxtec 2050, FOSS, Sweden). Ash content was investigated by incineration in a muffle furnace (MLW, Germany) at 550°C for 8 h. Crucibles were brought about the room temperature and weighed.

Fatty acid composition

Fatty acid composition was analysed in the Laboratory of Lipid Analysis in the Department of Ecology and Quality of Animal Production, Institute of Animal Science – Kostinbrod. Total lipids of the muscles were extracted according to the method of Bligh and Dyer (1959). Methyl esters of the lipids, isolated by preparative TLC were obtained, using 0.01% solution of sulphuric acid in dry methanol for 14 h, as described by Christie (1973). The fatty acid composition of total lipids was determined by GLC analysis using chromatograph C Si 200, equipped with capillary column (TR-FAME – 60 m x 0.25 mm x 0.25 μm) and hydrogen as a carrier gas. The oven temperature was first set at 160°C for 0.2 min, then raised until 220°C at a rate of 5°C/min and hold for 5 min. The temperatures of the detector and injector were 230°C. Methyl esters were identified, comparing to the retention times of the standards. Fatty acids are presented as percentages of the total amount of the methyl esters identified (Christie, 1973).

Statistical evaluation

The results were statistically evaluated by one-way ANOVA to determine the effect of the vegetable oils in the diet of the rainbow trout on the chemical and fatty acid composition of the fillets. Means of the groups were compared by protected Fisher LSD test, as differences below 0.05 were considered significant. The statistical evaluation was performed using STATISTICA 6.0 software (StatSoft Inc., 2002).

Results

Chemical composition

The content of the water, protein, lipids, dry matter and ash in the fillets of the rainbow trout, cultivated in recirculation system were within the normal range in the control and the groups, receiving linseed and sunflower oil with the feed (Table 3).

The linseed oil supplementation in the diet led to significantly higher water content in the fillets of the rainbow trout that received it – 72.10 ± 1.16% ($P \leq 0.05$), when compared to that of the control and ES fish, where it was respectively 4.96% and 4.22% lower. Significant influence of the oil supplementation ($P \leq 0.001$) was found for the protein content in the fillets. The protein content in the fish of the control group was 18.49 ± 0.04% and it was lower than that of the ES and EL rainbow trout, respectively by 6.87% and 9.90%. The vegetable oil supplementation did not change significantly the lipid content in the fillets of the rainbow trout from the control and the experimental groups. The values received were relatively close – 5.93 ± 0.60%, 6.73 ± 0.57% and 5.07 ± 0.49% ($P > 0.05$) (Table 3). Significant influence of the linseed oil concerning dry matter

Table 3

Chemical composition of the fillets of the rainbow trout (*Oncorhynchus mykiss* W)

Parameter	n	CG	ES	EL	Significance of the influence of the vegetable oils in the feed
		$\bar{x} \pm$ SEM	$\bar{x} \pm$ SEM	$\bar{x} \pm$ SEM	
Water, %	4	68.69 ± 0.01[a]	69.18 ± 0.78[a]	72.10 ± 1.16[b]	*
Protein, %	4	18.49 ± 0.04[a]	19.76 ± 0.18[b]	20.32 ± 0.27[b]	***
Lipids, %	4	5.93 ± 0.60	6.73 ± 0.57	5.07 ± 0.49	NS
Dry matter, %	4	31.31 ± 0.01[b]	30.82 ± 0.78[b]	27.90 ± 1.16[a]	*
Ash, %	4	1.58 ± 0.02	1.60 ± 0.06	1.51 ± 0.04	NS

*** P 0.001; ** P 0.01; * P 0.05; NS – non significant.
Values connected by different superscripts are significantly different ($P \leq 0.05$)

content was found. The dry matter content in the meat of the fish of EL group was 27.90 ± 1.16% and it was significantly lower than that of the fish of the control and ES groups by 12.22% and 10.46% respectively ($P \leq 0.05$). The ash content of the fillets of the control, ES and EL trout were almost equal-respectively 1.58 ± 0.02%, 1.60 ± 0.06% and 1.51 ± 0.04% and hence no

Table 4

Fatty acid composition of the fillets of the rainbow trout (*Oncorhynchus mykiss* W)

Fatty acids. %	n	CG	ES	EL	Significance of the influence of the vegetable oils in the feed
		$\bar{x} \pm$ SEM	$\bar{x} \pm$ SEM	$\bar{x} \pm$ SEM	
C14:0 Myristic	4	2.42 ± 0.45	2.68 ± 0.06	3.04 ± 0.01	NS
C16:0 Palmitic	4	21.52 ± 0.31[a]	21.13 ± 0.34[a]	19.93 ± 0.43[b]	*
C16:1 Palmitoleic	4	3.85 ± 0.32	3.69 ± 0.26	3.52 ± 0.01	NS
C18:0 Stearic	4	4.96 ± 0.10	5.23 ± 0.11	5.31 ± 0.09	NS
C18:1 Oleic	4	49.61 ± 1.92	48.12 ± 0.25	47.69 ± 0.45	NS
C18:2 Linoleic	4	11.03 ± 0.91[a]	13.79 ± 0.06[b]	12.61 ± 0.18[ab]	**
C18:3n-3 α-linolenic	4	1.37 ± 0.25[a]	0.91 ± 0.02[a]	3.38 ± 0.17[b]	***
C20:2 Eicosadienoic	4	1.14 ± 0.02[a]	1.21 ± 0.00[b]	1.03 ± 0.01[c]	***
C20:3 Eicosatrienoic	4	0.30 ± 0.01	0.32 ± 0.01	0.29 ± 0.01	NS
C20:4 Arachidonic	4	0.06 ± 0.03	0.04 ± 0.02	0.02 ± 0.01	NS
C20:5 Eicosapentaenoic	4	2.26 ± 0.07	1.83 ± 0.08	1.80 ± 0.28	NS
C22:5 Docosapentaenoic	4	0.36 ± 0.11	0.32 ± 0.02	0.35 ± 0.04	NS
C22:6 Docosahexaenoic	4	1.12 ± 0.17	0.74 ± 0.09	1.02 ± 0.08	NS
SFA[1]		28.90 ± 0.03	29.03 ± 0.39	28.28 ± 0.53	NS
UFA[2]		71.10 ± 0.03	70.97 ± 0.39	71.71 ± 0.53	NS
MUFA[3]		53.46 ± 1.60	51.81 ± 0.51	51.21 ± 0.47	NS
PUFA[4]		17.64 ± 1.57	19.16 ± 0.12	20.50 ± 0.06	NS
n-6[5]		12.53 ± 0.97[a]	15.36 ± 0.09[b]	13.95 ± 0.17[ab]	*
n-3[6]		5.11 ± 0.60[a]	3.80 ± 0.20[b]	6.55 ± 0.23[c]	**
PUFA/SFA		0.61 ± 0.05	0.66 ± 0.00	0.72 ± 0.01	NS
n-6/n-3		2.45 ± 0.10[a]	4.04 ± 0.24[b]	2.13 ± 0.10[a]	***

*** P 0.001; ** P 0.01; * P 0.05; NS – non significant.
Values connected by different superscripts are significantly different ($P \leq 0.05$)
[1]SFA – Saturated fatty acids
[2]UFA– Unsaturated fatty acids
[3]MUFA – Monounsaturated fatty acids
[4]PUFA – Polyunsaturated fatty acids
[5]n-6– ΣC18:2;C20:2;C20:3;C20:4
[6]n-3– ΣC18:3n-3;C20:5;C22:5;C22:6

significant effect of the vegetable oil supplementation on this parameter was detected (P > 0.05) (Table 3).

Fatty acid composition

The fatty acid composition in the fillets of the rainbow trout, cultivated in recirculation system in the three groups is presented in Table 4.

The vegetable oil supplementation did not affect significantly the contents of C14:0 and C18:0 of the fish from the control and the experimental groups and they were respectively within the range of 2.42 ± 0.45% – 3.04 ± 0.01% and 4.96 ± 0.10% – 5.31 ± 0.09% (P > 0.05). C16:0 is in the highest content of all the saturated fatty acids – 21.52 ± 0.31% in the control group, 21.13 ± 0.34% – in ES and 19.93 ± 0.43% – in EL group. The oil supplementation in the feed influenced significantly the content of this fatty acid, as it was the lowest in the rainbow trout fed linseed oil, when compared to the fish in the control and ES group (P ≤ 0.05). The vegetable oils in the feed for the rainbow trout did not have significant effect on the total content of the saturated fatty acids (SFA) in the fillets. The amounts determined in this study were 28.90 ± 0.03%, 29.03 ± 0.39% and 28.28 ± 0.53% respectively for the fish of the control, ES and EL groups (P > 0.05).

The vegetable oil supplementation in the diet for rainbow trout had no effect on the contents of C18:1 and C16:1 and the differences between the groups were insignificant (P > 0.05). C18:1 had the highest amount of the monounsaturated fatty acids 47.69 ± 0.45% – 49.61 ± 1.92%, as the lowest levels were displayed in the EL group. The content of C16:1 varied within 3.52 ± 0.01% – 3.85 ± 0.32%, and it was the highest in the control group and lowest in the EL group. No significant influence of the added vegetable oils was found on the total content of the monounsaturated fatty acids (MUFA) in the fillets.

The linseed oil supplementation in the feed of the experimental fish influenced significantly (P ≤ 0.001) the content of C18:3n-3 in the fillets. In the rainbow trout from EL group the amount was 3.38 ± 0.17% and it was substantially higher when compared to these ones of the control and ES groups. The content of C18:2 in the fillets were significantly changed (P ≤ 0.01) by the inclusion of the vegetable oils in the diet. Its quantity was the lowest in the control group – 11.03 ± 0.91%, while in the meat of the ES and EL trout it was increased respectively by 25.02% and 14.32%. The differences were significant between the control group and the group receiving sunflower oil. The dietary vegetable oil supplementation led to significant differences between groups, concerning the content of C20:2. It was the lowest in the EL group (1.03 ± 0.01%), whereas in the control and ES groups it was increased by 10.67% and 17.46% respectively (P ≤ 0.001). The vegetable oil supplementation in the feed had no effect on the content of C20:3, C20:4, C20:5, C22:5 and C22:6 in the fillets. The content of C20:3 in the fillets of the rainbow trout in the control and the experimental groups varied within the range of 0.29 ± 0.01% – 0.32 ± 0.01%, as it displayed the highest values in ES group. Arachidonic acid (C20:4) was in amounts of 0.02 ± 0.01% up to 0.06 ± 0.03%, and the contents of C20:5 was in the range of 1.80 ± 0.28% to 2.26 ± 0.07%. The percentages of these two fatty acids were the highest in the control group and lowest in the group fed linseed oil. The content of C22:5 in the control and the supplemented groups varied within 0.32 ± 0.02% – 0.36 ± 0.11%, while that of C22:6 was 0.74 ± 0.09% – 1.12 ± 0.17%. The vegetable oils included in the diet did not affect significantly (P>0.05) the total amounts of PUFA in the fillets of the rainbow trout and it varied between 17.64 ± 1.57% and 20.50 ± 0.06%. In this experiment we observed tendency toward higher content of PUFA in the fillets of the fish fed linseed oil, while their amount was lowest in the control group. The total amount of UFA in the meat of the rainbow trout of the three groups was similar – 71.10 ± 0.03%, 70.97 ± 0.39% and 71.71 ± 0.53% (for the control, ES and EL groups respectively), showing no influence of the vegetable oils on their content.

The amounts of n-6 PUFA in the fillets of the rainbow trout in the control, ES and EL groups were respectively – 12.53 ± 0.97%, 15.36 ± 0.09% and 13.95 ± 0.17%. The vegetable oil supplementation led to significant differences (P ≤ 0.05) in the contents of n-6 of the fillets of the fish of the control and ES groups.

The dietary vegetable oil supplementation influenced significantly (P ≤ 0.01) the content of n-3 PUFA in the groups. The total n-3 PUFA was the highest in the fillets of the trout receiving linseed oil – 6.55 ± 0.23%, whereas the lowest it was in the fish fed sunflower oil in the diet 3.80 ± 0.20%, The amount of n-3 PUFA in the rainbow trout of the control group was 5.11 ± 0.60%.

No significant influence of the vegetable oils on the PUFA/SFA ratio was observed and its values were 0.61 ± 0.05, 0.66 ± 0.00 and 0.72 ± 0.01, respectively for the control, ES and EL fish. The dietary vegetable oils supplementation led to significant differences between groups in regards to the n-6/n-3 ratio. Its value was highest in the fillets of the rainbow trout receiving sunflower oil (4.04 ± 0.24), while in the control group and the fish receiving linseed oil supplement the values were similar – 2.45 ± 0.10 and 2.13 ± 0.10, respectively (P ≤ 0.001).

Discussion

Chemical composition

The analysis of the data, concerning the chemical composition of the meat of the rainbow trout, cultivated in recirculation system showed that the dietary linseed oil supplementation in amount of 5% increased significantly the water content and decreased the dry matter content of the fillets. This is contrary to the results of Yildiz et al. (2013), who supplemented the feed of rainbow trout with cotton seed and rapeseed oils, Epler et al. (2009; 2010) when including 6% mixture of sunflower and linseed oil in the feed of carp (80:20), as well as Aprodu et al. (2012), who used olive, soya bean and fish oils. Zelenka et al. (2003) and Masiha et al. (2013 a, b) did not find differences in the water and dry matter content when investigating the influence of various vegetable oils in the diet of rainbow trout.

Our results for significantly higher protein content in the fillets of rainbow trout, receiving vegetable oils in the diet were confirmed by other researchers, when including lipid sources of vegetal origin in the feed of rainbow trout (Masiha et al., 2013 a, b; Yildiz et al., 2013), common carp (Aprodu et al., 2012), *Labeo rohita* (Gangadhara et al., 1997) and *Scophthalmus maximus* L. (Cho et al., 2005). Contrary to these results, Zelenka et al. (2003) found relatively equal protein content in the meat of rainbow trout, fed sunflower and linseed oil supplemented diet. The higher protein content in the experimental groups that was observed might be due to the higher energy level of the diet and the more suitable lipids, contributing to the complete assimilation of the protein in the feed (Caballero et al., 1999; Satpathy et al., 2003). The improved metabolism of the nutrients in the fish, fed vegetable oil supplemented diet had substantial impact, due to the increase of the content of the essential C18:2 and C18:3n-3.

Rainbow trout is considered average fatty fish with intramuscular lipid content of 2–7% (Jobling, 2001). Our results were within this range 5.07–6.73% and confirmed the statement. At the same time the lipid contents, determined in our experiment in the fillets of the oil supplemented fish were considerably higher, than those, reported by Zelenka et al. (2003), 3.6–3.9%, when using the same concentrations of linseed and sunflower oil in the diet of rainbow trout. In regards to the lipids and ash contents, we did not find significant differences between the groups. These results correspond to those of Zelenka et al. (2003) and Masiha et al. (2013 a, b), while Yildiz et al. (2013) determined significantly higher lipid content in the meat of rainbow trout, supplemented with vegetable oil.

Fatty acid composition

The analysis of the data for the fatty acid composition in the fillets of rainbow trout, cultivated in recirculation system showed that it reflected the fatty acid composition of the feed. The vegetable oil supplementation did not influence significantly the content of C14:0 and it remained relatively low 2.42–3.04%. These values were close to the reported by Zelenka et al. (2003) and Yıldız et al. (2013), however were considerably different from the determined by Masiha et al. (2013 a, b) – 0.03–0.04%. The vegetable oil supplementation in feed affected significantly the content of C16:0 and it was lower in the EL fish, compared to those of the control and ES groups. The levels, determined in this study were approximately 5% higher, than those, reported by Zelenka et al. (2003) and Masiha et al. (2013 a, b), but similar to the values of Yildiz et al. (2013). C14:0 and C16:0 are important for the human diet, due to their hypercholesterolemic effect. In this study these two fatty acids displayed similar content in the fish in the three groups.

Stearic acid (C18:0), considered as neutral in regards to cholesterolemia was in amounts 4.96–5.30%. Slightly lower contents (3.78–4.59%), when supplementing the feed with vegetable oils determined Zelenka et al. (2003) and Masiha et al. (2013 a, b), while Yildiz et al. (2013) reported values of 3.1% to 6.0 %.

The vegetable oils, added to the feed of rainbow trout did not affect the total SFA content in the fillets of the fish of the three groups. They varied within 28.28 ± 0.53% – 29.03 ± 0.39% and corresponded to the results of Yildiz et al. (2013) when supplementing rapeseed and cotton seed oils (16.08–29.30%). However they were lower than 21.84–27.74%, reported by Masiha et al. (2013 a, b) in experiments with rapeseed and linseed oil. Zelenka et al. (2003) also determined 22.70–23.98% total SFA in trials with sunflower and linseed oil. These authors showed significant differences in the content of the total UFA between groups, receiving various vegetable oil supplements, however such in recent our experiment were not observed. Vegetable oil supplementation in the feed of the rainbow trout did not influence the content of C16:1 and C18:1. The latter is the most abundant monounsaturated fatty acid and its content reached 47.69-49.61%. These values were close to these ones, reported by Masiha et al. (2013 a, b) 43.25–58.82%, but were considerably higher, than the reported by Zelenka et al. (2003) – 20.38–21.95 % and 17.20–45.70% – by Yıldız et al. (2013). The contents of C16:1 (3.52–3.85%) were lower, than the values determined by Zelenka et al. (2003) – 4.49–5.89%, but were higher that the amounts, observed by Yildiz et al. (2013) (2–3.60%), after vegetable oil supplementation in the feed. The total amount of MUFA in the fish fillets was not affected by the dietary vegetable oil supplementation. It corresponded to the quantity, determined by Masiha et al. (2013 a, b) and Yildiz et al. (2013), after supplementation with rapeseed, cottonseed and linseed oil. However it was higher than the amount, reported by Zelenka et al. (2003) – 27.61-30.54%, in experiments with sunflower and linseed oil.

The linseed oil supplementation influenced significantly the content of C18:3n-3 in the fillets of the fish and it was considerably augmented in the rainbow trout of EL group, when compared to the control and ES group (by 146.72% and 275.56%, respectively). The same was observed by Zelenka et al. (2003), who reported three times higher values of C18:3n-3, when supplementing the rainbow trout feed with 5% linseed oil. This indicates that C18:3, abundant in the linseed oil, pass unaltered and accumulate in the meat of the rainbow trout.

The content of C18:2 in the fillets changed significantly in response to vegetable oil supplementation in the diet of the rainbow trout. It was higher in the ES and EL fish, respectively by 25.02% and 14.32%, as significant differences were found between the control group and the group fed sunflower oil. Similar increase was reported by Zelenka et al. (2003) and Yildiz et al. (2013), while Masiha et al. (2013 a, b) presented considerably lower content. C18:2 and C18:3n-3 is precursors for the synthesis of n-6 and n-3 fatty acids in the organism, which makes them very important in both fish and human diet.

Dietary vegetable oil supplementation led to significant differences between the groups in the contents of C20:2 in the fillets of the rainbow trout. This corresponded to the significant results of Masiha et al. (2013 a, b) and Yildiz et al. (2013). In this study we found that the vegetable oils in the diet of the rainbow trout had no significant effect on the content of C20:3, C20:4. C20:5, C2:5 and C22:6. This was not in agreement with the results of other researchers, who reported significant effect of the vegetable oil supplements in the feed of the rainbow trout (Zelenka et al., 2003; Masiha et al., 2013 a, b; Yildiz et al., 2013). This might be due to the different vegetable oils and concentrations used. The total PUFA content in the fillets was not affected by the vegetable oils either. It tended to increase in the ES and EL fish, while the rainbow trout of the control group displayed the lowest PUFA content. Results similar to ours were observed by Masiha et al. (2013 a, b), while Zelenka et al. (2003) reported considerably higher total PUFA content of 44.35–49.52% in the meat of rainbow trout, receiving vegetable oil in the diet. The total UFA contents in the fish fillets were similar in the examined groups, thus indicating that the vegetable oil supplementing the diet had no effect on their total content. These results corresponded to the total SFA content determined in other studies on the influence of vegetable oils in the diet of rainbow trout (Zelenka et al., 2003; Masiha et al., 2013 a, b).

The vegetable oil supplementation led to significant differences in the contents of n-6 PUFA in the fillets of the control and sunflower oil fed rainbow trout. The amounts of n-6 PUFA in the fish of the three groups corresponded to the quantities, reported by Zelenka et al. (2003), at the same vegetable oils in the same concentrations. At the supplementation of the cottonseed and rapeseed oils, containing more n-6 PUFA, Yildiz et al. (2013) observed considerable augmentation of the content of these fatty acids in the meat of the rainbow trout. The content of n-3 PUFA in the fillet was the highest in the group receiving linseed oil supplemented diet, while in the group with sunflower oil it displayed lowest values. Higher amounts of n-3 in the meat of rainbow trout when supplemented various vegetable oils were received by Zelenka et al. (2003), Masiha et al. (2013 a, b), Yildiz et al. (2013), which could be explained with the longer period of feeding trials – 75–90 days.

The dietary vegetable oil supplementation did not affect the PUFA/SFA ratio in the fillets of the rainbow trout. Its values were in the favorable range of 0.61–0.72, since the recommended values should be > 0.4 (Simopoulos, 2004). Significant differences in n-6/n-3 ratio were observed between groups. The highest its values were in the rainbow trout, fed sunflower oil, while in the control and linseed oil supplemented group they were similar. Considerably lower values of this ratio (0.12–0.69%) were determined by Zelenka et al. (2003) and Masiha et al. (2013 a, b), while Yildiz et al. (2013), reported values close to ours (1.98–4.36%). The dietary sunflower and rapeseed oil supplementation in the feed of the rainbow trout though increasing the content of n-6 PUFA led to favorable ratio between the two families (n-6 and n-3) of the fatty acids.

Conclusions

The dietary linseed and sunflower oil supplementation in amount of 5% to the extruded feed of rainbow trout, cultivated in recirculation system influenced positively the chemical composition of the meat by increasing the protein content respectively by 6.87% and 9.90%, whereas the lipid content remained unchanged.

Positive changes in the fatty acid composition in response to the dietary sunflower and linseed oil supplementation in amount of 5% were observed. The content of C18:2 were increased by 25.02% and 14.32% respectively, while the PUFA/SFA ratio was unaffected. As a result of the sunflower oil supplementation the content of C20:2 were increased by 6.14% in the fillets. Linseed oil, included in the diet of the rainbow trout reduced the content of C16:0 by 7.98% but augmented the content of C18:3n-3 in the fillets by 146.72% and the total amount of n-3 PUFA by 28.18%. At the same time the n-6/n-3 ratio was decreased by 15.02%.

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