Fatty acid profile and cholesterol content in marketable rainbow trout *(Oncorhynchus mykiss)* reared in two aquaculture systems

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***Abstract*: Nowadays, salmon has been suggested to be the major human dietary source of n-3 polyunsaturated fatty acids (PUFA) of nutritional and medical interest. However, there is an increased interest in rainbow trout from aquaculture. Information on dietary intake of cholesterol through fish consumption can be important, especially to those with cardiovascular problems. The objective of this study was to compare lipid and cholesterol contents and fatty acid profiles of the lipid fraction of marketable rainbow trout fillets obtained from two fishponds with intensive production situated in Serbia (I) and Bosnia and Herzegovina-Republic of Srpska (II). Fish samples of similar size and weight were collected in August and September 2010. Fish was fed with formulated feed consisting of fish products, oils and fats (I) and fish meal, soybean protein products and corn (II). Lipid content of fish fillets was determined by standard ISO method. Cholesterol content and fatty acid profile were determined by using HPLC/PDA and GC/FID, respectively. Lipid and cholesterol content in the examined fish were 1.28% and 46.48 mg/100g (I) and 4.17% and 70.12 mg/100g (II), respectively. Fatty acids profile of rainbow trout fillets from two fishponds (I and II), quantities of saturated fatty acids, monounsaturated fatty acids and polyunsaturated fatty acids (% of total fatty acids) were determined. n-3/n-6 PUFA ratio was 1.53 (pond I) and 1.09 (pond II). Our results are discussed in relation to lipid source in fish feeds as the main factor responsible for cholesterol content and fatty acid profile variations in farmed rainbow trout.**

***Keywords:* rainbow trout, fatty acids, cholesterol**

I. INTRODUCTION

Uncontrolled and long-term exploitation of sea resources, as well as data on positive influence of n-3 polyunsaturated fatty acids (PUFA) on humans' health, contributed to increased demand for products from aquaculture. Nowadays, salmon has been suggested to be the major human dietary source of n-3 PUFA of nutritional and medical interest [1]. However, there is an increased interest in rainbow trout from aquaculture, which resulted in certain demands in respect to fish quality and its nutritive value.

Chemical composition of fish meat as well as fatty acid profile, in addition to the genetic factors, is as well influenced by water quality, its pH and temperature, feeding, used feed, i.e. season, oxygen content, motor activity, age and size of the fish [1, 2]. Fish reared in aquaculture can show certain variations in chemical composition, but these changes are more constant and can be predicted. However, in stable rearing conditions, fish growth is directly influenced by retention of feed and age [1].

Cholesterol intake through fish meat consumption is important, especially for humans with cardiovascular diseases. Literature data indicate that the level of cholesterol in blood, in addition to increased alimentary intake of cholesterol and excessive energy intake, is also under influence of increased intake of certain long chain saturated fatty acids (SFA) and increased intake of trans-isomers of unsaturated fatty acids [3]. Cholesterol content in freshwater fish is lower in comparison to sea fish and therefore nutrition which included freshwater fish is more favourable to human health [4].

For consumer health it is particularly important the ratio of SFA, monounsaturated fatty acids (MUFA) and PUFA, including n-3 and n-6 families as a factor for preventing various diseases [5]. Consumption of mainly long-chain PUFA (n-3 family), such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), plays an important role in human health promotion. Favourable influence of n-3 PUFA from fish meat on human health has been proven in numerous studies [6, 7], confirming the link between consumption of fish and prevention of coronary disease, especially myocardial infarction, atherosclerosis, hypertension and other cardio-vascular diseases [8]. Therefore, epidemiological studies recommend fish and fish-derived products inclusion in 2-3 meals in weekly menu [9].

Nutritive quality of freshwater fish is even better than quality of sea fish since fatty acid composition of freshwater fish is also characterized by high proportions of n-6 polyunsaturated fatty acids, especially linoleic and arachidonic acids. Freshwater fish can be source of n-3 PUFA, too, due to the fact that this type of fish has better ability of fatty acid desaturation and their transformation in long-chain PUFA (EPA and DHA) compared to sea fish [10].

It was concluded that, out of 30 fish species from aquaculture and free-catching, the highest amounts of n-3 PUFA were determined in farmed salmon and farmed trout (above 4g/100g). The highest variations in content of n-3 fatty acids were established in trout, as a consequence of different rearing methods and feeding systems, in different aquaculture conditions. Fatty acid profile in fish varies within and between species [11] and numerous factors are considered as significant factors which additionally contribute to these variations [12]. Fatty acid profile of fish feed has significant impact on fatty acid profile of fish meat [13]. Feed rich in n-3 fatty acids, in the same rearing conditions, significantly influences the increase of n-3/ n-6 PUFA ratio in fish tissues [12]. Nutrition with well balanced n-3/n-6 ratio is important for farming of healthy fish and for production of high quality food for human nutrition [14].

The objective of this study was to compare lipid and cholesterol content as well as fatty acid profile of marketable rainbow trout fillets obtained from fish reared in two aquaculture systems (I and II) with intensive production which are located in geographically different regions.

II. MATERIALS AND METHODS

Investigation was carried out on six samples of marketable rainbow trout of similar size and weight taken during August and September 2010th from two fish ponds with intensive production which are situated in Serbia (I) and Bosnia and Herzegovina-Republic of Srpska (II). Fish was fed with formulated feed consisting of fish products, oils and fats, products and by-products of grain (I) and fish meal, soybean protein products and corn and wheat (II). Along the year, temperature of water in fish pond I and II was 13^0C and 8^0C, respectively. Analysis was carried out on homogenized samples of fish muscle after evisceration and deprivation of skin, tail, head, fins and bones.

Total fat content was determined by ISO method [15]. Cholesterol content was determined by using Waters 2695 separation module with photodiode array detector (HPLC/PDA), on Phenomenex Luna C18 column, at 210 nm [16]. Lipids extracted by ASE200, Dionex, were converted to fatty acids methyl esters (FAME) by trimethylsulfonium hydroxide [17]. FAMEs were determined by using Shimadzu 2010 gas chromatograph equipped with flame ionization detector (FID) and cianopropyl HP-88 capillary column (100 m x 0.25 mm x 0.20 μm).

Data were statistically analysed by MINITAB Statistical Software (Release 14 for Windows). Analysis of variance (ANOVA) with Tukey's test (95% confidence interval) was applied. Values were considered significantly different when $p<0.05$.

III. RESULTS

The obtained results for total fat and cholesterol content in analysed fish samples from fish pond I and II are presented in Table 1.

Table 1 Total fat and cholesterol content in fillets of marketable size rainbow trout (mean ± SD), n = 6

Fish pond	I	II
Total fat (g/ 100g)	1.28 ± 0.42^a	4.17 ± 0.51^b
Cholesterol (mg / 100g)	46.48 ± 4.49^a	70.12 ± 14.25^b

Values in the same row marked with different letters indicate significant differences (p<0.05)

Fatty acid composition of marketable size rainbow trout from two fish ponds (I and II), (g100g-1 of total fatty acids) expressed as Σ SFA, Σ MUFA, Σ PUFA, Σ n-3, Σ n-6 and Σn-3/Σn-6, P/S, UFA/SFA ratios is presented in Table 2.

Table 2 Fatty acid composition (g $100g^{-1}$ of total fatty acids) in fillets of marketable size rainbow trout (mean ± SD), n=6

Fatty acid	Fish pond I	Fish pond II
Σ SFA	35.64 ± 3.61^a	29.14 ± 1.08^b
Σ MUFA	35.00 ± 2.89^a	33.05 ± 0.93^a
Σ PUFA	28.28 ± 1.49^a	36.78 ± 1.85^b
Σ n-3	17.08 ± 1.32^a	19.20 ± 0.74^b
Σ n-6	11.20 ± 0.91^a	17.58 ± 1.14^b
Σn-3/Σn-6	1.53 ± 0.17^a	1.09 ± 0.04^b
P/S	0.80 ± 0.11^a	1.26 ± 0.10^b
UFA/SFA	1.80 ± 0.27^a	2.40 ± 0.12^b

Values in the same row marked with different letters indicate significant differences (p<0.05)

IV. DISCUSSION

Lipid and cholesterol content in the examined fish samples from fish pond I were 1.28% and 46.48 mg/100g, respectively and from fish pond II 4.17% and 70.12 mg/100g, respectively. Results obtained for fish feed indicated to a higher content of fat in fish feed from fish pond II (25.33%) than in feed from fish pond I (15.85%).

Different literature data [18] indicate that fat content in marketable size trout fillets widely differs, from 2.7 to approx. 9%, depending on the age, physiological condition (spawning), time of catching and individual differences.

The determined content of cholesterol (46.48 and 70.12 mg/100g) is in agreement with the literature data: *Oncorhynchus mykiss* (60 mg/100g) [19], *Salmo trutta* (41 mg/100g) and *Salvelinus fontinalis* (117 mg/100g), [20].

The predominated groups of fatty acids in lipid fractions of the analysed fish fillets were SFA, 35.64% (fish from fish pond I) and PUFA, 36.78% (fish from fish pond II), while MUFA contents were similar (35.00% and 33.05%, respectively) in both fish ponds, what is in accordance with other published data, 38.55% MUFA [21]. Total content of n-3 fatty acids in rainbow trout fillets of fish from fish pond I and II was 17.08% and 19.20%, respectively. Depending on the nature of lipids in fish feed, presented data for n-3 content in rainbow trout are ranging from 13.3% to 16.1% [22]. Different n-3 PUFA (13.3-20.3%) and n-6 PUFA levels (5.1-19.9%) were reported regardless the source of lipids in feed (fish oil, rapeseed, soybean, and palm oil) as well as n-3/n-6 ratio ranging from 1.02 to 3.65.

Quality of fish lipids is determined by n-3/n-6 and PUFA/SFA ratios [23]. In the literature, n-3/n-6 value of 0.5-3.8 for freshwater and 4.7-14.4 for marine fish are reported [24]. Beside optimal quantities of essential fatty acids, the intake ratio is important, too. According to U.K. Department of Health [25], an ideal n-3/n-6 FA ratio is of 1:4, at maximum. In our study, higher amounts of n-3 in marketable size rainbow trout fillets and lower amounts of n-6 PUFA give very favourable n-3/n-6 ratio of 1.53 in fish from fish pond I and 1.09 in fish from fish pond II, data which are similar to ratio of 1.58 determined for rainbow trout in the study of Halilogly and Aras [11].

Regarding nutritional value, ratio between polyunsaturated and saturated fatty acids is very important, P/S index, which should be above 0.5 [26]. P/S index below 0.45 is considered inadequate [27] because it can lead to hypercholesterolemia. Based on our studies, the obtained P/S value in marketable rainbow trout was 0.80 (fish pond I) and 1.26 (fish pond II). Ratio between unsaturated (UFA) and saturated fatty acids (SFA) in fish fat is very important and preferably it should be above 3 [28]. Higher UFA/SFA ratio (2.40) was determined in rainbow trout from fish pond II in comparison to 1.80 in rainbow trout from fish pond I.

It was demonstrated the importance of water temperature on fatty acid profile of lipids in rainbow trout [29]. The most important effect of increased temperature is reflected in desaturation of long chain SFA and their oxidation, so share of unsaturated fatty acids decrease when temperature is increasing. Therefore, the established P/S and UFA/SFA ratios in the examined fish fillets might be a consequence of different composition of fish feed, of differences in water temperature in the two fish ponds (13^0C and 8^0C) as well as of their geographic location.

V. CONCLUSIONS

Nutritive value of the examined fish is high since its fatty acids composition is characterized by satisfactory content of n-3 PUFA as well as by high proportion of n-6 PUFA.

Rainbow trout was found to be a good source of n-3 PUFA and, besides other nutrients, this is the main reason for recommending it for human consumption.

This research enabled us to obtain some useful scientifically based information, as well as practical data, on cholesterol and fat content and fatty acid profile of rainbow trout, fish which is, next to carp, mostly preferred fish by consumers on the country level.

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