Fat Quality of Marketable Fresh Water Fish Species in the Republic of Serbia

Dragana LJUBOJEVIĆ[1], Miroslav ĆIRKOVIĆ[1], Vesna ĐORĐEVIĆ[2], Nikola PUVAČA[3], Dejana TRBOVIĆ[2], Jovan VUKADINOV[4] and Nada PLAVŠA[1]

[1]Department of Veterinary Medicine, [3]Department of Animal Science and Faculty of Agriculture, University of Novi Sad, Novi Sad, Republic of Serbia; [2]Institute of Meat Hygiene and Technology, Belgrade, Republic of Serbia; [4]Department of Infectious Diseases, Faculty of Medicine, University of Novi Sad, Novi Sad, Republic of Serbia

Abstract

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The chemical and fatty acid composition were evaluated of commercially important fish species (common carp, silver carp, bighead carp, grass carp, Wels catfish, and zander) which were collected from retail stores in the area of Novi Sad, Republic of Serbia. The amount of protein was the highest in zander (19.27%) and the lowest in grass carp fillets (14.73%). The percentage of fat ranged from 1.8 in zander to 10.07 in common carp. The total cholesterol content was the highest in Chinese carps fillets (approximately 65.38 mg/100 g), and the lowest in Wels catfish (33.14 mg/100 g). SFA were lowest in zander (28.6%). Bighead carp meat contained the highest percentage of PUFA (33.73%) while the lowest percentage was detected in common carp (20.1%). The chemical and fatty acid compositions of fish vary greatly between different species and within the same species. The quality of fish meat in Serbian retail stores is quite good but it should be improved by using feed mixtures on fish ponds.

Key words: chemical composition; cholesterol content; fatty acid; fresh water fish flesh; retail stores

The attainments concerning fat, protein, and cholesterol content, as well as the quality of fat in fish meat are important because the consumption of fish has been enhancing based on the recommendations of healthy nutrition (Komprda *et al.* 2003). The chemical composition of fish varies greatly from one species to another and from one individual to another depending on the diet, age, sex, environment and season (Celik *et al.* 2005; Steffens & Wirth 2007; Guler *et al.* 2008; Buchtová *et al.* 2010). Fatty acid composition also varies largely depending on the fish species, on their being wild fish or farm-raised, on the age of fish and on the origin of diets and its composition (Ćirković *et al.* 2011; Yeganeh *et al.* 2012; Ljubojević *et al.* 2013). Recently, several investigations of the meat quality and safety of fishes from Serbian fishponds were carried out (Trbović *et al.* 2011; Ćirković *et al.* 2012; Ljubojević *et al.* 2013), but there is no available data concerning fatty acids and chemical composition of warm water fish species on Serbian market. Therefore, the objective of this study was to assess the chemical and fatty acid compositions of commercially important fishes (common carp, silver carp, bighead carp, grass carp, Wels catfish, and zander) which were collected from retail stores in the area of Novi Sad.

MATERIAL AND METHODS

Sampling. Meat quality of common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Aristichthys nobilis*), grass

carp (*Ctenopharyngodon idella*), Wels catfish (*Silurus glanis*), and zander (*Stizostedion lucioperca*), which were obtained from retail stores in Novi Sad, was analysed in the present study. The samples were taken on 19th December (St. Nicolaus day), when the fish consumption is greatest in the Republic of Serbia and approximately half of the annual sales of fish is reached on that day. Eight samples of each fish species were taken from different retail stores (each sample of fish per species was taken from a different shop) and stored at –18°C till the next day when the analyses were performed (the samples were stored at a temperature of –18°C for less than 24 h). The weight within each fish species (marketable fish) was almost the same (average weight of common carp, silver carp, bighead carp, grass carp, Wels catfish, and zander were 2200, 2740, 2850, 1790, 2610, and 420 g, respectively). All fish were 2 years old (the end of growing season). All sampled fish were farm-raised (from different fish farms) in the semi-intensive systems of rearing, which is the main type of fish production in Serbia. In addition to natural food, cereals or extruded fish feed were supplemented depending on the feeding technology of the fishpond facilities. For chemical analyses, homogenised fish muscle samples without skin obtained from the dorsal body part (above the lateral line) were used.

Analysis of chemical composition of the fish. Water content in the fish filets was estimated by drying at 103 ± 2°C until their weight was constant for 24 hours. The level of crude protein (N × 6.25) was assessed with the Kjeldahl method (Manual Book, Kjeltec Auto 1030 Analyzer; Tecator, Höganäs, Sweden), and total ash was determined after incineration at 550 ± 25°C. Crude fat from the fish muscles was extracted with Soxhlet extractor.

Cholesterol determination. Direct saponification method (Maraschiello *et al.* 1996) was used for cholesterol determination in the fish muscle. In short, cholesterol in the fish fillets was measured using HPLC/PDA system (Waters 2695 Separation module/Waters photodiode array detector; Waters Corp., Illinois, USA), on a Phenomenex Luna C18 (2) reverse phase column, 150 mm × 3.0 mm, 5 µm particle size, with C18 analytical guard column, 4.0 × 2.0 mm (Bligh & Dyer 1959). The detection was performed at 210 nm and total analysis time was 10 minutes.

Fatty acid composition analysis. Fatty acid composition analysis was performed as described previously by Spirić *et al.* (2010). Briefly, the fatty acids in the fish filets were determined following the extraction of total lipids by means of accelerated solvent extraction (ASE) on Dionex ASE 200. The mixture of *n*-hexane and isopropanol (60:40, v/v) was used for lipid extraction at 100°C and nitrogen pressure of 10.3 MPa in two static cycles lasting in total 10 minutes. Fatty acid methyl esters were separated on a polar cyanopropyl aril column HP-88 (column length 100 m, diameter 0.25 mm, film thickness 0.20 µm; Agilent, Santa Clara, USA), in a programmed temperature range, on a capillary gas chromatograph (Shimadzu 2010; Shimadzu, Kyoto, Japan), with a flame ionisation detector. The temperature of the injector was 250°C and the detector temperature was 280°C. The carrier gas was nitrogen, of flow rate 1.33 ml min and split ratio 1:50. The injected volume was 1 µl, and the duration of analysis 50 min 30 seconds. The identification of fatty acid methyl esters was based on their retention times compared with the standard, Supelco 37 Component FAME Mix (Supelco, Bellefonte, USA). The content of each fatty acid was expressed as the percentage of the total.

Statistical analyses. The data were checked for normal distribution and homogeneity of variances before one-way ANOVA (Statistica Version 10.0; StatSoft Inc., Tulsa, USA) analysis. The data expressed as percentages (referring to fatty acids) were transformed with the arcsine transformation.

Table 1. Chemical composition of seven fish species obtained from retail stores

Parameters	Common carp	Silver carp	Bighead carp	Grass carp	Wels catfish	Zander
Moisture content (%)	73.16 ± 2.81^{a}	74.68 ± 1.49^{a}	74.48 ± 2.44^{a}	76.17 ± 1.67^{ab}	77.74 ± 0.89^{b}	77.89 ± 0.45^{b}
Protein content (%)	15.64 ± 0.98^{a}	18.01 ± 0.32^{b}	18.03 ± 0.34^{b}	14.73 ± 0.70^{a}	17.34 ± 0.53^{b}	19.27 ± 0.39^{c}
Fat content (%)	10.07 ± 3.18^{a}	6.1 ± 1.59^{bc}	6.29 ± 2.42^{bc}	8.02 ± 1.61^{ac}	3.96 ± 0.69^{bd}	1.8 ± 0.23^{d}
Ash content (%)	1.14 ± 0.09^{ab}	1.21 ± 0.05^{ac}	1.2 ± 0.03^{ae}	1.07 ± 0.16^{ad}	0.96 ± 0.12^{d}	1.04 ± 0.02^{bde}
Total cholesterol (mg/100g)	56.38 ± 6.48^{a}	65.38 ± 3.29^{b}	65.2 ± 2.19^{b}	65.29 ± 2.56^{b}	33.14 ± 1.58^{c}	42.34 ± 1.33^{d}

Values are means ± SD (n = 8); values in the same row with different letter notation statistically significantly differ at $P < 0.01$

The mean values were compared by the Tukey HSD test. The results were presented as means ± SD.

RESULTS

The results of the chemical composition determination are shown in Table 1. It was observed that fat content varies most in common carp (6.3–15%), bighead carp (3–10%), silver carp (4–8%), and at the least in zander (1.5–2.2%). Protein content also varied but less than fat content, and the variation was also the greatest in common carp (14.1–16.9%) and the lowest in silver carp (17.6–18.6%). Variation within the same species was noted in the amount of total cholesterol, which was the highest in common carp (43.2–65 mg/100 g). Interspecific differences of chemical composition were noticeable ($P < 0.01$).

Significant variations in the distribution of various fatty acids were noted between and within species. Fatty acid compositions, which are shown in Table 2, were ranged widely especially in the fillets of common carp, thus C16:0 was in the range of 17.3–33.4%. The amount of saturated fatty acids was notably constant in all examined species being around 30%, with palmitic acid being the dominant saturated fatty acid, no significant differences between species were observed ($P > 0.01$). The amount of C18:1*cis* was in a wide range

Table 2. Fatty acid composition of seven fish species obtained from retail stores

Fatty acid (%)	Common carp	Silver carp	Bighead carp	Grass carp	Wels catfish	Zander
C12:0	0.24 ± 0.2^{ab}	0.46 ± 0.2^{b}	0.37 ± 0.11^{bc}	0.10 ± 0.04^{a}	0.21 ± 0.14^{ac}	0.2 ± 0.13^{ac}
C14:0	1.47 ± 0.93^{a}	4.49 ± 1.27^{b}	3.82 ± 0.13^{ab}	1.49 ± 0.34^{a}	3.00 ± 1.52^{ab}	2.15 ± 2.41^{a}
C15:0	0.54 ± 0.58^{abc}	1.05 ± 0.23^{b}	0.77 ± 0.39^{abc}	0.29 ± 0.07^{c}	0.70 ± 0.25^{abc}	0.32 ± 0.04^{ac}
C16:0	22.68 ± 6.07	21.21 ± 2.53	20.2 ± 2.06	22.91 ± 0.37	19.31 ± 2.05	18.23 ± 1.8
C16:1n-7	5.93 ± 1.24^{a}	10.04 ± 1.45^{bc}	8.07 ± 1.4^{abe}	10.73 ± 0.01^{c}	9.49 ± 1.57^{bcd}	5.47 ± 1.51^{ae}
C17:0	1.27 ± 1.64	1.74 ± 0.69	1.17 ± 0.58	0.41 ± 0	1.02 ± 0.46	0.53 ± 0.16
C18:0	7.18 ± 2.57^{a}	5.37 ± 1.48^{ab}	6.19 ± 1.68^{a}	3.38 ± 0.12^{b}	5.75 ± 1.02^{ab}	6.98 ± 1.08^{a}
C18:1n-9 *cis*-9	35.84 ± 11.05^{a}	20.55 ± 3.87^{b}	19.84 ± 1.05^{b}	34.37 ± 1.5^{ac}	22.58 ± 4.07^{b}	26.3 ± 8.07^{abc}
C18:1n-9 *cis*-11	2.82 ± 1.81^{a}	4.51 ± 1.1^{ab}	4.16 ± 0.95^{ab}	4.46 ± 0.32^{ab}	6.00 ± 1.85^{b}	4.77 ± 0.42^{ab}
C18:2n-6	9.62 ± 3.48^{ac}	5.13 ± 1.08^{bd}	4.02 ± 1.23^{d}	10.39 ± 2.5^{c}	6.14 ± 1.6^{abd}	9.07 ± 3.23^{abc}
C18:3n-6	0.45 ± 0.44	0.35 ± 0.25	0.2 ± 0.09	0.11 ± 0.04	0.26 ± 0.23	0.18 ± 0.12
C18:3n-3	2.71 ± 1.58^{a}	5.91 ± 0.93^{b}	6.27 ± 1.29^{b}	3.75 ± 1.35^{ab}	3.92 ± 1.98^{ab}	2.2 ± 1.52^{a}
C20:0	0.17 ± 0.07	0.24 ± 0.19	0.28 ± 0.15	0.13 ± 0.05	0.22 ± 0.1	0.21 ± 0.06
C20:1n-9	1.7 ± 0.59^{ab}	1.26 ± 0.2^{a}	1.41 ± 0.4^{a}	1.03 ± 0.06^{a}	3.37 ± 2.29^{b}	1.35 ± 0.51^{a}
C20:2n-6	0.69 ± 0.23	0.41 ± 0.09	0.74 ± 0.37	0.43 ± 0.08	0.65 ± 0.19	0.43 ± 0.25
C20:3n-6	0.86 ± 0.3^{a}	0.47 ± 0.09^{b}	0.42 ± 0.16^{b}	0.72 ± 0.07^{ab}	0.58 ± 0.21^{ab}	0.50 ± 0.27^{ab}
C20:3n-3	0.64 ± 0.32^{a}	0.67 ± 0.14^{ab}	1.21 ± 0.79^{b}	0.36 ± 0.06^{a}	0.42 ± 0.26^{a}	0.41 ± 0.14^{a}
C20:4n-6	1.85 ± 1.1^{a}	3.4 ± 1.11^{a}	4.05 ± 1.73^{ab}	1.61 ± 0.48^{a}	3.55 ± 2.29^{a}	2.67 ± 1.3^{a}
C20:5n-3	1.09 ± 0.69^{a}	5.42 ± 1.52^{bd}	7.84 ± 1.89^{d}	0.96 ± 1.31^{a}	3.43 ± 2.17^{ab}	6.13 ± 1.78^{bd}
C22:5n-3	0.85 ± 0.34^{ad}	1.07 ± 0.2^{abd}	1.14 ± 0.46^{ac}	0.5 ± 0^{a}	1.82 ± 0.68^{bce}	1.55 ± 0.4^{cd}
C22:6n-3	1.32 ± 1.04^{a}	6.62 ± 1.7^{b}	7.82 ± 2.34^{b}	1.9 ± 2.5^{a}	7.62 ± 2.94^{b}	10.52 ± 1.74^{b}
SFA	33.55 ± 11.73	34.57 ± 2.74	32.82 ± 2.15	28.72 ± 0.88	30.22 ± 2.78	28.6 ± 2.73
MUFA	46.3 ± 11.57^{ab}	36.36 ± 4.58^{bc}	33.48 ± 1.6^{c}	50.6 ± 1.89^{a}	41.43 ± 5.2^{abc}	37.92 ± 9.16^{bc}
PUFA	20.1 ± 6.66^{a}	29.46 ± 4.96^{ab}	33.73 ± 3.36^{b}	20.72 ± 2.9^{a}	28.39 ± 6.97^{ab}	33.67 ± 6.87^{b}
Σ n-6	13.48 ± 3.76^{ab}	9.78 ± 2.17^{a}	9.31 ± 1.5^{b}	13.26 ± 2.21^{ab}	11.18 ± 1.91^{ab}	12.86 ± 2.75^{ab}
Σ n-3	6.61 ± 3.22^{a}	19.68 ± 2.95^{b}	24.54 ± 2.87^{b}	7.46 ± 5.11^{a}	17.21 ± 5.34^{b}	20.81 ± 4.34^{b}
n-3/n-6	0.48 ± 0.18^{a}	2.04 ± 0.22^{bd}	2.68 ± 0.46^{d}	0.68 ± 0.77^{ac}	1.52 ± 0.32^{b}	1.62 ± 0.17^{b}
n-6/n-3	2.78 ± 2.33^{a}	0.49 ± 0.05^{b}	0.38 ± 0.05^{b}	2.22 ± 0.74^{ac}	0.69 ± 0.16^{bc}	0.62 ± 0.06^{bc}
PUFA/SFA	0.66 ± 0.29^{a}	0.86 ± 0.21^{ab}	1.04 ± 0.17^{ab}	0.72 ± 0.13^{a}	0.96 ± 0.3^{ab}	1.17 ± 0.17^{b}

Values are means ± SD ($n = 8$); values in the same row with different letter notation statistically significantly differ at $P < 0.01$

in common carp fillets and the lowest value was observed in silver carp fillets (12.5%). The amount of C22:6n-3 varied between the species and within the same species, and it was the lowest in the fillets of common carp and most favourable in the fillets of zander. The greatest deviation of total SFA was observed in common carp and in the contents of MUFAs and PUFAs in catfish and zander. The lowest n-3/n-6 ratio was found in one sample of common carp (0.12), and the greatest one in one sample of bighead carp (3.7). This ratio also varied between the species, the lowest value having been observed in common carp and the highest in the fillets of bighead carp, without statistically significant differences between the silver and bighead carps.

DISCUSSION

Regarding chemical and fatty acid compositions of muscle tissue, it was expected that some major differences would be found within the same species and among different species in percentages of the nutrients monitored between the tested fish species in the present experiment because the fish came from the different environments, different species were included, and they were fed with different diets. High average values of the fat content observed in the fillets of Cyprinids, especially in those of common carp, showed that the energy-protein ratio was not balanced in the diet of these fishes in a number of ponds. Fauconneau *et al.* (1995) and Romvári *et al.* (2002) also reported that lipid content of common carp fillets show high variance (1–13%) in commercial size of fish depending mainly on previous nutrition. The total cholesterol content in the carps fillets is in agreement with the data of Bieniarz *et al.* (2001) and Kopicová and Vavreinová (2007) who reported slightly higher cholesterol content in the most analysed fish species (49–92 mg/100 g) in comparison with terrestrial animal meats (45–84 mg/100 g) (Piironen *et al.* 2002) and it was lower for catfish and zander (33 and 42 mg/100 g, respectively), which is in agreement with our previous results (Ćirković *et al.* 2012). The total cholesterol content in the animal tissues can be influenced by the composition of the diet (Komprda *et al.* 2003). That could be the explanation for the variations in cholesterol content because the examined fishes came from different ponds and the fed with different diet. The obtained results regarding to the fatty acid composition are in agreement with previous reported results referred to studied fish species (Jankowska *et al.* 2004; Çelik *et al.* 2005; Steffens & Wirth 2007; Ćirković *et al.* 2012). The chemical composition including the fatty acid profiles varies widely among different fish species as previously noted by Ćirković *et al.* (2012). The reason for the least desirable composition of fatty acid profile in the lipids of common carp can be accounted for by the type of food dominating in the diet. The traditional approach to the rearing of common carp in the Republic of Serbia is based on foods naturally occurring in ponds (zooplankton, benthos). The energy-producing component of their diet is supplemented with untreated cereals (corn and wheat). The feed rich in saccharides leads to an increase in the percentage of oleic acid (C18:1n-9) in the body lipids of the fish. At the same time, a decrease occurs in the percentage of n-3 PUFA (Fajmonová *et al.* 2003; Buchtová *et al.* 2007). According to the research conducted by Buchtová *et al.* (2010) and Ćirković *et al.* (2012), the carp grown on natural food had a high content of both n-6 and n-3 fatty acids. Ćirković *et al.* (2011) observed that PUFA/SFA ratio was the most favourable in the carp fed completed feed mixtures and the least in that fed with maize and wheat. All species of the warm water fish analysed contained significant quantities of the n-6 series, particularly C18:2 and C20:4. The presence of these and the other PUFA emphasises the potential of freshwater fish for use on special low fat diets. Wood *et al.* (2008) have suggested that the ratio of PUFA/SFA should be above 0.4, and according to that all the fish species examined revealed a favourable (from 0.66 to 1.17) PUFA/SFA ratio. Scollan *et al.* (2006) suggested that the n-6/n-3 ratio should not exceed 4 for the prevention of cardiovascular, heart, and certain chronic diseases. All studied species meet this suggestion. However, the European Food Safety Authority recommends the intake values: 2 g of n-3 PUFA ALA per day and 250 mg of EPA and DHA per day (EFSA 2009). The percentage values of fatty acids were transferred to weight in mg/g of fillets according to Exler *et al.* (1975). A 200 g of edible portion of fillets of common carp, silver carp, bighead carp, grass carp, Wels catfish, and zander contained 436, 1320, 1774, 412, 612, 420 mg of EPA+DHA, respectively; and 1198, 2160, 2780, 1076, 954, 524 mg of n-3 PUFA, respectively.

The elementary prerequisite for the sustainable carp and other fresh water fishes production, with favourable chemical and fatty acid compositions,

should be seen in the development of better feeding procedures. Completed formulated feed mixtures are necessary in modern fish farming because they improve the growth performance and chemical and fatty acid compositions in fish (Ćirković *et al.* 2011).

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Corresponding author:

Dragana Ljubojević, MA, University of Novi Sad, Faculty of Agriculture, Department of Veterinary Medicine, Novi Sad, Republic of Serbia; E-mail: ljubojevic.ljubojevicd.dragana@gmail.com