Chemical composition of body including fatty acids of four cyprinids fish species cultured at the same conditions

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SUMMARY

Chemical composition of meat including fatty acids of four two-years old cyprinid fish species cultured at the same conditions was compared in this study. Samples of two-years old common carp, silver carp, grass carp and tench were taken in the winter time from a pond where the production is taken place in the semi-intensive system of production. Moisture content was 77.6±0.41 in tench, 77.00±0.36 in silver carp, 76.22±1.03 in grass carp, and 75.02±0.29 in common carp ($p<0.01$). The amount of protein was 18.02±0.15 in the fillets of silver carp, 15.59±0.21 in carp, 14.8±0.08 in tench and 14.68±0.12 in grass carp fillets ($p<0.01$). Fat percentage in the fillets of silver carp, tench, grass carp and common carp was, respectively, 4.07±0.05; 5.78±0.11; 6.39±0.24 and 6.85±0.14 ($p<0.01$). Ash content in percentage was 0.84±0.03 for grass carp, 0.89±0.035 for common carp, 1.18±0.01 for silver carp and 2.00±0.04 for tench ($p<0.01$). The fatty acid composition of fish varies greatly depending on fish species. The amount of saturated fatty acids was the highest in tench (36.36±0.33) and lowest in common carp (24.23±0.06) ($p<0.01$). Tench contained the least amount of monounsaturated fatty acids (34.97%), and the largest percentage was measured in common carp (64.34%) ($p<0.01$). Silver carp contained the higest percent of polyunsaturated fatty acids 24.23% of which was 18.17% n-3 and 6.07% n-6, the lowest percentage was in common carp which contained 10.95% and the ratio n-3/n-6 was 0.14 ($p<0.01$). Fish species determined chemical composition and the relative fatty acid content in meat. Nutritive value of examinated freshwater fish is high since their fatty acid composition is characterized by favourable proportion of n-3 polyunsaturated fatty acids and by high proportion of n-6 polyunsaturated fatty acids, especially linoleic and arachidonic acids.

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INTRODUCTION

The high nutritional value of fish meat is reflected in the favorable content of protein, fat, carbohydrates, minerals and vitamins (Ćirković et al., 2002). It represents the most important dietary source of the n-3 highly unsaturated fatty acids (HUFA), that have particularly important roles in human nutrition reflecting their roles in critical physiological processes (Calder and Grimble, 2002). Fish proteins contain all the essential amino-acids for the human organism and it can be used as the sole source of protein in the diet (Vladau et al., 2008). Fish farming in Republic of Serbia is mostly conducted like rearing of common carp (*Cyprinus carpio* L.) in monoculture or in polyculture with silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Hypophthalmichthys nobilis*), grass carp (*Ctenopharyngodon idella*), catfish (*Silurus glanis*) and zander (*Stizostedion lucioperca*) (Ćirković et al., 2011a). Common carp is the most common fish species in our country, and the cyprinid fish are the predominant fish in world aquaculture with 54% of total world fish production (Ćirković et al., 2002; Tacon, 2006). The introduction of the so-called “Chinese carps” (grass carp, silver carp, bighead carp) into the Danube Basin was conducted in 1960s (Lenhardt et al., 2010). These herbivore fish very well exploit ecological potential of fish ponds and make production more economical. “Chinese carps” are well accepted in the market of our country because of its price, but there is a little information about their biological quality, and it was examined in the present study. Due to its palatable meat and high attractiveness for sport anglers, the tench is likely to have a great potential for future, either as a supplementary species for pond aquaculture or for stocking open waters. It is also necessary to take into account the nutritional quality of tench. Polycultures in China commonly include the use of silver carp, bighead carp; grass carp; common carp, crucian carp, Chinese bream, tilapia and black carp (Tacon et al., 1995). The Chinese carps have a long history of culture in China and Taiwan but are less domesticated than the common carp since captive breeding by induced spawning has been widespread only since the 60’s (Pullin, 1986). Large quantities of carps are taken from inland waters or cultured in China, Bangladesh, India and the Philippines (Pullin, 1986). Chinese carps have been spread throughout temperate and tropical zones for aquaculture and weed control (Pierce, 1983). Carps have been successfully introduced into many African countries, but few sustainable industries have resulted (FAO, 2006). The largest common carp industries are probably in Egypt and in Sudan (Pullin, 1986). Chinese carps have limited market potential in Africa (Safriel and Bruton, 1984). Grass carp were introduced into the United States in 1963 as potential biological control agents for nuisance aquatic weeds (Pierce, 1983). The largest carp culture industries are in Central and Eastern Europe, Israel and Russian federation (Bieniarz et al., 2001). In Hungary, polyculture predominates (Farkas et al., 1980). Poland is a country with a very long tradition of carp rearing which dates back seven hundred years (Bieniarz et al., 2001). In Poland the common carp is recommended as a component in polyculture with herbivorous fish, tench and catfish species (Harsanyi, 1987; Wiśniewolski, 1989; Duda, 1994). Carp culture in Western Europe, although possessing the longest history and tradition of aquaculture activity in the region (O'Grady and Spillet, 1985) has a considerable extent been overtaken by other forms of aquaculture (Muir, 1985). Tench is an important fish species in Czech and Poland pond polycultures, which are regularly dominated by common carp (Adamek et al., 2003; Steffens and Wirth, 2007).

Despite the fact that silver carp, grass carp, common carp and bighead carp were the top four cultivated fish species in the world (Tacon, 1996), little information exists concerning their dietary nutrient requirements under practical semi-intensive pond farming conditions. The information generated from laboratory-based feeding trials cannot be applied to the formulation of diets for use in practical conditions since the fish also derive a substantial part of their dietary nutrient needs from naturally available food organisms (Ćirković et al., 2002).

Investigations on fatty acids and total fat in pond-cultured carp were carried out in Hungary (Farkas et al., 1980; Farkas, 1984), in Israel (Viola et al., 1988), in the Czech Republic (Vacha and Tvrzicka, 1995), in Poland (Bieniarz et al., 2001; Steffens et al., 2005); and recently in Serbia (Trbović et al., 2009; Ćirković et al; 2010; 2011a, 2011b), but there is still a little information about meat quality of cyprinid fish species reared in polyculture. Analyses of the impact feed (natural, grains, formulated feed) on the proximate composition and fatty acids profile of tench reared in ponds have been presented in a several publications (Steffens et al., 1998; Vácha and Tvrzicka 2005; Wolnicki et al 2006; Ćirković et al., 2011c). In the case of these studies, the tench were reared under natural atmospheric conditions. There are little information about silver carp and grass carp body composition (Domaizon et al., 2000; Hsieha and Kuo, 2005; Steffens et al., 2005). Results related to meat quality of freshwater fish are differ in communications by previously mentioned authors, with differences mostly caused due to the analysis of fish of different age, from different breeding systems and fed with different food. The knowledge of the chemical and fatty acid composition for commercial important fish species such as common carp, silver carp, grass carp is desirable, due to the recent dietary and medical emphasis on the role of eating fish in human health (Connor, 2000; Calder and Grimble, 2002). Information concerning the chemical composition of freshwater fishes is of fundamental importance in the application of different feeding practice in fish production. This study was conducted to compare meat quality of two-year old common carp, silver carp, grass carp and tench, which were grown in polyculture in the same conditions.

MATERIAL AND METHODS

Pond management and fish samples

Fish were grown in earthen pond with a surface area of 10 ha and average depth of 1 m in the polyculture. The production of natural food was based on the natural production of benthic and planktonic organisms that were increased by application of agrotechnical measures such as drying of fish ponds during winter, soil treatment, fertilization and adding lime. Livestock manure (2000 kg/ha) was applied to the bottom of empty pond and later biweekly over the water surface (4000 kg/ha during growing season). Agricultural limestone was applied to the bottom of empty pond and over the water surface. Aeration of fish ponds was provided. Freshwater fish species were reared under variable natural atmospheric conditions. Fry were stocked at a density of 100,000 fish per ha in April. The fry were caught in May and transferred to other ponds at a density of 20,000 fish per ha. One-year-old fish were stocked at a density of 5,000 fish per ha in the second year of rearing. Samples of two years old of carp, silver carp, grass carp and tench were taken in the winter time in the second year of rearing. The average weight of samples were 1510, 1950, 800, 280g for common carp, silver carp, grass carp and tench, respectively. The production is taken place in the semi-intensive system of production and the fish were fed identical cereal feeds (corn and wheat (80:20)) at a feeding coefficient (the amount of feed converted for 1 kg of growth) of 2.8:1. 12 samples of each species of fish were taken. Water quality and environment conditions fluctuated within the range considered normal for carp pond conditions in Republic of Serbia (Ćirković et al., 2002).

Chemical analysis

The meat from dorsal muscles was used for chemical analysis. Chemical composition of fish muscle tissue was determined by standard SRPS ISO methods. Protein content was determined by Kjeldahl (N x 6.25) (Kjeltec Auto 1030 Analyzer, Tecator, Sweeden). Water content was determined by drying at 103±2ºC to constant weight. For determination of total fat, samples were hydrolyzed with 4M hydrochloric acid and extracted with petroleum ether by

Soxhlet apparatus (reference). Ash was determined by combustion at 550±25ºC (Trbović et al., 2009). Analyses were done in duplicate.

Extraction of lipids by ASE

Total lipids for fatty acids determination was extracted from fish muscle tissues by accelerated solvent extraction (ASE 200, Dionex, Sunnyvale, CA) (Spirić et al., 2009). The fat extract was further used for fatty acids determination.

Fatty acid analysis by capillary gas chromatography (CGC)

Fatty acid methyl esters were prepared by transesterification by using trimethylsulfonium hydroxide, according to SRPS EN ISO 5509:2007 procedure (Spirić et al., 2010). Analyses were done at the Institute of Hygiene and Meat Technology, Belgrade.

Statistical analysis

The calculations were performed with the Statistica 10 program (StatSoft Inc.). The average results are presented as means±SD. The differences between the mean values of the studied determinants were calculated with one-way analysis of variance (ANOVA), at 0.01 significance. When significant inter-group differences were determined ($p \leq 0.01$) further statistical analysis was performed with the Tukey HSD test.

RESULTS

Results of chemical composition of the fillets of the two-years old carp, silver carp, grass carp and tench, which were grown in polyculture in semi-intensive system, where the feeding is done by adding corn and wheat in relation to 80:20, are shown in Table 1. The amount of protein was highest in the fillets of silver carp (18.02±0.15), followed by common carp fillets (15.59±0.21), tench (14.8±0.08) and the lowest percentage of protein was found in grass carp fillets (14.68±0.12).

Table 1. Chemical composition of muscles of two years old freshwater fish

Parameters	Common carp	Silver carp	Grass carp	Tench
Moisture	75.02±0.29d	77.00±0.36b	76.22±1.03c	77.6±0.41a
Protein content	15.59±0.21b	18.02±0.15a	14.68±0.12d	14.8±0.08c
Fat content %	6.85±0.14a	4.07±0.05d	6.39±0.24b	5.78±0.11c
Ash content%	0.89±0.035c	1,18±0.01b	0.84±0.03c	2.00±0.04a

Values are means ± SD (n=12); Values in the same row with different letter notation differ significantly statistically at $p<0.01$

Fatty acid composition of the two-year old carp, silver carp, grass carp and tench is shown in Table 2.

Table 2. Fatty acid composition of two years old freshwater fish

Fatty acids %	Common carp	Silver carp	Grass carp	Tench
C12:0	0.14±0.01[b]	0.44±0.02[a]	0.12±0.01[b]	0.12±0.04[b]
C14:0	0.72±0.01[d]	3.82±0.02[a]	1.62±0.01[b]	1.22±0.04[c]
C15:0	0.01±0.01[d]	1.02±0.01[a]	0.32±0.00[c]	0.85±0.05[b]
C16:0	17.33±0.06[d]	22.12±0.05[c]	23.04±0.01[b]	24.59±0.19[a]
C16:1	6.23±0.01[d]	10.32±0.02[b]	10.73±0.01[a]	7.68±0.09[c]
C17:0	0.12±0.01[d]	1.37±0.01[a]	0.41±0.00[c]	1.02±0.01[b]
C18:0	5.79±0.02[b]	5.02±0.03[c]	3.37±0.10[d]	8.01±0.26[a]
C18:1cis-9	51.35±0.04[a]	22.56±0.01[c]	34.90±0.06[b]	19.90±0.08[d]
C18:1cis-11	4.54±0.04[c]	4.89±0.07[b]	4.60±0.05[c]	6.37±0.14[a]
C18:2. ω-6	8.75±0.06[b]	5.00±0.01[d]	11.28±0.04[a]	5.80±0.09[c]
C18:3.ω-6	0.12±0.01[c]	0.24±0.01[a]	0.12±0.01[c]	0.19±0.08[b]
C18:3. ω-3	0.64±0.00[d]	5.24±0.01[a]	3.27±0.01[c]	5.04±0.04[b]
C20:0	0.12±0.01[d]	0.26±0.01[b]	0.15±0.00[c]	0.68±0.06[a]
C20:1	2.22±0.01[a]	1.27±0.01[b]	1.06±0.01[c]	1.03±0.02[c]
C20:2	0.3±0.04[c]	0.36±0.01[c]	0.46±0.01[b]	0.53±0.02[a]
C20:3. ω-6	0.46±0.02[b]	0.46±0.01[b]	0.74±0.01[a]	0.46±0.02[b]
C20:3. ω-3	0.06±0.00[d]	0.60±0.01[a]	0.38±0.01[c]	0.46±0.02[b]
C22:1+20:4	0.74±0.01[d]	2.75±0.01[b]	1.44±0.01[c]	6.57±0.12[a]
C20:5. ω-3	0.19±0.02[d]	4.46±0.05[a]	0.49±0.01[c]	2.93±0.04[b]
C22:5. ω-3	0.18±0.01[d]	1.14±0.01[b]	0.50±0.00[c]	2.05±0.06[a]
C22:6. ω-3	0.25±0.01[d]	6.73±0.11[a]	1.01±0.00[c]	3.47±0.45[b]
SFA	24.23±0.06[d]	34.05±0.08[b]	29.03±0.09[c]	36.36±0.33[a]
MUFA	64.34±0.06[a]	39.04±0.08[c]	51.29±0.08[b]	34.97±0.17[d]
PUFA	10.95±0.09[d]	24.23±0.18[a]	18.26±0.04[c]	22.08±0.43[b]
ω-6	9.63±0.08[b]	6.07±0.03[d]	12.61±0.04[a]	6.98±0.10[c]
ω-3	1.32±0.02[d]	18.17±0.17[a]	5.65±0.02[c]	15.11±0.49[b]
ω-3/ω-6	0.14±0.00[d]	2.99±0.02[a]	0.45±0.00[c]	2.16±0.009[b]
ω-6/ω-3	7.28±0.08[a]	0.33±0.00[d]	2.23±0.01[b]	0.46±0.01[c]
PUFA/SFA	0.45±0.00[c]	0.71±0.01[a]	0.63±0.00[b]	0.61±0.02[b]
UFA/SFA	3.14±0.01[a]	1.94±0.01[c]	2.44±0.01[b]	1.75±0.02[d]

SFA saturated fatty acids, MUFA monounsaturated fatty acids, USFA unsaturated fatty acids, PUFA polyunsaturated fatty acids from the n-3 (n-3 PUFA) and n-6 (n-6 PUFA) families; Values are means ± SD (n=12); Values in the same row with different letter notation differ significantly statistically at p<0.01

In the present study, the amount of saturated fatty acids (SFA) was the highest in tench (36.36±0.33) and lowest in common carp (24.23±0.06). Dominant saturated fatty acids were palmitic fatty acid (C16:0), which was presented from 17.33% in common carp to 24.59% in tench, stearic acid (C18:0) in the amount of 3.37% (grass carp) to 8.01% (tench), myristic (C14:0) with the lowest content in meat of common carp (0.72%) and highest in silver carp (3.82%), and in low concentrations in all species were presented lauric (C12:0), pentadecylic (C15:0), margaric (C17:0) and arachidonic (C20:0). The most abundant monounsaturated fatty acid was oleic (C18:1, n9), from 19.9% in tench to 51.35% in common carp, then palmitoleic (C16:1, n7), 11-eicosenic (C20:1). Tench contained the least amount of monounsaturated fatty acids (MUFA) (34.97%), and the largest percentage was measured in carp (64.34%). Silver carp contained the highest percent of polyunsaturated fatty acids (PUFA) 24.23% of which was 18.17% n-3 and n-6 6.07%, the lowest percentage of PUFA was in common carp which contained 10.95%. PUFA/SFA, which is an indicator of the quality of lipids in the examined fish was 0.45 (common carp), 0.61 (tench), 0.63 (grass carp) and the most favourable was in silver carp 0.71. Ratio of unsaturated to saturated (UFA/SFA) fatty acids in fish lipids is also significant for meat quality and for studied species it was the best in fat of common carp 3.14, then grass carp 2.44; silver carp 1.94 and in fat of tench it was 1.75.

DISCUSSION

It was found that freshwater fish fat varies greatly in the percentage of saturated and unsaturated fatty acids and usually contains 15-36% saturated fatty acids and 58-85% unsaturated fatty acids (Domaizon et al., 2000; Fajmonova et al., 2003; Steffens et al., 2005; Vladau et al., 2008; Trbović et al., 2009; Ćirković et al., 2010; Zakes et al., 2010). Meat of fish contains high percentage of water (60-86%) (Ćirković et al., 2002). The results obtained in the present study confirmed data regarding to water content and it was the highest for tench, followed by silver carp, grass carp, and was lowest in common carp. Mammals and fish have a similar percentage of protein, which in fish is usually in the range of 14-20% (Spirić et al., 2009; Trbović et al., 2009; Ćirković et al, 2010) which is consistent with the present results, although some authors state that this range slightly higher and amounts to 13-25% (Vladau et al., 2008). The lipid content of fish varies depending on the fish species, the time of year and kind of offered food (Guler et al., 2008; Ćirković et al., 2011c). According to the present results percentage of fat ranged from 4.07±0.05 in the muscles of silver carp to 6.85±0.14 in the meat of common carp. Meat quality of common carp is highly variable, and changes depending on age, breeding system, and the diet. Although fat content in carp ranges from 2.3 to 16.8%, protein content lightly varies between 14 and 18% (Vladau et al., 2008; Trbović et al., 2009, Ćirković et al., 2010). According to Steffens et al. (2005) the fatty acid composition of common carp reflects, to a large extent, that of the diet, so the n-3/n-6 ratio varies between 0.8 and 2.4; while Ćirković et al. (2010) established the relationship of these fatty acids 0.54 for common carp fed only natural food; a similar ratio (0.5) were found by Fajmonova et al. (2003). Ćirković et al. (2011a) reported ratio of n3/n6 in range from 0.15 to 0.19 for common carp fed grains which is consistent with the present results (0.14). This could be attributed to the addition of cereals and obtained result is somewhat lower than results of Vasha et al. (2007) (0.19-0.27) for common carp fed with maize and it could be due higher water temperature in our region compared to Chez Republic. Cordier et al. (2002) and Tocher et al. (2004) demonstrated the importance of temperature on fatty acid composition in lipids of fish. The most important effect of temperature is reflected in desaturation of fatty acids and their betatoxidation, so that proportion of unsaturated fatty acids decreases with the increase of temperature. Higher temperature also influenced significantly higher growth rate of common carp in our region compared with Central Europe (Vasha et al., 2007; Steffens and Wirth; 2007). According to Buchtová et al. (2010) and Ćirković et al. (2010) common carp and tench grown-based on natural food had a high content of both n-6 and n-3 fatty acids, while the common carp and tench fed grains which are characterized by low levels of n-3 PUFA (Buchtová et al., 2010; Ćirković et al., 2011c), and a high concentration of oleic acid. The above statements are in agreement with the present results. Fatty acid composition in tench varies. The n-3:n-6 ratio is reported to range between 1.0 and 2.2 (Steffens et al., 2005) and between 1.93 and 3.6 (Jankowska et al., 2006). Ćirković et al. (2010) reported the n-3:n-6 ratio of 1.05 in tench. In the present study, the n-3:n-6 ratio was 2.16, and the percentage of SFA, MUFA, and PUFA 36.36; 34.97; and 22.08%, respectively. Tench reared in pond under different nutritional conditions in investigation by Steffens et al. (1998) had lipid content 2.0%, the amount of total n-3 was 14.5; n-6 12.8 and n3/n6 ratio was 1.1; which lower than in the present paper except for the n-6 series. Determined percentage of fat in silver carp muscle was lower compared to the results obtained by Domaizon et al. (2000), who examined the one-year and three-year old silver carp and measured lipid content in fillets in the range of 4.51 to 6.7%. Silver carp and grass carp fed phytoplankton, zooplankton, and macrophytes are rich in n-3 PUFA, especially EPA and DHA (Domaizon et al., 2000; Steffens and Wirth, 2005). The proportion of total n-3 fatty acids varies between 20 and 30% and the n-3:n-6 ratio is about 2 to 3 (Steffens et al., 2005). As age increased, the n-3:n-6 ratio in fillets of silver carp increased from 1.19 to 1.9 at 1 and 3 years old (Domaizon et al., 2000). Diet is also a contributing factor for different fatty acid profile. Zooplankton appears as the major contributor to the diet of one year old silver carp (90% of ingested biomass), whereas three years old silver carp exhibited a more evenly balanced food spectrum between zooplankton (45% of ingested biomass) and phytoplankton (55% of ingested biomass) (Domaizon et al., 2000). Shapiro (1985) also showed that mature carp tended to consume more phytoplankton than one year old silver carp. Thus, DHA level was 2.56% in one-year old silver carp and 7.76% in three-year old silver carp, while in the present studies in fillets of silver carp contained 6.73% DHA. According to results obtained in the present study, n3/n6 in silver carp was 2.99, which is in agreement with the results presented by Steffens et al. (2005), while this ratio in grass carp was lower and amounted 0.45. This can be attributed to the changed of natural food for grass carp, in this pond the amount of macrophyte vegetation was decreased, and grass carp are predominantly fed additional nutrients. Silver carp contained significantly higher amount of docosahexaenoic acid in relation to other species which were studied. It has been reported that the types and amounts of fatty acids in fish tissues vary with the geographic location, size, age, what the fish eat, reproductive status and seasons (Guller., 2008; Steffens and Wirth., 2007). Nutritive quality of examined freshwater fish is very high since their fatty acid composition is also characterized by high proportions of n-6 polyunsaturated fatty acids, especially linoleic and arachidonic acids.

Freshwater fish contain high levels of PUFA, which are very important in human nutrition (Vladau et al., 2008). Essential fatty acids affect the fluidity, flexibility, and permeability of membranes as well as involves in cholesterol transport and metabolism (Steffens et al., 2005). Arachidonic acid (C20:4), a precursors of the eicosanoids, was measured in high percentages our all sample groups. Since there are several biochemical interactions between the n-6 and n-3 series, a balanced proportion of these fatty acids in the diet is important for the functioning of human and animal life. The content of n-3 in two-year old carp in this study was lower than in the two-year carp fed only natural food from the pond, which was noted by Ćirković et al. (2010).

The reason for the least favourable composition of fatty acid profile in lipids of common carp can be accounted to 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) (Ćirković et al., 2002). The feed rich in saccharides leads to an increase in the percentage of the oleic acid (C18:1n-9) in body lipids of the fish. At the same time, there is a decrease in the percentage of PUFA n-3 (Fajmonová et al., 2003; Buchtová et al., 2007). Wood et al. (2008) have suggested that ratio of PUFA/SFA should be above 0.4 and according that all examined fish species have had favourable (from 0.45 to 0.71) PUFA/SFA ratio. Scollan et al., (2006) have advised that ω-6/ω-3 ratio should not exceed 4. All studied species meet this suggestion. The elementary prerequisite for sustainable carp and other fresh water fish 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 it improves growth performance and chemical and fatty acid composition in fish (Ćirković et al., 2011a). Supplemental feeding should contain more vegetable oils that will help to increase PUFA content in muscle lipids of the fish (Steffens and Wirth, 2007).

Conclusions

In conclusion, rearing fish in polyculture on natural feed with addition of grains with the use of agricultural limestone and livestock manure was achieved satisfactory results in terms of the final weight of two years old fish and their nutritive composition. The dependence of chemical composition and the relative fatty acid content of fish meat with fish species were established in the present study. Fat content was the highest in the fillets of common carp and protein content was the highest in muscle of silver carp with high degree of reliability in differences of the results ($p<0.01$). All examined species have had PUFA/SFA ratio higher than 0.4, and ω–6/ω–3 ratio was lower than 4 which are the prescribed values recommended from WHO/FAO organization. Components of fish meat, especially of common carp can be improved by improvement rearing procedures. Nutritive value of examined freshwater fish is high since their fatty acid composition is characterized by satisfactory proportion of n-3 polyunsaturated fatty acids and by high proportion of n-6 polyunsaturated fatty acids, especially linoleic and arachidonic acids. The meat of freshwater fish may be a valuable source of essential fatty acids for the consumer. It is necessary to take into account the stocking density of fish to grow in pond polyculture, as well as on the combination of appropriate species. In conclusion, nutrient composition varies widely among fish breed. Especially, lipid profile seems related more to the fish species, their consumption habits (herbivorous, omnivorous or carnivorous). However, it is difficult to rank the lines from best to worst from the point of view of human nutritive value.

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