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THE MEAT QUALITY OF SOME FRESHWATER FISH - NUTRITIVE AND TECHNOLOGICAL ASPECTS

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Fatty acids, microelements and heavy metals are very important components in human nutrition. The objective of this study was to establish whether there was a difference in these constituents and also how thermal treatment influences the content and composition of fatty acids of freshwater white fish from ponds or river water. The samples investigated were as follows: fishpond crucian carp (weed) and fish from the river Danube (mixed white fish). After dressing, separation, freezing and defrosting, one part of the fish was used for thermal treatment. Total lipids, microelements and heavy metals were determined in untreated and heat treated samples.

Total lipid contents of in fishpond fish and Danube fish were 5.63 and 6.70 %, respectively. A high proportion of unsaturated fatty acids was found regardless of the origin of the fish. Thermal treatment brought about a reduction in the polyunsaturated to saturated fatty acid ratio as follows: from 2.53 to 0.58 for fishpond fish and from 2.00 to 0.47 for Danube fish. The contents of toxic elements in the fish meat were within the limits of norms defined by legal regulations. The contents of iron (Fe), copper (Cu) and zinc (Zn) in the meat of fish from fishponds and the Danube were: 11.52 and 10.97; 0.98 and 0.78; 25.96 and 13.28 ppm, respectively.

The results obtained indicate that although there were some differences in composition of lipids and microelements between the investigated fish samples, from the aspect of nutrition they represent an important resource and might be used for making high quality and nutritively valuable products of the paté type.

Key words: freshwater fish, quality, lipids, microelements, heavy metals, thermal treatment

INTRODUCTION

There are many reports on the nutritive properties of fish meat in the literature, not only because of the high protein digestibility but also because of the content of omega-3 fatty acids, mineral matter and vitamins (Chen *et al.*, 1995; Morris *et al.*, 1995; Smiljanić, 1990; Mustafa and Medeiros, 1985; Mikavica *et al.*, 2000). The biological value of fish meat, as a foodstuff, had led to an increase in its consumption in the world (12 - 40 kg/capita). However, in our country, fish consumption is only 3.5 kg/capita (Mitrović *et al.*, 1998). Such a low level of consumption is probably due to dietary habits and inadequate marketing (fresh fish, rarely a semi-finished or ready-to-eat product)(Baltić and Teodorović, 1997). Investigations, some results of which are presented in this paper, have been undertaken in order to determine the nutritive properties and some technological aspects of freshwater white fish exploitation, including species which represent the so called "weed" in fishponds falling into the group of mixed white fish. So far this sort of fish has been offered exclusively fresh to consumers in the market or used in livestock nutrition. In the available literature we have found few records of its chemical composition and nutritive value.

The aim of the study was, therefore, to establish if there is a difference between fishpond fish and river fish in chemical composition, fatty acid content and microelements, which are components very important from the aspect of human nutrition. As one of the necessary safety measures the content of potentiallly toxic element was also determined. The influence of thermal treatment on these constituents was investigated as well.

MATERIALS AND METHODS

Unclassified white fish, so called "weed" from "Ečka" fishpond and Danube fish (mixed white fish) included: bream *(Abramis brama)*, barbel *(Barbus barbus L.)*, crucian carp *(Carrassius carrassius)*, catfish *(Ictalurus punctatus Le Seur)*, tench *(Tinca Tinca L.)* and silver carp *(Hypophtalmictys malitrix)*. Dressing, separation and freezing were done at the place of catch or in the industrial processing facility. Mechanically separated fish meat was used for the analysis. Each group of fish was represented with 5 samples.

After thawing, a part of the separated meat was used for immediate determination of chemical composition, total lipids, and composition of fatty acids, microelements and heavy metals. The other part was filled into cans of 150 g and thermally treated by pasteurization ($80^oC\pm2^oC$, 30 min) or sterilization ($118^oC\pm1^oC$, 25 min) ant then subjected to the same analyses. Chemical composition (moisture, fat, protein and ash) was determined in duplicate by AOAC methods (1995). The data are expressed as % of mass.

Total lipids were extracted using the method of Folch et al., (1957). Methyl esters of fatty acids of total lipids were prepared with diazomethane (De Boer and Becker, 1956). A Varian 3400 capillary gas chromatograph with a DB-1, 30 m fused silica capillary column with a programmed heating rate of 6/min, from 60 - 220^oC, a flame ionisation detector and splitsplees injector were used for quantitative analysis. The peaks were identified by comparison of the retention times with methylester standards ("Sigma"-USA, "Fluka"-Germany) run under identical conditions. The fatty acid content is given as the relative contribution of each fraction to the total area of the peaks in the gas chromatograms. A wet ashing procedure was used to prepare the samples for analysis of zinc, iron, cooper and toxic elements (arsenic, cadmium, lead and mercury) (Whiteside and Milner, 1984). Calibrators were prepared from Sigma Atomic Absorption Standards (USA) daily. All the samples were analysed for Cd, Pb, Zn, Fe and Cu by flame AAS (Whiteside and Milner, 1984), for Hg by "cold vapour" AAS, both on a Pye Unicam SP Atomic Absorption Spectrophotometer. Arsenic content was determined photometrically by the "molybdenum blue" method (Ellis, 1991). Data are expressed as ppm.

RESULTS AND DISCUSSION

The average contents of water, fat, crude protein and ash in the saples are shown in Table 1. Meat from fishpond fish contained more protein and less water and fat than meat from mixed white fish from the Danube. Ash content was practically equal. The overall mean value for water content (76.20 % for both groups of fish) was within the range 60 - 80 % reported by Žlender (2000) for fish meat but somewhat lower than the values reported by Jokić *et al.* (1999) for small mixed freshwater fish (78.0 %) and Mustafa and Medeiros (1985) for catfish (77.8 %). However, the mean value of water content for the Danube fish (77.56 %) completely agree with the reported data.

Table 1. Chemical composition for raw, pasteurized and sterilized fishpond fish and Danube fish (mixed white fish), %

Moisture	Raw	Pasteurised	Sterilized
Fishpond fish	74.84	74.26	74.27
Danube fish	77.56	77.12	76.83
Mean	76.20 (1.30)[a]	75.69 (1.25)[a]	75.55 (1.22)[a]
Crude protein	**Raw**	**Pasteurized**	**Sterilized**
Fishpond fish	16.05	16.84	16.67
Danube fish	14.09	14.02	13.68
Mean	15.07 (0.20)[a]	15.43 (0.18)[a]	15.18 (0.15)[a]
Fat	**Raw**	**Pasteurized**	**Sterilized**
Fishpond fish	5.63	5.45	5.12
Danube fish	6.70	6.45	6.45
Mean	6.16 (0.30)[a]	5.95 (0.25)[a]	5.78 (0.25)[a]
Ash	**Raw**	**Pasteurized**	**Sterilized**
Fishpond fish	1.04	1.00	0.98
Danube fish	1.07	1.04	1.09
Mean	1.05 (0.03)[a]	1.02 (0.03)[a]	1.04 (0.03)[a]

[a]- standard deviation

Average protein content for both groups of samples was 15.07 % and ranged within limits found elsewhere 12 - 24 % (Žlender, 2000) and 12.8 - 21.0 % (Baltić and Teodorović, 1997). Jokić *et al.* (1999) reported that small mixed freshwater fish contained 16.7% protein, while Mustafa and Medeiros (1985) reported 15.4 % protein for catfish.

Among the main ingredients for fish meat, the highest variations were found in fat content, not only between different fish species but also within the same species, depending on the season, type of nutrition, age, sex etc. According to Žlender (2000) and Baltić and Teodorović (1997) both groups may be classified as medium fat fish, containing 5.63 % or 6.70 % fat, respectively. Mustafa and Medeiros (1985) determined an average value of 4.5 % (ranging between 3.5 - 5.9 %) for catfish, while Jokić *et al.* (1999) found 4.0 % fat in small mixed white fish.

The average ash content of 1.05 % agrees with the data of Jokić et al. (1999) for small mixed white fish - 1.3 %, Baltić and Teodorović (1997) - 1.0 - 1.5 %, Žlender (2000) - 0.8 - 2.0 % and Mustafa and Medeiris (1985) - 1.2 %.

No differences were found in the contents of water, fat, proteins and ash in the thermally treated samples of fish meat which was expected since that meat was canned before treatment.

The contents of the investigated microelements in the meat of fishpond fish and Danube fish are shown in Table 2. Compared to the Danube fish, fishpond fish contained larger proportions of iron (11.52 and 10.97, respectively), zinc (25.96 and 13.28, respectively) and copper (0.98 and 0.78, respectively) which may be explained as a nutritional effect. The results for the iron content are higher than those reported by Jokić et al. (1999) for mixed white fish - 6 ppm and close to those for catfish - 10.0 ppm (Mustafa and Medeiros, 1985), and fishpond carp and silver carp - 11.0 ppm (Jokić *et al*, 1999). Regarding the zinc content, the obtained values are higher than those found by Mikavica *et al.* (2000) for barbel - 10.08 ppm and carp (fishpond) - 8.21 ppm and by Mustafa and Medeiros (1985) for catfish - 11.0 ppm. The fishpond fishmeat had a higher zinc content than the river fishmeat.

We found few data in the literature regarding the copper content. Mustafa and Medeiros (1985) reported variations for catfish ranging between 0.9 - 4.6 ppm copper depending on the season of the catch.

After the thermal treatment at the temperature of pasteurization, somewhat lower values for the contents for iron, zinc and copper were determined than after sterilization in both groups of fish meat samples.

Table 3 shows the results for toxic element contents in the investigated samples. In all the samples the contents of lead and cadmium were below the analytical limit of detection (< LDL). The contents of arsenic and mercury ranged within the legally permitted quantities in all the investigated samples and were significantly lower than the maximum values allowed As - 2 ppm; Hg - 0.5 ppm) (National regulation-FRY, 1992). The results obtained indicate that the sites of catch, as well as the processing site were remoted enough from potential sources of the toxic elements prevent contamination of the meat through water, soil or air. Also, the low concentrations of toxic elements in those freshwater fish samples indicate that at the time of catch their concentration in the water and surrounding soil through was at a satisfactory level. This is in accordance with the reports of Baltić and Teodorović (1997) that fish meat, being at the end of the food chain, is a suitable indicator of environmental contamination.

Table 2. Mineral content of raw, pasteurized and sterilized fishpond fishand Danube fish (mixed white fish), %

Zn (zinc)	Raw	Pasteurized	Sterilized
Fishpond fish	25.96	21.61	22.15
Danube fish	13.28	17.40	17.14
Mean	19.62 (3.05) [a]	19.51 (3.20) [a]	19.64 (3.15) [a]

Fe (Iron)	Raw	Pasteurized	Sterilized
Fishpond fish	11.52	9.75	10.78
Danube fish	10.97	11.34	11.44
Mean	11.24 (2.05) [a]	10.54 (2.30) [a]	11.11 (2.00) [a]

Cu (Copper)	Raw	Pasteurized	Sterilized
Fishpond fish	0.98	0.71	0.87
Danube fish	0.78	0.53	0.62
Mean	0.88 (0.13) [a]	0.62 (0.10) [a]	0.75 (0.10) [a]

[a] - standard deviation

Table 3. Toxic element content of raw, pasteurized and sterilized fishpond fish and Danube fish (mixed white fish), ppm

As (Arsenic)	Raw	Pasteurized	Sterilized
Fishpond fish	0.08	0.07	0.07
Danube fish	0.15	0.14	0.17
Mean	0.12 (0.02) [a]	0.11 (0.02) [a]	0.12 (0.02) [a]

Cd (Cadmium)	Raw	Pasteurized	Sterilized
Fishpond fish	< LDL*	< LDL*	< LDL*
Danube fish	< LDL*	< LDL*	< LDL*

Pb (Lead)	Raw	Pasteurized	Sterilized
Fishpond fish	< LDL*	< LDL*	< LDL*
Danube fish	< LDL*	< LDL*	< LDL*

Hg (Mercury)	Raw	Pasteurized	Sterilized
Fishpond fish	0.020	0.019	0.020
Danube fish	0.030	0.028	0.028
Mean	0.025 (0.002) [a]	0.023 (0.002) [a]	0.024 (0.002) [a]

* - LDL - lowest detectable limit (0.01 ppm for Cd; 0.03 ppm for Pb)
[a] - standard deviation

Table 4 shows the results for fatty acid content. It appears that the influence of the environment and the way of nutrition had an influence on the fatty acid composition. Thus, the proportion of lower fatty acids was higher in the river fish lipids while the proportions of higher fatty acids were similar in both groups of samples. These results are in accordance with our previous investigations (Bastić and Kočovski, 1998). The most abundant fatty acids were $C_{18:1}$ (40 %) and $C_{18:2}$

Table 4. Fatty acid composition of raw, pasteurized and sterilized fishpond fish and Danube fish (mixed white fish) (% of the total area of the peaks)

Trait[x]	Origin	Raw	Pasteurized	Sterilized
$C_{14:0}$	Fishpond fish	0.1	0.2	0.1
	Danube fish	0.2	0.1	n.d.[y]
$C_{16:0}$	Fishpond fish	1.6	3.0	1.7
	Danube fish	3.4	0.5	1.1
$C_{18:0}$	Fishpond fish	3.0	2.0	3.1
	Danube fish	2.0	2.8	2.6
$C_{20:0}$	Fishpond fish	0.9	1.8	2.5
	Danube fish	1.1	0.9	1.8
Σ SFA	Fishpond fish	5.6	7.0	7.4
	Danube fish	6.7	4.3	5.5
$C_{16:1}$	Fishpond fish	2.3	3.3	3.0
	Danube fish	5.3	4.4	4.8
$C_{18:1}$	Fishpond fish	40.0	16.4	25.0
	Danube fish	39.6	21.0	23.2
$C_{20:1}$	Fishpond fish	4.2	1.7	1.4
	Danube fish	3.0	1.0	2.2
Σ UFA	Fishpond fish	46.5	21.4	29.4
	Danube fish	47.6	26.4	30.2
$C_{18:2}$	Fishpond fish	10.5	1.6	1.9
	Danube fish	10.0	1.0	0.6
$C_{18:3}$	Fishpond fish	3.0	1.9	2.3
	Danube fish	2.3	4.0	1.7
$C_{20:2}$	Fishpond fish	0.5	1.6	0.1
	Danube fish	1.1	0.2	0.3
$C_{20:3}$	Fishpond fish	0.2	0.8	trace
	Danube fish	trace	trace	n.d.[b]
Σ PUFA	Fishpond fish	14.2	5.9	4.3
	Danube fish	13.4	5.2	2.6
PUFA/ SFA	Fishpond fish	2.53	0.84	0.58
	Danube fish	2.00	1.21	0.47

x) SFA - saturated fatty acid; UFA - unsaturated fatty acid; PUFA - polyunsaturated fatty acid
y) n.d. - not detected

(10 %), which confirms the finding of Meed and Fulco (1976) that freshwater fish lipids contain more C_{18} unsaturated and polyunsaturated fatty acids, and less C_{20} - C_{22} polyunsaturated fatty acids than seafish lipids. Although among omega - 3 fatty acids only $C_{18:3}$ was detected (3.0 and 2.3 %, in fishpond fish and river fish, respectively), it should be mentioned that among the omega - 6 essential fatty acids (EFA) found besides $C_{18:2}$, there were also $C_{20:2}$ and $C_{20:3}$. Their relative effect to linoleic acid ($C_{18:2}$ -6) was 46 and 102 (Meed and Fulco, 1976).

Thermal treatment reduced the polyunsaturated to saturated fatty acid ratio as follows: pasteurization of fishpond fish from 2.53 to 0.84 and of Danube fish from 2.00 to 1.21 while sterilization led to as value of 0.58 for fishpond fish 0.47 for river fish.

On the basis of the results obtained it can be concluded that there are some differences in the chemical composition, contents of microelements and composition of saturated and unsaturated fatty acids depending on the origin of the fish (fishpond or river). Thermal treatment decreased the polyunsaturated to saturated fatty acid ratio in both groups of investigated samples. There were no significant differences in the contents of toxic elements and in all the investigated samples they were within the norms defined by the legal regulations.

Finally, these results for chemical composition, zinc and essential fatty acid contents indicate that, although certain differences occured, meat of both groups of fish represents a nutritively valuable foodstuff and may be used for making high quality nutritious products for human consumption (pates, spreads etc.).

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KVALITET MESA NEKIH SLATKOVODNIH RIBA - NUTRITIVNI I TEHNOLOŠKI ASPEKTI

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SADRŽAJ

Cilj ovog rada je bio da se utvrdi da li postoje razlike u sastavu masnih kiselina, mikroelemenata i teških metala značajnih za ishranu ljudi u mesu slatkovodne bele ribe iz ribnjaka i vodotokova. Osim toga, ispitivan je i uticaj termičke obrade na sadržaj i sastav masnih kiselina. Ispitivani su karaši iz ribnjaka (korov) i mešana bela riba iz Dunava. Sadržaj ukupnih lipida iznosio je 5,16 % u ribama iz ribnjaka i 5,81% u ribama iz Dunava. Niže masne kiseline su bile zastupljenije u lipidima rečne ribe, dok su više masne kiseline podjednako zastupljene u obe grupe uzoraka. Termička obrada je uticala na smanjenje odnosa polinezasićenih prema zasićenim masnim kiselinama i to od 2,53 do 0,58 za ribe iz ribnjaka i od 2,00 do 0,47 za rečnu ribu. Sadržaj toksičnih elemenata u mesu riba kretao se u dozvoljenim okvirima. Sadržaj gvožđa, bakra, i cinka u mesu riba iz ribnjaka i Dunava iznosio je: 11,52 i 10,97; 0,98 i 0,78; 25,96 i 13,28 mg/kg, respektivno.