

Fatty acid composition of lipids in the carp (*Cyprinus carpio* L.) grown in different production systems

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The fatty acid composition of lipids in carps grown in earthen ponds (Fish-Farming Experimental Facility in Trivoditsi village), natural waters (free aquatory of Bistritsa reservoir) and net-cages (cage farm situated in the same reservoir) was analyzed by gas liquid chromatography. The oleic C18:1, palmitic C16:0 and linoleic C18:2, ω -6 acids with percent shares of 27.73 %, 22.97 % and 13.60 %, prevailed in fats extracted from meat of carps grown in Trivoditsi pond, while in triglyceride fraction of carps grown in free waters of Bistritsa reservoir the percentages of the same acids amounted to 33.97 %, 18.70 % and 23.37 % correspondingly. The content of saturated fatty acids varied from 21.63% to 37.33 % and that of unsaturated ones from 62.67 % to 78.37 %. In lipids of carps grown in earthen ponds (Trivoditsi village) the level of polyunsaturated eicosapentaenoic acid (C20:5, ω -3) was higher than in two other investigated carp groups.

The technology of breeding influenced the fatty acid profile of carp lipids mainly by type of applied fodder and abundance of available planktonic organisms.

Key words: *Cyprinus carpio* L., lipids, fatty acid composition.

INTRODUCTION

Fish fats are distinguished by big diversity of fatty acids composing them. The content of unsaturated fatty acids varies from 70 to 83 % and that of saturated ones from 17 to 30 %. As a consequence of this the human body absorbs the fish fats very well. Particularly well presented are the acids with 18, 20 and 22 carbon atoms and the ω -3 fatty acids (FA) – linoleic, linolenic and arachidonic, which, being of highest biological value are marked as essential ones.

According to availability of single fatty acids the lipids extracted from meat of two-year-old carps are either from oleic-linoleic-palmitic-oleic-palmitic-linoleic type where by the content of saturated fatty acids ranged between 22.0 – 34.3 % and of unsaturated ones between 65.7 – 78.0 %. Hadjinikolova [1], Cirkovic and coworkers [2] and Trbovich and coworkers [3] in their comparative studies pointed out the effect of breeding technologies and type of applied fodder on meat quality and FA profile of carp lipids.

In relation to the foregoing the goal of this work is to study the FA composition of meat of carps grown in different production systems by three breeding technologies.

EXPERIMENTAL

The fatty acid composition of lipids in scaly carp (*Cyprinus carpio* L.) of market size bred under conditions of three different technologies, which characteristics are presented on Table 1 is studied.

The fish grown in earthen ponds of the Fish Farming Experimental Facility in Trivoditsi village is fed with sunflower meal and grain, while extruded fish fodder and grain – wheat and screenings in ratio 70:30 are fed to fishes in free aquatory of Bistritsa reservoir. The fishes of the third experimental group held in net - cages in the same reservoir are fed with extruded fish fodder with 25 % protein and 12 % fat content.

During the experiment in the period May-October 2012 the physicochemical characteristics of the aquatic environment are recorded on monthly intervals. The measured water temperature, pH and concentration of dissolved oxygen were within the technological norms for carp ponds ensuring proper growing conditions.

For investigation a representative number of fishes are taken at random. The weight of single fishes caught in October 2012 varies between 810 – 1159 g. For analysis the individual samples are prepared from fish musculature (the lateral muscle) taken from one and the same position after removal of the skin and subsequent homogenization of the meat.

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Table 1. Characteristics of investigation production systems (sites).

Site/ Characteristics	Tri voditsi 2 Earthen pond No 10	Bistritsa reservoir Free aquatory	Bistritsa reservoir Net-cage farm
Area, dka	45	204	80
Volume, m ³	58 500	714000	320000
Depth, m	1.3	3.5	4.0
Degree of technology intensification	Semi-intensive carp rearing	Semi-intensive carp rearing	Intensive carp rearing

The fatty acid composition of lipids is determined by gas chromatography (GC) after transmethylation of the respective sample with 2 % H₂SO₄ in absolute CH₃OH at 50°C [4]. Fatty acid methyl esters (FAME) are purified by thin-layer chromatography (TLC) on 20x20 cm plates covered with 0.2 mm silica gel 60 G layer (Merck, Darmstadt, Germany) with mobile phase n-hexane: diethyl ether (97:3, v/v). GC is performed on a HP 5890 series II (Hewlett Packard GesmbH, Vienna, Austria) gas chromatographer equipped with a 60 m x 0.25 mm (I.D.) x 25 µm (film thickness) capillary DB - 23 column (Agilent J&W advanced, Agilent Technology, USA) and a flame ionization detector. The column temperature is programmed from 130°C (1 min), at 6.5°C/min to 170°C, at 3.0°C/min to 215°C (12 min), at 40°C/min to 230°C (3 min); injector and detector temperatures are kept at 270°C and 280°C. Hydrogen is the carrier gas at a flow rate 0.8 mL/min; split was 1:50. Identification of fatty acids is performed by comparison of retention times with those of a standard mixture of fatty acids subjected to GC under identical experimental conditions [5]. The analytical standard of fatty acid methyl esters (SUPELCO F.A.M.E. Mix C4-C24, purity ~99 %) is from Sigma-Aldrich Chemical Co. (St. Louis, MO, USA). All solvents and reagents are of analytical grade from Merck (Darmstadt, Germany) and are used without additional purification.

RESULTS AND DISCUSSION

The fatty acid composition data of lipids extracted from carp meat are presented in Table 2. The fatty acid composition of carps from earthen ponds in Trivoditsi village shows bigger shares for oleic C18:1 (27.73 %), palmitic C16:0 (22.97 %) and linoleic C 18:2, ω-6 (13.60 %) acids. The percentages of palmitoleic C16:1 (4.23 %), stearic C18:0 (7.37 %), linolenic C18:3, ω -3 (1.60 %), eicosapentaenoic C20:5, ω-3 (4.93 %), behenic C22:0 (3.73 %), and docosahexaenoic C22:6, ω-3 (6.12 %) acids are in the range from 1.60 % to 7.37 %. The percent shares of the remaining fatty acids are around or under 1.0 %. The level of unsaturated acids amounts to 62.67 % and of saturated ones to

37.33 % correspondingly. The content of monounsaturated fatty acids is in the range of 34.06 % and of polyunsaturated fatty acids is about 28.61 % correspondingly. The ratio of ω -6 to ω -3 polyunsaturated FAs is 1.24:1. According to availability of single FAs the lipids extracted from fish meat are from oleic-palmitic-linoleic type.

In the triacylglycerol fraction of fats extracted from meat of carps grown in the free aquatory of Bistritsa reservoir the percentages of oleic C18:1, linoleic C18:2, ω -6 and palmitic C16:0 acids are 33.97 %, 23.37 % and 18.70 %. The percent shares of palmitoleic C16:1 (3.77 %), stearic C 18:0 (5.53 %), linolenic C18:3 w-3 (3.03 %), eicosapentaenoic C20:5 w-3 (2.07 %) and docosahexaenoic C22:6 w-3 (2.40 %) acids vary in the range of 2.07 % to 5.53 %. The percentages of remaining fatty acids are around and under 1.0 %.

The content of unsaturated fatty acids (72.40 %) is 2.5 times more than that of saturated fatty acids (27.60 %) and the ratio between contents of monounsaturated to polyunsaturated fatty acids is 1.2:1. The total percentage of ω -6 polyunsaturated fatty acids is 25.20 %. The linolenic C18:2 acid with 23.37 % takes the biggest share from them. The content of ω -3 fatty acids is 7.50 %. They are presented by approximately equal quantities of linolenic C18:3 (3.03 %), eicosapentaenoic C20:5 (2.07 %) and docosahexaenoic C22:6 (2.40 %) acids. According to the shares of single fatty acids extracted from the fish meat the lipids are of oleic-linoleic-palmitic type.

The triacylglycerol fraction of lipids extracted from meat of carps grown in net-cages positioned in Bistritsa reservoir consists from three basic components - the oleic C18:1 (37.90 %), linoleic C18:2, ω-6 (28.10 %) and palmitic C16:0 (15.03 %) acids. The palmitoleic C16:1 (3.07 %), stearic C18:0 (4.73 %), linolenic C18:3, ω-3 (2.83 %), eicosenoic C20:1 (1.33 %), eicosapentaenoic C20:5, ω-3 (1.10 %) and docosahexaenoic C22:6, ω-3 (1.77 %) acids vary in the range from 1.10 % to 4.73 %. The content of the remaining fatty acids is under 1.0 %. The percentage of unsaturated fatty acids (78.37 %) prevails in the analyzed lipid samples. The percent of monounsaturated fatty

Table 2. Fatty acid (FA) composition of analyzed carp samples, (n=3).

Fatty acids, % wt	Breeding facilities and technologies					
	Tri voditsi 2 Earthen pond No 10		Bistritsa reservoir Free aquatory		Bistritsa reservoir Cage farm	
	x ± Sx	Cv	x ± Sx	Cv	x ± Sx	Cv
C 8:0	0.13 ± 0.041	43.301	0.00 ± 0.00	0.00	0.00 ± 0.00	0.00
C 12:0	0.13 ± 0.041	43.301	0.10 ± 0.00	0.00	0.10 ± 0.00	0.00
C 14:0	1.40 ± 0.324	32.733	1.17 ± 0.163	19.795	0.90 ± 0.10	0.071
C 14:1	0.20 ± 0.00	0.00	0.10 ± 0.00	0.00	0.10 ± 0.00	0.00
C 15:0	0.57 ± 0.041	10.189	0.33 ± 0.147	62.450	0.17 ± 0.041	36.641
C 16:0	22.97 ± 1.145	7.052	18.70 ± 1.485	11.230	15.03 ± 1.219	11.470
C 16:1	4.23 ± 0.642	21.434	3.77 ± 0.531	19.926	3.07 ± 0.147	6.788
C 17:0	0.33 ± 0.082	34.641	0.23 ± 0.082	49.487	0.10 ± 0.00	0.00
C 17:1	0.47 ± 0.041	12.372	0.33 ± 0.082	34.641	0.17 ± 0.041	34.641
C 18:0	7.37 ± 0.426	8.182	5.53 ± 0.432	11.042	4.73 ± 0.414	12.379
C 18:1	27.73 ± 2.628	13.401	33.97 ± 1.809	7.531	37.90 ± 1.768	6.596
C 18:2 (ω-6)	13.60 ± 1.098	11.415	23.37 ± 2.780	16.823	28.10 ± 1.377	6.928
C 18:3 (ω-6)	0.23 ± 0.041	24.744	0.37 ± 0.041	15.746	0.47 ± 0.041	12.372
C 18:3 (ω-3)	1.60 ± 0.255	22.535	3.03 ± 0.294	13.725	2.83 ± 0.294	14.694
C 20:0	0.10 ± 0.00	0.00	0.13 ± 0.041	43.301	0.10 ± 0.00	0.00
C 20:1	1.23 ± 0.082	9.362	1.30 ± 0.245	26.647	1.33 ± 0.286	30.311
C 20:2 (ω-6)	1.00 ± 0.00	0.00	0.73 ± 0.041	7.873	0.50 ± 0.071	20.000
C 20:3 (ω-3)	0.10 ± 0.00	0.00	0.00 ± 0.00	0.00	0.00 ± 0.00	0.00
C 20:4 (ω-6)	1.03 ± 0.041	5.587	0.73 ± 0.082	15.746	0.73 ± 0.041	7.873
C 20:5 (ω-3)	4.93 ± 0.817	23.406	2.07 ± 0.535	36.638	1.10 ± 0.187	24.052
C 22:0	3.73 ± 0.349	13.213	1.10 ± 0.510	65.556	0.30 ± 0.071	33.333
C 22:1	0.20 ± 0.00	0.00	0.23 ± 0.108	65.465	0.30 ± 0.00	0.00
C 23:0	0.10 ± 0.00	0.00	0.11 ± 0.071	47.141	0.07 ± 0.01	14.286
C 24:0	0.50 ± 0.082	20.377	0.20 ± 0.071	50.000	0.13 ± 0.041	43.301
C 22:6 (ω-3)	6.12 ± 1.824	41.381	2.40 ± 0.534	31.458	1.77 ± 0.634	50.733
Saturated FA	37.33 ± 1.735	6.574	27.60 ± 2.839	14.547	21.63 ± 0.909	5.944
Unsaturated FA	62.67 ± 1.735	3.916	72.40 ± 2.839	5.546	78.37 ± 0.909	1.641
Monounsaturated FA	34.06 ± 3.051	12.702	39.70 ± 1.243	4.428	42.87 ± 1.559	5.145
Polyunsaturated FA	28.61 ± 1.344	6.620	32.70 ± 1.598	6.913	35.50 ± 0.951	3.790
Σω-6	15.86 ± 1.064	9.482	25.20 ± 2.807	15.734	29.80 ± 1.310	6.215
Σω-3	12.75 ± 2.452	28.578	7.50 ± 1.227	23.133	5.70 ± 0.367	9.116
Ratio Σω-6:Σω-3	1.24 ± 0.354	35.714	3.36 ± 1.105	43.390	5.23 ± 0.535	14.377

acids (42.87 %) is higher than of polyunsaturated ones 35.50 %. In the composition of polyunsaturated fatty acids the percent of ω-6 fatty acids (29.80 %) is higher at the expense of the ω-3 fatty acids (5.70 %) whereby the ratio ω-6:ω-3 polyunsaturated fatty acids is 5.23. According to the shares of single fatty acids extracted from the fish meat the lipids are of oleic-linoleic-palmitic type.

The data analysis shows, that three basic components of triacylglycerol fraction of carps grown under conditions of three breeding technologies are palmitic acid C16:0 (from 15.03 % net-cages in Bistritsa reservoir to 22.97 % earthen ponds in Trivoditsi village); oleic acid C18:1 (from 27.73 % earthen ponds in Trivoditsi village to 37.90

% cages in Bistritsa reservoir) and linoleic acid C18:2 ω-6 (from 13.60 % earthen ponds in Trivoditsi village to 28.10 % net-cages in Bistritsa reservoir).

It is proved that according to shares of single fatty acids the lipids extracted from the meat of two-year-old carps are of oleic-linoleic-palmitic type (in free aquatory and cages of Bistritsa reservoir) and of oleic-palmitic-linoleic-type (in earthen pond in Trivoditsi village), where by the content of saturated fatty acids varies in the range 21.63 - 37.33 % and of unsaturated ones between 62.67 - 78.37 %. The individual fatty acid profile is affected by applied fodders in different breeding technologies. The obtained results are comparable with those reported by Hadjinikolova [1] in her

investigation of fatty acid composition of the carp. They also are consistent with the investigations of Cirkovic and coworkers [2] and Trbivic and coworkers [3] proving the influence of breeding technologies and type of applied fodder on fatty acid profile of carp lipids.

According to the guidelines of World Health Organization it is assumed that raw materials and natural products with ω -6: ω -3 fatty acid ratios lower than 5.0 are of low risk for human health. To this group belongs the meat of fishes reared in the earthen pond No 10 in Trivoditsi village and in the free aquatory of Bistritsa reservoir, while the ratio of fish group from net-cages of Bistritsa reservoir is 5.23.

The lipids of carp grown in earthen type ponds (Trivoditsi village) have relatively high percentage of polyunsaturated eicosapentaenoic C20:5, ω -3 (4.93 %), which content is 2-12 times higher than in two other investigated carp groups. Most probably this is due to the good natural food basis of the pond and good trophic level of zooplankton, which are properly supplementing the fish diet of fodder (sunflower meal and grain). This fact proves that breeding technologies including good development of planktonic organisms favor synthesis of eicosapentaenoic acid C20:5 ω -3, what is consistent with the studies of Mráz and coworkers [6].

CONCLUSION

The breeding technology affects the fatty acid profile of carp lipids mainly by type of applied fodder and degree of development of planktonic organisms.

The individual fatty acid profile of carp lipids from investigated groups is of oleic-linoleic-palmitic and oleic-palmitic-linoleic- type. The content of saturated fatty acids is in the range 21.63 - 37.33 % and of unsaturated ones - 62.67 - 78.37 %.

It is proved that the percentage of polyunsaturated eicosapentaenoic acid C20:5, (ω -3) in lipids of carp grown in earthen type ponds (Trivoditsi village) is several times higher than its content in the other investigated carp groups coming from free aquatory and net-cage farm in Bistritsa reservoir.

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МАСТНОКИСЕЛИНЕН СЪСТАВ НА ЛИПИДИ ОТ ШАРАН (*CYPRINUS CARPIO* L.) ОТГЛЕЖДАН В РАЗЛИЧНИ ПРОИЗВОДСТВЕНИ СИСТЕМИ

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(Резюме)

Анализиран е мастнокиселинният състав на липиди, изолирани от шаран, отглеждан в землени басейни (рибно-експериментална база в с. Три водици), в свободна акватория на язовир „Бистрица” и в садковите установки на същия язовир чрез газова хроматография. Олеиновата C_{18:1} (27,73%), палмитиновата C_{16:0} (22,97 %) и линоловата C_{18:2}, ω-6 (13,60 %) киселини преобладават в мазнината от месото на шаран, отглеждан в басейна на с. Три водици, докато в триацилглицероловата фракция, изолирана от шаран, отглеждан в язовир „Бистрица” количеството на тези киселини е съответно 33,97 %, 18,70 % и 23,37 %. Количеството на наситените мазнини варира от 21,63% до 37,33 %, а на ненаситените мастни киселини от 62,67 % до 78,37 %. В липидите от шаран, отглеждан в в басейна на с. Три водици количеството на полиненаситената ейкозапентаенова киселина (C_{20:5}, ω-3) е по-високо в сравнение с това в липидите на шарани, отглеждани в другите две производствени системи.

Технологията на отглеждане, която включва основно вида на фуража, използван за храна и вида на наличните планктонни организми оказва влияние върху мастнокиселинния състав на липидите, изолирани от месото на шарани, отглеждани в различни производствени системи.