www.trjfas.org
ISSN 1303-2712
Turkish Journal of Fisheries and Aquatic Sciences 17: 395-403 (2017) DOI: 10.4194/1303-2712-v17_2_19

RESEARCH PAPER

A Comparative Study on the Quality of Scaly and Mirror Carp (Cyprinus carpio L.) Cultivated in Conventional and Organic Systems

Dessislav K. Balev[1], Dessislava B. Vlahova-Vangelova[1,*], Pepa S. Dragoeva[1], Lyudmila N. Nikolova[2], Stefan G. Dragoev[1]

[1] University of Food Technologies, Meat and Fish Technology, Plovdiv, Bulgaria.
[2] Agricultural University, Animal Science, Plovdiv, Bulgaria.

* Corresponding Author: Tel.: +359.887298236;
E-mail: desislava_vangelova@abv.bg

Received 28 July 2016
Accepted 19 October 2016

Abstract

The objective of this study was to compare the quality of meat from scaly and mirror varieties of local population carp (*Cyprinus carpio* L.). The experiment was carried out with two of fish: cultivated in conventional system - the carp was fed with 4.5 kg wheat per kg of fish growth and cultivated in organic system – the carp was fed with natural food from the ponds. In comparison to the conventional systems, the meat obtained from organic cultivated carp (*Cyprinus carpio* L.), was with 0.2 – 0.4 more alkaline pH; 1.5 – 2.0% higher water holding capacity; 0.7 – 1.3% higher total lipid content; 2.4 - 4.1% higher PUFAs concentration; 0.13 – 0.14 % higher lypolitical activity; 10.8 - 23.3% higher color redness (*a**); 1.1 - 6.7% lower brightness of the color (*L**) and 52.7 - 72.7% lower color yellowness (*b**). The organic cultivated fresh and grill carp meat were assessed with 19 to 34% higher overall sensory scores resp. fish. The cultivation of carp in conventional system can be successfully replaced by organic cultivation.

Keywords: Natural feed, fatty acid composition, sensory properties, water holding capacity, free fatty acids, lipid oxidation.

Introduction

A large part of world carp production belongs to aquaculture, and the largest share (at about 80%) belongs to China (Teng et al., 2007). Far behind it, Indonesia, Vietnam, European Union, Russia, Bangladesh and Brazil can be identified as major producers. Throughout the European Union carp is a traditional dish (Ötles et al., 2010). Producers are trying to diversify the supply by opening small processing plants for semi-finished products (different types of fresh or smoked carp) and products prepared according to traditional recipes (Roberts et al., 1995). The aquaculture industry of thermophilic freshwater fish in Bulgaria is based on cultivation mainly of common carp (Zaykov, 2008).

The aquaculture from local population carp (*Ciprinus carpio* L.) cultivated in different aquatic systems may differ in terms of their growth, metabolism nutritional value, dietary qualities and technological properties of fish meat (Atanasov et al., 2009; Buchtová et al., 2010). More research is required to assess the impact of various technological approaches aimed at increasing fish quality (Nikolova, 2013).

Reproduction of carp is most often performed in hatcheries. After hatching, the larvae are transferred to small shallow pools or ponds with water rich in plankton, a sufficient food for the young carp (Zaykov, 2008). Thereafter the fish receive nutritional supplements, most commonly from grain or other mixed feed.

The carp is fishing yearly for direct consumption or for re-stocking of ponds for angling (Tokur et al., 2006). Most of the carp in Bulgaria is sold around St. Nicholas day and, therefore, most often stored in clean water, which improves the taste qualities before sale (Zaykov, 2008). Fish with a length 30-50 cm and weight 1.5 - 3.0 kg is most frequently offered on the market (Koehn, 2004). In the conditions of European climate, carp needed 3-4 years to reach these dimensions (Driver et al., 2005). Carp breeding is most frequently of a semi-intensive nature. Carp can be grown in mono- and multicultural (together with other freshwater species, such as pike, catfish or silver carp) or as part of a wider range of agricultural activities (Kestemont, 1995). The water basins, where carp is bred, often play an important role in enhancing biodiversity, water retention and flood protection (Dudgeon et al., 2006; Lavado et al., 2006).

Intensive technologies for fish farming are characterized by the following principles: growing highly productive species with large stocking density; feeding with a balanced feed without natural food; a

suitable hydrochemical regime; automation of production processes; elimination of seasonality in fish realization (Wetengere, 2011). These aquaculture systems have been criticized because lead to reduction of wild fish by changing its habitat (Naylor et al., 2000).

In recent years, the organic aquaculture in Europe and in particular in Bulgaria is developing quickly (Ötles et al., 2010). One possible reason is the existing acute shortage of research concerning issues in organic fish production (Ötles et al., 2010). It is a systematic study which would allow the development of norms and technological standards for organic aquaculture, taking into account the specificity of our region and production, as are the recommendations of the European Commission (Mente et al., 2011).

In organic production, fish of native species, which is more adapted to growing conditions, is preferred. A major aquaculture species from thermophilic freshwater fish, cultivated in Bulgaria is carp. For this reason, carp is the most suitable fish for organic production methods (Atanasova et al., 2008; Nikolova, 2013). It can be fattened in two-year and three-year cycles. The standards for the organic aquaculture in Europe require not less than 50% of output to be at the expense of natural food that develops in the water basins.

This study was aimed to survey the quality of Bulgarian local population carp under cultivation in a two-year cycle and compliance with the European standards for organic aquaculture. The planning of the organic production requires exact knowledge of the species' productivity and quality used which should comply with the EU requirements for carp farms. That is why, the objective of the study was to compare the quality of two varieties (scaly and mirror) of local population two-year common carp (*Cyprinus carpio* L.) cultivated in two different pond systems: conventional (carp fed with wheat addition) and organic one (carp fed with natural food, which has developed on its own in the water basins).

Materials and Methods

Fish Cultivation and Feeding

Two-year-old scaly and mirror common carp (*Cyprinus carpio* L.), (age 2+) of average weight of 1169±52 g and average total length 312.6±11 mm were delivered from the Experimental Fish Farm of the Institute of Fisheries and Aquaculture in Plovdiv, Bulgaria. The carp were divided into four groups: two control groups, CSC (control group scaly carp) and CMS (control group mirror carp), cultivated in conventional system in 3 ponds: 1, 2 and 3 and an two experimental groups, and two experimental croups: ESC (experimental group scaly carp) and EMS (experimental group mirror carp), cultivated in organic system in other 3 ponds: 4, 5 and 6. One and the same stocking density has been used in all experimental ponds: 1000 pcs.ha^{-1} one-year old carp (*Cyprinus carpio L.)*. All the ponds were supplemented with cattle manure (3000 kg.ha-^{1}).

The fish were fed as follows: control groups CSC and CMS with 4,5 kg wheat for increasing with 1 kg live weight; and experimental groups ESC and EMS - fed with a natural food that naturally has developed in the ponds without adding another food. The study was conducted during one vegetation period - from April to October. After that 40 carps were randomly selected from each group, slaughtered and measured for body length (with an accuracy of 0.1 mm) and for body weight (with an accuracy of 1 g) to determine overall body weight and to calculate mean body weight gains and mean individual gains.

Ponds' Water Quality

For the purposes of the experiment, six carp ponds have been used, with a total area of 1.73 ha, divided into two groups:

First group (ponds 1; 2; 3) for conventional cultivation (CSC and CMC) with 4.5 kg wheat feeding per kg of fish growth;

Second group (ponds 4; 5; 6) for organic cultivation (ESC and EMC) with natural food from ponds.

The physicochemical parameters of the water in the experimental ponds are presented in Table 1.

Sample Preparation

Samples for analysis were prepared immediately after fish catch and before the occurrence of rigor mortis. The average laboratory sample, including light fish musculature without skin and bones, was grinded twice by a mincer with a diameter of the grid holes 5 mm. The minced samples were stored in air- and moisture impermeable containers. Sampling was carried out following the Official Methods of Analysis of AOAC International (Latimer, 2012). After each grinding a careful mixing was conducted. The separate portions from the ground average sample were taken for analysis of the chemical parameters. Samples were packed into plastic bags and stored for 24 h at 0 - 4°C. Samples for GC analysis were prepared in a different manner. Immediately prior to analysis, deboned carp meat was divided into portions weighing about 500 g and each group was mixed thoroughly in electric homogenizer EB3251S (HKTDC, Xiamen, China) for 10 min. The final temperature of the samples was 12ºC. Each sample was weighed in 100 g portions. Each primary sample was wrapped in barrier film VerPack, type Colamin V-40 (Apostolidis K. & Co Ver Pack, Thessaloniki, Greece). The coated samples were placed in plastic containers with lids and stored in a refrigerator up to 12 h, until the time of their detection (Wilkes et al., 2000).

Determination of pH Value

After mixing 10 g of sample in 90 mL of be distilled water, the pH of the samples was measured with a pH-meter MS 2004 (Microsyst, Plovdiv, Bulgaria) equipped with a combined pH electrode S 450 CD (Sensorex pH Electrode Station, Garden Grove, USA) (Young et al., 2004).

Determination of Water Holding Capacity

WHC of fish meat was established following the procedure described by Modzelewska-Kapitula and Cierach (2009), which modifies the method of Grau & Hamm, 1953. The principle of the method consists in water removal from the test fish tissue under pressure, and further its absorption in the filter paper. The quantity of the "free" water was calculated by integration of the spot area formed by liquid adsorbed in the filter paper.

Determination of Total Volatile Nitrogen Compounds

The sample consisted of about 100 g fish flesh taken from at least three different points and mixed by grinding. TVN were determined by steam distillation with direct steam and captured in an acid solution with familiar concentration. The amount of TVN was determined calorimetrically with Nestlers' reagent (Antonacopoulos and Vyncke, 1989).

Extraction of Total Lipids

The extraction of total lipids from fish musculature was carried out by the Bligh and Dyer method, following recommendations of Iverson et al. (2001). A hundred g of sample was homogenized with 100 mL chloroform and 200 mL methanol (monophasic system). The solution was rehomogenized with 100 mL chloroform, following which 100 mL of either distilled water or weak salt solution (0.88% NaCl) was added. After filtration was performed under suction, the final biphasic system was allowed to separate into two layers and the lower (chloroform) phase was collected. For quantitative lipid extraction, the tissue residue was then rehomogenized with 100 mL chloroform, filtered, and the filtrate was added to the lower phase collected. Lipid content was then determined gravimetrically after evaporating a measured aliquot of the combined chloroform phase to dryness under nitrogen.

Determination of Fatty Acid Composition

The preparation of FAMEs was carried out based on the procedure of Ichihara and Fukubayashi (2010). Gas chromatography of FAMEs was held on

Table 1. Physicochemical parameters of the water in the experimental ponds

Parameters		Pond No					
		1	2	3	4	5	6
Temperature, ^{o}C	min	14.20	14.00	13.20	13.90	14.00	14.10
	max	25.00	26.90	23.90	24.10	24.90	24.00
	average	19.60	21.00	19.10	19.70	19.80	19.50
pH value	min	7.30	7.30	7.40	7.30	7.40	7.40
	max	8.50	8.60	8.40	8.60	8.60	8.60
	average	7.90	7.80	7.90	7.90	7.90	7.90
O_2, $mg.L^{-1}$	min	1.80	2.60	1.30	1.20	1.90	1.70
	max	16.00	11.40	13.60	15.20	16.30	14.80
	average	7.40	6.10	4.70	4.90	7.30	7.40
$N\text{-}NH_4^+$, $mg.L^{-1}$	min	0.12	0.12	0.11	0.11	0.12	0.11
	max	0.38	0.39	0.41	0.41	0.39	0.40
	average	0.22	0.23	0.24	0.23	0.22	0.22
$N\text{-}NO_3$, $mg.L^{-1}$	min	0.42	0.69	0.50	0.42	0.53	0.34
	max	6.84	1.40	1.80	4.44	2.75	6.94
	average	1.84	0.96	1.06	1.37	1.14	1.86
TN, $mg.L^{-1}$	min	0.63	0.89	0.79	0.53	0.65	0.56
	max	5.98	1.79	2.21	4.85	3.14	7.34
	average	1.96	1.19	1.30	1.60	1.36	2.08
NH_3, $mg\ .\ L^{-1}.10^{-2}$	min	0.35	0.28	0.33	0.24	0.22	0.45
	max	2.24	1.45	2.31	2.31	2.24	2.24
	average	1.12	0.82	1.00	0.91	0.89	1.19
$P\text{-}PO_4$, $mg.L^{-1}$	min	0.09	0.11	0.19	0.17	0.06	0.06
	max	0.66	0.31	0.46	0.67	0.43	0.47
	average	0.34	0.25	0.29	0.32	0.28	0.27
Oxidisability, $mg.L^{-1}$	min	5.70	5.20	5.60	5.20	4.80	5.54
	max	15.80	14.65	16.40	13.09	9.20	13.20
	average	10.35	9.64	9.89	10.46	7.49	7.66

Shimadzu GC-MS-17A (Shimadzu GmbH, Duisburg, Germany) equipped with CP wax 52CB capillary column (30 x 0.25 mm x 0.25 m) (Varian Chrompak, Middelburg, The Netherlands) equipped with a FID and Shimadzu ER-5A integrator (Shimadzu GmbH, Duisburg, Germany). As a carrier gas was used nitrogen at a rate 0.8 $cm^3.min^{-1}$ and power dividers 80:1. The gradient of the temperature was from 165 to 230°C, with a speed of $4°C.min^{-1}$. The samples were held at that temperature for 20 min. The temperature of the injector and detector were 260 and 280°C respectively. FAMEs were identified by comparison with the retention time of FAMEs commercial standards analyzed under the same experimental conditions. Each sample at the FAMEs analysis was analyzed in triplicate. The means and standard deviations of data are presented in Table 2. The preparation of fatty acid 4,4-dimethyloxazoline (4,4-DMOX) esters was conducted by the procedure of Svetashev (2011). For this purpose a gas chromatograph Agilent 6890 Plus System (Agilent Technologies, Santa Clara, USA) equipped with a 5793 Mass Selective Detector (Agilent Technologies, Santa Clara, USA) and a capillary column 30.00 m x 0.25 mm x 0.25 cm SP 2380 (Supelco, Belefonte, USA) was used.

Determination of Free Fatty Acids

The hydrolytic degradation of fish lipids was expressed by percentage of free fatty acids (FFA), which was determined using traditional titration method described by AOCS (Bernárdez et al., 2005).

Determination of TBARS

Two-thiobarbituric acid reactive substances (TBARS) were determined by the method described by Botsoglou et al. (1994). The absorbance of samples was measured with a uv-vis spectrophotometer Camspec M550 (Camspec, Cambridge, UK) at 432 nm.

Measurement of Color Characteristics

Color characteristics of the light carp muscles were determined by CIE Lab method (Christiansen et al., 1995). The colorimeter CR-410 (Konica Minolta Holding, Inc., Ewing, USA) supplied by the Sending Inc. (Tokyo, Japan) was used.

Sensory Analysis

Organoleptic characteristics of the fish samples were determined using a five member panel with proven tasting abilities. The members of the panel have filled out their assessments in tasting sheets with five grade scale. Descriptive characteristics for each of the grades were presented separately (Johnsen and Kelly, 2004).

Table 2. Effect of organic cultivation of mirror and scaly common carp (*Cyprinus carpio* L.) on the fatty acid composition of the total lipids extracted from light musculature

	Control groups		Experimental groups	
Fatty acids, %	CMC	CSC	EMC	ESC
C 10:0	Not identified	Not identified	0.06 ± 0.05	Not identified
C 12:0	1.27 ± 0.08^{a}	1.24 ± 0.10^{a}	1.47 ± 0.13^{b}	1.70 ± 0.14^{b}
C 14:0	0.23 ± 0.06^{b}	0.14 ± 0.04^{a}	0.37 ± 0.13^{b}	0.33 ± 0.09^{b}
C 16:0	21.65 ± 0.74^{b}	21.07 ± 0.66^{ab}	20.12 ± 0.70^{a}	21.86 ± 0.82^{b}
C 16:1	8.53 ± 0.27^{a}	8.03 ± 0.26^{a}	10.69 ± 0.14^{b}	10.71 ± 0.33^{b}
C 17:0	0.21 ± 0.07^{ab}	0.15 ± 0.03^{a}	0.38 ± 0.08^{bc}	0.27 ± 0.03^{b}
C 17:1	0.18 ± 0.01^{b}	0.10 ± 0.02^{a}	0.50 ± 0.07^{d}	0.36 ± 0.03^{c}
C 18:0	6.51 ± 0.22^{b}	6.19 ± 0.23^{b}	5.69 ± 0.25^{a}	6.34 ± 0.26^{b}
C 18:1	51.60 ± 1.53^{b}	53.50 ± 1.23^{b}	45.83 ± 1.15^{a}	46.19 ± 1.15^{a}
C 18:2	7.43 ± 0.39^{a}	8.09 ± 0.39^{a}	10.53 ± 0.39^{c}	9.57 ± 0.29^{b}
C 18:3	1.40 ± 0.06^{b}	0.79 ± 0.06^{a}	2.42 ± 0.20^{d}	1.69 ± 0.14^{c}
C 20:0	0.64 ± 0.06^{a}	0.70 ± 0.10^{a}	1.94 ± 0.12^{c}	0.98 ± 0.09^{b}
C 20:1	0.35 ± 0.03	Not identified	Not identified	Not identified
SFA	30.51 ± 0.27^{b}	29.49 ± 0.20^{a}	30.03 ± 0.24^{b}	31.48 ± 0.30^{d}
MUFA	60.66 ± 0.46^{b}	61.63 ± 0.38^{c}	57.02 ± 0.34^{a}	57.26 ± 0.38^{a}
PUFA	8.83 ± 0.23^{a}	8.88 ± 0.23^{a}	12.95 ± 0.30^{c}	11.26 ± 0.22^{b}

Control group - conventional ecosystem. The ponds are fertilized with 3000 $kg.ha^{-1}$ manure. The fish was fed with 4,5 kg wheat per kg of fish growth.

Experimental group - organic ecosystem. The ponds are fertilized with 3000 $kg.ha^{-1}$ manure. The fish was fed with a natural food naturally developed in the ponds.

Notes:

Average value ± standard deviation;

$^{a, b, c, d}$ *– indexes indicate statistically significant differences ($p < 0.05$) between compared average values in one row*

Symbols used: C 10:0 - capric acid; C 12:0 - lauric acid; C 14:0 - myristic acid; C 16:0 - palmitic acid; C16:1 - palmitoleic acid; C 17:0 - margaric acid, C 18:0 - stearic acid; C 18:1- oleic acid; C 18:2 - linoleic acid; C 18:3 - linolenic acid; C 20:0 - arachidic acid; C 20:1 - gadoleic acid;

Statistical Analysis

The obtained data, excluding FAME analysis, was analyzed by SPSS 11.0 software (SPSS Inc., Chicago, Illinois, USA). Nine repetitions (n = 9) for each sample were carried out. Data was processed by the ANOVA method with a $P<0.05$ (Tang et al., 2015).

Duncan's multiple comparison test (SPSS) with a no significant difference set at $P\geq0.05$ was used to compare sample means. Significant differences between means less than 0.05 were considered statistically significant (Broadhurst and Kell, 2006).

Results

pH Value

In all studied samples the pH values were significantly different ($P<0.05$). Higher pH values were found in the samples from the experimental group E in comparison to control group C. If the pH of CMC samples is used as a base, the pH of the EMC samples and ESC samples is higher by 5.46% and 3.05% resp. However, pH values vary within relatively small ranges of 6.566 and 6.925 (Table 3). pH values of control samples CSC scaly carp was 1.78% higher in comparison to control samples CMC mirror carp. On the contrary, the pH of the experimental samples mirror carp EMC was 2.35% higher than pH of the scaly carp ESC (Table 3).

WHC

The WHC of the white carp musculature of all studied samples varied within relatively small ranges between 16.62 and 18.65% (Table 3). The results obtained for WHC were in clear relation with pH values from white carp musculature. The samples with higher pH values are characterized by higher WHC (Table 3). The WHC of experimental samples EMC and ESC fed without supplements is significantly ($P<0.05$) higher than WHC of control samples CMC and CSC, fed with the addition of 4.500 kg wheat.kg^{-1} body weight growth.

However, 1.43% higher WHC of experimental samples EMC was found compared to the experimental samples ESC, but WHC of control samples CMC and CSC was not significantly different ($P\geq0.05$, Table 3).

Table 3. Effect of organic cultivation of mirror and scaly common carp (*Cyprinus carpio* L.) on the meat quality

Indicators	Control groups		Experimental groups	
	CMC	CSC	EMC	ESC
Physicochemical properties				
pH	6.566 ± 0.017^{a}	6.683 ± 0.021^{b}	6.925 ± 0.015^{d}	6.766 ± 0.014^{c}
WHC, %	16.621 ± 0.292^{a}	16.733 ± 0.207^{a}	18.645 ± 0.342^{c}	17.217 ± 0.233^{b}
TVN, mg.100 g^{-1}	2.371 ± 0.413^{a}	2.233 ± 0.284^{a}	2.222 ± 0.615^{a}	2.186 ± 0.417^{a}
Lipids quantity and quality				
Total lipids, g.100 g^{-1}	5.467 ± 0.237^{a}	5.817 ± 0.171^{a}	6.799 ± 0.136^{b}	6.504 ± 0.161^{b}
FFA, %	0.174 ± 0.069^{a}	0.209 ± 0.063^{a}	0.318 ± 0.036^{b}	0.342 ± 0.056^{b}
TBARS, mg MDA.kg^{-1}	0.289 ± 0.043^{a}	0.287 ± 0.023^{a}	0.265 ± 0.035^{a}	0.253 ± 0.045^{a}
Instrumentally determined color characteristics				
Brightness of the color (L^*)	55.897 ± 0.097^{b}	57.644 ± 0.853^{b}	55.273 ± 0.865^{a}	54.002 ± 1.041^{a}
Red component of the color (a^*)	9.955 ± 0.485^{a}	9.517 ± 0.581^{a}	11.732 ± 0.567^{b}	11.028 ± 0.492^{b}
Yellow component of the color (b^*)	9.857 ± 0.587^{b}	10.357 ± 0.493^{b}	5.995 ± 0.562^{a}	6.453 ± 0.526^{a}
Sensory scores of fresh fish (at max. 5.00)				
Carp appearance	3.417 ± 0.267^{a}	3.117 ± 0.234^{a}	4.125 ± 0.256^{b}	4.067 ± 0.233^{b}
Musculature color	3.251 ± 0.123^{a}	3.503 ± 0.165^{a}	4.103 ± 0.154^{b}	4.352 ± 0.169^{b}
Carp flavor	3.417 ± 0.234^{a}	3.501 ± 0.253^{a}	3.583 ± 0.266^{a}	3.753 ± 0.267^{a}
Carp texture	3.583 ± 0.368^{a}	3.583 ± 0.369^{a}	3.752 ± 0.357^{a}	3.667 ± 0.393^{a}
Sensory scores of grilled fish (at max. 5.00)				
External appearance	3.753 ± 0.232^{a}	3.752 ± 0.231^{a}	4.325 ± 0.293^{b}	4.283 ± 0.267^{b}
Meat color	3.366 ± 0.202^{a}	3.801 ± 0.253^{a}	4.301 ± 0.104^{b}	4.502 ± 0.172^{b}
Flavor	3.918 ± 0.166^{a}	3.533 ± 0.250^{a}	3.602 ± 0.204^{a}	4.004 ± 0.303^{a}
Consistence	3.751 ± 0.352^{a}	4.001 ± 0.397^{a}	4.183 ± 0.268^{a}	4.167 ± 0.402^{a}
Taste	3.752 ± 0.131^{a}	3.757 ± 0.124^{a}	4.209 ± 0.128^{b}	4.252 ± 0.136^{b}

Control group - conventional ecosystem. The ponds are fertilized with 3000 kg.ha^{-1} manure. The fish is additionally fed with 4,5 kg wheat per kg of fish growth.

Experimental group - organic ecosystem. The ponds are fertilized with 3000 kg.ha^{-1} manure. The fish in is fed with a natural food naturally developed in the ponds.

***Notes*:**

average value ± standard deviation;

$^{a, b, c, d}$ *– indexes indicate statistically significant differences ($p < 0.05$) between compared average values in one row*

TVN

No significant (P≥0.05) differences for TVN in the four examined carp samples were determined (Table 3).

Total Lipids

In all investigated samples the total lipid content in the white carp musculature did not vary in a wide range and was between 5.467 and 6.799% (Table 3). Significantly higher (P < 0.05) total lipid content of the carp meat was found in experimental samples EMC and ESC. This means that the conventional carp cultivation with the addition of 4.5 kg of wheat for increasing with 1 kg live weight was characterized by lower levels of total lipids compared to the organic one (Table 3). There are no significant differences in lipid content between scaly and mirror carp both in experimental samples EMC and ESC, and in control samples CMC and CSC were not established (P≥0.05).

Fatty Acid Composition

The analysis of the fatty acid composition of scaly and mirror carp shows that the type of cultivation plays a significant role on the fatty acid composition of the total lipids (Table 2). The highest (P<0.05) content of PUFAs was found in the experimental samples EMC (Table 2). The PUFAs content in the experimental samples ESC was 1.69% lower (P<0.05) compared to EMC samples. The content of PUFAs in the control samples CMC and CSC were significantly lower (P<0.05) - 2.38 to 4.12%, respectively. The reliable differences among PUFAs contents of control samples CMC and CSC were not established. Contrary to what MUFAs contents in experimental samples EMC and ESC were significantly lower (P<0.05), as well as the SFAs - was higher (P<0.05) compared to the control samples. The highest levels of C 18:3 - linolenic acid, C 17:1 - heptadecenoic acid, C 18:2- linoleic acid, and C 20:0 - arachidic acid were found in experimental samples EMC as well as in samples ESC. In comparison to the conventional system of feeding with addition of wheat, the organic cultivation of carp alters in a certain extent the fatty acid composition of lipids, increasing the proportion of beneficial PUFA and decreasing the MUFA content. In that respect, the factor scaly variety of carp had not so pronounced influence. However, it should be noted that fatty acid composition of lipids extracted from the light muscles of mirror carp (experimental samples EMC) were a bit better in terms of human health, compared with those of scaly carp (experimental samples ESC).

Free Fatty Acids

The FFA of the white carp musculature of all studied samples varied within a relatively small range between 0.174 and 0.342% (Table 3). The FFA of samples EMC and ESC, was significantly (P < 0.05) higher than FFA of the control samples CMC and CSC, (Table 3). These results demonstrate that the lipids of organically cultivated carp were a little more susceptible to hydrolytic degradation compared to samples carp reared in a conventional system.

TBARS

There is no significant difference in TBARS of all studied samples (P≥0.05) (Table 3).

Instrumentally Measured Color Characteristics of Carp Meat

The data obtained for meat color characteristics (Table. 2) showed that in experimental samples EMC and ESC the statistically significantly lower (P<0.05) color brightness (*L**) (between 1.13 to 6.74%) and yellow color component (*b**) (between 52.75 to 72.76%), as well as higher red color component (*a**) (between 10.78 to 23.27%) were measured. The color characteristics (L*,a*,b*) of the mirror and scaly carp from one cultivating system (CMC, CSC, EMC and ESC) were not significantly different (P≥0.05).

Sensory Analysis

It was estimated that sensory scores for flavor and texture of fresh carp, as well as for flavor and consistence of grilled fish were not significantly different (P≥0.05) in all four analyzed samples (CMC, CSC, EMC and ESC) (Table 3). On the contrary, the sensory scores of experimental samples EMC and ESC for appearance and meat color of fresh carp, and taste of grilled fish was significantly (P < 0.05) higher compared to control samples CMC and CSC (Table 3).

No statistically significant differences (P≥0.05) between the sensory scores of samples scaly and mirror carp, grown in one pond system (conventional or organic), were identified.

Discussion

Probably carp feeding with natural food lead to larger glycogen accumulation in fish muscle (Ruane et al., 2002).

Similarly to our pH findings, Ruane et al. (2002) discussed modification of the reserves of muscle energy through an additional carp feeding. It leads to the occurrence of acute stress reactions, and shows lower pH value 1 h *post mortem* respectively. Our results indicate that the carp type (scaly or mirror) did not affect on the meat pH (Table 3). So established, pH data is in good agreement with the hypothesis expressed by Patiño et al. (2005), according to which the pH of the aquatic environment determines the

internal tissue acidity of fish meat.

Our results on the carp meat WHC prove the Olsson et al. (2007) hypothesis that the whole system of fish meat production from the selection through the technology of rearing and feeding, and the manner of fish storage, may affect the WHC of fish. The results show that organic cultivation allows higher WHC than when carp is cultivated in a conventional system.

The absence of significant differences in TVN levels of four carp samples can be explained with the fact that they are nitrogen volatile substances with alkaline nature (represented mostly by mono-, di-, and trimethylamine and ammonia). TVN are contained in very small amounts in the fresh water fish (Baixas-Nogueras et al., 2003). Since the examined carps were freshly caught, the microbial spoilage was not yet manifested. Therefore, in this early post-mortem period the TVN concentration was negligible.

Obviously, the quality of food supplies, specific for each of the studied systems of fish cultivation, is critical to the total lipid content of fish meat. The levels of total lipids in carp samples identified by us are in a good agreement with the widely accepted belief that fish feeding is particularly important and directly affects not only lipid content, but also the proximate composition of fish in general (Cho and Bureau, 2001; Koehn, 2004). Feed for common carp are usually based on grain, as in the control groups C in this experiment. On the other hand, a specific influence on the levels of total lipids in fish muscles can be exerted by anti-nutritional factors, including the presence of a number of inhibitors (Hendricks, 2002). The presence of such substances in the ponds can affect the absorption of food and lead to different physiological effects in fish (Francis et al., 2001).

As the control groups carp (samples C) were fed with wheat (rich source of starch), these samples are characterized by very low levels of n-3 PUFAs and relatively high levels of oleic acid (C18:1). Our results on fatty acid composition of carp lipids confirmed previously published data (Csengeri, 1996; Mráz et al., 2012).

Similarly to us Ozogul et al. (2005) have established the very low initial values for FFA, in order of 0.57 - 0.59% during storage of European river eel (*Anguilla anguilla*) on ice. These results prove that there is a close link between the release of FFA and loss of fish freshness. The absence of statistically significant differences in FFA is due to initial lipolytic changes in the total lipid fraction of carp light muscles 1 - 2 h post mortem (Losada et al., 2005). A similar hypothesis is confirmed for other fish species (Akintola and Lawal, 2011). The fish cultivation and feeding with natural food and supplement wheat does not change the lipolytic activity of muscles (Kyrana and Lougovois, 2002). TBARS data established by us is in good agreement with a very small and statistically indistinguishable TBA values reported by Ozogul et al. (2005) and Kyrana and Lougovois (2002). The perception that the FFA and TBARS can not be used as reliable indicators for loss of fish freshness has been accepted. Obviously TBARS can not provide actual results for assessing the extent of lipid oxidation in the early post-mortem fish stages. The results indicate that neither type of carp cultivation nor the carp scaly variety affect on the formation of significant concentrations of secondary products of lipid peroxidation in fish meat on the first day after the catch. This is due to the fact that the malondialdehyde can react with other fish components as nucleosides, nucleic acid, proteins and phospholipids. On the other hand, this reaction may vary depending on the type of fish (Icekson et al., 1998).

Color characteristics of carp flesh measured by us are consistent with those reported by Papoutsoglou et al. (2000). They correspond well with the relatively high sensory scores of carp samples. High organoleptic assessments related to the saltwater fish are also reported by other researchers (Kyrana and Lougovois, 2002; Akintola and Lawal, 2011).

Conclusions

In comparison to the conventional systems, the meat obtained from organic cultivated local population carp (*Cyprinus carpio* L.) is characterized with more alkaline pH, higher water holding capacity, total lipid content, PUFAs concentration, lypolitical activity, color redness (*a**), and lower color brightness (*L**) and yellowness (*b**). The meat obtained from organically cultivated carp had better sensory properties for fresh carp, as well as grilled fish. The type of aquatic system (organic or conventional) influenced on pH, water holding capacity and fatty acid composition of cultivated carp. The carp cultivation in organic system may replace with success the conventional system cultivation (when the fish is fed with 4.5-kg wheat addition for 1 kg growth).

Acknowledgments

This study was accomplished thanks to the implementation of Research Project of Institute of Fisheries and Aquaculture - Plovdiv (Study of productive characteristics of carp from the local population purpose of its use in organic production) funded by the Agricultural Academy, Sofia (Ministry of Agriculture and Food, Bulgaria).

References

Akintola, A.J. and Lawal, O. 2011. Biochemical factors involved in the resistance of some smoked tropical fish samples to insect attack. Turkish Journal of Biology, 35: 89-93. http://dx.doi.org/10.3906/biy-0810-8

Antonacopoulos, N. and Vyncke, W. 1989. Determination of volatile basic nitrogen in fish: A third collaborative

study by West European Fish Technologists' Association (WEFTA). Zeitschrift Lebens-Unter Forschung A., 189: 309-316. http://dx.doi.org/10.1007/ BF01683206

Atanasov, A., Nikolov, G., Kiryakova, G. and Yordanova, L. 2009. Comparison of the trout (*Oncorhynchus mykiss*) and carp (*Cyprinus caprio*) meat with other white and red meat. Trakia Journal of Sciences, 7: 200-202. [In Bulgarian] http://tk.uni-sz.bg/files/ E4_et_al.pdf

Atanasova, R., Hadjinikolova, L. and Nikolova, L. 2008. Investigations on the biochemical composition of carp fish (*Cyprinidae*) blood serum at conditions of organic aquaculture. Bulg. Journal of Agricultural Science, 14: 117-120. http://www.agrojournal.org/14/02-01-08.pdf

Baixas-Nogueras, S., Bover-Cid, S., Veciana-Nogues, M.T. and Vidal-Carou, M.C. 2003. Suitability of volatile amines as freshness indexes for iced Mediterranean hake. Journal of Food Science, 68: 1607-1610. http://dx.doi.org/10.1111/j.1365-2621.2003.tb12299.x

Bernárdez, M., Pastoriza, L., Sampedro, G., Herrera, J.J.R. and Cabo, M.L. 2005. Modified method for the analysis of free fatty acids in fish. Journal of Agricultural Food Chemistry, 53: 1903-1906. http://dx.doi.org/10.1021/jf040282c

Botsoglou, N.A., Fletouris, D.J., Papageorgiou, C.E., Vassilopoulos, V.N., Mantis, A.J. and Trakatellisp, A.G. 1994. Rapid sensitive and specific thiobarbituric acid method for measuring lipid peroxidation in animal tissue, food and feedstuff samples. Journal of Agricultural Food Chemistry, 42: 1931-1937. http://dx.doi.org/10.1021/jf00045a019

Broadhurst, D.I. and Kell, D.B. 2006. Statistical strategies for avoiding false discoveries in metabolomics and related experiments. Metabolomics. 2: 171-196. http://dx.doi.org/ 10.1007/s11306-006-0037-z

Buchtová, H., Svobodová, Z., Kocour, M. and Velíšek, J. 2010. Chemical composition of fillets of mirror crossbreds common carp (*Cyprinus carpio* L.). Acta Veterinaria Brno, 79: 551-557. http://dx.doi.org/10.2754/avb201079040551

Cho, C.Y. and Bureau, D.P. 2001. A review of diet formulation strategies and feeding systems to reduce excretory and feed wastes in aquaculture. Aquaculture Research, 32: 349-360. http://dx.doi.org/10.1046/j.1355-557x.2001.00027.x

Christiansen, R., Struksnæs, G., Estermann, R. and Torrissen, O.J. 1995. Assessment of flesh colour in Atlantic salmon, *Salmo salar* L. Aquaculture Research, 26: 311-321. http://dx.doi.org/10.1111/j.1365-2109.1995.tb00919.x

Crivelli, A.J. 1983. The destruction of aquatic vegetation by carp. Hydrobiologia. 106: 37-41. http://dx.doi.org/10.1007/BF00016414

Csengeri, I., 1996. Dietary effects on fatty acid metabolism of common carp. Archives of Animal Nutrition, 49: 73-92. http://dx.doi.org/10.1080/17450399609381866

Driver, P.D., Closs, G.P. and Koen, T. 2005 The effects of size and density of carp (*Cyprinus carpio* L.) on water quality in an experimental pond. Archiv fur Hydrobiologie, 163: 117-131. http://dx.doi.org/10.1127/0003-9136/2005/0163-0117

Dudgeon, D., Arthington, A.H., Gessner, M.O., Kawabata, Z.I., Knowler, D.J., Lévêque, C., Naiman, R.J., Prieur-Richard, A.H., Soto, D., Stiassny, M.L.J. and Sullivan, C.A. 2006. Freshwater biodiversity: importance, threats, status and conservation challenges. Biological Reviews, 81: 163-182. http://dx.doi.org/10.1017/S1464793105006950

Francis, G., Makkar, H.P.S. and Becker, K. 2001. Antinutritional factors present in plantderived alternate fish feed ingredients and their effects in fish. Aquaculture, 199: 197-227. http://dx.doi.org/10.1016/S0044-8486(01)00526-9

Grau R., and Hamm G. 1953. Eine enfache Methode zur Bestimmung der Wasserbindung im Muskel, Die Naturwissenschaften, 40: 29-30.

Hendricks, J.D. 2002. Adventitious Toxins, in: Halver, J., Hardy, R. (Eds.), Fish Nutrition. Academic Press Elsevier Science, San Diego, California, pp. 601-649.

Ichihara, K. and Fukubayashi, Y. 2010. Preparation of fatty acid methyl esters for gas-liquid chromatography. The Journal of Lipid Research, 51: 635-640. http://dx.doi.org/10.1194/ jlr.D001065

Icekson, I., Drabkin, V., Aizendorf, S. and Gelman, A. 1998. Lipid oxidation levels in different parts of the mackerel, *Scomber scombrus*. Journal of Aquatic Food Product Technology, 7: 17-29. http://dx.doi.org/10.1300/J030v07n02_03

Iverson, S.J., Lang, S.L., Cooper, M.H. 2001. Comparison of the Bligh and Dyer and Folch methods for total lipid determination in a broad range of marine tissue. Lipids, 36: 1283-1287. http://dx.doi.org/10.1007/s11745-001-0843-0

Johnsen, P.B. and Kelly, C.A. 2004. A technique for the quantitative sensory evaluation of farm-raised catfish, in: Gacula, M.C. (Ed.), Descriptive Sensory Analysis in Practice. Food & Nutrition Press, Inc., Trumbull, Connecticut, pp. 289-300. http://dx.doi.org/ 10.1002/9780470385036.ch3d

Kestemont, P. 1995. Different systems of carp production and their impacts on the environment. Aquaculture, 129:347-372. http://dx.doi.org/10.1016/0044-8486(94) 00292-V

Koehn, J.D. 2004. Carp (*Cyprinus carpio*) as a powerful invader in Australian waterways. Freshwater Biology, 49:882-894. http://dx.doi.org/10.1111/j.1365-2427.2004.01232.x

Kyrana, V.R. and Lougovois, V.P. 2002. Sensory, chemical and microbiological assessment of farm-raised European sea bass (*Dicentrarchus labrax*) stored in melting ice. International Journal of Food Science and Technology, 37:319-328. http://dx.doi.org/ 10.1046/j.1365-2621.2002.00572.x

Lavado, R., Ureña, R., Martin-Skilton, R., Torreblanca, A., del Ramo, J., Raldúa and D., Porte, C. 2006. The combined use of chemical and biochemical markers to assess water quality along the Ebro River. Environmental Pollution, 139: 330-339. http://dx.doi.org/ 10.1016/j.envpol.2005.05.003

Latimer, G.W. Jr. 2012. Official methods of analysis of AOAC International. nineteenth ed. AOAC International, Gaithersburg, Maryland. ISBN 0-935584-83-8

Losada, V., Piñeiro, C., Barros-Velázquez, J. and Aubourg, S.P. 2005. Inhibition of chemical changes related to freshness loss during storage of horse mackerel (*Trachurus trachurus*) in slurry ice. Food Chemistry, 93: 619-625. http://dx.doi.org/10.1016/ j.foodchem.2004.09.041

Mente, E., Karalazos, V., Karapanagiotidis, I.T. and Pita, C.

2011. Nutrition in organic aquaculture: an inquiry and a discourse. Aquaculture Nutrition, 17: 798-817. http://dx. doi.org/10.1111/j.1365-2095.2010.00846.x

Modzelewska-Kapitula, M. and Cierach, M. 2009. Effect of pressure and sample weight on free water content in beef estimated according to Grau-Hamm method using computer image analysis. Science Nature and Technology, (Pl) 3: 1-6. http://www.npt.up-poznan.net/pub/art_3_144.pdf

Mráz, J., Máchová, J., Kozák, P. and Pickova, J. 2012. Lipid content and composition in common carp – optimization of n-3 fatty acids in different pond production systems. Journal of Applied Ichthyology, 28: 238-244. http://dx.doi.org/10.1111/j.1439-0426.2011.01904.x

Naylor, R.L., Goldburg, R.J., Primavera, J.H., Kautsky, N., Beveridge, M.C.M., Clay, J., Folke, C., Lubchenco, J., Mooney, H. and Troell M 2000. Effect of aquaculture on world fish supplies. Nature, 405: 1017-1024. http://dx.doi.org/doi:10.1038/35016500

Nikolova, L. 2013. Impact of some technological factors on the growth of carp fish (*Cyprinidae*) reared in authchthonous polyculture. Bulgarian Journal of Agricultural Science, 19: 1391-1395. http://www.agrojournal.org/19/06-33.html

Olah, J. 1986. Carp prodation in manured pond, in: Billard, R., Marcel, J. (Eds.), Aquaculture of Cyprinids. INRA, Departmen of Hydrobiology, Paris, pp. 295-347. ISBN 2-85340-791-8

Olsson, GB., Seppola, M.A. and Olsen, R.L. 2007. Water-holding capacity of wild and farmed cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) muscle during ice storage. LWT - Food Science and Technology, 40: 793-799. http://dx.doi.org/10.1016/j.lwt.2006.04.004

Ötles, Y., Ozden, O. and Ötles, S. (2010) Organic fish production and the standards. Acta Scientiarum Polonica technologie Aliment, 9: 125-131. http://www.food.actapol.net/pub/1_2_2010.pdf

Ozogul, Y., Ozyurt, G., Ozogul, F., Kuley, E. and Polat, A. 2005. Freshness assessment of European eel (*Anguilla anguilla*) by sensory, chemical and microbiological methods. Food Chemistry, 92: 745-751. http://dx.doi.org/10.1016/j.foodchem.2004.08.035

Papoutsoglou, S.E., Mylonakis, G., Miliou, H., Karakatsouli, N.P. and Chadio, S. 2000. Effects of background color on growth performances and physiological responses of scaled carp (*Cyprinus carpio L.*) reared in a closed circulated system. Aquacultural Engineering, 22: 309-318. http://dx.doi.org/10.1016/S0144-8609(00)00056-X

Patiño, R., Bolamba, D., Thomas, P. and Kumakura, N. 2005. Effects of external pH on hormonally regulated ovarian follicle maturation and ovulation in Atlantic croaker. General and Comparative Endocrinology, 141: 126-134. http://dx.doi.org/10.1016/i.vgcen.2004.12.006

Roberts, J., Chick, A., Oswald, L. and Thompson, P. 1995. Effect of carp, *Cyprinus carpio* L., an exotic benthivorous fish, on aquatic plants and water quality in experimental ponds. Marine and Freshwater Research, 46: 1171-1180. http://dx.doi.org/10.1071/MF9951171

Ruane, N.M., Huisman, E.A. and Komen, J. 2002. The influence of feeding history on the acute stress response of common carp (*Cyprinus carpio*). Aquaculture, 210: 245-257. http://dx.doi.org/10.1016/S0044-8486(01)00819-5

Svetashev, V.I. 2011. Mild method for preparation of 4,4-dimethyloxazoline derivatives of polyunsaturated fatty acids for GC-MS. Lipids, 46: 463-467. http://dx.doi.org/10.1007/ s11745-011-3550-4.

Tang, K., Congedo, P.M. and Abgrall, R. 2015. Sensitivity analysis using anchored ANOVA expansion and high-order moments computation. International Journal for Numerical Methods in Engineering, 102: 1554-1584. http://dx.doi.org/10.1002/nme.4856

Teng, Y., Liu, H., Lv, J.Q., Fan, W.H., Zhang, Q.Y. and Qin, Q.W. 2007. Characterization of complete genome sequence of the spring viremia of carp virus isolated from common carp (*Cyprinus carpio*) in China. Archives of Virology, 152: 1457-1465. http://dx.doi.org/10.1007/s00705-007-0971-8

Tokur, B., Ozkütük, S., Atici, E., Ozyurt, G. and Ozyurt, C.E. 2006. Chemical and sensory quality changes of fish fingers, made from mirror carp (*Cyprinus carpio* L., 1758), during frozen storage (-18°C). Food Chemistry, 99: 335-341. http://dx.doi.org/10.1016/j.foodchem.2005.07.044

Wetengere, K. 2011. Socio-economic factors critical for intensification of fish farming technology. A case of selected villages in Morogoro and Dar es Salaam regions, Tanzani. Aquaculture International, 19: 33-49. http://dx.doi.org/10.1007/s10499-010-9339-2

Wilkes, J.G., Conte, E.D., Kim, Y., Holcomb, M., Sutherland, J.B. and Miller, D.W. 2000. Sample preparation for the analysis of flavors and off-flavors in foods. Review. Journal of Chromatography A, 880: 3-33. http://dx.doi.org/10.1016/S0021-9673(00)00318-6

Young, O.A., West, J., Hart, A.L. and van Otterdijk, F.F.H. 2004. A method for early determination of meat ultimate pH. Meat Science, 66:493-498. http://dx.doi.org/ 10.1016/S0309-1740(03)00140-2

Zaykov, A. 2008. Aquaculture - principles and technologies, first ed. Kabri, Sofia [In Bulgarian] ISBN 954-693-033-4.