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SOME QUALITATIVE PROPERTIES OF COMMON CARP (*CYPRINUS CARPIO*, L. 1758) FROM DIFFERENT AQUATIC ENVIRONMENT IN N. MACEDONIA

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ABSTRACT

The main purpose of this study was to consider some qualitative properties of farmed and wild common carp (*Cyprinus carpio*, L. 1758) from waters in N. Macedonia. The qualitative properties of the common carp were established by determination of the chemical composition of the fish meat, the energy value of meat, and the microbiological analysis for the total number of microorganisms on fish skin and presence of *Salmonella* sp. and *Listeria monocytogenes*. The results obtained during the examination of the chemical composition of the common carp meat from the aquaculture shown the mean value of 71.27 % water, 19.98 % proteins, 4.23 % fats and 0.98 % ash. The results of the common carp meat from open waters were as follows: 76.03 % water, 10.02 % proteins, 2.92 % fats, and 1.06 % ash. The differences in the values of fat content between fish meat from aquaculture and open waters carp are statistically significant on level ($p<0.05$). The differences in the values of protein content are statistically significant on level ($p>0.05$). The significantly higher energy value is established in the common carp meat from aquaculture (507.817 kJ/100 gr) compared to the meat from open waters (285.706 kJ/100 gr), as a result of significantly higher values of fat and protein content in aquaculture common carp.

Such results for examined qualitative parameters in cultivated and autochthonous common carp from N. Macedonia are the first published results for our country.

1. Introduction

Cyprinid fish species, including common carp (*Cyprinus carpio* L. 1758) are predominant fish species in the world's aquaculture, accounting for 54% of total fish production (FAO, 2006).

Common carp (*Cyprinus carpio* L. 1758) is one of the most valuable and consumed fish species in N. Macedonia. It is the predominant fish species in the cyprinid aquaculture facilities in our country and successfully bred in aquaculture (warm water - cyprinid fish farms and cage farms) where it covers 60 - 80% of the total fish population. The dominant form of aquaculture production of common carp is the semi-intensive farming system, where the fish diet is based on a combination of natural foods and complementary foods (cereals - wheat, corn, and barley).

Regarding the open waters, common carp is one of the most important components in the overall ichthyomass of Prespa Lake.

From a nutritional point of view, fresh fish and fish products are important for proper nutrition and prevention of health in humans. The high nutritional value of fish meat is due to

the favorable composition and ratio of proteins, fats, minerals, and vitamins, as well as the significant presence of unsaturated fatty acids, especially n-3 PUFA (Connor, 2000; Sidhu, 2003). The composition of protein in fish is better compared to the protein composition of other animals, which is mainly due to the more favorable amino acid composition and the number of free amino acids (Toppe et al., 2007; Buchtová et al., 2010). Fish proteins contain all the essential amino acids for the human body and can be used as the only source of protein in the diet (Vladau et al., 2008). In terms of fat, mammal meat contains a higher percentage of fat compared to fish meat (Saičić et al., 2010), but in terms of composition, fish fat differs from fat in mammals due to its higher content of monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids. The fat content of fish varies depending on the fish species, the season, as well as the type of food (Guler et al., 2008; Čirković et al., 2011).

Ljuboević et al. (2013) in their research on the chemical composition of carp (average weight 1420 g) of open water (Danube River) in Serbia received the following results: 73.73% water, 16.69% protein, 7.13% fat, and 0.88% ash.

Yeganeh et al. (2012) conducted a study on the chemical composition of aquaculture carp and open water carp during all four seasons and found that the fat and protein content in carp samples decreased from summer to spring, so in aquaculture carp, 17.6% protein in summer and 15.9% protein in spring were determined, while in open water carp 18.2% protein in summer and 17.9% protein in spring were determined. In terms of fat, in the samples of carp from aquaculture 5.1% fat in summer and 1.5% fat in spring were found, while in open water carp, 3.8% fat in summer and 2.8% fat in spring were found.

Čirković et al. (2012) in their research on the chemical composition of carp grown in the Echka fishpond, Serbia, determined the presence of 16.21% protein, 2.42% fat, 80.36% water and 1.02% ash.

Afkhami et al. (2011) in their research on the chemical composition of carp from a fish farm in Iran obtained the following results: 15.2% protein, 3.53% fat, 1.5% ash and 75.48% water.

According to Čirković et al. (2011), the chemical composition of a three-year-old carp raised in semi-intensive conditions and fed with barley, corn and wheat with 40:30:30 was: 70.67% water, 15.81% protein, 11.73% fat and 0.93% ash. The percentage of water, protein, fat and ash in a three-year-old carp fed with a complete pelleted food was: 70.94, 17.68, 10.41 and 0.94, respectively.

Marcu et al. (2010) in their research on the chemical composition of carp weighing 785 - 2010 g, from aquaculture in Romania, obtained the following results: 76.06% water, 17.79% protein, 5.07% fat and 1.07% ash.

Bud et al. (2008) in their research on the chemical composition of open water carp from Romania, obtained the following results: 73.22% water, 16.6% protein, 8.97% fat and 1.20% ash.

Hadjinikolova (2008) in her research on the chemical composition of carp from waters in Bulgaria received the following results: 74.55% water, 16.21% protein, 8.30% fat and 0.94% ash, while the energy value of fish meat was 717.3 kJ.100g-1.

The main purpose of this study was to consider some qualitative properties of farmed and wild common carp (*Cyprinus carpio*, L. 1758) from waters in N. Macedonia. This means that the common carp is grown at different ambient conditions in the aquatic environment, as well as different feed.

2. Materials and methods

2.1. Materials

Examinations in this study were performed on samples of common carp (*Cyprinus carpio*, L. 1758) from two different aquatic environments: aquaculture facility (cyprinid fish farm) and open waters (natural lake). Carp samples were taken in the spring season. The average mass of common carp samples from aquaculture was 1200 g, while the average

length, 42 cm. The average mass of common carp samples from the lake was 1450 g, while the average length, 70 cm.

The cyprinid fish farm is located near the city of Bitola (N. Macedonia), i.e. the southeastern part of Pelagonia. It was built in 1960/61 by enclosing part of the old riverbed of Crna Reka with two embankments. It covers an area of 170 ha and it is the biggest cyprinid fish farm in N. Macedonia. The land on the old riverbed of Crna Reka is very fertile, which contributes to the fish farm is very productive, i.e. rich in zoo and phytoplankton. The traditional approach to carp breeding is based on food that is naturally present in the fish farm (zooplankton and benthos, i.e the flora and fauna at the bottom), but the diet is supplemented with unprocessed cereals (wheat, corn, barley).

Figure 1. Cyprinid fish farm "Zhabeni", Bitola (N. Macedonia) (original)

Prespa Lake is the second - largest natural lake in N. Macedonia. In terms of the composition of the fish settlement, it is typically a cyprinid lake. The autochthonous ichthyofauna in Prespa Lake consists of the following fish species: common carp, Pelister trout, eel, Prespa gomnushka, belvica, black barbell, Prespa scab, Prespa grunec, Prespa maple and Prespa pinch.

Figure 2. Prespa Lake (N. Macedonia) (original)

2.2. Methods

During examinations, the following methods for determination of the chemical composition of fish meat were used:

- Determination of moisture content - ISO 712:2009;
- Spectrophotometric determination of total nitrogen according to Kjeldahl - HACH DR 400 procedure method 2410;
- Determination of the total fat by gravimetric method (Soxhlet extraction) - AOAC method 2003.6;
- Determination of ash in an oven at 700°C - ISO 3593:1981;

Methods for microbiological analyses of fish meat that were used:

- Horizontal method for detection and enumeration of *Listeria monocytogenes* - ISO 11290 - 1:2008;
- Horizontal method for detection and enumeration of *Salmonella* sp. - ISO 6579 - 2008;
- Horizontal method for the enumeration of microorganisms - ISO 4833:2003.

Methods for physical - chemical properties of the water that were used are:

- pH determination - ISO 1052:1994;
- Chloride determination - ISO 9297:1989;
- Spectrophotometric determination of nitrates - HACH DR 400 procedure Method 8039;
- Spectrophotometric determination of iron - HACH DR 400 procedure Method 8365;
- Spectrophotometric determination of nitrites - HACH DR 400 procedure Method 8507;
- Turbidity determination of translucency - ISO 7027:1999;
- Spectrophotometric determination of ammonia - HACH DR 400 procedure Method 8038;
- Determination of chemical oxygen demand, Merck Method Spectroquant 1.18752.0001;
- Total nitrogen determination - Merck Method Spectroquant 1.14537.0001.

Methods for microbiological analyses of water that were used:

- Detection and enumeration of coliform bacteria and *Escherichia coli* - ISO 9308 - 1:2000;

- Detection and enumeration of intestinal enterococci and *Streptococcus faecalis* - ISO 7899 - 2:2000.

The energy value (EV) of common carp meat was calculated according to the formula:

EV (кJ/100g) = proteins (%) x 17.16 + fats (%) x 38.96 (Vitcenko et al., 1981).

Standard descriptive statistical analyses (Microsoft Office Excel 2010, Data Analysis ToolPak and t - test) were used for results processing.

3.Results and discussions

The qualitative properties of the common carp were established by determination of the chemical composition of the fish meat, the energy value of meat and the microbiological analysis for the total number of microorganisms on fish skin and presence of *Salmonella* sp. and *Listeria monocytogenes*. The main purpose of the research produced additional analyses that determine the physical - chemical properties and also a microbiological analysis of the water in which the common carp resides.

Considering the results of the physical - chemical and microbiological analysis of the water samples from the fish farm and Prespa Lake, the following results were obtained:

Table 1 Physical – chemical properties of water samples

Parameters	Fish farm	Prespa Lake
Temperature	14.2°C	24°C
Dissolved oxygen	10.7 mg/l	10.1 mg/l
Represent of oxygen - saturation	103 %	105 %
5-day biochemical consumption of O_2 at 20 °C	1.00 mg/l	2.60 mg/l
Chemical oxygen consumption	5.00 mg/l	5.00 mg/l
Suspended matters	2 mg/l	1.86 mg/l
Dry residue of filtered water	225.0 mg/l	211.0 mg/l
pH	8.68	8.85
Nitrites	0,010 mg/l	0,000 mg/l
Nitrates	1.97 mg/l	0.000 mg/l
Chlorides	21.30 mg/l	15.60 mg/l
Ammonia	0.020 mg/l	0.020 mg/l
Electro conductivity	402.000 ms/cm	398.000 ms/cm
Total phosphorous	0.005 mg/I	0.004 mg/I
Total nitrogen	0.236 mg/I	0.193 mg/I

Table 2 Microbiological properties of the water samples

Parameters	Fish farm	Prespa Lake
The probable number of thermo-tolerant coliform bacteria in 100 ml	10	10
Streptococcus of fecal origin in 100 ml	50	0

The water quality is a combination of chemical, physical and biological parameters. It`s properties affect the general fish condition and determines the fish growth and health. As a result, water quality is a major factor to be taken into account when planning fish breeding.

Based on the physical - chemical and microbiological properties of the water samples from a fish farm and Prespa Lake, the water is classified into class II (according to the Regulation on water classification Official Journal of RM 18/99), which is allowed for fish production.

Considering the results of the microbiological analysis for the total number of microorganisms on fish skin and the presence of *Salmonella* sp. and *Listeria monocytogenes*, the following results were obtained:

Table 3 Microbiological analysis of common carp

Parameters ($\bar{x}$)	**Total number of microorganisms (log CFU/cm^2)**	***Salmonella* sp.**	***Listeria monocytogenes***
Fish farm	4.26	0	0
Prespa Lake	3.66	0	0

Legend: $\bar{x}$ - mean value

In terms of determining the total number of microorganisms on the skin of common carp, in our study average value of 4.26 (a fish farm) and 3.66 (Prespa Lake) log SFU/cm2 were considered, which is in correlation with the findings of Adams and Moss (2008) which concluded that the total number of microorganisms on the fish skin surface ranged from 2.00 - 7.00 log CFU/cm2.

Considering the results of the chemical composition and energy value of the common carp meat from aquaculture and open waters, the following results were obtained:

Table 4 Chemical composition (%) of the common carp meat from aquaculture and open waters

Chemical components	**Fish farm**				**Prespa Lake**			
	$\bar{x}$ ± SD	**min**	**max**	**CV**	**$\bar{x}$ ± SD**	**min**	**max**	**CV**
Water	71.266 ± 0.499	70.60	71.80	0.007	76.033 ± 1.400	74.20	77.60	0.018
Proteins	19.983 ± 0.103	19.85	20.10	0.005	10.020 ± 0.059	9.96	10.10	0.005
Fats	4.233 ± 0.213	3.94	4.44	0.050	2.920 ± 0.169	2.75	3.15	0.057
Ash	0.983 ± 0.071	0.91	1.08	0.072	1.064 ± 0.005	1.06	1.07	0.004

Legend: $\bar{x}$ - mean value; SD – standard deviation; min – minimum value; max – maximum value; CV – coefficient of variation.

Table 5. Comparative indicators of the chemical composition (%) and energy value (κJ/100 g) of the common carp meat from aquaculture and open waters

Parameters	Water	Proteins	Fats	Ash	Energy value
Fish farm	**71.266** ± 0.499	**19.983**[a] ± 0.103	**4.233**[b] ± 0.213	**0.983** ± 0.071	507.l817
Prespa Lake	**76.033** ± 1.400	**10.020**[a] ± 0.059	**2.920**[b] ± 0.169	**1.064** ± 0.005	285.706

[a]The differences in the values with the same superscripts are statistically significant on level p>0.05
[b]The differences in the values with the same superscripts are statistically significant on level p<0.05

In fish farms, common carp use natural and additional foods. The common carp feed additionally only during the summer. In our study, the diet of farmed carp is based on food that is naturally present in the fish farm (zooplankton and benthos, i.e. the flora and fauna found at the bottom), but it is supplemented with unprocessed cereals (wheat, corn, barley).

Regarding the open waters, the benthic zone is an essential part of the lake's biotope. Nutrients, organic matter and microorganisms are present here at a much higher density compared to those in fish farm water. The common carp, in any case, covers its food needs from the benthos of the fish farm or lake, so their characteristics affect the meat quality, directly through their consumption and indirectly through the water.

The results obtained during the examination of the chemical composition of common carp meat from the aquaculture shown the mean value of 71.27 % water, 19.98 % proteins, 4.23 % fats and 0.98 % ash. On the other hand, the results of the common carp meat from open waters were as following: 76.03 % water, 10.02 % proteins, 2.92 % fats and 1.06 % ash.

The results obtained from our study of the chemical composition of aquaculture carp are in correlation with the findings of Yeganeh et al. (2012) (17.6% - 15.9% protein, 5.1% - 1.5% fat, 76.7% - 81.4% water, 0.6% - 1.2% ash); Čirković et al. (2012) (16.21% protein, 2.42% fat, 1.02% ash and 80.36% water); Afkhami et al. (2011) (15.2% protein, 3.53% fat, 1.5% ash and 75.48% water); Čirković et al. (2011) (70.67% water, 15.81% protein, 11.73% fat and 0.93% ash) and Marcu et al. (2010) (water 76.06%, protein 17.79%, fat 5.07%, ash 1.07%).

The results obtained from the study of the chemical composition of open water carp are in correlation with the results of Ljuboević et al. (2013) (73.73% water, 16.69% protein, 7.13% fat and 0.88% ash); Bud et al. (2008) (73.22% water, 16.6% protein, 8.97% fat and 1.20% ash) and Hadjinikolova (2008) (74.55% water, 16.21% protein, 8.3% fat and 0.94% ash).

In our study, the common carp meat from aquaculture contained significantly less water (71.27%) compared with the one from open waters (76.03%). Fat content in the common carp from aquaculture was 4.23 %, which is significantly higher compared with the one from open waters (2.95 %). In our tests, the differences in the values of fat content are statistically significant on level (p<0.05).

Kaushik (1995) considered that the fat content in fish meat is directly related to nature and fat content in the food, while the water content of fish meat is inversely proportional to the fat content. The inversely proportional relationship between fat and water content in farmed and wild common carp has also been established by Love (1970), which is in correlation with our results.

Also, significantly higher values for the protein content in the common carp from aquaculture (19.98%) compared to the common carp from open water (10.02%) were observed. In our tests, the differences in the values of the protein content of common carp from aquaculture and open waters are statistically significant on level (p>0.05). The average

amount of ash is slightly higher in common carp from open waters (1.06 %) compared with the one in aquaculture (0.98 %).

The data from the literature reviews related to the chemical composition of common carp differ, especially regarding the fat content, which ranges from 2.3 - 16.8 %, while due to protein content, the variations are much smaller and range from 14 - 18% (Vladau et al., 2008; Trbović et al., 2009; Čirković et al., 2011). However, the protein content of fish meat is not strongly influenced by external nutrition because it mostly depends on internal factors such as the fish species and size of the fish.

The differences in ash content in the common carp meat from both environments are quite minimal and were not statistically significant.

The energy value (EV) of common carp meat was calculated according to the formula. The significantly higher energy value is established in the common carp meat from aquaculture (507.817 kJ/100 gr) compared to the meat from open waters (285.706 kJ/100 gr), as a result of significantly higher values of fat and protein content in aquaculture common carp.

According to the fat content, fish are classified into: lean fish (fat content of less than 2%), fish with small fat content (2 - 4 %), moderate fatty fish (4 - 8 %) and fatty fish (more than 8% fat) (Ackman, 1989). According to the received fat content in our study, common carp from aquaculture is being classified as moderate fatty fish (4.23 % fat), while common carp from open waters as fish with small fat content (2.92 %). These differences probably stem from the location of the fish samples, the season, the nutritional condition of the fish, the conditions in the aquatic environment, the fish size and age, etc.

4. Conclusions

Considering the results of the microbiological analysis for the total number of microorganisms on fish skin, the average value in common carp of aquaculture was 4.26 log CFU/cm^2, while in common carp of open water, 3.66 log CFU/cm^2.

The results obtained during the examination of the chemical composition of common carp meat from aquaculture and open waters determined the mean value of 71.27% water, 19.98% protein, 4.23% fat and 0.98% ash, as well as, 76.03 % water, 10.02 % protein, 2.92 % fat and 1.06 % minerals, respectively.

The differences in the values of certain chemical parameters shown that there is a significant difference ($p>0.05$) between the protein content of common carp from aquaculture and open waters, respectively.

A significant difference ($p<0.05$) is also considered between the fat of common carp from aquaculture and open waters, respectively.

There is a correlation between the fat content of fish meat and the percentage of water in muscle tissue, and the relationship between these indicators depends on the ambient conditions of the water ecosystem.

Regarding the fat percentage, i.e. 4.23% (common carp from aquaculture) and 2.92% (common carp from open waters), the examined carp samples belong to the group of fish with a small amount of fat (open water common carp) and medium fat fish (aquaculture common carp).

The results obtained for the energy value of fish meat indicate that the energy of the common carp meat from aquaculture (507.817 kJ/100g) is significantly higher compared to the one from open waters (285.706 kJ/100 g). These differences are due to the higher fat and protein content of aquaculture carp.

Feeding, dietary supplements, food conversion as well as food supplements increase (or restore) the growth rate and this is generally related to the increase of fat content. Other factors (temperature, steroid supplements) indirectly stimulate the diet resulting in increased fat content. This is very important because the intake of high - quality food to stimulate growth and reduce the breeding time in aquaculture production results in an increase in the fat content of fish meat.

In fish from aquaculture, the differences in chemical composition are less variable since in these systems the breeding factors can be controlled. The results suggest that the chemical composition of the fish may vary greatly during the catch season. This is due to physiological factors and environmental changes, i.e. spawning, migration, starvation or overeating.

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