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RESEARCH ON THE FULTON CONDITION FACTOR, THE HEPATO-SOMATIC INDEX AND THE BIOCHEMICAL COMPOSITION OF CARP (*CYPRINUS CARPIO*) FROM 3 DIFFERENT SOURCES, IN ROMANIA

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Abstract

This study was conducted to evaluate the Fulton condition factor, the hepatosomatic index and the biochemical composition of carp meat (Cyprinus carpio) from aquaculture, reared in earthen ponds (CB), in floating net cages (CV) and in the wild, represented by the Danube River (CD). Significant differences were observed (P<0.05) between the mean values of the Fulton condition factor for fish from the three sources. Regarding the hepatosomatic index and visceral fat, the lowest values were obtained for the CD samples, and the highest in CV. The highest mean value of the protein content (18.55 ± 1.01%) was obtained in the specimens reared earthen ponds (CB), but the values did not differ significantly (P = 0.29) from the CD samples. The differences in lipid content of aquaculture fish meat reared in floating net cages (CV) and in the wild (CD) were statistically significant (P<0.05). In conclusion, fish from aquaculture has a better state of maintenance than that in the wild, fact demonstrated by the values of the Fulton Index. However, wild specimens have a much lower hepatosomatic index and visceral fat values than aquaculture fish.

***Key words**: aquaculture, biochemistry, Cyprinus carpio, Fulton, wild.*

INTRODUCTION

In recent years, aquaculture has become a real industry, being one of the great sources of protein with a high biological value. Although fish is considered a healthy food, with beneficial effects on the cardiovascular system, especially due to unsaturated fats such as Omega-3 and Omega-6, in Romania fish consumption is quite low. In the UK, the advice from the authorities is to eat at least two servings of fish a week in order to benefit from its positive health effects (FSA, 2008).

Currently, aquaculture tends to develop very fast, becoming more and more intensive, in order to rapidly increase production, but also to increase profit (Schlag & Ystgaard, 2013). However, the intensification of fish production methods has raised a number of issues for consumers concerned about the consumption of aquaculture fish. As some consumers consider wild fish to be relatively expensive, aquaculture fish may be an alternative for them (Schlag & Ystgaard, 2013).

Rearing fish in floating net cages is widespread in the world, being one of the methods of intensive fish production in tropical areas (Liao et al., 2004). It has the advantage of using existing water resources (rivers, lakes, etc.) (Masser, 2008).

The common carp (*Cyprinus carpio*) is one of the most cultivated and consumed freshwater fish in the world (Böhm et al., 2014). It is a species of fish that easily adapts to different environmental conditions, being reared and marketing since ancient times.

Carp aquaculture in floating net cages has become increasingly popular worldwide (Yee et al., 2012). This involves rearing fish in cages made of netting, with meshes of different sizes, depending on the species cultivated, and open to the surface, placed on a floating frame and which are anchored by a pontoon.

This study aimed to investigate the differences in Fulton condition factor, hepatosomatic index and biochemical composition of wild carp (Danube) and aquaculture carp, reared in earthen ponds and floating net cages.

MATERIALS AND METHODS

The biological material involved in this study was represented by the common carp (*Cyprinus carpio*), caught from 3 different aquatic environments. A number of 10 specimens, weighing between 1.5-1.9 kg and 3 years old, were captured for comparison from: the wild (Danube river - CD) and from an earthen pond (CB) and floating net cages (CV) belonging to the same fish farm.

The floating cages had the size 6 m × 6 m × 3 m, the fish density was 130 kg/m^3. The food administered in the cages was represented by an extruded fodder with a granulation of 6 mm and a protein content of 30%. In the earthen pond, the fish density was 1500 kg/ha, the fish consumed only the food available in the pond (zooplankton and benthos).

The data collected for comparison included the fish mass, determined gravimetrically using a Kern-type scale, the total and standard length, measured using an instrument called "ichthyometer", the height and circumference of the fish - determined using a tailoring meter.

Based on these data, the Fulton condition factor was calculated according to the formula:

$$CF = W*100 / Ls^3,$$

where:

W - fish mass (g);

Ls - fish standard length (cm).

The condition factor reflects the physiological state of the fish and the availability of food (Le Cren, 1951), which may indicate their well-being in the environment (Morado et al., 2017). A higher value of this index shows a better condition of the fish.

The internal organs were then carefully separated and the liver, spleen, heart, and visceral fat were weighed. The hepatosomatic index (HSI) was determined as a percentage of the weight of the liver in relation to body weight. Hepatosomatic index (HSI) and the condition factor (CF) are important in assessing the resources provided by the environmental that are available to the fish (Rizzo & Bazzoli, 2020).

Biochemical analyses for fish meat were performed in duplicate and consisted in the determination of moisture, ash, total protein content, fatty substances and energy value of the meat. All samples were treated under the same conditions. At the beginning of the analysis, the samples were allowed to reach room temperature and were homogenized.

The moisture was determined by drying 5 g of the sample in an oven at 130°C to constant mass. The ash was calculated by calcining the sample in the calcination furnace at 600°C for 4 hours. The Kjeldahl method was used to determine the total nitrogen content of the sample, then multiplied by 6.25 (protein conversion factor). To determine the content of fatty substances, the Soxhlet method of fat extraction with solvents was applied (AOAC, 2004).

The calculation of the energy value is based on the following conversion factors: 4 kcal/g for proteins, respectively 9 kcal/g for lipids, according to Regulation (EU) No 1169/2011.

Data analysis

The data obtained were presented as mean ± standard deviation. One-way analysis (ANOVA) was used to assess the differences between the means, followed by the Bartlet test to verify the homogeneity of the variances and the t-test to compare the means of each parameter determined. The differences were considered significant at values of $P<0.05$.

RESULTS AND DISCUSSIONS

Biometric and bioindicator data, including fish mass and standard length, as well as hepatosomatic index and visceral fat, are presented as mean ± standard deviation in Table 1.

The results showed variations in fish mass for close standard lengths, especially in the case of aquaculture fish. This can be explained by different food availability in the two environments, fish reared in earthen pond having only a small part of the artificial food, being forced to procure natural food existing in the environment (Resen et al., 2017).

The average weight for the specimens collected from the earthen pond, floating net cages and from the natural environment (Danube River) was 1614.23 g, 1889.39 g, respectively 1601.5 g.

Table 1. Biometric data and fish bioindicators from 3 different sources

Fish source		Weight (g)	Standard length (cm)	CF	HIS (%)	Visceral fat (%)
		mean ± sd				
Farmed	Pond (CB)	1,614.23 ± 98.8	35.72 ± 0.71	3.54 ± 0.21	2.02 ± 0.2	1.33 ± 0.06
	Floating net cage (CV)	1,889.39 ± 113.4	36.81 ± 1.88	3.81 ± 0.39	2.15 ± 0.18	1.77 ± 0.04
Wild/Danube River (CD)		1,601.5 ± 22.9	42.92 ± 146	2.04 ± 0.18	1.63 ± 0.04	0.05 ± 0.01

The average standard lengths were 35.72 cm for CB, 36.81 cm for CV and 42.92 cm for CD. Based on these data, the Fulton condition factor (CF) was calculated, an indicator that provides information about the physiological state of the fish (Lima et al., 2002).

The highest value of the Fulton condition factor was recorded for aquaculture fish, caught from floating net cages (CF = 3.81), followed by that of fish reared in the earthen pond (CF = 3.52), while for fish caught from the natural environment (Danube River) the factor had the lowest value (CF = 2.04) (Figure 1).

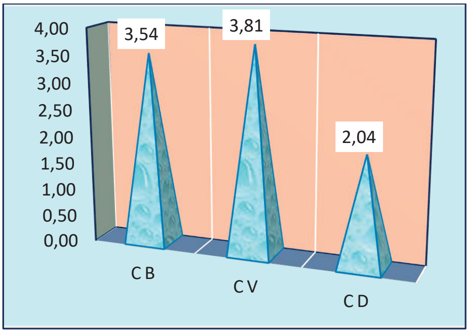

Figure 1. Fulton condition factor for fish from 3 different environments

A Fulton coefficient higher than 1 indicates a good condition of the fish in the studied population (Datta et al., 2013). The fact that the highest value was recorded for specimens reared in floating net cages shows that they had better access to food than other specimens, who were not given additional food, having only food available in the environment in which they lived.

The results of the statistical analysis for the hepatosomatic index (HSI) showed significant differences between the samples studied from three environments ($P < 0.05$). However, the values recorded in CB and CV indicated insignificant differences ($P = 0.23$). Highly significant differences were between CB and CD ($P = 0.0003$), as well as between CV and CD ($P<0.05$). The highest mean value of the hepatosomatic index was recorded in CV, being 6.17% higher than in CB and approximately 32% higher than in CD (Figure 2). The results obtained in this study for HSI were higher than those of Sharma & Ram (2020) who studied the hepatosomatic index in different age groups for common carp.

Gebremichael et al. (2021) obtained a hepatosomatic index value of 2.17% for common carp fed a diet in which fishmeal was 100% replaced by black solider fly meal.

For *Clarias gariepinus*, in 2017, Adesina observed a progressive decrease in the values of the hepatosomatic index with the increase of the level of cooked sunflower seed flour, as replacement for soy flour in feeding diets (from 3.11% to 0.87%).

Regarding the amount of visceral fat of the analysed samples, the statistical tests indicated highly significant differences ($P<0.01$) between the samples captured from the 3 sources. The highest amount of visceral fat was observed in fish reared in floating net cages (CV) (1.77%), while wild fish, from CD, had the lowest amount (0.05%) (Figure 2).

In fish meat, fat plays a very important role, increasing its nutritional value and improving sensory characteristics (Ceballos et al., 2020).

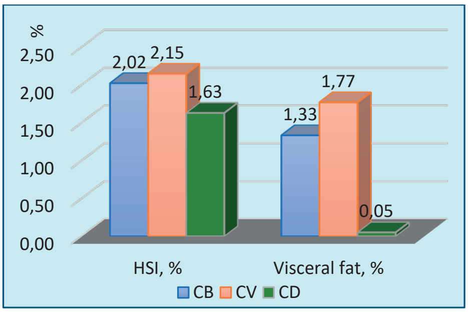

Figure 2. Hepatosomatic index and visceral fat in common carp reared in 3 different sources

However, high fat deposits in the abdominal cavity can have a negative impact on the consumer.

The biochemical composition of fish meat from the 3 sources studied is presented in Table 2.

The results indicated differences in the percentage of protein in the meat of the studied specimens. The highest protein content was recorded in the samples captured from CB (18.55%), followed by those from CD (18.18%), while the lowest percentage was recorded in the CV samples (16.91%) (Figure 3), the results being comparable to those obtained by (Xiu-Ping et al., 2017).

Table 2. Biochemical composition of fish from different sources

Fish source	Proteins (g%)	Lipids (g%)	Moisture (g%)	Ash (g%)	Energy value (kcal/100 g)
CB	18.55 ± 1.01	4.81 ± 1.11	74.93 ± 0.71	1.31 ± 0.21	117.50
CV	16.91 ± 0.38	10.43 ± 0.93	71.40 ± 1.09	0.83 ± 0.03	161.54
CD	18.18 ± 0.08	1.47 ± 0.02	78.81 ± 0.14	1.20 ± 0.03	85.98

Statistical analysis of the data obtained showed that the percentage of meat protein was significantly higher in CB ($P = 0.00074$) compared to CV, but there were no significant differences between CB and CD ($P = 0.29$). Significant differences existed between CV and CD ($P<0.05$).

Protein content is important when it comes to the texture and quality of fish meat. A low-protein meat tends to lose more water during cooking, which affects the texture of the meat. (Afkham et al., 2011).

In terms of moisture, the highest water content was in the CD samples (78.81%), while the CV samples had the lowest amount (71.40%) (Figure 4), the differences recorded being significant ($P<0.05$).

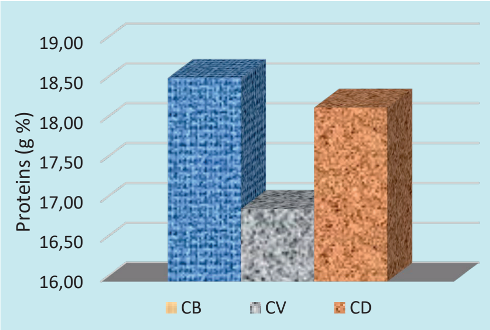

Figure 3. Protein content of *Cyprinus carpio* from 3 sources

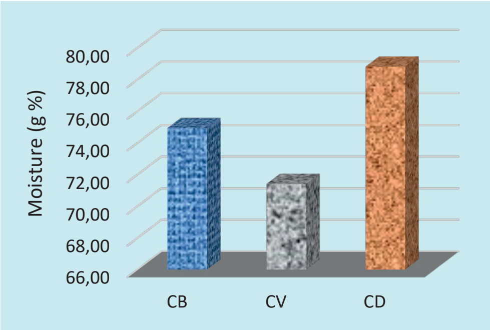

Figure 4. Moiesture content of *Cyprinus carpio* from 3 sources

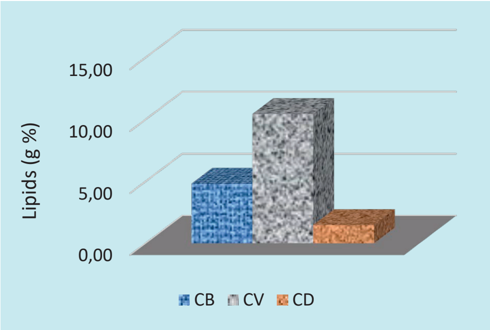

Figure 5. Lipids content of *Cyprinus carpio* from 3 sources

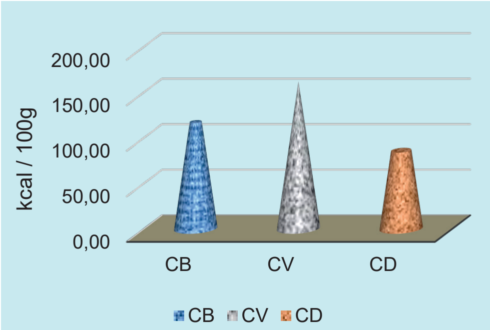

Figure 6. Energy value of *Cyprinus carpio* from 3 sources

It is known that the fat content of meat increases with the accumulation of biomass, this being associated with a decrease in water content. However, the main factor that influences the fat content is diet. (Fauconneau et al., 1995). The carbohydrate content of artificial food increases the fat content of meat.

Analysing the lipid content of meat, a high value is observed in the meat of the CV samples (10.43%), followed by CB (4.81%) and CD (1.47), the differences between all sources being highly significant ($P<0.01$) (Figure 5). The fact that the specimens reared in the floating net cages had access to artificial food, determined the accumulation of lipids in the muscle tissue, unlike the specimens from the wild environment, which had to compete for food.

The results obtained in this study regarding the lipid content are comparable to those obtained by Resen et al. (2017) and Mocanu et al. (2019), for common carp. Similar values were obtained for other freshwater fish (Kamal et al., 2007; Hama & Kamel, 2013).

Due to the high values for lipid and protein content, the energy value of fish in aquaculture was significantly higher (117.5 kcal/100 g in CB, respectively 161.54 kcal/100 g in CV), compared to wild fish (85.98 kcal/100 g) (Figure 6), similar results were obtained by Blazhekovikj & Ahmed (2020) for wild and aquaculture carp in Macedonia.

CONCLUSIONS

In conclusion, this study showed that fish from aquaculture have a better state of maintenance than those in the wild, as evidenced by the value of the higher Fulton index.

However, wild carp have much lower hepatosomatic index and visceral fat values than aquaculture fish, because additional feed leads to the accumulation of fat in tissues and around organs.

Regarding the quality of carp meat, it was influenced by the administration of feed, which led to an increase in lipid content in CV and CB. Higher fat levels have contributed to increase the energy value of fish in aquaculture.

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