CHROMIUM (CR), NICKEL (NI) AND ZINC (ZN) LEVELS IN EDIBLE MUSCLE AND SKIN TISSUES OF *CYPRINUS CARPIO* L. IN ÇAMLIGÖZE DAM LAKE, SIVAS, TURKEY

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Abstract. In this study, Cr, Ni and Zn levels were determined by atomic absorption spectrophotometry in edible muscle and skin tissues of *Cyprinus carpio* in Çamlıgöze Dam Lake located at Central Anatolian region of Turkey. The maximum levels were found to be 0.12 (Cr), 2.15 (Ni), 0.51 (Zn) µg/g in the muscle and 0.15 (Cr), 2.07 (Ni), 1.97 (Zn) µg/g in the skin of *Cyprinus carpio*. It was determined that Ni was the highest metal in tissues. The highest Cr and Zn levels were determined in the skin of *Cyprinus carpio*, whereas the highest Ni levels were measured in the muscle. The heavy metal accumulation orders for the tissues were as follows: Ni>Zn>Cr in Çamlıgöze Dam Lake. There was important statistical differences, especially at the level of zinc accumulation in tissues ($p<0.001$). There was a significant and positive correlation between age, total length, weight and metal levels for Cr ($r>0.25$, $p<0.05$) in the muscle and skin of *Cyprinus carpio* in Çamlıgöze Dam Lake. The levels of the tested Cr, Ni and Zn were within the acceptable limits of FAO.

Keywords: *Cyprinus carpio*, fish, Cr, Ni, Zn, metal accumulation.

CHROMO, NIKELIO IR CINKO KONCENTRACIJA ÇAMLIGÖZE EŽERO (SIVASAS, TURKIJA) PAPRASTŲJŲ KARPIŲ *CYPRINUS CARPIO* L. RAUMENYSE IR ODOJE

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Santrauka. Šiame darbe atominės absorbcijos spektrofotometriniu metodu nustatyta Cr, Ni ir Zn koncentracija paprastojo karpio (*Cyprinus carpio*) raumenų ir odos audiniuose. Tyrimui naudoti paprastieji karpiai, sugauti Turkijos Centrinio Anatolijos regiono dirbtiniame Çamlıgöze ežere. Didžiausia nustatyta metalų koncentracija *Cyprinus carpio* raumenyse buvo 0,12 (Cr), 2,15 (Ni), 0,51 (Zn) µg/g, o odoje – 0,15 (Cr), 2,07 (Ni), 1,97 (Zn) µg/g. Didžiausia koncentracija audiniuose būdinga Ni. Sunkieji metalai Cr ir Zn daugiausia kaupiasi *Cyprinus carpio* odoje, o didžiausia Ni koncentracija buvo rasta raumenyse. Minėtų sunkiųjų metalų koncentracija Çamlıgöze ežero paprastųjų karpių audiniuose pagal gausą išsidėsto taip: Ni>Zn>Cr. Pastebėti tam tikri statistiniai skirtumai, ypač reikšmingi Zn kaupimuisi audiniuose ($p<0,001$). Nustatyta stipri teigiama Cr ($r>0,25$, $p<0,05$) koncentracijos *Cyprinus carpio* odoje ir raumenyse koreliacija su žuvų amžiumi, kūno ilgiu ir svoriu. Rasta Cr, Ni ir Zn koncentracija neviršijo MŽŪO patvirtintų leistinų ribų.

Raktažodžiai: *Cyprinus carpio*, žuvis, Cr, Ni, Zn, metalų kaupimasis.

Introduction. Metals, especially heavy metals, are important contaminants of aquatic environments worldwide. Metal pollution has increased with the technological progress of human society. Industry, mining and advanced agriculture, household waste and motor traffic are all among the activities considered to be major sources of metal pollution. Metals can accumulate in aquatic organisms, including fish. Fish are an important component of human nutrition, and those from contaminated sites present a potential risk to human health. Since fish occupy the top of the aquatic food chain, they are suitable bioindicators of metal contamination. Metals are well known inducers of oxidative stress, and assessment of oxidative damage and antioxidant defences in fish can reflect metal contamination of the aquatic environment (Livingstone, 2003; Luoma and Rainbow, 2008; Sevcikova et al. 2011). *C. carpio* occupies a significant place in Turkey's fishing activities and it has widespread distribution in our freshwater ecosystems such as lake, pond and dam lake. Moreover, *C. carpio* has considerable commercial potential in our domestic market (Demirkalp, 2007).

This study was carried out to investigate Cr, Ni and Zn levels in edible muscle and skin tissues of *C. carpio* in Çamlıgöze Dam Lake established on the Kelkit Stream which is a branch of the Yeşilırmak River at the Central Anatolian region of Turkey.

Materials and methods

Study Area. The study area is Çamlıgöze Dam Lake located at Central Anatolian region of Turkey (Fig. 1). Geographical cordinates of Çamlıgöze Dam Lake are 40° 13' 45" N, 38º 04' 36" E). Çamlıgöze Dam Lake is situated approximately 140 km north-east of Sivas province centre. The Çamlıgöze Dam was constructed between 1987 and 1998 on the Kelkit Stream, a tributary of Yeşilırmak River. Çamlıgöze Dam is a 37 m high rock-fill of a power plant. The water of Çamlıgöze Dam Lake is mainly used for production of electric energy, commercial fishing, aquaculture, irrigation and recreation. The surface area and maximum depth of the Çamlıgöze Dam Lake are 5 km^2 and 30 m respectively (Dirican et al. 2009).

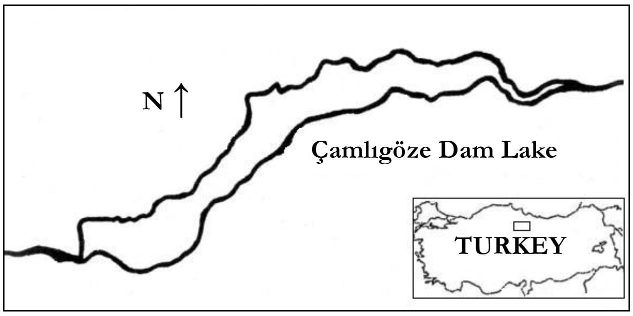

Fig. 1. **Location of Çamlıgöze Dam Lake in Turkey**

Sampling and sample preparation. This study was carried out between January and December, 2011. Fish samples were collected with nets of various mesh sizes (20, 30, 40 and 60 mm) from Çamlıgöze Dam Lake. Fish samples were transferred to the laboratory to record age, total body length and total wet weight. Body weight and total length of each individual were measured with a precision of 0.1 g and 0.1 cm, respectively. Fish samples were washed with water, packed in polyethylene bags and stored at -20 ^{0}C until analysis. Scales taken from under dorsal fin were used for age determination. For this purpose, scales were kept in 3% NaOH solution for 24 hours, and then washed in distilled water and treated with 70% alcohol solution (Lagler, 1966). After cleaning, the scales were examined under a steromicroscope to allow age determination. Approximately 1 or 2 g of the muscle, skin and liver samples were dissected from 12 fish specimens. Soft tissues were extracted from each fish samples using a plastic knife. After that, they were individually transferred to 20 ml glass vials, previously washed with 0.1 N nitric acid, dried and weighed. They were dried for 24 hours at 105 ^{0}C and kept in an oven. Then samples were kept at room temperature for 24 hours by adding 3 ml nitric acid. During the next step, the samples were kept on a slightly hot metal plate until the color disappeared. The slowly heated vapours were mineralized. 1 ml of sulfuric acid followed by 1–2 drops of nitric acid were added to the samples. The digested samples were diluted to 50 ml with distilled water (Çalta et al. 2000; Çalta and Canpolat, 2006). The solution was transferred and filtered through 0.45 µm nitrocellulose membrane filter and ready for analysis (Alam et al. 2002). Analysis of the heavy metals in the fish samples was carried out using a GBC AVANTA flame atomic absorption spectrophotometer to determine the levels of Cr, Ni and Zn. The levels of Cr, Ni and Zn metals were expressed as µg/g (wet weight). The absorption wavelengths were as follows: 428.9 nm for Cr; 351.5 nm for Ni and 213.9 nm for Zn. The detection limits were 0.2–0.6 ppm for Cr; 0.2–0.8 ppm for Ni and 0–1.5 ppm for Zn, respectively.

Statistical analysis. Unpaired t test was performed in order to evaluate the differences in *C. carpio* between muscle and skin. Spearman correlation analysis was used to reveal relationships between heavy metal levels and age, total length, weight specimens of *C. carpio*. SPSS for windows version 17.5 statistical software was used for all data analysis. A p-value lower then 0.05 was considered statistically significant.

Results and discussion. A total of twelve specimens of *C. carpio* were caught from the Çamlıgöze Dam Lake. Some characteristics of *C. carpio* in the Çamlıgöze Dam Lake are given in Table 1. The ages of the captured specimens of *C. carpio* ranged from 2 to 6 years and the 3rd group was dominant in the population. The total length of *C. carpio* population in the Çamlıgöze Dam Lake ranged from 21.3 cm to 3.2 cm. The mean total length of all *C. carpio* samples was determined to 26.800±4.856 cm. The weights of *C. carpio* ranged between 275.1 g and 1070.7 g. The mean determined weight of all *C. carpio* samples was 481.625±230.100 g in the Çamlıgöze Dam Lake.

Table 1. **Some characteristics of *Cyprinus carpio* in Çamlıgöze Dam Lake**

Species	N	Age (year) Mean±SD	Total Length (cm) Mean±SD	Weight (g) Mean±SD
Cyprinus carpio	12	3.58±1.240 (2–6)	26.800±4.856 (21.3–39.2)	481.625±230.100 (275.1–1070.7)

N – number of observations, SD – standard deviation, minimum and maximum values are given in parentheses

The levels of Cr, Ni and Zn expressed as µg/g wet weight in muscle and skin of *C. carpio* living in the Çamlıgöze Dam Lake are given in Table 2. Levels of metals varied depending on different tissues in *C. carpio*. The muscle of *C. carpio* had the highest levels of Cr (0.12 µg/g), Ni (2.15 µg/g) and Zn (0.51 µg/g). The skin of *C. carpio* had the highest levels of Cr (0.15 µg/g), Ni (2.07 µg/g) and Zn (1.97 µg/g). The highest Cr (0.15 µg/g) and Zn (1.97 µg/g) level was determined in the skin of *C. carpio*. The highest Ni (2.15 µg/g) level was determined in the muscle of *C. carpio*. The highest Cr and Zn levels were determined in skin of *C. carpio*, whereas the highest Ni levels were measured in the muscle. The order of mean metal levels except for Zn in various tissues of *C. carpio* was in the following order: muscle>skin. Mean levels in the muscle and skin of *C. carpio* were found as follows: Ni>Zn>Cr and Zn> Ni>Cr, respectively in Çamlıgöze Dam Lake (Table 2). The results showed that metal accumulation of Cr and Zn in the skin is higher than in the muscle of *C. carpio* from the Çamlıgöze Dam Lake. The significance levels of heavy metal accumulation in the tissues were analyzed with t test. There was important statistical differences, especially at the level of Zn accumulation in tissues (p = 0.000). The highest accumulation of Zn was observed in the skin with 1.97 µg/g while the lowest accumulation of Zn was observed in the muscle with 0.27 µg/g in the Çamlıgöze Dam Lake. There are no statistical differences, among the levels of Cr and Ni in tissues (p>0.05).

Table 2. **Descriptive values and the comparison results of Cr, Ni, Zn levels in tissues of *Cyprinus carpio* in Çamlıgöze Dam Lake**

Elements	Muscle Mean ±SD	Skin Mean ±SD	t	p
Cr	0.062±0.032 (0.02–0.12)	0.055±0.052 (nd–0.15)	0.380	0.708
Ni	0.998±0.653 (0.03–2.15)	0.818±0.669 (0.03–2.07)	0.670	0.510
Zn	0.375±0.081 (0.27–0.51)	1.173±0.364 (0.65–1.97)	–7.405	0.000*

SD – standard deviation, nd: not detected, minimum and maximum values are given in parentheses, the asterisks notation (* – p<0.001 extremely significant) show the significance level of t test

Spearman correlation analysis was used to determine the relationship between the variables. Correlation coefficients (r) and levels of significance (p) for the relationships between heavy metals level with the variables of age, total length and weight of *C. carpio* are given in Table 3. There was a significant and positive correlation between age, total length, weight and metal levels for chromium in the tissues of *C. carpio*. A medium and positive correlation was observed in the muscle of *C. carpio* for Cr (r = 0.603*, p = 0.038; r = 0.604*, p = 0.037; r = 0.625*, p = 0.030). In the skin of *C. carpio*, a very weak positive correlation was observed between chromium and age (r = 0.356, p = 0.256). Similarly, in the skin of *C. carpio*, a very weak positive correlation was observed between Cr and total length (r = 0.313, p = 0.321) in the Çamlıgöze Dam Lake. In contrast, no significant positive correlations between the levels of Ni and Zn in muscle and skin were found. In this study, we found a very weak negative correlation between the levels of Ni, Zn and tissues of *C. carpio*. In the muscle of *C. carpio*, a very weak negative correlation was observed between Ni and total length (r = –0.280, p = 0.379). Similarly, in the muscle of *C. carpio*, a very weak negative correlation was observed between Zn and total length (r = –0.277, p = 0.38). In the skin of *C. carpio*, a very weak negative correlation was observed between Ni and total length (r = –0.392, p = 0.208) in the Çamlıgöze Dam Lake (Table 3). Different metals differed in their capabilities to be taken up and accumulated by *C. carpio*. The uptake of Cr (r = 0.603*, p = 0.038; r = 0.604*, p = 0.037; r = 0.625*, p = 0.030) increases with its increasing levels in muscle. Positive correlations were found for Cr accumulation of the muscle and skin, while for the Ni and Zn levels in these tissues the negative associations were characteristically related to size.

Pollution with heavy metals has become a serious environmental and public health hazard because the levels released into the environment from industrial processes often exceed the permissible levels. Due to their bioaccumulative and non-biodegradable properties, heavy metals constitute a core group of aquatic pollutants. Their high toxicity even in low levels can produce cumulative deleterious effects in a wide variety of fish and other aquatic organisms. Cr one of the most common ubiquitous pollutants in the environment, does not occur naturally in the pure metallic form. Cr enters into various environmental matrices (air, water, soil) from a wide variety of natural and anthropogenic sources. The aquatic toxicology of Cr depends on both biotic and abiotic factors (Vutukuru et al. 2007; Velma et al. 2009). The Cr level in muscle and skin tissues varied from 0.02 µg/g to 0.12 µg/g, mean value of 0.062±0.032 µg/g and nd to 0.15 µg/g, mean value of 0.055±0.052 µg/g respectively for *C. carpio* from the Çamlıgöze Dam Lake (Table 2). There are various studies on Cr levels in *C. carpio* from different freshwater ecosystems in the World and Turkey. The mean Cr values in muscle of *C. carpio* obtained in this study were lower than those obtained by Altındağ and

Yiğit (2005) in *C. carpio* from the Beyşehir Lake, Turkey. Similarly, the mean Cr values in all of the examined tissues of *C. carpio* obtained in this study were lower than those obtained by Mendil and Uluözlü (2007) in *C. carpio* from the Bedirkale Dam Lake, Boztepe Dam Lake, Belpınarı Dam Lake, Avara Dam Lake, Ataköy Dam Lake and Akın Dam Lake, Turkey. The mean Cr values in the muscle of *C. carpio* obtained in this study were lower than those obtained by Zhang et al. (2007) in *C. carpio* from the Three Gorges Reservoir, China. The mean Cr values in the muscle of *C. carpio* obtained in this study were lower than those obtained by Kalyoncu et al. (2012) in *C. carpio* from the Işıklı Dam Lake and Karacaören Dam Lake, Turkey. The mean Cr values in the muscle of *C. carpio* obtained in this study were lower than those obtained by Patino et al. (2012) in *C. carpio* from the Mead Lake National Recreation Area, USA. The mean Cr values in the muscle of *C. carpio* obtained in this study were higher than those obtained by Çiçek and Koparal (2001) in *C. carpio* from the Porsuk Dam Lake, Turkey. The mean Cr values in the muscle of *C. carpio* obtained in this study were higher than those obtained by Karataş (2008) in *C. carpio* from the Bedirkale Dam Lake, Turkey. Cr values did not determine to these reported in *C. carpio* tissues from the Keban Dam Lake, Turkey; Taihu Lake, China; Enne Dam Lake, Turkey; Beyşehir Lake, Turkey, Manyas Lake, Turkey and Karacaören-II Dam Lake, Turkey (Çalta and Canpolat, 2006; Qiao-qiao et al. 2007; Köse and Uysal, 2008; Tekin-Özan and Kır, 2008; Çiçek et al. 2009; Kır and Tumantozlu, 2012). Cr values were similar to these reported in *C. carpio* tissues from the Kasumigaura Lake, Japan and Porsuk Dam Lake, Turkey (Alam et al. 2002; Çiçek and Koparal, 2001). The mean levels of Cr in muscle and skin were 0.062±0.032 µg/g and 0.055±0.052 µg/g, respectively which was lower than the acceptable limit (1 µg/g) in fish tissues set by FAO (1983).

Table 3. **Spearman correlation coefficients** (r) **and levels of significance** (p) **for the relationships between heavy metal levels and age, total length, weight of *Cyprinus carpio***

Characteristics	Muscle			Skin		
	Cr	Ni	Zn	Cr	Ni	Zn
Age	r = 0.603* p = 0.038	r = –0.164 p = 0.610	r = –0.075 p = 0.817	r = 0.356 p = 0.256	r = –0.244 p = 0.444	r = –0.175 p = 0.586
Total Length	r = 0.604* p = 0.037	r = –0.280 p = 0.379	r = –0.277 p = 0.384	r = 0.313 p = 0.321	r = –0.392 p = 0.208	r = –0.235 p = 0.463
Weight	r = 0.625* p = 0.030	r = –0.070 p = 0.829	r = 0.004 p = 0.991	r = 0.183 p = 0.569	r = –0.119 p = 0.713	r = –0.109 p = 0.737

The asterisk notation (* – p<0.05) show the significance level of the correlation coefficients in the table

Ni is one of the microelements which occur in trace amounts in living organisms. It constitutes a potential hazard to the environment media (air, water and soil). This is due to its extensive and widespread utilization in various industries: it is a common by-product of electroplating industries, steel production, metal mining, smelting, refining, ceramic and processing along with fuel combustion, and waste incineration activities. Effluents that spread to streams, rivers and lakes may disrupt the integrity of the aquatic environment. Ni is considered as an important toxic pollutant and is continuously released into the biosphere by some anthropogenic activities such as industrial and urban sewage. Excess of Ni contamination is a real hazard to aquatic ecosystems due to its persistence and bioaccumulation (Atchison et al. 1987; Ebrahimzadeh et al. 2011). The nickel level in muscle and skin tissues varied from 0.03 µg/g to 2.15 µg/g, mean value of 0.998±0.653 µg/g and 0.03 µg/g to 2.07 µg/g, mean value of 0.818±0.669 µg/g respectively for *C. carpio* in the Çamlıgöze Dam Lake (Table 2). There are various studies on Ni levels in *C. carpio* from different freshwater ecosystems in the World and Turkey. The mean Ni values in all of the examined tissues of *C. carpio* obtained in this study were lower than those obtained by Mendil and Uuözlü (2007) in *C. carpio* from the Bedirkale Dam Lake, Boztepe Dam Lake, Belpınarı Dam Lake, Avara Dam Lake, Ataköy Dam Lake and Akın Dam Lake, Turkey. Similarly, the mean Ni values in muscle of *C. carpio* obtained in this study were lower than those obtained by Barlas (1999) in *C. carpio* from upper Sakarya River Basin, Turkey. The mean Ni values in muscle of *C. carpio* obtained in this study were lower than those obtained by Mendil et al. (2010) in *C. carpio* from the Yeşilırmak River, Turkey. The mean Ni values in muscle of *C. carpio* obtained in this study were lower than those obtained by Kalyoncu et al. (2012) in *C. carpio* from the Işıklı Dam Lake and Karacaören Dam Lake, Turkey. The mean Ni values in muscle of *C. carpio* obtained in this study were higher than those obtained by Alam et al. (2002) in *C. carpio* from the Kasumigaura Lake, Japan. The mean Ni values in muscle of *C. carpio* obtained in this study were higher than those obtained by Karataş (2008) in *C. carpio* from the Bedirkale Dam Lake, Turkey. The mean Ni values in muscle of *C. carpio* obtained in this study were higher than those obtained by Kandemir et al. (2010) in *C. carpio* from the Bafra Fish Lakes, Turkey. Ni values did not determine to these reported in *C. carpio* tissues from the Enne Dam Lake, Turkey and Atatürk Dam Lake, Turkey (Köse and Uysal, 2008; Karadede and Ünlü, 2000). The mean levels of Ni in muscle and skin were 0.998±0.653 µg/g and 0.818±0.669 µg/g, respectively which was lower than the permissible limit (10 µg/g) in fish tissues set by FAO (1983).

The primary anthropogenic sources of Zn in the environment (air, water, soil) are related to mining and metallurgic operations involving zinc and use of commercial products containing zinc. Zn is one of the most important trace metals in the body, and participates in the biological function of several proteins and enzymes. Despite being an essential trace element, Zn is toxic to most organisms above certain levels. Zn is known to bioaccumulate in some aquatic organisms (WHO, 2001; Ho, 2004; Maity et al. 2008). The Zn level in muscle and skin tissues varied from 0.27 µg/g to 0.51 µg/g, mean value of 0.375±0.081 µg/g and 0.65 µg/g to 1.97 µg/g, mean value of 1.173±0.364 µg/g respectively for *C. carpio* from the Çamlıgöze Dam Lake (Table 2). There are various studies on Zn levels in *C. carpio* from different freshwater ecosystems in the World and Turkey. The mean Zn values in muscle of *C. carpio* obtained in this study were lower than those obtained by Alam et al. (2002) in *C. carpio* from the Kasumigaura Lake, Japan. Similarly, the mean Zn values in the muscle and skin of *C. carpio* obtained in this study were lower than those obtained by Çalta and Canpolat (2006) in *C. carpio* from the Keban Dam Lake, Turkey. The mean Zn values in the muscle of *C. carpio* obtained in this study were lower than those obtained by Zhang et al. (2007) in *C. carpio* from the Three Gorges Reservoir, China. The mean Zn values in the muscle of *C. carpio* obtained in this study were lower than those obtained by Karataş (2008) in *C. carpio* from the Bedirkale Dam Lake, Turkey. The mean Zn values in the muscle of *C. carpio* obtained in this study were lower than those obtained by Mendil et al. (2010) in *C. carpio* from the Yeşilırmak River, Turkey. The mean Zn values in the muscle of *C. carpio* obtained in this study were lower than those obtained by Kalyoncu et al. (2012) in *C. carpio* from the Işıklı Dam Lake and Karacaören Dam Lake, Turkey. The mean Zn values in the muscle of *C. carpio* obtained in this study were lower than those obtained by Patino et al. (2012) in *C. carpio* from the Mead Lake National Recreation Area, USA. The mean Zn values in the muscle of *C. carpio* obtained in this study were higher than those obtained by Khan et al. (2012) in *C. carpio* from the Shah Alam River, Pakistan. The mean levels of Zn in the muscle and skin were 0.375±0.081 µg/g and 1.173±0.364 µg/g, respectively which was lower than the acceptable limit (150 µg/g) in fish tissues set by FAO (1983).

Conclusion. This study provides new information on the levels of Cr, Ni and Zn in edible muscle and skin tissues of *C. carpio* from Çamlıgöze Dam Lake. The highest Cr and Zn levels were determined in the skin of *C. carpio*, whereas the highest Ni levels were measured in the muscle. All results were below the limits for fish proposed by FAO and were safe within the acceptable limits for human consumption in the edible tissues of *C. carpio* from the Çamlıgöze Dam Lake. However, periodical monitoring of these metals in the fish from the Çamlıgöze Dam Lake consumed by public is recommended. Consequently, heavy metals pollution affects not only aquatic organisms, but also public health as a result of bioaccumulation in the food chain.

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Received 11 June 2012
Accepted 12 June 2013