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## Determination of macro and micro element levels in muscle tissues of cultured and wild rainbow trout, *Oncorhynchus mykiss*

**Tayfun karataş****Abstract**

The aim of this study was to compare the differences between cultured and wild rainbow trouts in terms of macro and micro element levels in muscle tissues. The samples obtained from rainbow trout tissues were analyzed for Na, Ca, P, K, Mg, Cr, Cu, Fe, Mn, Ni, Se and Zn levels by ICP-OES method. The levels of Na, Ca, P, K and Mg in the muscle tissues of cultured rainbow trout were found to be higher than that of wild rainbow trouts. The levels of Cr, Fe, Mn, Ni, and Se in muscle tissues of wild rainbow trout were higher and, the level of Cu was lower when compared to the cultured rainbow trout. The differences in macro and micro element levels determined between cultured and wild rainbow trout could be related to the differences in their environmental conditions and dietary element concentrations.

**Keywords:** Fish, Heavy metals, ICP-OES, Mineral substance**1. Introduction**

Metal pollution raised from industrial wastes, agricultural and urban sewage may lead to serious health problems for organisms living in aquatic conditions. Metals accumulate in fish tissues with pathways such as respiration and feed intake <sup>[1]</sup>. The major elements such as Potassium, Phosphorus, Calcium, Sodium and Magnesium, essential to cellular metabolism, are very common and generally found in high concentrations in biological tissues <sup>[2, 3]</sup>. The metals such as iron, copper, zinc and manganese are known as essential metals for fish and are important in biological systems. However, the essential metals can lead to toxic effects if the metal intake is excessively increased <sup>[4]</sup>. For example; the level of nickel in organisms is generally low, however, chronic nickel intake has been determined to be an increased risk of chronic lung cancer <sup>[5]</sup>. Fish is widely consumed in many zones of Turkey, because of high protein content, low saturated fat and omega fatty acids known to support good health <sup>[6]</sup>. The micro elements (iron, copper, zinc, chromium, selenium and manganese) in muscle tissue of fish are part of enzymes, hormones and cells. All the elements affect the homeostatic behavior of fish, which may vary due to excess or deficiency of any of the factors. Excessive or deficient value of a factor may lead to serious disorders in biochemical processes, which may result in many diseases <sup>[7]</sup>. Insufficient intake of micro elements can cause symptoms of nutritional deficiency. Nowadays, the industrial and urban wastes are directly dumped into the aquatic environment leading to bioaccumulation and biomagnification of heavy metals in fish. Fish are known as the best indicators of metal pollution in aquatic systems depending on size and age <sup>[8]</sup>. Micro elements required for plant, animal and human lives have beneficial or harmful effects depending on concentration and amount. Therefore, the aquatic pollutants have an important toxic potential <sup>[9]</sup>. In recent years, fish has played an important role in human nutrition and thus require the investigation on metal accumulation <sup>[10]</sup>. Humans particularly consume muscle tissue of fish. Because, macro and micro elements found in muscle tissue of the fish are substances needed by the cells in a healthy body. Therefore, all of macro and micro elements accumulated in muscle tissue and is transferred to man by means of the food chain <sup>[11]</sup>. Pollution is important in terms of determination of the chemical quality in muscle tissue of fish living in the marine, lake and ponds <sup>[6]</sup>. In the present study, levels of macro (K, P, Na, Ca, Mg) and micro elements (Cr, Cu, Fe, Mn, Ni, Se and Zn) in muscle tissue of cultured and wild rainbow trouts have been determined and discussed in the light of their role in organisms.

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## 2. Materials and Methods

Wild rainbow trouts were randomly caught from the Kuzgun dam lake (latitude 40°13'21"N; longitude 41°2'3"E) (Figure 1)

and cultured rainbow trouts were obtained from an enterprise engaged in production of commercial trout (Figure 2) and was conducted in April and May 2013.



**Fig 1:** Placement of Erzurum city in Turkey



**Fig 2:** Kuzgun Dam lake in Erzurum, Turkey

The average weights of fish used in research were  $241.3 \pm 3.6$  g and  $265.4 \pm 3.2$  g for wild rainbow trout and cultured rainbow trout, respectively. Composite samples of thirty individual fish for every group were obtained from Kuzgun Dam Lake and an enterprise engaged in production of commercial trout. The fish were then brought to laboratory in the Faculty of Fisheries. The samples were washed with distilled water, dissected to take out muscle tissues by using steel knife and dried in Microwave oven at 105 °C for 24 hours. After complete dry, the samples were finely crushed by using mortar and pestle and weighed to 2 g using an electronic weighing balance [12]. The tissues were digested overnight followed by hot plate method (120 °C) after mixing with 20 ml concentrated nitric acid and perchloric acid (2:1 v/v) (Merck) up to complete dryness. All samples were completed to 50 mL with 20% conc. nitric acid in distilled water and then filtered with Whatman filter paper (11 ml) and element concentrations were determined by using Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES). ICP-OES with radial torch equipped with argon saturation assembly was used for the determination of Na, Ca, P, K, Mg, Na, Cr, Cu, Fe, Mn, Ni, Se and Zn. High purity (99.99%) argon was used as plasma, auxiliary and nebulizer gas. The gas flows were kept at 15.0

l/min for plasma, 1.50 l/min for auxiliary and 0.56 l/min for nebulizer. Radio frequency (R.F) power of the plasma generator was 1.35 kW. Vertical height of the plasma was fixed at 7 mm. Sample uptake time of 30.0 sec, delay time of 5 sec, rinse time of 10 sec, initial stabilization time of 10 sec and time between replicate analysis of 5 sec was maintained throughout the studies for ICP-OES [13-15]. Element concentrations were calculated in milligrams/kilogram (dry weight).

The data was analyzed using (SPSS 15.0 package program) ONE-WAY analysis to evaluate differences in element concentrations between the muscle tissues in cultured and wild rainbow trout.

## 3. Results and Discussion

The Na, Ca, P, K, Mg, Na, Cr, Cu, Fe, Mn, Ni, Se and Zn concentrations of water in the two sampling sites were compared with international standards (Table 1). The obtained results showed that the macro and micro element levels in waters did not exceed WHO (World Health Organization), EC (European Community), EPA (Environment Protection Agency), WPCL (Water Pollution Control Legislation), and TSE-266 (Turkish Standards) guidelines [16-20]. The macro and

micro elements levels of water in Kuzgun Dam Lake and ponds were lower when compared to the metal levels in Gediz River [21], Avsar Dam Lake [22], and Atatürk Dam Lake [23], Hazar Lake [24], Demirköprü Dam Lake [25], and Lapland Lakes and Siberian ponds [26, 27].

**Table 1:** The average concentrations of macro and micro elements in water of the Kuzgun Dam Lake and Ponds

Parameters	Ponds	Kuzgun Dam Lake
Temperature <sup>a</sup>	10.2 C <sup>o</sup>	17
Ph <sup>a</sup>	7.25	7.9
NO <sub>2</sub> <sup>a</sup>	0.012	-
NO <sub>3</sub> <sup>a</sup>	16.65	0.76
Hardness <sup>a</sup>	103.1	250.9
Ca <sup>b</sup>	47	41
P <sup>b</sup>	38	29
K <sup>b</sup>	3.2	-
Na <sup>b</sup>	14.17	0.46
Mg <sup>b</sup>	7.09	12.9
Fe <sup>b</sup>	0.05	2.8
Cu <sup>b</sup>	0.2	0.6
Ni <sup>b</sup>	0.04	0.16
Mn <sup>b</sup>	0.01	0.043
Zn <sup>b</sup>	0.13	0.64
Cr <sup>b</sup>	0.28	0.46
Se <sup>b</sup>	-	-

<sup>a</sup> Results of laboratory analysis of water done in Erzurum Hıfzıssıha Institute

<sup>b</sup> Results of ICP-OES method done in the Department of Soil, Faculty of Agriculture, Ataturk University

Average macro (Ca, Na, Mg, K, P) and micro element levels (Cr, Cu, Fe, Mn, Ni, Se and Zn) in muscle tissue of cultured and wild rainbow trout have been tabulated in Tables 2-3. The macro elements, essential to cellular metabolism, are very common and particularly found in high concentrations in biological tissues [2, 3]. Levels of K, P, Ca, Na and Mg in muscle tissues of cultured rainbow trout were found to be higher than that of wild rainbow trout (Table 3). Differences observed between muscle tissues of both fish were statistically significant ( $p < 0.05$ ). The metal concentration in cultured and wild rainbow trout (for Ca, Na, Mg, K, P) in our study was found to be higher than muscle tissues of cultured rainbow trout caught from Ataturk Dam Lake [28]. The higher levels of macro elements in tissue of fish may affect human metabolism as well.

**Table 3:** Macro levels (mg/kg) in muscle tissues of cultured and wild rainbow trout (dry weight).

Macro Element*	Cultured rainbow trout	Wild rainbow trout
Ca	48.13±10.3 <sup>a</sup>	11.3±0.06 <sup>b</sup>
Na	1247.0±71.9 <sup>a</sup>	827.6±50.6 <sup>b</sup>
Mg	335.7±38.9 <sup>a</sup>	260.3±37.2 <sup>b</sup>
K	3052.1±152.7 <sup>a</sup>	2625.2±143.5 <sup>b</sup>
P	3357.2±178.0 <sup>a</sup>	2845.1±154.6 <sup>b</sup>

\*Results are expressed as mean±standard deviation. Values with the same superscript do not differ significantly ( $p > 0.05$ ).

Fe and Cu are known as essential elements and play an important role in biological systems of organisms, including fish. The present study showed that levels of Fe, Cu and Mn in tissues of wild rainbow trout were high in concentration than

in tissues of cultured rainbow trout ( $p < 0.05$ ). (Table 2). Fallah *et al.* [4] has demonstrated that the dark muscles contain higher Fe and Cu levels than light muscles. The obtained results for levels of Fe, Cu and Mn in muscle tissue of wild rainbow trout differ from results of the studies done before on different species from Al- Arab River, Northwest Atlantic, Ataturk Dam Lake, Yesilirmak River [29-33]. The maximum Cu level for fish has been determined as 20 mg/kg according to Turkish Food Codex [34]. However, Cu level in analyzed fish samples in our study was found to be lower than legal limits.

Zinc concentration in the investigated fish samples ranged from 17.4–34.7 mg/kg. Statistically significant differences in Zn levels between cultured and wild rainbow trout were observed ( $P < 0.05$ ). Zinc concentrations in fish living in the Swan and Boeuf lakes have been reported as 45-60.9 ppm and 4.62–14.6 mg/ kg [35, 36]. Zinc is known to be involved in most metabolic pathways in humans and zinc deficiency can lead to loss of appetite, growth retardation, skin changes and immunological abnormalities. The maximum zinc level permitted for fishes is 50 mg/kg according to TFC [37]. However, Zn levels of cultured and wild rainbow trout were found to be lower than the legal limits.

**Table 2:** Micro element levels (mg/kg) in muscle tissues of cultured and wild rainbow trout (dry weight)

Mikro Elements*	Cultured rainbow trout	Wild rainbow trout
Cr	0.462±0.14 <sup>a</sup>	0.597±0.17 <sup>a</sup>
Cu	3.31±0.60 <sup>a</sup>	8.125±1.72 <sup>b</sup>
Fe	3.65±0.69 <sup>a</sup>	9.834±3.58 <sup>b</sup>
Mn	0.929±0.22 <sup>a</sup>	6.849±0.35 <sup>b</sup>
Ni	0.338±0.02 <sup>a</sup>	0.441±0.12 <sup>a</sup>
Se	1.827±0.47 <sup>a</sup>	2.145±0.49 <sup>a</sup>
Zn	17.46±3.08 <sup>a</sup>	34.750±5.92 <sup>b</sup>

\*Results are expressed as mean±standard deviation. Values with the same superscript do not differ significantly ( $p > 0.05$ ).

Selenium, Chromium and Nickel levels in muscle tissue of the fish samples ranged between 1.8-2.1, 0.46-0.59, 0.33-0.44 mg/kg, respectively (Table 2). There was no a significant difference in levels of Se, Cr and Ni between the tissues of cultured and wild rainbow trout ( $P > 0.05$ ). Our results are in accordance with studies done on cultured and wild sea bass [37] [38], yellow perch [39], haddock [40] and common carp [41]. However, our results showed lower levels of Cr accumulation when compared to the muscle tissue of *Cyprinus carpio* from Avsar Dam Lake, Atatürk Dam Lake and Gölcük Lake [42]. Selenium is an essential element for humans and animals due to regulation of thyroid hormone metabolism. It protects against to the toxic effects of mercury [43]. Chromium is essential for normal carbohydrate and lipid metabolism. The role of chromium in glucose metabolism has been reported for poult and mammals [44]. Chromium is considered to be a cofactor for insulin activity and part of an organic tolerance factor [45]. Nickel is not an essential element but as a trace element it may be beneficial to activate some enzyme systems [4].

#### 4. Conclusion

Both wild and cultured rainbow trout were found to be rich in macro and micro elements. Differences observed in the concentrations of macro and micro elements between the two fish groups may be closely related to seasonal and biological differences (species, size, dark/white muscle, sex and sexual

maturity), area of catch, processing method, food source, environmental conditions such as water chemistry, salinity, temperature and contaminants and pollution. Based on this study, I recommend consumption of cultured rainbow trout in the human diet as there will be less chances of metal toxicity.

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