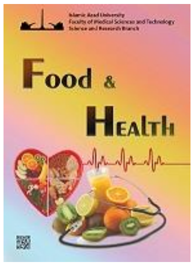
Food & Health 2019, 2(3): 39-42



Food & Health Journal

Journal homepage: fh.srbiau.ac.ir

Comparative study of macroelements levels in tissues of cultured and wild *Capoeta damascina* using ICP-OES technique

Hadi Monji[1,2], Pegah Rahbarinejad[3*]

[1] Department of Cellular and Molecular Nutrition, Faculty of Nutrition Science and Food Technology, National Nutrition and Food Technology Research Institute, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[2] Department of Nutrition, Science and Research Branch, Islamic Azad University, Tehran, Iran

ARTICLE INFO

Original Article

Article history:
Received 14 August 2019
Revised 07 November 2019
Accepted 21 November 2019
Available online 20 December 2019

Keywords:
Macroelements
Fish
Capoeta damascina
Human health

ABSTRACT

Fish and seafood are rich in many nutrients, including proteins, amino acids, vitamins, and omega-3 essential fatty acids. Fish are also a rich source of calcium, phosphorus, iron, zinc, potassium, sodium, and iodine. Hence, this study aims to assess the macroelement (Na, K, Ca, Mg, and P) content of liver and muscle in the wild and farmed *Capoeta damascina* and its beneficial health for the local consumer. Macroelements were investigated in the farmed and wild fish (*C. damascina*) from Armand River in Chaharmahal-va-Bakhtiari province, Iran, by inductively coupled plasma-optical emission spectrometry (ICP-OES). Also, Daily Value % for all macroelements was assessed. Potassium was the most abundant macroelement in tissues of both fish species, whereas sodium was the lowest. There was a significant difference between calcium, magnesium, and potassium in comparing elements content between liver and muscle. However, there was no significant difference in the phosphorus and sodium content. The calcium content of farmed tissues was higher than wild tissues. However, it was not any significant difference in levels of phosphorus, magnesium, potassium, and sodium between wild and farmed fish. Also, both wild and farmed fish were excellent sources of phosphorus and good sources of magnesium. Both farmed and wild fish muscle are good sources for phosphorous and magnesium that may reach beneficial health for the local consumers. Farming of *C. damascina* suggested to less capturing of wild *C. damascina* for reserving the ecosystem.

1. Introduction

The world's growing population has increased food insecurity, undernutrition, micronutrient deficiency, unsafe food consumption, limited access to food, and food demand. Therefore, the need for quality foods has become increasingly important (1). Fish and seafood are rich in many nutrients, including proteins, amino acids, vitamins, and omega-3 essential fatty acids. Fish are also a rich source of calcium, phosphorus, iron, zinc, potassium, sodium, and iodine. It has a low-calorie density and is an essential component of the Mediterranean diet (1-3). The accumulation of these elements can be affected by the food chain and the fish's habitat. On the other hand, local fish consumption is associated with increased food security for local people and contributes to a sustainable food system (2-4). According to the available information, per capita fish consumption for each Iranian was about 9.1 kg in 1990, increasing in recent years (5). Macroelements have an essential role in human health (4). For instance, sodium and potassium regulate some enzyme activity and osmotic pressure within the cell. Magnesium regulated over 300 enzymes in the cells. Calcium is vital for bone health. It also controls muscle contraction and plays an important role in normal blood clotting. Phosphorus is needed for healthy bones and energy storage and production (5). *Capoeta damascina* or Teledei belongs to *Teleostei* and *Actinopterygii*, *Cypriniformes*, *Cyprinidae* (*Capinidae*), and *Capoeta*. Its other names are Siahmahi (blackfish) and Sardeh, and is mostly used for consumption and recreational fishing in Iran. This fish is consumed in many Asian and European countries as an

*Corresponding author: Department of Nutrition, Science and Research Branch, Islamic Azad University, Tehran, Iran.
E-mail address: pegah.rahbarinejad@gmail.com (Pegah Rahbarinejad).

essential part of the diet (7, 8). In the last decade, many efforts have been made to breed this fish (7). Differences in the quality of farmed and wild fish have always been debated. Several studies have reported differences in the chemical composition of different farmed and wild fish (6-8). These reports cited variation in environmental conditions and diet as the main reasons for this difference (9, 10). Therefore, this study aimed to measure and compare the macroelement (Na, K, Ca, Mg, and P) content of muscle and liver of farmed and wild *C. damascina*.

2. Material and methods

2.1. *Rearing conditions of C. damascina*

Wild *C. damascina* were captured from the 10-fishing site of Armand River in Chaharmahal-va-Bakhtiari province, Iran. In this study, 4–8 fish were caught from each of the river's fishing sites. Transferred to the animal house laboratory of Shahrekord University, Iran; and randomly distributed into 6 tanks (10 fish per each tank). To adopt the wild fish to laboratory conditions, the fish were kept in fresh water for a week. During the rearing period, the fish were hand-fed with a commercial common carp diet (Behparvar Co., Karaj, Iran, containing 38% protein, 11% lipid, 8.5% ash, and 10% moisture) two times a day. The rearing condition of water in each tank was under continuous aeration to prepare adequate dissolved oxygen. The water also regularly passed through a sand filter to eliminate sediments. The water renewal rate in the system was 50% every week to reach reasonable water quality limits. The rearing condition was as follows: temperature, 19.5–22 8C; dissolved oxygen concentration, 6.5–8.3 mg O2/l; pH, 6.9–7.6; and ammonia–nitrogen, 0.02–0.05 mg/l. 20 adult wild *C. damascina* also collected from the same station and transferred to the lab.

2.2. Preparation of samples

Both wild and farmed fish were slaughtered by immersing in ice-cold water. The mean weight and length (mean ± SEM) of fish were 201.52±5.83 g and 20.24±2.8 cm for wild and 211.67±8.21 g and 22.33±2.6 cm for farmed fish, respectively. There were no significant differences ($p>0.05$) in weight and length between farmed and wild fish. The fish were beheaded, eviscerated, deboned, skinned, and filleted. The liver and muscle of fish were dissected, and the samples packed with a polyethylene bag and stored at −20 °C before analysis.

2.3. Analytical procedures

The fillet and liver were dried in an oven at 60–65 °C until a constant weight was obtained, cooled in room temperature, and then milled in a food mill. According to the method of previous studies, digestion of the samples was performed using high-pressure decomposition vessels, known as the digestion bomb, according to the method of previous studies (9). In brief, A sample (0.5 g) was mixed with 8 ml of 68% nitric acid (super purity quality; Romil Ltd., Cambridge, UK) and 4 ml of 30% hydrogen peroxide (Merck, Darmstadt, Germany) in a Teflon container. The system was heated up to 140 °C for 130 min. Then cooling to room temperature, and filtered using a 0.45 μm nitrocellulose membrane filter, after that transfer to a 25 ml acid-washed volumetric flask and made up to volume with adding double deionized water. The blank digest was also carried out in the same way. The elements (calcium, magnesium, potassium, sodium, and phosphorous) were analyzed by inductively coupled plasma-optical emission spectrophotometer (ICP-OES Horiba Jobin-Yvon Ultima 2 CE) according to the following conditions (Table 1). The concentrations found were within 93–101% of the certified values for all measured macroelements.

Table 1. ICP-OES instrumental operating conditions.

Parameter	
RF generator power (W)	1400
Frequency of RF generator (MHz)	27.12
Plasma gas flow rate (l/min)	13
Auxiliary gas flow rate (l/min)	0.9
Nebulization gas flow rate (l/min)	0.85
Sample uptake rate (ml/min)	1
Type of detector	Solid state
Type of spray chamber	Cyclonic
Injector tube diameter (mm)	0.3
Measurement replicates	3
Element (λ/nm)	As 228.812; Ba 455.404 Cd 214.438; Co 238.892 Cr 267.716; Cu 324.756 Fe 259.941; Mn 260.560 Mo 281.615; Ni 221.648 Pb 220.353; Se 196.090 Sr 407.771; Zn 213.856

2.4. Estimated daily intake and evaluation of daily value

Estimated Daily Intake (EDI) depends on the element concentration, meal size, and body weight. The following hypotheses were considered to assess the daily intake of elements through fish consumption: Food preparation did not affect the absorption of elements (10). The average adult body weight (BW) of individuals 70 kg was considered. Meal size (MS) for fish consumption for adults 227 grams (11, 12) was noticed. Therefore, the daily intake was done according to the equation described in previous studies (13):

$$EDIm = MS \times C / BW$$

where, EDIm is the estimated intake per meal, MS meal size, C trace element concentration (micrograms per gram of wet weight), and BW (bodyweight).

For various calculations, the elements' concentrations were converted to wet weight/gram of fish. The daily value (DV %) of a nutrient represents the recommended daily intake (RDI: Reference Daily Intakes) of a particular nutrient consumed by a certain amount (serving) of a food. Here, the serving was considered equal to one serving of fish and 227 grams.

$$DV = (EDIm / RDI) \times 100$$

where, DV <5% is a poor source, DV = 10-19% is a good source, and DV> 20% is a rich nutrient source.

2.5. Statistical analysis

The t-test analyses by SPSS 20 software were used to assess the difference between liver and muscle of farmed and wild fish, and between the similar tissue in farmed and wild fish. The difference value ($p<0.05$) indicated a statistically significant difference.

3. Results and disscusiin

The concentrations of elements in the muscle and liver of wild farmed fish are shown in Table 2. We found that the highest and lowest levels of both fish's macro elements were related to potassium and sodium, respectively. In comparing elements content between liver and muscle, there was a significant difference between calcium, magnesium, potassium However, there was no significant difference in the phosphorus and sodium content. Differences between the concentrations of liver and muscle tissue elements may be related to the tendency of elements to react with metallothioneins. The concentration of metallothioneins in the liver is much higher than in muscle, due to the accumulation of elements in higher concentrations in the liver (14-16). Comparing elements between similar tissues (liver-liver, muscle-muscle) of two fish, the calcium content of farmed tissues was higher than wild tissues. However, it was not any significant difference in levels of phosphorus, magnesium, potassium, and sodium between wild and farmed fish.

Table 2. Levels (Means ±SEM, μg/g of dry weight) of heavy metals and trace elements in muscle and liver of farmed and wild *Capoeta damascina*.

Elements	Farmed		Wild	
	Liver	Muscle	Liver	Muscle
Ca	0.71 ±0.03^{bA}	0.93 ±0.04^{aA}	0.61 ±0.02^{aB}	0.78 ±0.05^{aB}
P	6.02 ±1.47	5.87 ±1.03	5.33 ±1.67	4.98 ±1.54
Mg	1.05 ±0.29	15.4 ±2.19	0.89 ±0.36	1.14 ±0.42
Na	0.76 ±0.13^{a}	8.43 ±1.03^{b}	1.12 ±0.23^{b}	0.85 ±0.17^{a}
K	8.73 ±1.39^{a}	2.05 ±0.56^{b}	16.1 ±3.17^{b}	7.54 ±1.58^{a}

$^{a\text{-}b}$ Different small letters for each element are statically significant between the muscle and liver of farmed or wild fish ($p<0.05$).
$^{A\text{-}B}$ Different capital letters for each element are statically significant between identical tissues of farmed and wild fish ($p<0.05$).

According to Table 3, both wild ad farmed fish were excellent sources of phosphorus and good sources of magnesium.

Table 3. DV % per meal (227 g) for fish consumption.

Elements	DRI (mg/d)	Cultured		Wild	
		Muscle	Liver	Muscle	Liver
Ca	1000	5%	4%	4%	3%
P	1250	25%	26%	21%	23%
Mg	420	13%	12%	14%	11%
Na	2300	2%	2%	2%	3%
K	4700	10%	17%	9%	18%

Assessment of essential elements in the fish edible tissues indicates its nutritional value for diet consumption. Because seafood and fish are an important source of protein and nutrients and play a key role in a human's diet, it is crucial to know the fish components. In the present study, the composition of macroelements in the muscle and liver of wild and farmed *C. damascina* in Armand River of Lordegan city was measured using an accurate ICP / OES instrument. The elements such as calcium, magnesium, potassium, sodium, and phosphorous have vital roles in molecular and cellular metabolism in the body, hence known as essential elements. We found that calcium concentration was significantly higher in the muscle and liver tissue of farmed fish ($p<0.05$), while, there was no significant difference between farmed and wild fish in magnesium, potassium, sodium, and phosphorous concentration ($p>0.05$). The liver has a higher sodium and potassium concentration, and muscle has a higher calcium content. It is associated with anatomical and physiological properties of the liver: first exposure to the bloodstream from intestine and gill, Hematopoietic, antioxidant defense, detoxification, and excretion function, and also elevated the concentration of metallothionein (14-16). Calcium is the most abundant element in the body and may help lower hypertension and may help protect against colon cancer and obesity (17). In this study, the concentration of calcium in farmed *C. damascina* was higher than wild blackfish. This study's results along with previous studies on perch Yellow (18) correspond. Contrary to the present study, Custodio in 2011 (19) showed that calcium concentrations were the same in wild and farmed species in Seabass and Gilthead Seabream. Also, in a study conducted by Roy in 2006 on haddock oil, calcium concentration was higher in wild species (20). Phosphorus is the second most abundant element in the body after calcium. Chronic hypophosphatemia can cause rickets in children and osteomalacia in adults (21). In this study, no significant difference was observed between the phosphorus concentrations of different farmed and wild fish tissues. Unlike the previous study, phosphorus was higher in farmed species in on haddock oil species (20) and yellow perch (18). Magnesium is an element that is involved in many enzymes' comportments and in lowering blood pressure and stroke. Recent studies have shown that its consumption in Western countries is lower than the average requirement (22). In this study, no significant difference was observed between the magnesium concentrations of different farmed and wild farmed *C. damascina* tissues. This study's results are consistent with previous studies on haddock oil species (20) and salmon (23). However, in contrast to the present study in González in 2006, it was shown that magnesium was higher in farmed yellow perch (18). Potassium is the major intracellular cation and is involved in neurotransmission, muscle contraction, and pH regulation. Inadequate intake is associated with high blood pressure and arrhythmias (24). In the current study, no significant difference was observed between the potassium concentrations of different farmed and wild farmed *C. damascina* tissues. This study's results are consistent with previous studies on seabass and gilthead seabream (19). However, in the ROY study in haddock fish (20) and the González study in yellow perch, the potassium concentration was higher in the farmed species (18). Sodium is the body's main extracellular cation and is involved in maintaining osmotic pressure, transmitting nerve messages, and transmitting substances in some reactions (25). No significant difference was observed between different farmed and wild farmed *C. damascina* tissues' sodium concentrations. This study's results are consistent with previous studies on small haddock oil species (20). However, a 2006 study by González found that sodium was higher in wild yellow perch than in farmed fish (18).

4. Conclusion

Both farmed and wild fish muscle are good sources for phosphorous and magnesium that may reach beneficial health for local consumers. Farming of *C. damascina* suggested to less capturing of wild *C. damascina* for reserving the ecosystem.

Reference

1. Lund EK. Health benefits of seafood; Is it just the fatty acids? *Food Chemistry*. 2013;140(3):413-20.
2. Bogard JR, Farmery AK, Little DC, Fulton EA, Cook M. Will fish be part of future healthy and sustainable diets? *The Lancet Planetary Health*. 2019;3(4):e159-e60.
3. Adel M, Copat C, Saeidi Asl MR, Conti GO, Babazadeh M, Ferrante M. Bioaccumulation of trace metals in banded Persian bamboo shark (*Chiloscyllium arabicum*) from the Persian Gulf: A food safety issue. *Food and Chemical Toxicology*. 2018;113:198-203.
4. Ersoy B, Çelik M. Essential elements and contaminants in tissues of commercial pelagic fish from the Eastern Mediterranean Sea. *Journal of the Science of Food and Agriculture*. 2009;89(9):1615-21.
5. Varol M, Sünbül MR. Macroelements and toxic trace elements in muscle and liver of fish species from the largest three reservoirs in Turkey and human risk assessment based on the worst-case scenarios. *Environmental Research*. 2020;184:109298.
6. Fallah AA, Nematollahi A, Saei-Dehkordi SS. Proximate composition and fatty acid profile of edible tissues of *Capoeta damascina* (Valenciennes, 1842) reared in freshwater and brackish water. *Journal of Food Composition and Analysis*. 2013;32(2):150-4.
7. Yildiz M, Şener E, Timur M. Effects of differences in diet and seasonal changes on the fatty acid composition in fillets from farmed and wild sea bream (*Sparus aurata* L.) and sea bass (*Dicentrarchus labrax* L.). *International Journal of Food Science & Technology*. 2008;43(5):853-8.
8. Dincer T, çaklı ş, Cadun A. Comparison of proximate and fatty acid composition of the flesh of wild and cultured fish species. *Archiv fur Lebensmittelhygiene*. 2010;61:12-7.
9. Fallah A, Saei-Dehkordi S, Nematollahi A. Comparative study of heavy metal and trace element accumulation in edible tissues of farmed and wild rainbow trout (*Oncorhynchus mykiss*) using ICP-OES technique. *Microchemical Journal*. 2011;98:275-9.
10. Alasalvar C, Taylor KDA, Zubcov E, Shahidi F, Alexis M. Differentiation of cultured and wild sea bass (*Dicentrarchus labrax*): total lipid content, fatty acid and trace mineral composition. *Food Chemistry*. 2002;79(2):145-50.
11. Copat C, Arena G, Fiore M, Ledda C, Fallico R, Sciacca S, et al. Heavy metals concentrations in fish and shellfish from eastern Mediterranean Sea: Consumption advisories. *Food and Chemical Toxicology*. 2013;53:33-7.
12. USEPA. Risk assessment and fish consumption limits. Washington DC: United States Environmental Protection Agency. 2000.
13. Adel M, Dadar M, Fakhri Y, Oliveri Conti G, Ferrante M. Heavy metal concentration in muscle of pike (Esox lucius Linnaeus, 1758) from Anzali international wetland, southwest of the Caspian Sea and their consumption risk assessment. *Toxin Reviews*. 2016;35(3-4):217-23.
14. Olsvik PA, Gundersen P, Andersen RA, Zachariassen KE. Metal accumulation and metallothionein in two populations of brown trout, Salmo trutta, exposed to different natural water environments during a run-off episode. *Aquatic Toxicology* (Amsterdam, Netherlands). 2000;50(4):301-16.
15. Falfushynska HI, Stoliar OB. Function of metallothioneins in carp Cyprinus carpio from two field sites in Western Ukraine. *Ecotoxicology and Environmental Safety*. 2009;72(5):1425-32.
16. Yancheva V, Stoyanova S, Velcheva I, Petrova S, Georgieva E. Metal bioaccumulation in common carp and rudd from the Topolnitsa reservoir, Bulgaria / Akumulacija metala u šarana i crvenperki iz umjetnog jezera Topolnitsa u Bugarskoj. *Arhiv za higijenu rada i toksikologiju*. 2014;65:1-10.
17. Han C, Shin A, Lee J, Lee J, Park JW, Oh JH, et al. Dietary calcium intake and the risk of colorectal cancer: a case control study. *BMC Cancer*. 2015;15:966-.
18. González S, Flick GJ, O'Keefe SF, Duncan SE, McLean E, Craig SR. Composition of farmed and wild yellow perch (*Perca flavescens*). *Journal of Food Composition and Analysis*. 2006;19(6):720-6.
19. Custódio PJ, Pessanha S, Pereira C, Carvalho ML, Nunes ML. Comparative study of elemental content in farmed and wild life Sea Bass and Gilthead Bream from four different sites by FAAS and EDXRF. *Food Chemistry*. 2011;124(1):367-72.
20. Roy PK, Lall SP. Mineral nutrition of haddock Melanogrammus aeglefinus(L.): a comparison of wild and cultured stock. *Journal of Fish Biology*. 2006;68(5):1460-72.
21. Menezes Filho Hd, Castro LCGd, Damiani D. Hypophosphatemic rickets and osteomalacia. *Arquivos Brasileiros de Endocrinologia & Metabologia*. 2006;50:802-13.
22. Al Alawi AM, Majoni SW, Falhammar H. Magnesium and Human Health: Perspectives and Research Directions. *International journal of endocrinology*. 2018;2018:9041694.
23. Kelly BC, Ikonomou MG, Higgs DA, Oakes J, Dubetz C. Mercury and other trace elements in farmed and wild salmon from British Columbia, Canada. *Environmental Toxicology and Chemistry*. 2008;27(6):1361-70.
24. He FJ, MacGregor GA. Beneficial effects of potassium on human health. *Physiologia Plantarum*. 2008;133(4):725-35.
25. Farquhar WB, Edwards DG, Jurkovitz CT, Weintraub WS. Dietary sodium and health: more than just blood pressure. *Journal of the American College of Cardiology*. 2015;65(10):1042-50.