Plant Archives Volume 21, No 1, 2021 pp. 785-794 *e-ISSN:2581-6063 (online), ISSN:0972-5210*

Plant Archives

Journal home page: www.plantarchives.org

DOI Url: https://doi.org/10.51470/PLANTARCHIVES.2021.v21.no1.104

DETERMINATION OF SOME ESSENTIAL AND NON-ESSENTIAL MINERAL ELEMENTS IN EDIBLE TISSUE IN THREE FISH SPECIES FROM GREATER ZAB RIVER, ERBIL GOVERNORATE, KURDISTAN REGION OF IRAQ

Barakat Samad Mala Abd and Samad Sofy Omar*

Department of Fish Resource and Aquatic Animals, Salahaddin University, Erbil, Iraq

*Email: samadsofy@yahoo.com

(Date of Receiving-28-11-2020; Date of Acceptance-05-03-2021)

ABSTRACT

The purpose of the current study was to determine certain mineral components in edible tissue in different species of fish from Greater Zab River, Erbil Governorate- Kurdistan Region-Iraq. A total of 180 fish namely *Capoeta trutta,* Chondrostoma regium and Leuciscus cephalus were collected from Gali Balinda, Bn Khiveta, Galiesule, Pirsal and Bekhme between July and November 2019. After removal of eviscerated, deboned, head and fins, fish were washed with purified water and muscle samples were collected above the lateral line between the dorsal fin and the caudal fin, then dried for important and non-essential metals examination at 75^{0}C for 48 h. Results showed that levels of K, Na, P, Ca, Cd and Hg in the edible tissue of Chondrostoma regium fish were significantly higher than in the *Capoeta trutta* and *Luciobarbus esocinus* fish, whereas the edible tissue in *Capoeta trutta* exhibited the highest mean values for lead, barium and arsenic. In all species, the highest concentrations of K, Na, and Mg were recorded in Gali Balinda, whereas the highest concentration of P and Ca were recorded in Pirsal during studied period. According to the results, the government should have environmental policies to improve, keep and enrich the water quality assessment in Greater Zab River.

Keywords: *Capoeta trutta,* Chondrostoma regium and Leuciscus cephalus, macro-nutrients, micro-nutrients, mineral content, Greater Zab River

INTRODUCTION

Fish meat is the main source of good quality protein and minerals which is essential for humans. However, it may sometimes contain unwanted components such as heavy metals. Heavy metals generally go into the aquatic environment by natural accumulation of metals exist in atmospheric, volcanic matrix degradation or anthropogenic practices induced by industrial effluent, household drainage, mining and farm waste (Ambedkar and Muniyan, 2011).Fish is one of the most significant considerations in measuring trace metal contamination and evaluating the quality of fish. Fish are often found at the end of the aquatic food chain and can absorb metals and spread them by food to humans, causing chronic or acute diseases (Maurya and Malik 2016). Fish are susceptible to an increase in the concentration of toxins in the water (metals, chemical pollutants). The extent of metal deposition in fish organs and tissues depends on the taxonomic ownership, age habits, physical-biochemical features and chemical status of the aquatic ecosystem of the fish species.

Greater Zab River is the most important River in Kurdistan Region of Iraq that provides water supply for drinking, irrigation and fishery. In aquatic environments, industrial and domestic wastes are discharged without being treated. The contamination of heavy metals in the marine ecosystem has lately become a global issue because they are indestructible and most of them have harmful effects on animals (Ali, 2017). While fish is a significant component of the human diet,because of its high nutritional quality, the nutritional values of fish could be influenced by some factors including bioaccumulation of the mineral elements of edible tissue of fish through direct consumption of water and food. Therefore, the study was aimed to investigate the bioaccumulation of mineral components in some fish species such as Chinchinok (*Capoeta trutta*), Dureshka (Chondrostoma regium), Behary (Leusicus cephalus) collected monthly (July – November, 2019) from Greater Zab River in the Kurdistan Region, Iraq.

MATERIALS AND METHODS

Study Area

In the Kurdistan region, the Tigris is the main river that is a prime source for human use. The Tigris, since it is potable and passes through major cities throughout the country, is used for drinking. The Tigrs River is 1,850 km long, rising about 25 km southeast of the city of Elazig and about 30 km from the headwaters of the Euphrates in the Taurus Mountains of eastern Turkey (the Kurdistan of Turkey). The River then runs for 400 km through North Kurdistan in Turkey before becoming the boundary between Syria and Turkey. This stretch of 44 km is the only portion of the river that is situated in Syria (Eastern Kurdistan). The remaining 1,418 km is completely within

Kurdistan Region and Iraq (Isaev and Mikhailova, 2009). Within the Kurdistan Region, it has five tributaries from north to south includes Al-Khabour (Peshkhabur), Greater and Lesser Zab, Awaspy and Serwan. With the initial force given by steep slopes, all these tributaries bring their erosion products into the plain, where they join the Euphrates (Rzoska, 1980).

One of the major tributaries of the Tigris is Great Zab, which deposits in east of the Tigris River. Greater Zab originated from the mountainous region of northwestern Iran and southeastern Turkey (North and Western Kurdistan), also known as Eastern and Northern Kurdistan. More specifically, it located between 36–37°N and 43–44°E (Ali, 2006) In addition; Great Zab originates in the Northern Kurdistan region of Turkey, close to the Lake of Van, and combines with the Tigris in the Kurdistan region. The length of Great Zab is 392 km, and around 300km are located in the Kurdistan region. Furthermore, it enters the Kurdistan region from Pish Khabur village, and its distance from the Erbil capital city is 35km (Shekha, 2008). During this study, samples were collected from five sampling areas of the Greater Zab River, from Gali Balinda to Bekhme village (Fig 1).

Fig 1 Satellite image of the study area (North east of Erbil)

Fish sampling and preparation

A total of 180 fish were used as samples for the current study. Three fish species namely *Capoeta trutta, Chondrostoma regium* and *Leuciscus cephalus* were collected from Gali Balinda, BnKhiveta, Galiesule, Pirsal and Bekhme by local fisherman. The fishes were then transferred to the laboratory analyses College of Agricultural Engineering Sciences, Salahaddin University-Erbil in a live in a container with local river water in the same day of capture and their species were identified according to Coad (2010).The fish was eviscerated, deboned, separated from the head and tail, and then cleaned with purified water. Muscle samples were obtained between the dorsal fin and the caudal fin above the lateral line and dried for 48 h at 75 ˚C.The dried samples packed in polyethylene bags and stored at 4°C for heavy metals analysis.

Metals analysis

The analysis of heavy metals was conductedusing Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) (Spectro Genesis EOP II, Spectro Analytical Instruments DmbH, Kleve, Germany) following the procedure described by(Haldere *t al.,* 2020)

Data analysis

The obtained data during the period of this study were statistically analyzed using Statistical Analysis System programme(SAS, 2005). Duncan Multiple Range Test (Duncan, 1955) used to diagnose the significant differences among the means of levels for each factor affecting fish measurements of studied locations.

RESULTS AND DISCUSSIONS

Essential mineral elements of edible tissue of fish species

Fish is an important source of various vital elements and, at low levels, are therefore essential for human life, whereas vital elements at high concentrations can be toxic. Recently, attention has been extended to the determination of elements in fish due to the nutritional benefits of essential elements and toxicological concerns related to the anthropogenic influx of toxins. The shortage of vital ingredients contributes to inappropriate metabolic processes mediated by the enzyme and resulting in organ malfunctions, chronic diseases and finally death (Ersoy and Çelik, 2009). The basic mineral elements are commonly categorized into two major categories, which are the macro-elements and the micro-elements, according to their concentration in the animal body.

Macro-element concentrations

Inside the body, macro components have several functions. They work with vitamins to initiate the dev-elopment of hormones and speed up metabolic processes. The mean values ± standard error of macro-element concentrations such as potassium (K), sodium (Na), phosphor (P), magnesium (Mg) and calcium (Ca) concentrations in the edible tissue of three fish species (*Luciobarbus esocinus, Capoeta trutta* and *Chondrostoma regium*) collected from different location (GaliBalinda, BnKhiveta, Galiesule, Pirsal and Bekhme) are given in Table 1. The most plentiful components in the edible tissues were K, Na, Mg and Ca.Concentrations of these elements varied from 2.22 to 21.18 mg / kg. Ca > Mg > K > Na were the usual order for each fish species obtained from different locations during the study period. The results showed that the K, Na, P and Ca levels in the edible tissue of *Chondrostoma regium* fish were significantly *(P≤0.05)* higher than in the *Capoeta trutta* and *Luciobarbus esocinu*s fish. However, the highest *(P≤0.05)* Mg concentration was detected in *Capoeta trutta* fish than the other species. In general, several experiments on the bioaccumulation of metals by different fish species have also shown that certain fish species have the capacity to accumulate many folds of some heavy metals in their muscles than in their

Table 1 Means ± standard error for the macro elements concentration (mg/kg) in edible tissue of fish species obtained from different locations during study period.

	No.	K	Na	P	Mg	Ca
Fish species (Local name)						
Luciobarbus esocinus	60	4.493 ± 0.17[c]	2.215 ± 0.09[c]	1.045 ± 0.28[b]	7.779 ± 0.28[c]	15.400 ± 0.52[b]
Capoeta trutta	60	5.603 ± 0.16[b]	3.309 ± 0.14[b]	0.368 ± 0.06[c]	13.295 ± 0.25[a]	20.000 ± 0.55[a]
Chondrostoma regium	60	6.799 ± 0.28[a]	3.892 ± 0.14[a]	1.501 ± 0.05[a]	11.611 ± 0.64[c]	20.383 ± 0.57[a]
P value		<.0001	<.0001	<.0001	<.0001	<.0001
Sample Location						
GaliBalinda	36	6.095 ± 0.41[a]	3.402 ± 0.21[a]	1.001 ± 0.11[b]	12.100 ± 0.72[a]	19.722 ± 0.73[a]
BnKhiveta	36	5.449 ± 0.35[ab]	3.215 ± 0.28[ab]	0.836 ± 0.10[c]	9.702 ± 0.57[c]	17.416 ± 0.94[b]
Galiesule	36	5.056 ± 0.25[b]	2.787 ± 0.16[b]	0.864 ± 0.09[bc]	10.453 ± 0.59[bc]	17.722 ± 0.88[b]
Pirsal	36	5.897 ± 0.27[a]	3.143 ± 0.16[ab]	1.157 ± 0.10[a]	11.254 ± 0.52[ab]	19.777 ± 0.72[a]
Bekhme	36	5.661 ± 0.24[ab]	3.147 ± 0.14[ab]	1.001 ± 0.10[b]	10.966 ± 0.45[ab]	18.333 ± 0.63[ab]
P value		0.0218	0.0802	<.0001	<.0005	0.0212
Overall Mean	180	5.632 ± 0.14	3.139 ± 0.09	0.972 ± 0.04	10.895 ± 0.26	18.594 ± 0.36

surrounding water bodies, through diffusion through skin and gills as well as through oral intake or drinking of water (Ambedkar and Muniyan, 2011; Ashraf *et al.,* 2012; and Igwegbe *et al.,* 2014). In all species, the highest concentrations of K, Na, and Mg were recorded in Gali Balinda, whereas the highest concentration of P and Ca were recorded in Pirsal during studied period. The lowest levels of K, Na were found in Galiesule and P, Mg and Ca in Bn Khiveta. Such differences in the composition of metals can be due to the varying levels of contamination at these sites.Potassium is closely associated with sodium and maintains the organism's proper water balance, it is also the main cation of intracellular liquid, enzyme ingredient, occurs in digestive juices, regulates water balance (cellular volume, intracellular osmotic pressure), affects acid-base equilibrium, ensures appropriate functioning of nerves and muscles including those in the myocardium, rises the absorptivity of cell membranes (an antagonist of calcium), and rises the activity of secreting glands. Its deficiency can extremely negatively affect the functioning of the heart muscle (Nölle *et al.,* 2020). In particular, Sodium plays the major role in balancing osmotic pressure and the absorption of carbohydrates (Yeltekin and Oğuz, 2018). The contents of potassium and sodium in the edible tissue of fish species evaluated ranged between 4.493 to 6.799 mg / kg and from 2.215 to 3.892 mg / kg and the highest mean concentration were observed in *Chondrostoma* regium fish while the lowest concentration value were detected in *Luciobarbus esocinus* fish. As applied to the proposed values of all three samples, the concentrations of these minerals can be viewed as strong sources of these minerals.

Along with calcium and magnesium, phosphorus is a major bone component. This mineral has shown considerable variations in concentration between fish species, ranging from 0.368 - 1.501 mg/ kg, the highest phosphorus content of 1.501 mg/ kg found from the *Chondrostoma regium* fish. The range of phosphorus concentrations found in the current work is lower than the FAO range of 6.8-55 mg/ kg, and other freshwater fish found by Tao *et al.,* (2012), (19.8 - 24 mg/ kg) and Alaş *et al.,* (2014), (23.2-42.6 mg/ kg).

In certain enzyme processes, magnesium is an activator and retains the electrical potential of nerves. In some fish species (*Cephalipholis enak, Lutjanus fulvus and Parupeneus indicus*), magnesium ranged within a comparatively small range (0.22-0.33 mg/100g) and was found in higher amounts (0.39-0.52 mg/100g) in other fishes (*Velamugils eheli, Dussumieria acuta, Carangoides chrysophrys, Hemiramphus far, Arius subrostratus and Sardinella albella*).Magnesium is used in the construction of bones and teeth, metabolism, nucleic acid synthesis, proteins, and thermoregulation. It takes part in the vision process and activates some of the enzymes. It also plays an important role in the flow of information between muscles and nerves and prevents coagulation of the blood (protects against thrombosis in arteries and heart - defense against infarction). The mean magnesium concentrations in the edible tissue of the fish species ranged from 7,779 to 13,295 mg/kg. The FAO and World Health Organisation (2004) indicated that mineral needs were 19, 44.6 and 57.35 mg/100g in the normal diet for pre-school infants, adult women and pregnant women, respectively.Lilly *et al*., (2017) statedthat the magnesium values of 0.52, 0.39, 0.47, 0.42, 0.22, 0.41, 0.30, 0.33 and 0.39 mg/100g in wet samples of *Sardinella albella*, *Dussumieria acuta*, *Arius subrostratus*, *Hemiramphus far*, *Cephalopholis boenak*, *Carangoides chrysophrys*, *Lutjanus fulvus*, *Parupeneu sindicus* and *Valamugils eheli*, respectively, which were lower compared to the presentresults. The variation in habitats, seasons, area of catch and many other physical and environmental factors in these studies may be attributed to this (Lilly *et al*., 2017).

Calcium is essential for forming and sustaining bones and teeth as well as encouraging the proper functioning of

Table 2 Means ± standard error for the micro elements concentration (mg / kg) in edible tissue of fish species obtained from different locations during study period.

Treatment	No.	Fe	Zn	Mn	Cu	Cr	I	Se	Ni	Mo
Fish species (Local name)										
Luciobarbus esocinus	60	12.962 ± 0.278^{a}	2.155 ± 0.082^{c}	0.293 ± 0.014^{a}	0.067 ± 0.003^{b}	0.003 ± 0.0002^{c}	0.978 ± 0.034^{b}	0.002 ± 0.0001^{b}	0.002 ± 0.0001^{b}	0.004 ± 0.0002^{a}
Capoeta trutta	60	8.363 ± 0.292^{c}	5.277 ± 0.232^{a}	0.183 ± 0.008^{b}	4.760 ± 0.302^{a}	0.006 ± 0.0004^{b}	0.962 ± 0.035^{b}	0.039 ± 0.002^{a}	0.011 ± 0.0008^{a}	0.0006 ± 0.0001^{b}
Chondrostoma regium	60	10.397 ± 0.261^{b}	2.736 ± 0.123^{b}	0.270 ± 0.011^{a}	0.159 ± 0.008^{b}	0.010 ± 0.001^{a}	1.342 ± 0.041^{a}	0.003 ± 0.0001^{b}	0.003 ± 0.0002^{b}	0.004 ± 0.0002^{a}
P value		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Sample Location										
GaliBalinda	36	10.699 ± 0.525^{a}	3.624 ± 0.269^{ab}	0.282 ± 0.020^{a}	1.769 ± 0.416^{ab}	0.006 ± 0.0009^{a}	1.178 ± 0.058^{a}	0.016 ± 0.003^{a}	0.006 ± 0.0008^{a}	0.002 ± 0.0003^{b}
BnKhiveta	36	11.110 ± 0.468^{a}	3.880 ± 0.432^{a}	0.196 ± 0.007^{b}	2.272 ± 0.572^{a}	0.007 ± 0.0009^{a}	0.993 ± 0.052^{b}	0.017 ± 0.003^{a}	0.006 ± 0.0009^{a}	0.003 ± 0.0003^{ab}
Galiesule	36	9.538 ± 0.498^{b}	3.371 ± 0.247_{ab}	0.243 ± 0.016^{a}	1.562 ± 0.372^{bc}	0.006 ± 0.001^{a}	0.976 ± 0.050^{b}	0.013 ± 0.002^{a}	0.005 ± 0.006^{a}	0.003 ± 0.0004^{a}
Pirsal	36	10.312± 0.401^{ab}	2.993 ± 0.255^{c}	0.278 ± 0.018^{a}	1.121 ± 0.355^{c}	0.006 ± 0.0009^{ab}	1.187 ± 0.057^{a}	0.013 ± 0.004^{a}	0.005 ± 0.001^{a}	0.003 ± 0.0003^{a}
Bekhme	36	11.212 ± 0.445^{a}	3.080 ± 0.271^{bc}	0.245 ± 0.016^{a}	1.585 ± 0.397^{bc}	0.004 ± 0.0004^{b}	1.136 ± 0.053^{a}	0.014 ± 0.003^{a}	0.006 ± 0.0007^{a}	0.003 ± 0.0004^{a}
P value		0.0055	0.0073	0.0002	0.0046	0.0742	<.0001	0.5606	0.5314	0.0316
Mean	180	10.574 ± 0.212	3.390 ± 0.136	0.249 ± 0.007	1.662 ± 0.192	0.006 ± 0.0004	1.094 ± 0.025	0.015 ± 0.001	0.006 ± 0.0004	0.003 ± 0.0001

muscles, nerves and the heart. Skeletal calcium acts as a source for the provision of calcium for other body activities, such as intracellular messaging, and calcium deficiency occurs in osteoporosis after a long delay time (Lilly *et al*., 2017). In order to avoid low bone mineral density, reduce the risk of fragility fractures, and osteoporosis at a mature age, sufficient dietary calcium is required during life. Higher bone mineral density has been correlated with seafood intakes greater than 250g a week (McManus and Newton, 2011). It should be understood from the evidence that seafood, because of the sensitivity of calcium to macro and micro nutrient interactions, can improve bone density when eaten within an otherwise balanced diet. The calcium concentration level was between 15,400 and 20,383 mg/kg wet sample for both samples. The amount of calcium ranges from one fish species to another, with the highest value of *Chondrostoma regium*and *Capoeta trutta* was observed and the lowest value of *Luciobarbus esocinus* was observed. The calcium contents in edible tissue of fish species in the present study were in agreement with values reported for *golden snapper* (21.36 mg/100g) *Japanese threadfin bream* (16.76 mg/100g) and *Spanish mackerel* (319.70 mg/100g) (Lilly *et al*., 2017).

Micro-element Concentration

Trace or micro elements are minerals present in fish tissues in small amounts. Many trace elements act as a co-factor or prosthetic groups in enzymatic reactions (Yeltekin and Oğuz, 2018). The results of micro-elements concentrations (mg/kg) in the edible tissue of fish species obtained from different location during the study period are presented in Table 2. The concentrations of micro elements in the selected studied species are varied quietly such as iron (8.363 - 12.962 mg / kg), zinc (2.155 - 5.277 mg / kg), manganese (0.183 - 0.293 mg / kg), copper (0.067 - 4.760 mg / kg), chromium (0.003 - 0.010 mg / kg), iodine (0.962 - 1.342 mg / kg), selenium (0.002 - 0.039 mg / kg), nickel (0.002 - 0.011 mg / kg) and molybdenum (0.0006 - 0.004 mg / kg). The order of the levels of the micro elements obtained from the three different fish species in four different sites and four months Fe > Zn > Cu > I >Mn> Se > Ni> Cr>Mo (Table 2). In this study, the lowest mean concentration of iron was observed in *Capoeta trutta* which was significantly (*P≤0.05*) lower than other two studied species and the highest was found in *Luciobarbus esocinus*. The highest concentration of zinc was detected in *Capoeta trutta* which was significantly higher (P≤0.05) than other two species. The highest concentration of manganese was found in *Luciobarbus esocinus* which was significantly (*P≤0.05*) higher than other two studied species and the highest recorded in *Luciobarbus esocinus.* Also, *Capoeta trutta* fish species was found to contain highest copper contents which were significantly higher than other two species. Chromium content showed significantly (*P≤0.05*) higher values in *Chondrostoma regium* as compared to those in the other species. The highest concentration of iodine was investigated in *Chondrostoma regium* which was significantly (*P≤0.05*) higher than other studied fish. The highest concentration of selenium and nickel were recorded in *Capoeta trutta* which was significantly (*P≤0.05*) higher than other

Table 3 Means ± standard error for the non-Essential elements concentration (mg / kg) in edible tissue of fish species obtained from different location during study period.

Treatments	No.	Cd	Pb	Hg	Ba	As
Fish species (Local name)						
Luciobarbus esocinus	60	0.038 ± 0.001[a]	0.002 ± 0.0001[b]	0.002 ± 0.0001[a]	0.063 ± 0.003[c]	0.002 ± 0.0001[b]
Capoeta trutta	60	0.011 ± 0.001[b]	0.007 ± 0.0003[a]	0.0003 ± 0.00009[b]	0.365 ± 0.020[a]	0.023 ± 0.001[a]
Chondrostoma regium	60	0.045 ± 0.005[a]	0.002 ± 0.0001[b]	0.002 ± 0.0001[a]	0.180 ± 0.018[b]	0.002 ± 0.0001[b]
P value		<.0001	<.0001	<.0001	<.0001	<.0001
Sample Location						
GaliBalinda	36	0.024 ± 0.002[b]	0.004 ± 0.0005[a]	0.001 ± 0.0002[a]	0.198 ± 0.030[ab]	0.010 ± 0.001[a]
BnKhiveta	36	0.027 ± 0.003[b]	0.003 ± 0.0004[ab]	0.001 ± 0.0002[abc]	0.248 ± 0.036[a]	0.010 ± 0.002[a]
Galiesule	36	0.031 ± 0.004[b]	0.004 ± 0.0005[a]	0.001 ± 0.0001[c]	0.173 ± 0.022[b]	0.008 ± 0.001[a]
Pirsal	36	0.044 ± 0.009[a]	0.003 ± 0.0004[b]	0.001 ± 0.0002[ab]	0.191 ± 0.026[ab]	0.008 ± 0.002[a]
Bekhme	36	0.029 ± 0.002[b]	0.004 ± 0.0004[a]	0.001 ± 0.0001[bc]	0.201 ± 0.027[ab]	0.009 ± 0.001[a]
P value		0.0283	0.0175	0.0024	0.1032	0.6032
Mean	180	0.031 ± 0.002	0.003 ± 0.0002	0.001 ± 0.0001	0.202 ± 0.013	0.009 ± 0.0009

selected species in current study. The highest concentration of molybdenum was detected in *Luciobarbus esocinus*, while the minimum values were recorded at *Capoeta trutta* (Table 2). Microelement content in fish muscle tissues is self-regulated; however, their levels can vary because of certain biological conditions, such as species (Rajkowska and Protasowicki, 2013).

According to the location of catching fish, iron was found to be higher in Bekhme and significantly higher than that in Galiesule only. The highest concentrations of zinc, copper, chromium and selenium were recorded in fish caught from BnKhiveta which was significantly higher than other selected locations. While, fish caught in Gali Balinda contained the highest concentration of manganese which was significantly ($P\leq0.05$) higher than BnKhiveta, but did not differ significantly with other selected locations. On the other hand, the highest concentration of I was observed in fish caught from Pirsal which was significantly higher than other selected places except GaliBalinda and Bekhme. The differences in the levels of nickel in all locations were not significant. The level of molybdenum was observed to be the same (0.003 mg/ kg) in fish caught from all locations except in that caught in GaliBalinda. A number of researchers have suggested that fish are exposed to ambient metal concentrations, whether the background metal content is in uncontaminated or degraded waters of a given geographical area (Komjarova and Blust, 2009; Sauliutė and Svecevičius, 2015).

For a variety of physiological functions in the body, iron is essential, but most notably, for the transport of oxygen across the body. Anemia is caused by iron deficiency, one of the world's most prevalent mineral deficiency disorders, affecting an estimated two billion people (Latham, 1997). The iron concentration in *Luciobarbus esocinus*, *Capoeta trutta* and *Chondrostoma regium* was 12.962, 8.363 and 10.397 mg / kg of wet samples respectively. The level of iron in the current study was higher than in the samples of fish from Bangladesh (Begum *et al*., 2005), Nigeria (Turkmen *et al*., 2008) and Turkey (Dural and Bickici, 2010) but lower than fishes from Caspian sea (Fariba *et al*., 2009) and south west coast of India (Rejomon *et al*., 2010).The literature examined for this research indicates that the iron content in fish differs considerably from country to country due to variations in environmental factors, fish diet, water quality and species studied.

For the synthesis of DNA and RNA, proteins, insulin and sperm, zinc is necessary and is essential for the proper functioning of the immune system and the release of more than 80 enzymes. The metabolism of carbohydrates, fats, proteins and alcohol is concerned. The defensive mechanism against free radicals includes it. It also affects the sense of taste and scent and the texture of hair and nails (Alloway, 2009). As zinc binds to the protein, foods such as seafood, which are sources of both zinc and protein, optimize bioavailability of dietary zinc (Read *et al*., 2014). The zinc values of the current study were 0.528 - 0.216 mg/100 g which were within the FAO ranges of 0.23 - 2.1 mg/100 g. Observations on zinc were similar to other studies (De *et al*., 2010 and Lilly *et al*., 2017), although, higher than fishes from Malaysia (Kamaruzzaman *et al*., 2010), Turkey (Dural and Bickici, 2010) and Okavango Delta of Botswana (Mogobe *et al*., 2015), but lower than from southwest coast of India (Rejomon *et al*., 2010).

In reproductive processes and the proper functioning of the central nervous system, manganese is very important (Mogobe *et al*., 2015). It is an important factor for proper functioning in marginal quantities because manganese participates in the construction of glucose and fatty acid metabolizing enzymes that are a structural element of bones and skin (Lilly *et al*., 2017). The levels of manganese concentration in fish in this study ranged from 1.83 to 2.93 mg/100 g, within the FAO allowable limit

(0.0003 - 25.2 mg/100 g).Compared with this research, Kwansa-Ansah et al. (2012) obtained 0.30 - 0.41 mg/100 g in tilapia fish species in Lake Volta, Ghana, and Alaş et al. (2014) found 0.028 - 0.040 mg/100 g in the fleshy portion of fish in Turkey. Several earlier experiments found a lower manganese concentration level in fish. However, fishes from Saudi Arabia accumulate high level of manganese (15.1 mg/100g wet sample) (Ganhi, 2010) when compared with fish samples of this study. Dural and Bickici (2010) reported a similar concentration of manganese in the muscle tissue of fish.

Like zinc, copper is also a component of several enzymes, but is found in food at very low levels. The recommended daily requirement of copper in human nutrition varies from 1.5-2.5 mg, according to Wildman and Medeiros (2000). The concentration of copper in fish species ranges from 0.067-4.760 mg/100 g according to this work. This is much lower than the suggested daily consumption, assuming a single serving of 100 g fish per day, but this is not a concern because copper deficiencies are erratic. The copper concentrations were similar to other studies (Rejomon *et al.,* 2010; Mogobe *et al.,* 2015; and Lilly *et al.,* 2017). However, higher than that reported by Turkmen *et al.,* (2008); Raja *et al.,* (2009); Dural and Bickici (2010); and Kamaruzzaman *et al.,* (2010), but lower than earlier report from this area (De *et al.,* 2010) and fishes from Gresik coastal waters of Indonesia (Soegianto and Hamami, 2007).

Chromium is an important trace element in the diet of living organisms, also known as a glucose tolerance factor, which serves as a physiological enhancer of insulin production, binding to insulin and potentiating its action. At optimum levels, chromium decreases the metabolically needed amount of insulin by increasing the number of insulin receptors (Yildiz *et al*., 2004). Chromium was present at moderately low concentrations in the range of 0.003 - 0.010 mg / kg in selected fish species. In the current analysis, the chromium content in fish muscle samples was smaller than the values recorded for *Ctenopharyngodon idellus* (0.196mg/kg) and *Cyprinus carpio* (0.059mg/kg) by Qin *et al*., (2015).

As a portion of thyroid hormones that affect reproduction, growth and development, energy metabolism, neuromuscular function and protein synthesis, iodine has been recognized to be an important trace element in humans. Control in many countries includes regulation of the amount of iodine intake by nutritional materials with respect to the value of iodine. For example, iodization of table salt at 76 µg/ g has been mandatory in Canada since 1949 and the Iranian national program of supplying iodine in salt was started in 1994 (Ansari *et al*., 2010). The mean value of iodine in *Luciobarbus esocinus*, *Capoeta trutta* and *Chondrostoma regium* was found to be 0.978 ± 0.034, 0.962 ± 0.035 and 1.342 ± 0.041mg / kg, respectively. The recommended daily dose of dietary iodine is 180 - 200 µg for adults, > 100 µg for children and should be at least 230 µg per day throughout pregnancy (Horst et al., 2005). The World Health Organization (WHO) reports that about 1.6 billion individuals are at risk of iodine deficiency diseases worldwide (WHO, 2004).The main iodine supply occurs via nutrition and seafood is the most important natural source containing a relatively large amount of iodine (Eckhoff and Maage, 1997). Many researches on the iodine content of various fish species from different countries have shown that the accumulation of iodine in fish from different aquatic resources differs from species to species and often depends on the type of the species, environmental conditions, or can vary seasonally (Ansari *et al*., 2010 and Sobolev *et al*., 2020).

Selenium is an important micronutrient that is essential in limited doses for biological processes, although there is a restricted spectrum of dosage between the essential dose and fish toxicity. Selenium levels in the meat samples, depending on the examined edible tissue of fish species, varied between 0.002 and 0.039 mg / kg. The highest selenium concentration was found in the muscle from *Capoeta trutta* and the lowest value was observed in *Luciobarbus esocinus* and *Chondrostoma regium* muscles. The selenium concentration range in muscle tissue has been reported as 0.002 - 0.3 mg/ kg for different fish species (Medeiros *et al*., 2012).

Selenium is an important nutrient that plays a vital role in guarding tissues against oxidative impairment as a component of glutathione peroxides in humans. Despite the fact that selenium is an important nutrient, inhaling and ingesting higher concentrations predisposes one to have severe health consequences. Selenium seems to influence the capacity of liver proteins to enact some chemical mutagens (Medeiros *et al*., 2012).

Being a borderline factor, nickel is important for human health at trace levels. Acute toxicity comes from a competitive association with five main components: calcium, cobalt, copper, iron and zinc (Khaled, 2004). According to the present study, nickel content in muscle of the edible tissue of three fish species obtained from various places ranged between 0.002 and 0.011 mg/ kg. The appropriate amount of nickel in the human body is responsible for the regulation of prolactin and stabilization of RNA and DNA structures, but at very high concentrations it can be negatively affected on human health (Chowdhury *et al*., 2011). Nickel concentrations obtained from fish species in the present work were lower than the permitted mercury limit of 0.2 mg / kg (FAO/ WHO, 2011).

Molybdenum tissue content ranged from 0.0006 - 0.004 mg/ kg. The obtained results for molybdenum were lower than the standard permissible levels, 0.034 mg / kg (FAO/ WHO, 2011). For compared with the findings of the current research, no prior records of Mo concentrations in fish samples could be identified.

Non-Essential Elements Concentration

Non-essential elements are certain elements that are synthesized in the body and supplied in limited amounts by diet as well. Accumulation in the atmosphere with non-essential metals, such as radioactive metals, adds to issues expressed by policymakers and research communities owing to possible health hazards and food poisoning issues (Aliko *et al*., 2018). Toxic metals can affect the liver, intestine, digestive system and brain, and can cause cancer in populations with prevalent fish-based diets for higher-ranking users (Kundera *et al*., 2014). In addition, toxic metals can enter the nucleus of the cell and induce mutagenesis (Simionov *et al*., 2019). In recent years, pollution of the marine environment has grown and is associated with an exponential growth in the human population and therefore with an upward trend in anthropogenic demand, a reality that can affect all aquatic environments (Harangi *et al*., 2017). The results of non-essential elements concentration (mg / kg) in the edible tissue of fish species obtained from the different locations during the study period are shown in Table 3.

The edible tissues *of Chondrostoma regium* presented the highest mean values for cadmium and mercury which were significantly ($P≤0.05$) higher than *Capoeta trutta*, whereas the edible tissue in *Capoeta trutta* exhibited the highest mean values for lead, barium and arsenic (Table 3). There was an obvious seasonal pattern to metal contamination in the fish samples of the selected species and locations. While fish muscle is not an active tissue in the aggregation of heavy metals, it is well known. (Elnabris *et al*., 2013), the present thesis concerned the amounts of heavy metals in the muscles of the fish since it is the most eaten component of the Iraqi people. In addition, it has been reported that certain fish can accumulate significant quantities of metals in their tissues in contaminated areas, often reaching the maximum permissible limits.

The concentrations of non-essential heavy metals are varied according to the location. The highest level of cadmium was recorded in fish caught in Pirsal which was significantly higher ($P≤0.05$) than the other four selected locations. The highest levels of lead and mercury were recorded in fish caught in Gail Balinda which were significantly higher than the other four selected locations. The highest concentrations ($P≤0.05$) of barium were detected in fish caught in BnKhiveta while the lowest was in Galiesule. There were no significant differences in arsenic among five locations.

One of the most toxic heavy metals is known to be cadmium. To all living beings, it is a non-essential feature. In recent decades, cadmium-related degradation of the marine environment has risen dramatically, leading to a rise in the deposits of cadmium in the tissues of aquatic species in all food chain processes. A major ecological concern is the accumulation of cadmium in living organisms, especially because of its capacity to accumulate very rapidly. Cadmium excretion from living organisms, on the other hand, is a sluggish process (Okocha and Adedeji, 2011). Because of its role in the elevated prevalence of breast, pulmonary, gastric, prostate, ovarian, endometrial, pancreas and kidney cancers, cadmium is a human carcinogen (Tamele and Loureiro, 2020). Cadmium concentration obtained in this study ranged between 0.011 to 0.045 mg/ kg, which falls within FAO mean ranges of 0.014–0.055 mg / kg.

Extreme anemia, irreversible brain injury, developmental defects, fertility complications, reduced intelligence and a number of other diseases have been found to be caused by lead toxicity. According to the Agency for Toxic Substances and Disease Registry, a division of the U.S. Public Health Service, meat, especially fishes, is the main exposure of lead to the general population in food (McNamara, 2008). However, the results of this study show that there are significantly lower levels of lead in the edible tissue of fish species. *Luciobarbus esocinus*, *Capoeta trutta* and *Chondrostoma regium* have levels of 0.002, 0.007 and 0.002 mg / kg correspondingly, which were lower than the maximum lead level of 0.7 mg / kg allowed by FAO/WHO (2011).

Mercury is an important toxic contaminant of the food chain. Although the body contains a trace amount of mercury, its biological significance was not found. Mercury is a naturally occurring material which is discharged from natural sources into the atmosphere and also as a result of industrial contamination. Inorganic mercury in water by the action of microorganism's changes to much more toxic methyl mercury, which accumulates in the tissues of aquatic animals that receive it from food and water. Mercury has toxic effects on the nervous, digestive and immune systems. Mercury was detected at concentrations ranging in the middle of 0.0003 and 0.002 mg/kg^{-1} for the three fish species and none of the fish exceeded the recommended limit of 1.0 mg / kg (FAO/WHO, 2011).

Arsenic is one of the heavy metals that can be toxic in food if present in high amounts. The obtained results showed that the arsenic contents in the edible tissue of fish species ranged between 0.002 and 0.023 mg/kg^{-1}. The lowest arsenic value recorded in *Luciobarbus esocinus* and *Chondrostoma regium*, while the highest concentrations were found in *Capoeta trutta*. However, the obtained results for arsenic were lower than the standard permissible level 2.0 mg/kg (FAO/WHO, 2011).

CONCLUSION

The findings of the current research indicated that the essential and non-essential element concentrations of three fish species were different according to fish species and place of catching. *Chondrostoma regium* fish from Gali Balind alocation contained the highest concentration of K, Na, P, Ca and Cd and Hg. In all species, the highest concentrations of K, Na, and Mg were recorded in Gali Balinda, whereas the highest concentration of P and Ca were recorded in Pirsal during studied period.

REFERENCES

Alaş, A., Özcan, M.M. and Harmankaya, M. (2014). Mineral contents of the head, caudal, central fleshy part, and spinal columns of some fishes. *Environmental monitoring and assessment*, 186(2), pp.889-894.

Ali, I.SH. (2017). Water Quality Assessment for Greater Zab River and Bioaccumulation of Toxic Heavy Metals in Some Local Fish Species, Erbil, Kurdistan Region of Iraq.M.SC. Thesis, College of Agriculture, Salahaddin University-Erbil, Kurdistan Region, Iraq.

Ali, L.A. (2006). A study of macroinvertebrates community in the middle sector of Greater Zab River, Iraq.Ph.D. Dissertation, Univ. of Baghdad. Iraq.

Aliko, V., Qirjo, M., Sula, E., Morina, V. and Faggio, C. (2018). Antioxidant defense system, immune response and erythron profile modulation in gold fish, Carassiusauratus, after acute manganese treatment. *Fish and shellfish immunology*, 76, pp.101-109.

Alloway, B.J. (2009). Soil factors associated with zinc deficiency in crops and humans. *Environmental Geochemical Health*, 31: 537-548.

Ambedkar, G. and Muniyan, M. (2011). Bioaccumulation of some heavy metals in the selected five freshwater fish from Kollidam River, Tamilnadu, *India.Adv. Appl. Sci. Res*, 2(5), pp.221-225.

Ansari, M., Raissy, M., Shakeryan, A., Rahimi, E. and Fadaeifard, F. (2010). Determination of iodine in the muscles of two marine fish species and lobster from the Persian Gulf. *Journal of Food, Agriculture and Environment*, 8(3/4 part 1), pp.228-229.

Ashraf, M.A., Maah, M.J. and Yusoff, I. (2012). Bioaccumulation of heavy metals in fish species collected from former tin mining catchment.

Begum, A., Amin, M.N., Kaneco, S. and Ohta, K. (2005). Selected elemental composition of the muscle tissue of three species of fish, Tilapia nilotica, Cirrhinamrigala and Clariusbatrachus, from the fresh water Dhanmondi Lake in Bangladesh. *Food chemistry*, 93(3), pp.439-443.

Chowdhury, M.Z.A., Siddique, Z.A., Hossain, S.A., Kazi, A.I., Ahsan, A.A., Ahmed, S. and Zaman, M.M. (2011). Determination of essential and toxic metals in meats, meat products and eggs by spectrophotometric method. *Journal of the Bangladesh Chemical Society*, 24(2), 165-172. Available at: https://doi.org/10.3329/jbcs.v24i2.9705.

Coad, B.W. (2010). Fresh water fishes of Iraq. Sofia-Moscow: 294pp.

De, T.K., De, M., Das, S., Ray, R. and Ghosh, P.B. (2010). Level of heavy metals in some edible marine fishes of mangrove dominated tropical estuarine areas of Hooghly River, North East Coast of Bay of Bengal, India. *Bulletin of environmental contamination and toxicology*, 85(4), pp.385-390.

Duncan, D.B. (1955). Multiple Range and Multiple Test. Biometrics. 11: 1-42.

Dural, M. and Bickici, E. (2010). Distribution of trace elements in the tissues of Upeneuspori and Upeneusmolucensis from the Eastern cost of Mediterranean, Iskenderun Bay, Turkey. *J Anim Vet Adv*, 9, pp.1380-1383.

Eckhoff, K.M. and Maage, A. (1997). Iodine content in fish and other food products from East Africa analyzed by ICP-MS. *Journal of Food Composition and Analysis,* 10(3), pp.270-282.

Elnabris, K.J., Muzyed, S.K. and El-Ashgar, N.M. (2013). Heavy metal concentrations in some commercially important fishes and their contribution to heavy metals exposure in Palestinian people of Gaza Strip (Palestine).*Journal of the Association of Arab Universities for Basic and Applied Sciences,* 13(1), pp.44-51.

Ersoy, B. and Çelik, M. (2009). Essential elements and contaminants in tissues of commercial pelagic fish from the Eastern Mediterranean Sea.*Journal of the Science of Food and Agriculture*, 89(9), pp.1615-1621.

FAO/WHO (Food and Agriculture Organization Ministry of Agriculture Fisheries and Food/ World Health Organization). (2011). Joint FAO/WHO food standards programme codex committee on contaminants in foods. *Food*, 2011, 1-89.

FAO/WHO (Food and Agriculture Organization Ministry of Agriculture Fisheries and Food/ World Health Organization).(2004). Expert Committee on Food Additives.WHO food additives series, Geneva, Switzerland.

Fariba, Z., Hossein, T., Siamak, A.R., Meshkini, A.A. and Mohammad, R. (2009). Determination of copper, zinc and iron levels in edible muscle of three commercial fish species from Iranian coastal waters of the Caspian Sea. *Journal of Animal and Veterinary Advances*, 8(7): 1288.

Ganhi, H.H.A. (2010). Heavy metals pollution level in marine hammour fish and the effect of popular cooking methods and freezing process on these pollutants. Journal of Dairy and Food Sciences 5(2): 119-126

Harangi, S., Baranyai, E., Fehér, M., Tóth, C.N., Herman, P., Stündl, L., Fábián, I., Tóthmérész, B. and Simon, E. (2017). Accumulation of metals in juvenile carp (Cyprinuscarpio) exposed to sublethal levels of iron and manganese: survival, body weight and tissue. Biological trace element research, 177(1), pp.187-195.

Halder, D., Saha, J.K. and Biswas, A., 2020. Accumulation of essential and non-essential trace elements in rice grain: Possible health impacts on rice consumers in West Bengal, India. *Science of The Total Environment*, 706, p.135944.

Horst, M. (2005).Learning L2 vocabulary through extensive reading: A measurement study. *Canadian Modern Language Review*, 61(3), pp.355-382.

Igwegbe, A.O., Negbenebor, C.A., Chibuzo, E.C. and Badau, M.H. (2014).Effects of season and location on heavy metal contents of fish species and corresponding water samples from Borno State of Nigeria.Glo. *Adv. Res. J. Med. Med. Sci*, 3(3), p.64.

Isaev, V.A. and Mikhailova, M.V. (2009).The hydrography, evolution, and hydrological regime of the mouth area of the Shatt al-Arab River.Water resources, 36(4), p.380.

Kamaruzzaman, S.N. and Zawawi, E.M.A. (2010). Influence of Employees' Perceptions of Colour Preferences on Productivity in Malaysia Office Buildings. *Journal of Sustainable Development*, 3(3), 283-293.

Khaled, A. (2004). Seasonal concentrations of some heavy metals in muscle tissues of Siganusrivulatus and Sargussargus fish from El-mex Bay and eastern harbour, Alexandria, Egypt.

Komjarova, I. and Blust, R. (2009). "Effects of Na, Ca, and PH on the Simultaneous Uptake of Cd, Cu, Ni, Pb, and Zn in the Zebrafish Danio rerio: A Stable Isotope Experiment." *Environmental Science and Technology* 43 (20): 7958–7963.

Kundera, I.N., Aulanni'am, A. and Santoso, S. (2014). Ekspresiprotein ADHF36 strain salmonella typhidaribeberapadaerah di indonesia. JurnalKedokteranHewan-*Indonesian Journal of Veterinary Sciences,* 8(1).

Kwansa-Ansah, E.E., Akoto, J., Adimalo, A.A. and Nam, D. (2012). Determination of Toxic and Essential Elements in Tilapia species from Volta lake with Indictively Coupled Plasma-Mass Spectrometry. *Int. J. Environ. Prot*. 2:30-34.

Latham, M.C. (1997). Human nutrition in the developing world (No. 29).*Food and Agriculture Org*.

Lilly, T.T., Immaculate, J.K. and Jamila, P. (2017). Macro and micronutrients of selected marine fishes in Tuticorin, South East coast of India. *International Food Research Journal*, 24(1).

Maurya, P.K. and Malik, D.S. (2016). Bioaccumulation of xenobiotics compound of pesticides in riverine system and its control technique: a critical review. *Journal of Industrial Pollution Control*, 32(2).

McManus, A. and Newton, W. (2011). Seafood, nutrition and human health: A synopsis of the nutritional benefits of consuming seafood.

Medeiros, M.J.M., Silva, J.F., Faustino, M.V.S., Santos, M.F.G., ROCHA, L.S. and Carneiro, L.C. (2012). Aceitação sensorial e qualidademicrobiológica de trufas de cajuobtidasartesanalmente.Holos, 2, pp.77-86.

Mogobe, O., Mosepele, K. and Masamba, W.R.L. (2015). Essential mineral contents of common fish

species in Chanoga, Okavango Delta, Botswana, 9(9): 480-486.

Nkansah, M.A. and Ansah, J.K. (2014). Determination of Cd, Hg, As, Cr and Pb levels in meat from the Kumasi Central Abattoir. *International Journal of Scientific and Research Publications*, 4(8), 1-4.

Nölle, R., Beltrop, K., Holtstiege, F., Kasnatscheew, J., Placke, T. and Winter, M. (2020). A reality check and tutorial on electrochemical characterization of battery cell materials: How to choose the appropriate cell setup. *Materials Today*, 32, pp.131-146.

Okocha, R.C. and Adedeji, O.B. (2011). Overview of cadmium toxicity in fish. *Journal of Applied Sciences Research*, 7(7), pp.1195-1207.

Qin, D., Jiang, H., Bai, S., Tang, S. and Mou, Z. (2015). Determination of 28 trace elements in three farmed cyprinid fish species from Northeast China.*Food Control*, 50, pp.1-8.

Raja, P., Veerasingam, S., Suresh, G., Marichamy, G.

and Venkatachalapathy, R. (2009). Heavy metal concentration in four commercially valuable marine edible fish species from Parangipettai coast, south east coast of India. *Journal of Animal and Veterinary Advances*, 1(1): 10-14.

Rajkowska, M. and Protasowicki, M. (2013). Distribution of metals (Fe, Mn, Zn, Cu) in fish tissues in two lakes of different trophy in Northwestern *Poland. Environmental monitoring and assessment*, 185(4), pp.3493-3502.

Read, E.S., Barrows, F.T., Gaylord, T.G., Paterson, J., Petersen, M.K. and Sealey, W.M. (2014). Investigation of the effects of dietary protein source on copper and zinc bioavailability in fishmeal and plant-based diets for rainbow trout. *Aquaculture*, 432, pp.97-105.

Rejomon, G., Nair, M. and Joseph, T. (2010). Trace metal dynamics in fishes from the southwest coast of India. *Environmental monitoring and assessment*, 167(1-4), pp.243-255.

Rzoska, J. (1980). Euphrates and Tigris. Mesopotamia Ecology and Destiny, The Hague, Boston, London, 122.

SAS (2005).SAS/STAT 'Usere's Guide for Personal Computers, Release 8.00.SAS Institute Inc., Cary, NC, USA.

Sauliutė, G. and Svecevičius, G. (2015). Heavy metal interactions during accumulation via direct route in fish: a review. *Zoology and Ecology*, 25(1), pp.77-86.

Shekha, Y.A. (2008). The effect of Erbil city wastewater discharge on water quality of Greater Zabriver, and the risks of irrigation. Ph.D., University of Baghdad.

Simionov, I.A., Cristea, V., Petrea, S.M., Mogodan, A., Nicoara, M., Baltag, E.S., Strungaru, S.A. and Faggio, C. (2019).Bioconcentration of Essential and Nonessential Elements in Black Sea Turbot (Psetta Maxima Maeotica Linnaeus, 1758) in Relation to Fish Gender.*Journal of Marine Science and Engineering,* 7(12), p.466.

Sobolev, N., Aksenov, A., Sorokina, T., Chashchin, V., Ellingsen, D.G., Nieboer, E., Varakina, Y., Plakhina, E., Onuchina, A., Thomassen, M.S. and Thomassen, Y. (2020).Iodine and bromine in fish consumed by indigenous peoples of the Russian Arctic.*Scientific Reports*, 10(1), pp.1-8.

Soegianto, A. and Hamami, A. (2007). Trace metal concentrations in shrimp and fish collected from Gresik coastal waters, *Indonesia. Science Asia,* 3, pp.235-238.

Tamele, I.J. and Loureiro, P.V. (2020). Lead, Mercury and Cadmium in Fish and Shellfish from the Indian Ocean and Red Sea (African Countries): Public Health Challenges. *Journal of Marine Science and Engineering*, 8(5), p.344.

Turkmen, M., Turkmen, A. and Tepe, Y. (2008).Metal contaminations in five fish species from Black, Marmara, Aegean and Mediterranean seas, *Turkey.Journal of the Chilean Chemical Society*, 53(1), pp.1424-1428.

WHO (World Health Organization). (2004). Guidelines for drinking-water quality.3rd Edition, World Health Organization (WHO), Geneva.p. 540.

Wildman, R. and Medeiros, D. (2000).*Advanced human nutrition*. Florida, USA: CRC Press LLC, Boca Raton.

Yeltekin, A.Ç. and Oğuz, A.R. (2018). Some macro and trace elements in various tissues of Van fish variations according to gender and weight. ArquivoBrasileiro de MedicinaVeterinária e Zootecnia, 70(1), pp.231-237.

Yildiz, A.O., Parlat, S.S. and Yazgan, O. (2004).The effects of organic chromium supplementation on production traits and some serum parameters of laying quails.Revue Méd.Vét, 155(12), pp.642-646.