

Chemical compositions and minerals of some commercially important fish species from the South Caspian Sea

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Abstract: The objective of the current study was determined chemical composition (including protein, lipid, ash and moisture) and content of minerals (Zn, Mn, Fe, Cu, Cr, Ca, Na, Mg, Mo, P, Se, K, I and F) in five fish species from the South Caspian Sea. The chemical analysis revealed that the protein content of common kilka, Caspian kutum, common carp, pike perch and golden grey mullet was 18.35%, 21.39%, 19.37%, 20.35% and 21.28% of the fresh weight, respectively. The lipid content and ash ranged from 1.97-10.23%, 1.15-3.33% of the fresh weight, correspondingly. The concentrations of several elements in the fishes were significantly different among the species in each country. Concentration of Cr was the highest in muscle of Caspian kutum. The highest concentrations of Fe, Ca, Na, I and F were found in the common carp among the five species ($p < 0.01$). Phosphorus value was highest in the pike perch, whereas Zn, Mg and P were highest in muscle of the common kilka. Many of the aforementioned indices had significant statistical differences ($P \leq 0.01$) and the cluster analysis results of mineral content showed that Caspian kutum and golden grey mullet had good similarity, followed by the pike perch and common carp, respectively; and common kilka had no resemblance with others.

Key words: Chemical composition, mineral, fish species, Caspian Sea

Introduction

Fish is one of the most important sources of animal protein available, and has been widely accepted as a good source of protein and other elements for the maintenance of a healthy body (Arannilewa, 2005). As compared to red meat, fish flesh is easily digestible because it contains long muscle fibers. In addition, fish is a good source of fluorine and iodine required for the development of strong teeth and prevention of goiter in man (Arannilewa, 2005). Moreover, the consumption of fish has been linked to health benefits such as reduced risk of coronary heart disease. A preventive and/or curative effect has also been reported for arterial hypertension (Millar and Waal-Manning, 1992), human breast cancer (Rose and Connoll, 1993), colon and prostate cancer (Marchioli, 2001 and 2002; URL, 2002), inflammatory diseases (Belluzi *et*

al., 1993; James and Cleland, 1996), asthma (Dry and Vincent, 1991; Hodge *et al.*, 1996) and disorders of the immune system (Kenneth, 1986; Levine and Labuza, 1990). In addition, fish oil helps to prevent brain aging and Alzheimer's disease (Kyle, 1999).

Besides, the Caspian Sea is the largest inland body of water in the world (Anan, 2005). Bony fishes such as Caspian kutum, golden grey mullet, common carp, pike perch and cartilaginous fishes such as common kilka abound in it together with commercially valuable species in the Caspian Sea. Yet, no detailed chemical study of mineral content and chemical composition of these fishes is available.

Thus this study was carried out to determine chemical compositions (including protein, lipid, ash and moisture) and content of minerals (Zn, Mn, Fe, Cu, Cr, Ca, Na, Mg, Mo, P, Se, K, I and F) of five fish species of the South Caspian Sea.

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Figure 1. Sampling locations of fishes in Caspian Sea

Materials and methods

Fish species

The fish species used for this study were Caspian kutum (*Rutilus frisii kutum*), golden grey mullet (*Liza aurata*), common carp (*Caprinus carpio*), pike perch (*Sander lucioperca*) and common kilka (*Clupeonella cultiventris caspia*), all purchased (in the same genus, weight and size; November 2006; 25-30 specimens; middle size value) from three different harbors (Figure 1): Anzalii (station 1), Babolsar (station 2) and Torkaman (station 3) located in North of Iran, represented by West, South and East of Southern Caspian Sea, respectively. The weights and lengths of these species were 840±10 g and 62±3 cm, 760±10 g and 48±2 cm, 830±15 g and 40±3 cm, 430±15 g and 30±2 cm, and 60±5 g and 10±2 cm, respectively. On board the fish specimens were beheaded, gutted and the edible sections were selected. The edible sections of each species from each harbor were mixed and transferred to the laboratory 5 hours post-capture on arrival in ice. These were used in the final analyses.

Chemical composition analysis

The proximate analysis was carried out according to the procedures of the Association of Official Analytical Chemists (AOAC, 1990). Moisture was determined by drying the samples in an oven (Memmert-500, Germany) at 105°C to constant weight (Egan *et al.*, 1990); crude ash was determined

by incineration in a muffle furnace (Heidolph-3001k, Germany) at 550°C for 10 hours (Egan *et al.*, 1990) and crude protein was determined by the Kjeldahl method ($N \times 6.25$) using an automatic Kjeldahl system (Kjeltec auto, model 1030, Germany) (Egan *et al.*, 1990). Finally, lipid was determined according to the method described by Bligh and Dyer (1959).

Mineral analysis

Concentrations of 12 elements (Zn, Mn, Fe, Cu, Cr, Ca, Na, Mg, Mo, P, Se and K) were measured using ICP (Perkin-Elmer, model Optima 2100DV, Australia) according to the manufacturer’s recommendations (Perkin-Elmer Corp. 1989), while the procedure used for measuring concentration of fluorine (Light and Cappuccino, 1975) and iodine (Egan *et al.*, 1990) has been described previously.

Statistical analysis

The obtained resulting data were presented as mean ± standard deviation (SD) of three separated determinations and given to the analysis of variance (ANOVA). The significant mean was compared by Duncan’s test at $\alpha=1\%$ level using SAS 6.03 (1990) software. Within this analysis various items are grouped or classified in a cluster by their similarities yielded in the data. Cluster analysis was displayed using Ward’s method. The linkage in a dendrogram shows the order of dissimilarity designated as a distance index (Krzanowski, 1995).

Table 1. Chemical compositions of fish species (% wet weight)

Fish species	Moisture	Crud ash	Crud lipid	Crud Protein
<i>R. frisii kutum</i>	72.4± 0.2 ^c	1.3± 0.1 ^c	6.7± 0.0 ^b	21.4± 0.6 ^a
<i>L. aurata</i>	74.8± 0.1 ^b	1.2± 0.0 ^c	4.9± 0.0 ^c	21.3± 0.2 ^a
<i>C. carpio</i>	77.8± 0.0 ^a	1.2± 0.0 ^c	3.6± 0.0 ^d	19.4± 0.9 ^{bc}
<i>S. lucioperca</i>	77.7± 0.1 ^a	1.5± 0.1 ^b	2.0± 0.0 ^e	20.4± 0.4 ^{ab}
<i>C. cultriventris caspia</i>	70.8± 0.4 ^d	3.3± 0.1 ^a	10.2± 0.1 ^a	18.4± 0.4 ^c

Data is expressed as mean ± SD of three separated determinations.

^{a-d} Value in the same columns with different superscript letters within a same strain are significantly different (p<0.01).

Results and discussion

The chemical analysis of samples is presented in Table 1. The identified species contain 1.97-10.23% fat. Based on the fat content, *L. aurata*, *C. carpio* and *S. lucioperca* were distinguished as lean fish, whereby the fat content was lower than 5% by weight (Bennion and Scheule, 2003), while *C. cultriventris caspia* and *R. frisii kutum* were classified as fat fish. Feeley *et al.* (1972) and Osman *et al.* (2001) reported that low-fat fish species have higher water content and, as a result, their flesh is whiter in color. The crude protein content ranged from 18.35% (*C. cultriventris caspia*) to 21.39% (*R. frisii kutum*). Crude ash ranged from 1.15% in *C. carpio* to 3.33% in *C. cultriventris caspia*.

Concentrations of 14 elements in the samples of fish species are shown in Table 2. Selenium (Se, 0.04 ± 0.00) and molybdenum (Mo, 0.08 ± 0.00) levels corresponded to each other in the study and nearly similar values were found for all fish species. Selenium is an antioxidant which prevents damage of the cells due to rancidification and delays the pathological ageing process. It inhibits chromosome damage, mutations and cancer. An intake of 70 µg for healthy men and 50 µg for healthy women suffices to keep the kinetics in balance. There are no known diseases which can be directly connected with molybdenum deficiency. Molybdenum is an interesting trace mineral, but it is also one which needs to be investigated more thoroughly. The significance of Mo for health is not very well known. Nevertheless, it is classified as an essential trace element because it is a component of at least three enzymes. Human requirements for Mo are not known in any detail, although the RDAs (Recommended Dietary Allowance) in various countries range from 100 to 500 µg (Tolonen, 1990).

The maximum concentration of chromium (Cr) in fish samples was 0.78 mg/kg. Although chromium Cr is an essential element helping the body to use sugar, protein and fat, at the same time it is carcinogenic for organisms (Institute of Medicine, 2002). Excessive amounts of Cr may cause adverse health effects (ATSDR, 2004). Requirements for Cr are not yet known. According to American estimates, a daily intake of 50-200 µg is a safe and adequate dosage (Tolonen, 1990).

The levels of manganese (Mn) in all samples ranged from 0.12 to 0.17 mg/kg. Daily intake of small amounts of Mn is needed for growth and good health in humans, otherwise deficiency of Mn can cause nervous system problems (Demirezen, 2006). The RDA for Mn is 3.8 mg, and a number of studies have indicated that actual daily intake is closer to 5-6 mg. (Tolonen, 1990).

The average copper (Cu) concentration was 1.02 to 2.6 mg/kg in the samples investigated. Furthermore the highest average concentrations of Cu were observed in *C. carpio* (2.58 mg/kg). Copper is essential for good health, but very high intakes can cause health problems such as liver and kidney damage (ATSDR, 2004). The RDA for Cu is 2 mg, but, in Finland, for instance, the average daily diet contains 1.7 mg of Cu.

Iron (Fe) level was highest in *C. carpio* with 12.55 mg/kg. Fish is a major source of Fe for adults and children. Iron deficiency causes anemia (Demirezen, 2006). The average intake of Fe is too low, although many people receive more than 18 mg per day, which is the RDA (Tolonen, 1990).

The results obtained from this study showed that the zinc (Zn) contents of samples were between 3.34 and 16.1 mg/kg. As shown in Table 2, the lowest Zn concentrations were found in *S. lucioperca* (3.34 mg/kg). Zinc is an essential element in human diet. Too

Table 2. Mineral compositions of fish species given as mg/kg dry weight

	<i>R. frisii kutum</i>	<i>L. aurata</i>	<i>C. carpio</i>	<i>S. lucioperca</i>	<i>C. cultriventris caspia</i>	Average daily intake
Ca	275 ± 7 d	274 ± 13 d	966 ± 36 a	635 ± 10 c	828 ± 9 b	1500.0 mg
Mn	0.16 ± 0.03 a	0.12 ± 0.01 a	0.17 ± 0.01 a	0.17 ± 0.05 a	0.14 ± 0.03 a	6.1 mg
Mg	244 ± 4 c	206 ± 4 d	276 ± 6 b	149 ± 3 e	333 ± 4 a	440.0 mg
Fe	4.49 ± 0.17 c	6.16 ± 0.10 b	12.55 ± 0.21 a	4.18 ± 0.10 c	4.60 ± 0.29 c	19.0 mg
Zn	5.46 ± 0.36 c	7.66 ± 0.35 b	7.44 ± 0.30 b	3.34 ± 0.56 d	17.23 ± 0.98 a	16.0 mg
Cu	2.36 ± 0.14 a	1.10 ± 0.07 c	2.58 ± 0.14 a	2.48 ± 0.18 a	1.75 ± 0.08 b	1.7 mg
Cr	0.78 ± 0.06 a	0.16 ± 0.01 c	0.74 ± 0.03 ab	0.67 ± 0.03 b	0.11 ± 0.04 c	29.0 µg
F	0.31 ± 0.03 a	0.18 ± 0.04 b	0.36 ± 0.04 a	0.28 ± 0.02 a	0.14 ± 0.02 b	250.0 µg
Mo	0.08 ± 0.00 a	0.08 ± 0.00 a	0.08 ± 0.00 a	0.08 ± 0.00 a	0.08 ± 0.00 a	120.0 µg
Se	0.04 ± 0.00 a	0.04 ± 0.00 a	0.04 ± 0.00 a	0.04 ± 0.00 a	0.04 ± 0.00 a	30.0 µg
I	1.17 ± 0.25 bc	0.73 ± 0.15 c	1.77 ± 0.15 a	1.57 ± 0.21 ab	0.80 ± 0.20 c	-
Na	488.17 ± 10 d	650 ± 5 c	786 ± 7 a	486 ± 10 d	679 ± 10 b	17.0g
K	2174 ± 90 c	2201 ± 75 c	2388 ± 41 b	2678 ± 36 a	1809 ± 24 d	4500.0mg
P	1249 ± 182 bc	1457 ± 2 c	2012 ± 2 b	1077 ± 60 d	3185 ± 7 a	2000.0 mg

Data is expressed as mean ± SD of three separated determinations

^{a-c} Value in the same columns with different superscript letters within a same strain are significantly different (p<0.01)

little Zn can cause problems; however, too much Zn is harmful to human health (ATSDR, 2004). Opinions about Zn requirements are widely divergent. The adult RDA for Zn is 15 mg (Tolonen, 1990).

Highest levels of fluorine (F) was found in *C. carpio*, followed by *R. frisii kutum*, *S. lucioperca*, *L. aurata* and *C. cultriventris caspia* with 0.36, 0.31, 0.28, 0.18 and 0.14 mg/kg, respectively. The most important function of F is to prevent caries in the teeth. It strengthens the enamel and thus protects the teeth from the attacks of bacteria and acids. Fluoride has also been associated with increased incidence of cardiovascular disease. In the United States the RDA for F is 1.5-4 mg for healthy adults. Some researchers maintain that 4 mg should be the absolute maximum dosage (Tolonen, 1990).

Iodine (I) levels were also significantly highest in *C. carpio*, with an average value of 1.77 mg/kg. Iodine plays a role in the regulation of the thyroid gland activity. The RDA for I is 100-200 µg per day (Tolonen, 1990).

The results obtained from this study showed that the phosphorous (P) and magnesium (Mg) contents of samples were 1077.27-3184.77 and 148.77-333 mg/kg, respectively. The highest average concentrations of P and Mg were observed in *C. cultriventris caspia*. Magnesium is an essential mineral for cell function and it occupies a key role in all reactions with

phosphate. The cells also require Mg for cell division and enzyme production. The RDA for P and Mg is 300-450 and 2000 mg per day, respectively (Tolonen, 1990).

The levels of potassium (K) and sodium (Na) in all samples ranged from 1809.06-2678.36 mg/kg and 488.17-786 mg/kg, respectively. Potassium is required for the normal functioning of the nerves and muscle, the sugar metabolism, acid-base balance and oxygen metabolism in the brain. The heart also needs potassium. Sodium regulates the electrolyte and acid-alkali balances, the conductive capacity of the nerves, muscle contractions and the production of adrenaline and amino acids. The human sodium requirement is about 3 g per day. Most people have a K intake of between 2-4 g per day on average (Tolonen, 1990).

The concentrations of several elements in the fishes were significantly different among the species in each country. Concentration of Cr was the highest in muscle of *R. frisii kutum*. The highest concentrations of Fe, Ca, Na, I and F were found in the *C. carpio* among the five species (p<0.01). Phosphorus value was highest in the *S. lucioperca*, whereas Zn, Mg and P were highest in muscle of the *C. cultriventris caspia*.

According to Esmailzadeh Kenari *et al.* (2004) report the levels of P and Ca in *R. frisii kutum* were 267.8 – 269.9 and 84.58 – 93 mg/100g, respectively.

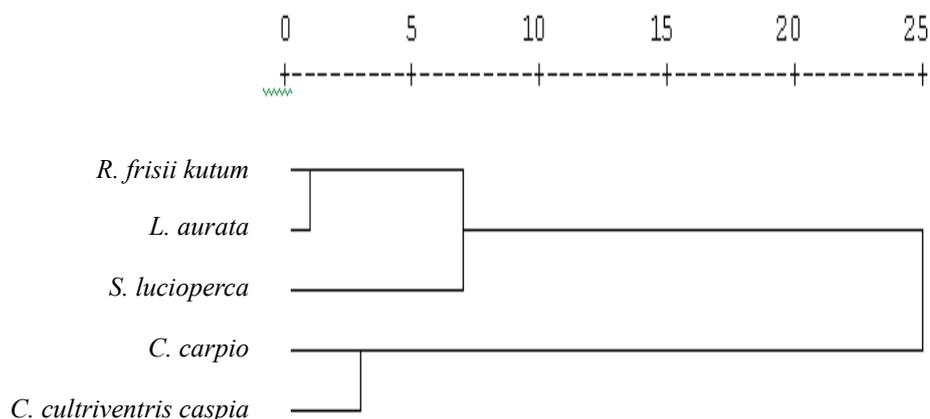


Figure 2. Dendrogram of fish species using Ward's method based on minerals content

This may be because of different analytical methods being used or that analytical data was obtained from other sample lots. Based on our literature studies, there were no information on the amount of other elements in fish and, therefore, we could not compare our results with those of other studies. The result of the cluster analysis is shown in Figure 2. The dendrogram was classified into groups by arbitrarily applying a rescaled distance cluster Ward's method. The cluster analysis results showed that the *R. frisii kutum* and *L. aurata* had good similarity, followed by the *S. lucioperca* and *C. carpio*, respectively. In addition, *C. cultriventrus caspia* had no similarity with other species.

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