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Bioavailability of Ca, K, Mg and Na in Arabian Yellow Finned Sea Bream (*Acanthopagrus arabicus*) with Estimated Daily Intake for Human Consumption

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Abstract. Yellow finned sea bream (*Acanthopagrus arabicus*) is a commercially important fish of coastal water of Pakistan. It is widely consumed by the people within and outside the country. Therefore, the paper investigates the concentration of macro-minerals (Ca, K, Mg and Na) in its meat and gills. The concentrations of different elements demonstrated statistically significant difference ($P < 0.01$) between meat and gills of the fish. Significantly higher concentrations of calcium and lower concentrations of potassium and sodium were recorded in gills compared to those in meat. In meat, mean concentrations were found in the order Na (5.41%) > K (3.44%) > Ca (2.16%) > Mg (0.24%), while in gills, the mean concentrations were Ca (57.72%) > Na (3.43%) > K (1.19%) > Mg (0.31%). Statistically significant correlations ($P < 0.05$) were noted between the body weight and the concentrations of calcium and magnesium in the meat of fish. The results are also compared with estimated daily intake and dietary reference intake values. The present study suggests that *Acanthopagrus arabicus* is an important source of macro-minerals for human consumption.

Keywords: estimated daily intake, gills, macro-minerals, *Acanthopagrus arabicus* and meat

Introduction

Fish is a significant source of dietary minerals to address deficiencies in people, especially in under developed countries (Roos *et al*., 2007; Roos *et al*., 2003; Larsen *et al*., 2000) to prevent many human diseases, including osteoporosis, cardiovascular disease and hypertension. The occurrence of osteoporosis in third world countries could be reduced through dietary intake of small fish since the soft bones of small fish are very rich in calcium (Flammini *et al*., 2016; Hansen *et al*., 1998).

Nonetheless, elevated dietary intake of sodium increases blood pressure that raises the risk of stroke and premature death due to cardiovascular diseases in many countries around the world (Barat *et al*., 2013; Fries, 1976). Therefore, balanced dietary intake of different minerals, even from fish, is vital for proper functioning of human organs and organ systems.

Consequently, many studies have been conducted to reveal the level of elements in different species of fish (Porto *et al*., 2016; Ali *et al*., 2013; Al-Busaidi *et al*., 2011; Younis *et al*., 2011; Fallah *et al*., 2010; Zeynali *et al*., 2009; Musaiger and D'Souza, 2008; Al-Jedah *et al*., 1999) so as to ascertain the availability of the required minerals in the diet of humans to recuperate, particularly in case of any deficiency.

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The present paper investigates four macro-minerals, *viz*. calcium, magnesium, potassium and sodium in the meat and gills of Arabian yellow finned sea bream (*Acanthopagrus arabicus*) since, it is edible, ecologically and economically important fish of the coastal waters of Pakistan. The fish occurs adequately throughout the Persian Gulf from Oman to Pakistan in shallow waters (Iwatsuki, 2013).

The fish is harvested commercially and no major threat has yet been identified by International Union for Conservation of Nature (IUCN). Therefore, sufficiently large quantities of Arabian yellow finned sea bream are supplied by Karachi Fish Harbour, which is the largest fish harbour of the country and situated on the northern border of Arabian sea. This study also compared the concentrations of different macro-minerals with Dietary Reference Intake (DRI) and Estimated Daily Intake (EDI) values.

Materials and Methods

Sampling. Fish was purchased from a local dealer immediately after arrival at west wharf near Karachi Fish Harbour in 2015 on monthly basis and were sent to laboratory for analysis. All the sea breams were weighed and their total length was measured. 40 g each of meat and gills were removed from the fish. Each sample was placed in plastic zip lock bags, tagged and frozen at -21 °C.

Sample preparation and chemical analysis. Each frozen sample was oven dried at 105 °C to get a constant weight and then homogenized with the help of Pastel mortar. Seven mili litre of nitric acid (HNO_3) was added in each sample and then left them for overnight. One mili litre of hydrogen peroxide (H_2O_2) was added in each sample and was kept in microwave digestion system (Anton Paar Multi-wave ECO Microwave Digestion System, Austria) for 30 min at 180 °C (800 W). All the samples were thoroughly digested. Each sample was made up to 25 mL volume of distilled water.

Elemental analysis. Flame photometer (JENWAY, UK) was used to measure potassium and sodium. Each sample was diluted to 10 ppm before running the samples. Atomic Absorption Spectrophotometer (Hitachi Z-8000 Polarized Zeeman, Japan) was used for calcium and magnesium analysis. For quality control, recovery analysis was done and overall recovery was found between 90 and 99%.

Statistical analysis. Descriptive statistics and Pearson's correlation analysis was performed by using SPSS 22 (IBM) to demonstrate the relationship between the fish body weight with the minerals in the gills and the meat and statistical significance was set to $P<0.01$ and $P<0.05$. Analysis of variance (ANOVA) was used to demonstrate, whether the concentration of different minerals differed significantly between the meat and the gills and to determine, whether the concentration of different minerals differed significantly among different months.

The estimated daily intake was calculated by the following relationship (Zhong *et al*., 2006).

$$EDI = C_{metal} (W/bw)$$

where:

EDI = estimated daily intake, C_{metal} = concentration of metals, W = average daily intake of fish and bw = body weight.

Five gram of fish was taken as average daily consumption per person in Pakistan, considering a 70 Kg person (FAO, 2010) for calculating estimated daily intake, which was then multiplied by average estimated concentration of each nutrient, which was available in the fish (Ahmed *et al*., 2016).

Results and Discussion

The concentrations of macro-minerals in samples of meat (Fig. 1a, 1b, 1c, 1d) and gills (Fig. 2a, 2b, 2c, 2d) during different months are presented. The concentrations of calcium, potassium and sodium demonstrated statistically significant difference ($P < 0.01$) between the meat and the gills of the fish. The concentrations of calcium in gills were significantly higher compared to those in meat. On the contrary, the concentrations of potassium and sodium in gills were significantly lower than those in meat. Nonetheless, the concentrations of magnesium revealed statistically non-significant difference between the gills and the meat.

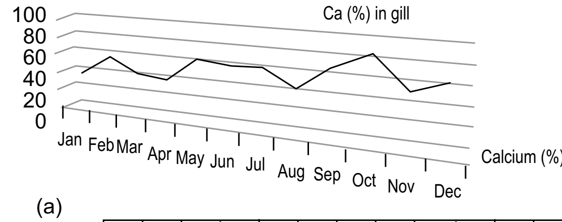
The meat of the fish revealed statistically non-significant difference of all the macro-minerals among various months. Nevertheless, the meat exhibited statistically significant difference ($P < 0.01$) among the concentrations of four different macro-minerals. In meat, sodium recorded highest average concentration (5.41 ± 0.68%) while magnesium showed lowest average concentration (0.24 ± 0.07%) (Table 1a). However, the gills of the fish demonstrated statistically significant difference ($P < 0.01$) of all the macro-minerals among various months. The highest concentrations of calcium (85.31%), magnesium (0.43%), potassium (1.88%) and sodium (4.68%) in gills were found in October (Fig. 1a), July (Fig. 1d), September (Fig. 1c) and December (Fig. 1b), respectively. While in meat, highest concentrations of calcium (4.31%) were observed in April (Fig. 2a), potassium (4.01%) in September (Fig. 2c), sodium (7.12%) (Fig. 2b) and magnesium (0.43%) (Fig. 2d) in May. Moreover, the gills disclosed statistically significant difference ($P < 0.01$) among the concentrations of four different macro-minerals. In gills, calcium recorded highest average concentration (57.72 ± 14.24 %), while magnesium showed lowest average concentration (0.31 ± 0.05 %) (Table 1b).

In fish, the concentrations of macro-minerals also depend up on its body weight and length. The present study demonstrated statistically significant ($P < 0.05$) correlation of body weight with calcium and magnesium, while it revealed non-significant correlation of the body weight with potassium and sodium.

Statistically significant correlations ($P < 0.05$) were observed between the body weight and the concentrations of calcium and magnesium of the meat (Table 2a). Nonetheless, sodium concentrations in the gills differed significantly ($P < 0.05$) with the body weight (Table 2b). Moreover, the concentration of sodium of the gills differed significantly ($P < 0.05$) with the body weight. However, non-significant correlations were noted between the body weight and the concentrations of magnesium and potassium, which was found in the gills.

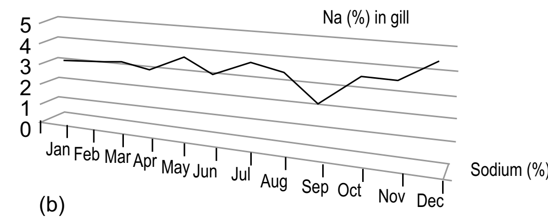
The results demonstrate that the meat and the gills of *Acanthopagrus arabicus* is an important source of calcium, potassium, magnesium and sodium, which could be consumed by humans to recover from their deficiencies. The gills of the fish exhibited the highest concentrations of calcium, which may be an important dietary source to address human diseases such as osteoporosis and proper functioning of heart, nerves and muscles (Pravina *et al*., 2013; Peacock, 2010 a). Magnesium is required for a variety of physiological functions of humans (Vormann, 2003). It helps to produce hormones, maintains heartbeat and muscles movement and regulates other essential nutrients like calcium, potassium and sodium in the human body (Winiarska-Mieczan, 2014). Potassium and sodium ions are indispensable for the maintenance of cellular homeostasis of human tissues. These electrolytes help to maintain osmotic pressure, distribute water in different body fluid areas, maintain pH, regulate cardiovascular and other muscular functions and act as cofactor for enzymes (Pohl *et al*., 2013).

The current study suggests that the body weight of fish could be used to estimate the concentration of various macro-minerals in the meat and gills of fish. The study could be extended to reveal the association between body weight and different minerals, which are found in various body parts of other fish species. The dietary reference intake (DRI) per day, which was recommended by National Institutes of Health, USA (2017), is provided to compare them with the estimated daily intake (EDI) values of macro-minerals calculated in meat and gills so as to recommend the meat and the gills of *Acanthopagrus arabicus* for its required dietary intake to maintain good health of the people, particularly of nutrient deficient population of the world. Similar



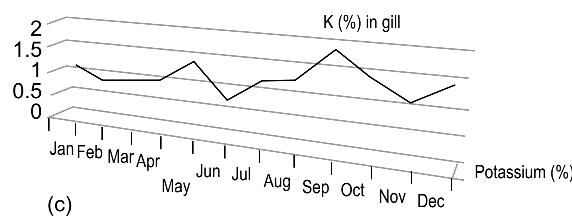
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Calcium (%)	37.83	57.79	42.51	40.93	66.32	62.26	63.63	44.8	71.5	85.31	54.22	65.53

Fig. 1a. Concentration of calcium (%) in gill during different months of the study.



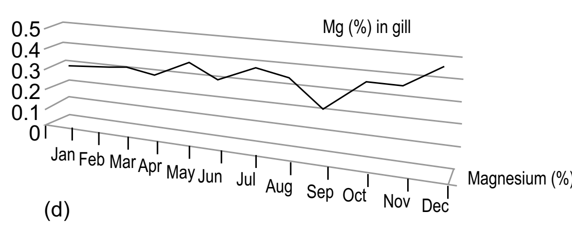
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sodium (%)	3.1	3.11	3.24	3	3.76	3.11	3.81	3.58	2.35	3.67	3.7	4.68

Fig. 1b. Concentration of sodium (%) in gill during different months of the study.



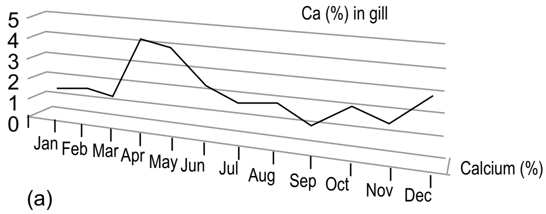
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Potassium (%)	1.11	0.83	0.9	1	1.41	0.72	0.19	1.26	1.88	1.43	1.09	1.49

Fig. 1c. Concentration of potassium (%) in gill during different months of the study.



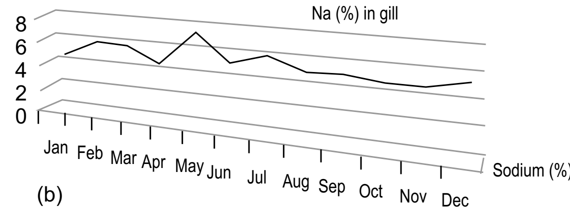
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Magnesium (%)	0.24	0.29	0.27	0.28	0.33	0.31	0.43	0.27	0.33	0.35	0.28	0.36

Fig. 1d. Concentration of magnesium (%) in gill during different months of the study.



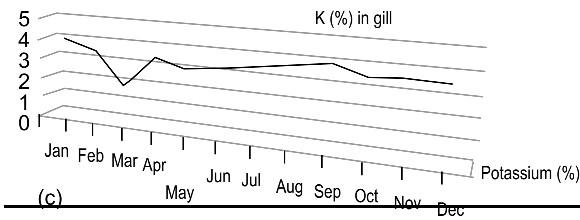
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Calcium (%)	1.37	1.46	1.16	4.31	3.99	2.31	1.64	1.86	1.15	2.1	1.6	2.94

Fig. 2a. Concentration of calcium (%) in meat during different months of the study.



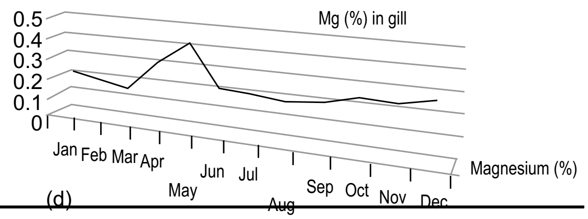
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sodium (%)	4.76	5.79	5.72	4.71	7.12	5.19	5.96	5.17	5.18	4.91	4.93	5.5

Fig. 2b. Concentration of sodium (%) in meat during different months of the study.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Poyssium (%)	3.97	3.47	1.79	3.43	3.09	3.3	3.57	3.76	4.01	3.57	3.69	3.67

Fig. 2c. Concentration of potassium (%) in meat during different months of the study.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Magnesium (%)	0.22	0.19	0.16	0.32	0.43	0.21	0.21	0.19	0.21	0.25	0.25	0.28

Fig. 2d. Concentration of magnesium (%) in meat during different months of the study.

Table 1a. Mean, standard deviation (SD), estimated daily intake (EDI) and daily dietary reference intake (DRI) (NIH, USA, 2017) for meat of *Acanthopagrus arabicus*

Elements (%)	Mean ± SD	DRI (mg)	EDI (mg)	Mean ± SD (TL of fish in mm)	Mean ± SD (B.Wt. of fish in g)
Calcium	2.16 ± 1.06	1000	0.04	234.42±15.55	263.83±39.06
Magnesium	0.24 ± 0.07	(413-317)	0.004		
Potassium	3.44 ± 0.58	4700	0.063		
Sodium	5.41 ± 0.68	1500	0.103		

*SD = Standard deviation; TL= Total length; B.Wt. = Body weight.

Table 1b. Mean, standard deviation (SD), estimated daily intake (EDI) and daily dietary reference intake (DRI) (NIH, USA, 2017) for gills of *Acanthopagrus arabicus*

Elements (%)	Mean ± SD	DRI (mg)	EDI (mg)	Mean ± SD (TL of fish in mm)	Mean ± SD (B.Wt. of fish in g)
Calcium	57.72 ± 14.24	1000	1.03	234.42±15.55	263.83±39.06
Magnesium	0.31 ± 0.05	(413-317)	0.005		
Potassium	1.19 ± 0.33	4700	0.022		
Sodium	3.43 ± 0.58	1500	0.065		

*SD = Standard deviation; TL= Total length; B.Wt. = Body weight.

approach by Barrento *et al*. (2009) provided comparison between dietary reference intake (DRI) and compositions of macro & trace elements in brown crab.

Parpia *et al*. (2018) studied presence of potassium, sodium and phosphorus additives in fish and other meat products and suggested that these additives can contribute to dietary levels of sodium and phosphorus in human so patients with chronic kidney disease should be careful about the intake of these fish and other meat products.

This study suggested that *Acanthopagrus arabicus* is a good source of calcium, magnesium, potassium and sodium. Similarly, Ahmed *et al*. (2016) estimated some other essential metals from *Acanthopagrus arabicus* such as Iron, Manganese and Zinc. Hence, this fish could be consumed by the population, who lack these minerals in their diet which are essentially required for proper functioning of different organs and organ systems of humans. Similar approach by Abdel-Raheem *et al*. (2019) provided observations on presence of good amount of Ca, Mg, Na and K in the meat of camel and recommended it as a healthy option for human diet.

Table 2a. Pearson's correlation between body weight of *Acanthopagrus arabicus* and the concentration of various macro-minerals in meat

	Meat				
	Ca	K	Mg	Na	B.Wt (g)
Ca	1	-0.027	0.858**	0.243	0.306*
	-	0.935	0.000	0.447	0.333
K	-0.027	1	0.070	-0.394	0.071
	0.935	-	0.829	0.205	0.826
Mg	0.858**	0.070	1	0.443*	0.490*
	0.000	0.829	-	0.149	0.105
Na	0.243	-0.394	0.443*	1	0.088
	0.447	0.205	0.149	-	0.785
B.Wt (g)	0.306*	0.071	0.490*	0.088	1
	0.333	0.826	0.105	0.785	-

** = Correlation is significant at the 0.01 level (2-tailed);
* = Correlation is significant at the 0.05 level (2-tailed).

Table 2b. Pearson's correlation between body weight of *Acanthopagrus arabicus* and concentrations of macro-minerals in gills

	Gills				
	Ca	Mg	K	Na	B.Wt (g)
Ca	1	0.628*	0.324*	0.096	0.631*
		0.029	0.304	0.767	0.028
Mg	0.628*	1	0.393*	0.421*	0.271
	0.029	-	0.205	0.173	0.395
K	0.324*	0.393*	1	0.083	0.277
	0.304	0.205	-	0.797	0.384
Na	0.096	0.421*	0.083	1	0.540*
	0.767	0.173	0.797	-	0.070
B.Wt (g)	0.631*	0.271	0.277	0.540*	1
	0.028	0.395	0.384	0.070	-

* = Correlation is significant at the 0.05 level (2-tailed).

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Conflict of Interest. The authors declare no conflict of interest.

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