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Chemical Composition and Mineral Contents of Six Commercial Fish Species from the Arabian Gulf Coast of Saudi Arabia

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Abstract: The study evaluated the dressing percentage, nutritional quality and mineral composition of six commercial fish species (Scads, *Alepes djedaba*, Emperors, *Lethrinus lentjan*, Kingfish, *Scomberomorus commerson*, Jobfish, *Lutjanus malabaricus*, Coral trout, *Plectropomus maculates* and Groupers, *Epinephelus chlorostigma*) from the Arabian gulf coast of Saudi Arabia. The Kingfish (*Scomberomorus commerson*) showed the highest (90.9%) dressing percentage followed by Grouper (80.6%) and Coral trout (80.3%) whereas the lowest (72.9%) was for Emperors. scad fish (*Alepes djedaba*) had lowest skin and bone weights. Significant ($p<0.05$) differences were observed in the proximate chemical composition of fish muscles in these species. The highest percentage of protein (21.51%) was found in Coral trout followed by Kingfish (20.68%) and Scads (20.64%). The lowest fat content (0.43%) was observed in Groupers (*Epinephelus chlorostigma*) whereas the highest fat content (1.12%) was in Kingfish. The highest energy value (4.02 MJ kg^{-1}) in fish muscles was observed in Coral trout. Significant ($p<0.05$) differences were also observed in the mineral composition of fish muscles in these species. All the fish species proved to be a good source of many important minerals. In spite of the expected pollution threats of coastal waters, it was interesting to note that the amount of heavy metals such as lead and cadmium present in fish muscles were relatively low (0.1-0.26 and 0.007-0.02 mg kg^{-1}, respectively). It is concluded that these fish species contribute towards a safe, healthy and nutritious food for human consumption.

Key words: Chemical composition, minerals, fish species, Arabian gulf, Saudi Arabia

INTRODUCTION

Fish provides the best quality of protein and many other important nutrients including essential fatty acids and minerals. The average per capita consumption of fish in Saudi Arabia has increased drastically over the past 30 years and the demand for sea food is continuously on the increase (Ministry of Agriculture, 2003). Fishes caught from the coastal waters of Saudi Arabia are generally sold fresh in the local market. Koc *et al*. (2009) observed that consumer's preferences in selecting fish for consumption significantly depended on variety, supply channel, price and production methods. The success of sea food industry depends on gaining the consumer's acceptability and confidence on the quality and safety of sea food. In nature many of trace elements even in low concentrations may exert harmful or beneficial effects on aquatic animals. These elements are introduced to the environment both through natural processes and as a consequence of human activities such as industrial or fuel combustion. The contribution of elements and their ions in creation of pollution problems are of serious concern because their toxic effects can be substantial even at extremely low concentrations. Heavy metals enter the aquatic food chain through direct consumption of water and biota and through the gills in case of fish. Therefore, some aquatic organisms have the ability to concentrate contaminations to more than million times as compared to their concentration found in the water (Kahle and Zauke, 2002). The actual role of many trace metals in human health is however, very complex and is still not fully understood. This makes it difficult to evaluate their safe levels for human consumption (ILO/UNEP/WHO, 2002). In many developed countries upper limits for the

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concentration of these elements in fish have been set in order to safeguard the public health. Saudi Arabia has set the maximum limits for concentrations of lead, cadmium and arsenic in fish and shellfish at 2, 0.5 and 1 μg g^{-1}, respectively (SASO, 1997).

Accumulation of trace metals in aquatic organisms is one of the most striking effects of pollution in aquatic system. Some of these elements are assimilated by marine organisms for individual metabolic processes. However, their capacity to form complex with organic substances can result in concentrations up to 1000 times higher than their assimilation and fixation in tissues becoming toxic to organisms. Heavy metals have a great ecological significance due to their toxicity and accumulative behavior and can decrease the marine species diversity and ecosystems (Buhl, 1997; Austin, 1999; Matta *et al*., 1999). Therefore, the consumption of sea food may impose health hazards on humans. A wide range of metals and metallic compounds present in the marine environment pose risks to human health through the consumption of marine fish where the amount of contaminants and exposure are significant (Han *et al*., 1998; Osfor *et al*., 1998; Chan *et al*., 1999). Cadmium is an extremely toxic and hazardous metal that can cause oxidative stress and may lead to cancer in humans (Tandon *et al*., 2003; Filipic *et al*., 2006). Similarly, the lead toxicity is of great concern due to its cumulative effect in the body as a result of its binding with biological chelating agents (Fabris *et al*., 2006). There are various sources of water pollution that enter the aquatic system mainly from industrial waste waters. Regional differences have been reported in the concentration of heavy metals in fish.

According to Al-Saleh and Shinwari (2002) the concentration of cadmium, lead, nickel, vanadium and arsenic varied in fish species from the Arabian gulf of Saudi Arabia. Kosanovic *et al*. (2007) observed significantly higher concentrations of various metals in fish muscles and liver from the area with higher industrial activity on the western coast of United Arab Emirates. Zeynali *et al*. (2009) reported that the concentration of copper, zinc and iron in the edible muscles of 3 commercial fish species from the Iranian coastal water of Caspian sea varied significantly.

The Arabian gulf has been subjected to inputs of trace elements from the variety of sources and it has been estimated that the oil pollution in the gulf represents 4.7% of the total oil pollution in the world (NRC, 1985). The aim of this study was to determine the chemical composition and mineral contents of six commercial marine fish species from the Arabian gulf coast of Saudi Arabia and to evaluate the impact of pollution in coastal water in terms of accumulation of heavy metals in fish muscles.

MATERIALS AND METHODS

Six economically important commercial fish species (Table 1) from the Arabian gulf coast of Saudi Arabia were selected for this study. Five representative samples of each fish species were obtained from Saudi Fisheries company. The samples were packed in ice boxes and were immediately transferred to the lab for further processing and analysis.

Body weight and length: The body weight and length (total length and standard length) of fish were recorded. The fish were then processed to remove head, skin and bones and the muscles and the weight of all these components was recoded. The weight of fish without head was also recorded. The dressing percentage of fish was calculated as % of fish weight without head = fish weight without head/total fish weight×100. Proximate of chemical composition (Moisture, protein, lipids and ash) was determined according to the standard analytical procedures of AOAC (1995). The gross energy content of fish muscles was calculated from the protein, lipids and carbohydrates contents by multiplying with the factors 23.64, 39.54 and 17.15 MJ kg^{-1}, respectively as described by Ali *et al*. (2008).

Determination of minerals in fish muscles: The mineral contents (Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Phosphorus (P), Zinc (Zn), Iron (Fe), Copper (Cu), Manganese (Mn), Cadmium (Cd) and Lead (Pb) in fish muscles were determined using the Atomic Absorption Spectrophotometer (Model AA-680/ Shimadzu) according to the method as described by AOAC (1995).

Statistical analysis: The data collected was subjected to statistical analysis using one way Analysis of Variance (ANOVA). The average values (means±standard deviation) were compared by using Fisher's Least Significant Differences test (LSD-test) as described by Snedecor and Cochran (1989).

Table 1: English, arabic and scientific names of fish species used in the study

English name	Arabic name	Scientific name
Scad	Bayad	*Alepes djedaba*
Emperors	Shaour	*Lethrinus lentjan*
Kingfishes	Kanad	*Scomberomorus commerson*
Jobfishes	Hamrah	*Lutjanus malabaricus*
Coral trout	Najil	*Plectropomus maculates*
Grouper	Hamour	*Epinephelus chlorostigma*

RESULTS AND DISCUSSION

The averages values of Standard Length (SL), Total Length (TL), Body Weight (BW) and Head Weight (HW) for various fish species are shown in Table 2. Overall significant ($p<0.05$) differences were observed in these parameters among various fish species. However, no significant differences ($p>0.05$) were observed in the standard length of Scad, Emperor and Jobfish. The Kingfish showed the highest standard length (48.92±2.82 cm) whereas the scad had the lowest (24.42±6.53 cm). Similar trend was observed for total length. Similarly the highest average body weight (1602.8±123.0 g) was observed for Kingfish and the lowest for Scad (309.5±165.0 g). No significant differences ($p>0.05$) were however, observed in the average body weights among Scad, Jobfish and Emperor. The highest head weight was observed for Coral trout flowed by Grouper, Emperors and Kingfish. The lowest Head Weight (HW) was observed for Scad. The data on the Body Weight without Head (BW-H), Skin Weight (SW), Skeletal Weight (SkW), Muscle Weight (MW) and dressing percentage (Percentage of body weight without head, BW-H%) is shown in Table 3. Overall significant ($p<0.05$) differences were also observed in these parameters among various fish species. Similar to total body weight, the Kingfish on the average showed the highest body weight without head as compared to all other species whereas the Scad had the lowest BW-H. The highest muscle weight was also observed for kingfish. The lowest muscle weight was observed for Groupers. Similarly the highest dressing percentage (BW-H%) was also observed for Kingfish whereas the lowest dressing percentage (BW-H%) was observed for Emperors. The values for skin weight and skeletal weight also differed significantly ($p<0.05$) among various fish species. These results are important for the consumers in making an informed decision before purchasing to get the maximum benefits for the money spent in terms of nutritional outputs as the head of fish is an inedible part and is mostly wasted. The results are in agreement with the data reported by El-Harthy (1992). People living in the western region of Saudi Arabia prefer Coral trout fish because of its delicious taste and high amount of edible meat. However, the Grouper, Jobfish, Coral trout and Scad did not show any significant ($p>0.05$) differences in the dressing percentage.

Chemical composition of fish muscles: The chemical composition and energy value of fish muscles (as percentage on fresh weight basis) is shown in Table 4. Overall significant ($p<0.05$) differences were observed in the chemical composition and energy value of fish muscles among various fish species. The highest moisture content (79.58%) was obverted in Emperors followed by Jobfish and Grouper. The lowest average moisture content was observed in Kingfish. These results are in agreement with those reported by El-Faer *et al.* (1992). They selected five economical fish species from Arabian gulf and found that similar results for moisture in Scad and Emperors fish also their data for moisture in Grouper

Table 2: Standard Length (SL), Total Length (TL), Body Weight (BW) and Head Weight (HW) of various fish species (Mean±SD)

Fish species	SL (cm)	TL (cm)	BW (g)	HW (G)
Scad	24.42±6.53^{c}	30.70±10.23^{c}	309.5±165.00^{c}	57.38±25.3200^{c}
Emperors	27.52±5.50^{c}	34.12±6.960^{c}	595.38±271.0^{bc}	156.64±58.7800^{b}
Kingfishes	48.92±2.82^{a}	58.62±3.160^{a}	1602.8±123.00^{a}	146.68±17.5800^{bc}
Jobfishes	25.30±0.75^{c}	30.50±1.090^{c}	395.4±8.2000^{c}	90.03±4.01000^{bc}
Coral trout	36.48±7.88^{b}	43.94±8.820^{b}	1322.8±417.00^{a}	266.32±104.140^{a}
Grouper	29.70±6.14^{bc}	36.42±6.900^{bc}	852.4±271.80^{b}	180.77± 130.66^{ab}

Table 3: Body Weight without Head (BW-H), Skin Weight (SW), Skeletal Weight (SkW), Muscles Weight (MW) and percentage of body weight without head (BW-H%) for fish species (Mean±SD)

Fish species	BW-H (g)	SW (g)	SkW (g)	MW (g)	BW-H (%)
Scad	252.30±139.70^{d}	14.23±9.260^{d}	24.04±10.73^{d}	s197.20±128.10^{d}	80.48±2.940^{b}
Emperors	438.90±212.70^{cd}	38.70±14.48^{cd}	62.26±29.07^{c}	287.70±234.00^{c}	72.90±15.11^{c}
Kingfishes	1456.40±105.50^{a}	74.60±4.100^{b}	188.48±23.42^{a}	990.50±99.700^{a}	90.87±0.380^{a}
Jobfishes	306.20±3.9000^{d}	45.84±0.410^{c}	50.88±1.010^{cd}	139.60±1.3000^{d}	77.24±0.550^{b}
Coral trout	1056.30±362.50^{b}	107.63±46.27^{a}	114.62±32.68^{b}	631.80±183.10^{b}	80.34±1.740^{b}
Grouper	669.60±146.80^{c}	39.88±10.37^{cd}	64.79±25.26^{b}	64.79±25.260^{c}	80.58±8.780^{b}

Table 4: Chemical composition of fish muscles (Percentage of fresh weight basis) for experimental fish (Mean±SD)

Fish species	Moisture	Protein	Lipid	Ash	Energy (MJ kg^{-1})
Scad	76.80±1.56^{b}	20.64±0.36^{b}	0.79±0.15^{c}	1.20±0.06^{bc}	3.80±0.22^{a}
Emperors	79.59±1.59^{a}	18.56±0.76^{c}	0.45±0.16^{d}	1.18±0.10^{c}	3.31±0.19^{b}
Kingfishes	76.49±0.21^{b}	20.68±0.78^{b}	1.12±0.16^{a}	1.27±0.06^{b}	3.93±0.22^{a}
Jobfishes	79.16±0.48^{a}	18.91±0.76^{c}	0.49±0.05^{d}	1.38±0.07^{a}	3.40±0.17^{b}
Coral trout	77.12±0.16^{b}	21.51±0.24^{a}	0.98±0.15^{b}	1.21±0.05^{bc}	4.02±0.14^{a}
Grouper	78.87±0.48^{a}	18.60±0.24^{c}	0.43±0.09^{d}	1.07±0.04^{d}	3.31±0.10^{b}

Table 5: The average mineral content in fish muscles of various fish species (Mean±SD in mg/100 g)

Fish/Minerals	Scad	Emperors	Kingfish	Jobfish	Coral trout	Grouper
Calcium (Ca)	22.60±1.53000[c]	51.620±6.18000[a]	8.12±1.02000[e]	14.52±2.65000[d]	32.58±1.93000[b]	25.10±1.96000[c]
Phosphorus (P)	255.80±22.0800[bc]	281.200±8.26000[a]	231.60±23.1500[bc]	193.20±8.35000[d]	181.80±6.46000[d]	260.60±33.7500[ab]
Magnesium (Mg)	17.85±1.08000[bc]	17.090±1.43000[c]	23.19±1.48000[a]	22.42±0.62000[a]	17.42±2.84000[c]	19.56±0.38000[b]
Sodium (Na)	67.00±9.72000[a]	60.400±4.51000[b]	51.60±3.21000[cd]	61.00±2.24000[ab]	47.00±4.85000[d]	57.00±2.35000[bc]
Potassium (K)	437.40±9.91000[a]	451.60±24.66000[a]	458.00±27.9400[a]	393.20±16.8400[b]	300.60±9.45000[c]	323.20±16.8700[c]
Iron (Fe)	0.504±0.0260[a]	0.528±0.02700[a]	0.400±.0.028[b]	0.432±0.0500[b]	0.520±0.0490[a]	0.496±0.0460[a]
Copper (Cu)	0.072±0.0230[b]	0.028±0.01100[f]	0.076±0.0090[a]	0.068±0.0180[c]	0.056±0.0090[d]	0.052±0.0110[e]
Manganese (Mn)	0.048±0.0110[a]	0.024±0.00900[b]	0.028±0.0110[b]	0.052±0.0110[a]	0.048±0.0110[a]	0.028±0.0110[a]
Zinc (Zn)	0.59±0.15300[NS]	0.592±.176000[NS]	0.464±0.0930[NS]	0.352±0.1090[NS]	0.448±0.2700[NS]	0.692±0.2180[NS]
Cadmium (Cd)	0.002±0.0006[a]	0.0007±0.0003[bc]	0.001±0.0020[b]	0.0009±0.001[bc]	0.0008±0.002[bc]	0.0007±0.001[c]
Lead (Pb)	0.021±0.1530[ab]	0.024±0.00500[ab]	0.010±0.0000[c]	0.026±0.0050[a]	0.020±0.0000[b]	0.020±0.0000[b]

is also in agreements with the results of this study. Ewaidah (1993) however, reported lower moisture values in Scad muscle as compared to the results. The results of this study are also in line with the data obtained by Ewaidah (1993) and Al-Khalifa (1998) who reported similar results for moisture in Emperors and Jobfish. In contrast these researchers found lower moisture content in Kingfish fish than the results. Clement and Lovell (1994) and Erickson (1992) reported that moisture content in Nile tilapia (*Oreochromis niloticus*) and Catfish (*Ictalurus punctatus*) was less than that observed in these fish species. Based on the results of the study is can be concluded that the best economic fish is Kingfish which has lower moisture content followed by Scad, Coral trout, Grouper, Jobfish and Emperors.

The highest protein content (21.51%) in fish muscles was observed for Coral trout followed by Kingfish (20.68%) and Scad (20.64%). However, the protein values did not show any significant differences among Scad and Kingfishes. The Emperors showed the lowest protein content (18.56%). However, no significant ($p>0.05$) differences were observed in protein content of Emperors, Grouper and Jobfish. These results are in agreement with El-Faer *et al*. (1992) who observed almost similar results for protein contents in Scad, Emperors, Grouper, Jobfishes and Kingfish. Clement and Lovell (1994) found that protein content in *Oreochromis niloticus* was similar to Kingfish. The researchers observed higher protein contents in these fishes as compared to those (Codfish, Plaice and Hoddock) collected from Quebec, Canada (Zee *et al*., 1990).

The lipid content in fish muscles also differed significantly ($p<0.05$) among various fish species. The highest value (1.12%) was observed in Kingfishes fish whereas the lowest level (0.43%) was found in Grouper. However, no significant differences were observed in lipid levels of muscles among Emperors, Jobfish and Grouper. The lipid contents in fish muscles depends on a number of factors including species, age of fish, capture season, feeding habits and reproduction (Ali *et al*., 2000). These results are in line with the findings of Ewaidah (1993), who reported similar results for muscle lipid contents in Grouper and Emperors. In contrast, El-Faer *et al*. (1992) observed higher lipid contents in similar fish which might be due to regional variability and differences in the ecosystem in which the fish live or because of seasonal differences in fish sampling. Significant ($p<0.05$) differences were also observed in the ash content of fish muscles among different fish species. The highest ash content (1.38%) was observed in Jobfish whereas the lowest value (1.06%) was found in Grouper. These results are in agreement with the data reported by El-Faer *et al*. (1992), who observed similar result in fishes from the Arabian gulf.

The energy value of fish muscles also differed significantly ($p<0.05$) among fish species. The highest energy value (4.02 MJ kg^{-1}) in fish muscles was found in Coral trout whereas the Grouper showed the lowest (3.31 MJ kg^{-1}). However, no significant ($p<0.05$) differences were observed in the energy value of fish muscles between Scad, Kingfishes and Coral trout. The chemical composition and energy value of fish muscle may vary with the type of feed, its digestibility as well as many other factors (Diana, 1995; Al-Asgah, 1999). These results may help the people to make informed decision in selecting their preferred fish.

Mineral contents in fish muscles: The data on the average mineral content in fish muscles for various fish species is shown in Table 5. Significant ($p<0.05$) differences were also observed in the mineral content of fish muscles among different fish species. The results indicated that all fish species represented a good source of various important essential minerals (Calcium, phosphorous, magnesium, sodium and potassium) and trace elements (Iron, copper, manganese and zinc). The level of calcium in the muscles of various fish species ranged from 8.12-51.62 mg/100 g, the highest concentration was observed in Emperors whereas the lowest amount was in Kingfish. Similar results were observed for phosphorus. However, the lowest concentration of phosphorous was recorded in Coral trout fish muscles (181.8 mg/100 g). The highest level of magnesium (23.19 mg/100 g) was observed in Kingfish whereas the lowest level was found in Emperors (17.09 mg/100 g). Variable results were also observed for sodium and potassium levels in different fish species. These fish species represent a good source of potassium and low in sodium. The highest concentration of potassium was observed in Kingfish (458 mg/100 g) whereas the lowest was in Coral trout fish (300.6 mg/100 g). However, no significant differences were observed in potassium levels of Scad, Emperors and Kingfishes. The concentration of iron, copper and manganese differed ($p>0.05$) significantly in various fish species. However, no significant ($p<0.05$) differences were observed in the concentration of zinc among various fish species. The highest concentration of iron (0.53 mg/100 g) was observed in the muscles of Emperors. On the other hand the highest concentration of copper (0.08 mg/100 g) was found in Kingfish whereas the lowest level (0.03 mg/100 g) was found in Emperors.

Two toxic heavy metals (Cadmium and lead) were also determined in these fish species to establish the extent of coastal water pollution and accumulation of these heavy metals in fish muscles. The level of Cadmium (Cd) in different fish species ranged between 0.0007-0.002 mg/100 g. The lowest value (0.0007 mg/100 g) was found in Emperors and Grouper whereas the highest concentration (0.0022 mg/100 g) was observed in Scad. The results are in agreement with values reported by Kosanovic *et al.* (2007) for Emperors (Red-spot emperor *Lethrinus lenrjan*). Al-Saleh and Shinwari (2002) reported that the concentrations of cadmium and vanadium in Rabbitfish and Emperors were significantly higher than Double bar bream and Greasy-grouper. Similarly the amount of Lead (Pb) in different fish species differed significantly and the ranged between 0.011-0.025 mg/100 g. The highest concentration (0.025 mg/100 g) was found in Jobfish whereas the lowest concentration (0.011 mg/100 g) was observed in Kingfish. No significant ($p<0.05$) differences in lead concentration were observed among Coral trout, Emperors, Grouper and Scad. The results are in agreement with those reported by Abdallah (2008) who found that the concentration of some heavy metals (Cd, Pb and Zn) in muscles for marine fishes collected from coastal water of Mediterranean sea in Egypt were different between species for all elements.

The concentration of minerals and trace element levels are known to vary in fish depending on various factors such as their feeding behavior, environment, ecosystem and migration even in the same area (Andres *et al.*, 2000; Canli and Atli, 2003; Abdallah, 2007). Accumulation of minerals in fish liver can vary widely depending on the fish species, age, time and region of sampling as well as individual specie mechanism of detoxification (Ritterhoff and Zauke, 1998). Since, the fish muscle is the most important part for human consumption, the metal concentrations obtained from fish liver analysis as in case of Red-spot emperor are a good indicator of bioaccumulation but have little or no influence on the metal body burden (Kosanovic *et al.*, 2007). The concentration of these minerals, trace elements as well as the heavy metals as reported in the study do not constitute a dangerous factor for human health and appear to be below permissible limits for human consumption (Cu, Zn and Cd data 10, 150 and 0.2 $\mu g\ g^{-1}$, respectively) wet weight by the Australian National Health and Medical Research Council (Sharif *et al.*, 1991). The results are also in agreement with results obtained by Al-Yousuf *et al.* (2000) they concluded that heavy metals accumulation in liver tissues and muscles for *Lethrinus lentjan* were within the safe limits and do not pose a risk for human health.

The attention has to be focused by the Kingdom of Saudi Arabia on keeping the pollution levels under control in these valuable recreational and commercial waters of Arabian gulf coast. The international organizations have also to ensure forbidding reoccurrence of previous and further pollution tragedies in the Arabian gulf region. Copper, zinc and manganese are essential trace elements in human nutrition however, higher intakes can cause various health problem (Demirezen and Uruc, 2006). The Turkish legislation establishes maximum levels for Cu and Zn above which human consumption is not permitted as 20.0 and 50.0 mg kg^{-1}, respectively (Anonymous, 1996). In order to assess whether metal levels found in Red-spot emperor in Arabian gulf region are safe for human consumption, a comparison is made to reference values for fish flesh (Zauke *et al.*, 1999; Kosanovic *et al.*, 2007). The values obtained in this study when compared to the data available from literature indicated lower concentrations of heavy metals which shows that the consumption of these 6 fish species is safe for human health.

CONCLUSION

All the 6 fish species proved to be a good source of protein, lipids and many important minerals and trace elements. In spite of the expected pollution threats to the coastal waters of Arabian gulf, it was interesting to note that the amount of heavy metals (such as lead and cadmium) present in fish muscles was relatively low. Based on these results, it is concluded that these fish species contribute towards a safe and healthy nutritious food for human consumption. However, there is a need for further studies on the evaluation and risk characterization from the consumption of sea food from the Arabian gulf coast. It is also important to establish and carefully interpret the acceptable maximum daily dietary intake levels of heavy metals and various contaminants contributed from seafood for different age and gender groups in the Kingdom of Saudi Arabia.

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