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Accumulation of selected heavy metals in kidney, heart, liver and muscle tissues of *LethrinusMiniatus* fish from the Arabian Gulf

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ABSTRACT

The increased discharge of heavy metals to marine environment have drawn attention to monitor and control the contamination level of public food supplies particularly fish.The analytical results obtained from this study were compared within acceptable limits for human consumption set by various health institutions. In the current study, the accumulation of eight heavy metals, lead (Pb), cadmium (Cd), manganese (Mn), copper (Cu), zinc (Zn), iron (Fe), nickel (Ni) and chromium (Cr)in kidney, heart, liver and muscle tissues of LethrinusMiniatus fish caught from Arabian Gulfwere quantitatively determined andhad been reported. Metal concentrations in all the samples were measured using Atomic Absorption Spectroscopy. Analytical validation of data was carried out by applying the same digestion procedure to standard reference material (NIST-SRM 1577b bovine liver).Levels of lead (Pb) in the liver tissue (0.60µg/g) exceeded the limit set by European Commission (2005) at 0.30µg/g. Zinc concentration in all tissue samples were below the maximum permissible limit (50 µg/g) as set by FAO. The maximum mean Cd concentrationof 0.15µg/g was found in the kidney tissue. Highest content of Mn in the studied tissues was seen in the kidney tissue (2.13µg/g), whereas minimum was found in muscle tissue (0.87µg/g). The present study led to the conclusion that muscle tissue is the least contaminated tissue in Lethrinus Miniatus and consumption of organs should be avoided as much as possible.

Key words: Fish tissues; Accumulation; Heavy metals; Atomic Absorption Spectroscopy

INTRODUCTION

Over the past few decades, heavy metals discharged to marine environment have drawn attention to find contamination level of public food supplies particularly fish. Owing to high nutritional value of fish, their market demand continues to increase exponentially. But at the same time, fish are a significant source of human exposure to a variety of pollutants and contaminants.Bioaccumulation of various metals and their genotoxic potential were studied in the different fish organ samples collected from different water sources and provided an integratedbaselinedataof the enhancedbioavailabilityofmetalsin fishes [11,2,6]. Fish accumulates heavy metals in their tissues several times higher than their levels in ambient water by absorption through gills and consumption of contaminated food. Therefore, the determination of heavy metals in the tissues of commercial fish is important for assessing exposure risk to consumers [13].

The Gulf represents a complex dynamical system influenced by natural process and a wide range of human activities and socio-political events. The principalexisting environmental effects on coastal environments of gulf

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include land filling, dredging, oil pollution, solid waste pollution and recreation. In addition to marine pollution from oil, other toxic substances may well reach the marine and coastal environment. These could originate from numerous petrochemical and other industrial plants sited around the Gulf coast. The fisheries of the Gulf are of global as well as regional importance. The Kingdom of Saudi Arabia, in general, and the Eastern Province, in particular, has experienced vast social, economic and urban development during the last twenty years. This development is reflected in the industrial and urban sectors, the size of coastal population, and the spread of public services and facilities. However, this vast development was accompanied by several activities that have caused general environmental challenges, particularly those related to marine environment. Refineries and chemical industry wastes contribute significantly to metal pollution of Arabian Gulf. Saudi Arabia occupies 80% of the area of the Arabian Peninsula and is bordered on the west by the Red Sea and on the east by the Gulf that lies between Iran and the Arabian Peninsula.Catch rates are generally higher in the Arabian Gulf for most fishing methods with catches/day ranging from 132Kg/day for trap fishing boats in the Arabian Gulfcompared with 23Kg/day for trap fishing boats in the Red Sea.

Fish are susceptible to acute and chronic environmental changes and they show a classical stress response. Liver plays an important role in protecting internal homeostasis in fish. Highly dynamic nature and its regulatory function in many metabolic pathways makes this organ valuable to monitor pollution index. Liver accumulates high concentrations of metals, irrespective of uptake route. Liver is considered as a good monitor of water contamination with metals since their concentrations are directly reflected in the liver. Metal levels in the liver rapidly increase during exposure and remain high for a long period whereby other organs are already cleared. Muscle forms the major part of fish body weight and is also valuable for economic reasons [10].

The Arabia Gulf is one of the most important seafood resource of Saudi Arabia. Therefore, monitoring the concentrations of heavy metals in fish tissue is important to guard against any ill-effects it may cause to health of consumers. Recently, several workers have used fish tissues as bio-indicators of heavy metals in marine ecosystems [16,14,3]. The present study was carried out in view of the scarcity of information about heavy metals contents in edible tissues of commercial fish.

Experimental:

Fresh fish samples of both sexes of *Lethrinus Miniatus* fish were procured from local market in Dammam, Eastern Province, Saudi Arabia. The length and weight of the samples was measured prior to dissection. Approximately 5 g each of muscle, heart, kidneys, and the liver were taken from each fish. The tissue samples were washed with doubly distilled de-ionized water and kept refrigerated in polythene bags till analyzed. The tissues to be analyzed were grounded with stainless steel kits and glass equipment. Each sample analyzed was composed of several individuals, at least 4 to 6 fish tissues were pooled together. Wet digestion of the samples was carried out by taking exactly 3-4 g of defrosted sample in a 50mL Erlenmeyer flask with 10mL of specpure conc. nitric acid.After 15 minutes of digestion at room temperature, about 10mL mixture of specpure nitric and perchloric acid (4:1v/v) was added and mixture was heated and maintained at 70±5^{o}C for 12 hours on a hot plate. The mixture was shake gently till the digestion was complete and a clear residue was obtained. The residue was dissolved in doubly distilled de-ionized water and transferred to 25mL flask and diluted up to the mark [3]. For each series of 10 samples, two blanks were run to check the possible contamination. Metal concentrations in all the samples were measured using a Varian SpectrAA 220Atomic Absorption Spectrophotometer.

The accuracy of the method was evaluated by applying same digestion procedure to standard reference material (NIST-SRM 1577b bovine liver). The achieved results were in good agreement with certified values. All metal concentrations were determined on a wet weight basis (µg/g). The results along with detection limits are given in Table I.

Table I: Trace metal levels in SRM NIST 1577b, recoveries and detection limits

Metal	Certified Value (µg/g)	Exp.Value (µg/g)	Recovery (%)	LOD (µg/g)
Fe	184	182±14	99	0.017
Zn	127	126±7	99	0.01
Mn	10.5	10.3±0.7	98	0.019
Pb	0.129	0.126±0.02	97.6	0.098
Cd	0.5	0.48±0.04	96	0.092
Cu	160	157±9	98	0.011

RESULTS AND DISCUSSION

Metal concentrations in kidney, heart, muscle and liver tissue of *Lethrinus Miniatus*fish based on wet weight (µg/g) are summarized in Table II. The data obtained indicates that metals showed different affinity to various organs. The major part of total body loads is accumulated in liver and kidney. As reported in the Table II, Fe was determined to be highest, followed by Znin all tissues of *Lethrinus Miniatus.*Iron is an important component of respiratory system but its higher concentration may cause gill damage, impaired metabolism and osmoregulation.High accumulation of Zn in the liver tissue (12.9µg/g) could be attributed to specific metabolism processes and enzymatic reactions taking place in the liver [15]. Zinc concentration in all tissue samples were below the maximum permissible limit (50µg/g) as set by FAO Fishery Circular No.464, 1983. Zinc also acts as a catalyst in metal biomolecules bound to amino acid side chains containing N, O or S donor ligand [12]. Higher concentration of Zn in fish results in destruction of gills [4]. High concentration of Fe may lead to gill damage and disturbed metabolism in fish [7].

Table II: Trace metal concentrations in kidney, heart, muscle and liver tissues of *Lethrinus Miniatus* fish based on wet weight (µg/g)

		Pb	Cd	Mn	Cu	Zn	Fe	Ni	Cr
Kidney	Range	0.09-0.92	0.09-0.32	0.85-3.56	1.1-5.78	2.99-18.94	18.92-36.33	0.1-0.55	0.96-3.87
	average±SD	0.30±0.23	0.15±0.06	2.13±0.84	2.80±1.16	9.74±3.79	26.19±4.94	0.23±0.13	1.91±0.86
Heart	Range	0.06-1.18	0.05-0.13	0.32-2.37	1.09-3.42	3.23-17.88	9.87-19.45	0.07-0.47	0.09-1.14
	average±SD	0.21±0.29	0.080±0.21	1.26±0.55	2.35±0.61	8.93±3.06	14.50±2.83	0.22±0.16	0.59±0.34
Muscle	Range	0.05-0.98	0.05-0.11	0.24-1.89	2.53-6.89	5.39-14.65	19.45-33.29	0.05-0.07	0.08-0.45
	average±SD	0.30±0.24	0.07±0.017	0.87±0.44	3.73±1.07	10.89±2.21	25.36±4.04	0.06±0.01	0.17±0.09
Liver	Range	0.11-1.36	0.06-0.21	0.11-1.87	1.76-4.98	9.34-17.34	24.33-35.83	0.06-0.1	0.28-1.47
	average±SD	0.63±0.36	0.09±0.04	0.64±0.47	3.52±0.90	12.91±2.02	30.19±2.87	0.074±0.012	0.85±0.29

Maximum Cu concentration was encountered in muscle tissue (3.73µg/g), followed by liver (3.52µg/g). Maximum permissible limit set for Cu in the fish tissue by FAO is 10mg/kg. Copper can induce respiratory distress in the fish and it is to be noted that thy most hypoxia sensitive species is also the most Cu sensitive.

The Chromium levelswere found to be high in the kidney tissue (1.91µg/g). Chromium plays a vital role in glucose metabolism but its high concentration may lead to retarded growth and chromosomal aberrations. The permissible limits set for Cr by FAO are 1.0 mg/Kg.

Maximum mean cadmium concentration was found to be 0.15µg/g in the kidney tissue (Table II).Cadmium species have little affinity towards the available active sites in kidney tissue to form tetrahedral or square planer cadmium complexes [15]. However, the binding rate of sulphurhydryl groups, feeding habits, excretion rate and solubility of cadmium complexes and availability of Cd complexing sites are possible factors accounting for elevated levels [12,9]. Highest lead concentration was found in liver (0.63µg/g) followed by kidney and muscle (0.30µg/g). This was higher than the limit set by European Commission at 0.3µg/g for lead [8]. It is well known that human beings are exposed to lead through consumption of contaminated water and food [1,5]. Therefore, lead levels in Lethrinus Miniatus liver could pose a health risk to consumers.

Maximum nickel contents were detected in kidney tissue (0.23µg/g). No limit was set by FAO (1983) for Ni. In low concentrations, Ni is an essential element that serves as cofactor for many enzymes; however, at higher levels it is toxic. It may cause hallucinations and nerve damage in human beings. It is worth mentioning that Ni was detected in all tissue samples. Highest content of Mn in the studied tissues was seen in the kidney tissue (2.13µg/g), whereas minimum was found in muscle tissue (0.87µg/g). Figure 1 represents levels of various metals in the tissues studied. Liver tissue was found to be most contaminated in terms of heavy metals. This may be due to its role as the main organ for synthesis of proteins and other compounds that have high affinities for metals. In addition to that liver is the main site for detoxification of various contaminants and pollutants. The concentrations of various metals in the muscle tissue were relatively low as compared to liver, kidney and heart. This is attributed to the nature of muscle being a less metabolically active tissue. This is also supported by the fact that blood circulation is less extensive in muscle tissue as compared to vital organs like liver, kidney and heart [16].

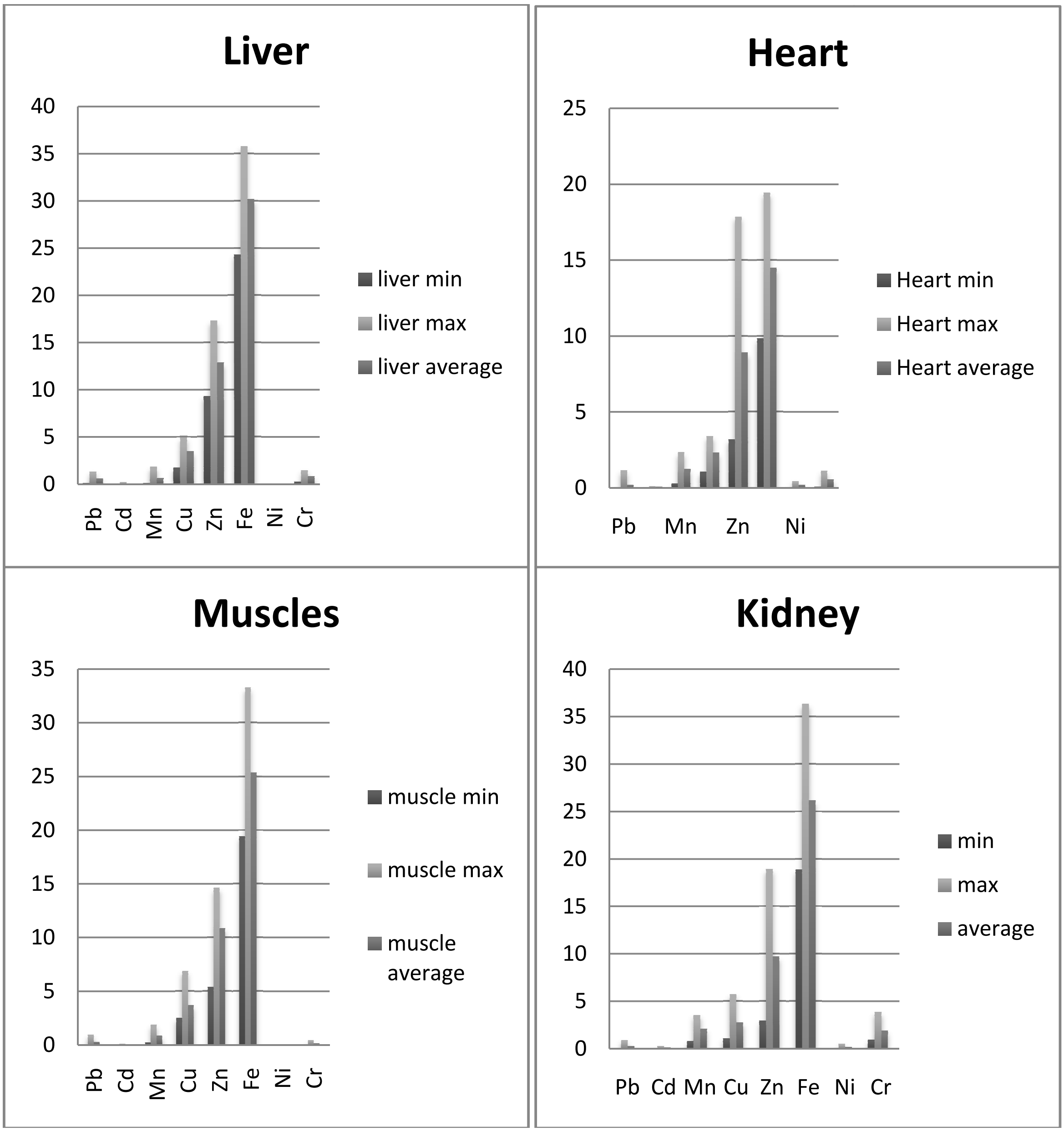

Fig. 1: Levels of heavy metals in different tissues of *Lethrinus Miniatus* fish

Conclusion:

It would be reasonable to conclude from the present study that muscle tissue is the least contaminated tissue in LethrinusMiniatus fish and consumption of organs should be avoided as much as possible.

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