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Levels of Some Essential Heavy Metals in Commercially Important Fish Species Collected from Markets in Monrovia, Liberia

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ABSTRACT

Heavy metal levels in fish are of particular global interest because of the potential risk to humans who consume them. While attention has focused on self-caught fish, most of the fish eaten by the public comes from commercial sources. In this study, sixty samples covering 29 commercial fish species were randomly obtained from major fish markets in and around Monrovia, Liberia and analyzed for copper (Cu), zinc (Zn) and iron (Fe). A mixture of HNO_3, $HClO_4$ and H_2SO_4 was used for complete oxidation of organic tissue. Concentrations of the selected metals were measured using an atomic absorption spectrophotometer. The concentrations of metals (µg g^{-1} wet weight basis) ranged as follows: Cu 0.101-2.990; Zn 1.783-6.013 and Fe 2.122-6.804. The metal levels in the edible fish muscle tissues were generally below the FAO/WHO maximum permissible limits. On average, the order of metal concentrations in the fish muscle was Zn>Fe>Cu. The study showed that all the tested fish species are safe for human consumption with respect to levels of Cu, Zn and Fe.

Keywords : Heavy Metal, Fish, Atomic Absorption Spectrophotometer, Monrovia

I. INTRODUCTION

Over the last few years, there has been growing interest in determining heavy metal levels in the marine environment and attention was drawn to the measurement of contamination levels in public food supplies, particularly fish (Al bader, 2008; Al-Weher, 2008; Alinnor and Obiji, 2010; Igwemmar *et al*., 2013, Ngumbu *et al*., 2016). Toxicological and environmental studies have prompted interest in the determination of contaminant levels in fish and other seafood products. The ingestion of food is an obvious means of exposure to metals, not only because many metals are natural components of foodstuffs but also because of environmental pollution (Copat *et al*., 2012). For most nonoccupationally exposed individuals, diet is the main route of exposure to environmental contaminants such as heavy metals. Since diet represents the main route of exposure to heavy metals, and fish represent a part of diet, it is likely that contaminated fish could be a dangerous dietary source of certain heavy metals (Llobet *et al.*, 2003).

Metals such as copper, zinc and iron are essential heavy metals and are known to perform important metabolic functions in biological systems but may become potentially toxic beyond certain threshold limits (Duruibe *et al*., 2007).

Fish and shellfish products are essential dietary components because they are excellent sources of vitamin, minerals and proteins. Fish consumption also offers omega-3 polyunsaturated fatty acids which are very important for normal growth and are known to reduce the incidence of heart diseases, stroke and preterm delivery (Davisglus *et al*., 2002). Despite the excellent benefits that fish consumption offer, the susceptibility of the products to metal contamination has been of keen global interest amongst scientific researchers (Yilmaz, 2003; Al-Weher, 2008; Roach et al., 2008). The present study was therefore carried out in view of the scarcity of information about heavy metal contents in marine organisms from this region. In this paper, the levels of Cu, Zn and Fe in 29 commercially important fish species are reported. The results of this study will help in generating data needed for the assessment of toxic metal intake from these species.

II. METHODS AND MATERIAL

A total of 60 samples covering twenty nine fish species were purchased randomly from major fish markets in and around Monrovia from June 1, 2013 to August 14, 2013. The species for analysis were based on their availability at the time of sampling. Species obtained were reflective of what was meant for human consumption. All samples were obtained fresh on different occasions from the markets and transported on ice to the laboratory and kept in a freezer. A portion of the edible muscle tissue was removed from the dorsal part of each fish, homogenized and stored in cleaned-capped glass vials and kept in a freezer. The samples were later transported to the chemistry laboratory of KNUST in cooled containers and kept in a freezer until analysis.

Double distilled water and analytical grade reagents (BDH Chemicals Ltd, Poole, England) were used for all the analyses, cleaning and sampling procedures. All glassware and bottles used were thoroughly washed by soaking them overnight in 10 % (v/v) HNO_3 and rinsing in double distilled water. They were then rinsed once with 0.5 % (w/v) $KMnO_4$ and three times with double distilled water. All glassware were air-dried prior to used.

The edible muscle tissues removed from the dorsal part of the fish were digested by an open tube procedure (Voegborlo and Adimado, 2009). In the digestion procedure, 1.0 g of homogenized tissue was weighed into a 50-ml Pyrex glass test tube (26 mm x 47mm) and 2 ml H_2O, 4 ml HNO_3-$HClO_4$ (1:1) and 10 ml H_2SO_4 was added in turn. The mixture was then heated at a temperature of 210^oC for about 30 minutes when a colorless solution was obtained. The digest was allowed to cool to room temperature and later diluted with distilled water to the 50 ml mark. The solution was then shaken thoroughly and finally transferred into clean capped bottles and kept in a fridge for analysis. Blanks and replicates were obtained for over 13% of the samples.

Concentration of Cu, Zn and Fe in the digests were determined using Flame Atomic Absorption Spectrophotometer PG 990 (PG Instruments Ltd., China), equipped with a dynamic reaction cell. Before analysis, standard solutions (Merck NJ, USA) were used to calibrate the instrument and calibration curves were prepared. Each sample was analyzed in duplicate. For analytical quality control, reagent blanks and sample replicates were randomly inserted in the analysis process to assess contamination and precision. Recovery studies were conducted to demonstrate the efficiency of the overall procedure. Recovery of the metals was determined by spiking one sample with increasing amounts of metal standard solution. The spiked samples were then taken through the same digestion procedure (as all other samples) and analyzed for heavy metal concentrations.

III. RESULT AND DISCUSSION

A total of 60 samples comprising 29 fish species were analyzed for copper (Cu), iron (Fe) and zinc (Zn). To determine the degree of precision of the analytical procedure, three replicates of one sample were spiked with increasing concentrations of the metals of interest. The spiked sample was then digested and analyzed for the metals. The recovery rates were in the range 85% - 105%. A certified reference material *(*Fish Homogenate IAEA-407*)* was processed *(*in quintuplicate) along with samples to determine the accuracy of the method (Table 1).

Table 1: Analytical result (in µg g-1) of certified reference material IAEA-407 (Fish Homogenate), showing local laboratory values and recommended values

Metal	Measured value (Mean±SD)	n	Certified value (Mean±SD)
Cu	3.27±0.20	5	3.28±0.40
Fe	141.0±4.0	5	146.0±14.0
Zn	65.8±1.2	5	67.1±3.8

Note: n = number of samples

All the fish species analyzed in this study are consumed by humans. Results of Cu, Fe and Zn levels in the edible muscle tissues of fish (µg g^{-1} on wet weight basis) from markets in Monrovia, Liberia are presented in Table 2. On average, Zn was the most accumulated in all the fish samples with *Scomberomorus tritor* (6.013 µg g^{-1}) having the highest mean concentration and *Cephalopholis taeniops* (1.783 µg g^{-1}) the lowest. The result showed values lower than the FAO/WHO (1983) recommended limit of 50 µg g^{-1} in food. The concentration of Zn observed in this study is comparable to levels reported by other authors. For example, the concentration of Zn in the literature have been reported in the range of 2.67-19.1 µg g^{-1} in market fish from South China (Cheung *et al*., 2008), 2.8-6.8 µg g^{-1} in fish from West Pomerania, Poland (Magdalena *et al*., 2009), 10.27-19.74 µg g^{-1} in fish from Euphrates, Turkey (Mol *et al.*, 2010) and 2.19-5.86 µg g^{-1} in fish from Cape Fear River watershed, North Carolina, USA (Michael *et al.*, 2011). Zinc is an essential element in human diet. A deficiency of zinc is marked by retarded growth, loss of taste and hypogonadism, leading to decreased fertility. Excess Zn intakes may result to symptoms of acute toxicity (Sivapermal *et al*., 2007).

Iron is an essential component of haemoglobin which is responsible for oxygen transportation in the body. Severe Fe deficiency in human causes anaemia, while excess Fe intakes may result to symptoms of acute toxicity (Fraga and Oteiza, 2002). Mean Fe concentration ranged from 2.122 to 6.804 µg g^{-1} on wet weight basis, with *Sardinella maderensis* recording the highest mean Fe concentration and *Arius latiscutatus* the lowest. Mean Fe levels in all the fish species reported in this study were far below the FAO/WHO (1989) recommended limit of 100 µg g^{-1} in food. Fe concentrations recorded in this study are either in agreement or lower than most published Fe concentrations in fish from non-polluted areas of the world. For example, the concentrations of Fe in the literature have been reported in the range of 2.35-7.72 µg g^{-1} in commercial fish species from the Ann-Ping coastal waters, Taiwan (Chen and Chen, 2001), 3.65-6.12 µg g^{-1} in commercial fish species from Gwagwadala market, Nigeria (Igwemmar *et al*. 2013), 3.41-15.14 µg g^{-1} in fish from Nitra River, Slovakia (Andreji *et al*., 2005) and 5.96-10.8 µg g^{-1} in fish from Nsawam, Ghana (Anim *et al*., 2011).

Copper is an essential micronutrient involved in certain physiological processes and metabolic activities in organisms. Although important, studies have shown that elevated levels of copper can be dangerous to human health (Goyer, 1991; Gwozdzinski, 1995). Mean Cu concentration ranged from 0.101 to 3.230 µg g^{-1} wet weight, with *Sardinella aurita* recording the highest and *Trachinotus goreensis* the lowest Cu concentration. Mean Cu levels in all the fish species reported in this study were below the FAO (1983) recommended limit of 30 µg g^{-1} in fish and fishery products. The concentration of Cu observed in this study is comparable to levels reported by other authors. For example, the concentration of Cu in the literature have been reported in the range of 0.7 to 2.0 µg g^{-1} in fish from Iskenderun bay, Turkey (Yilmaz, 2003) and 0.3-2.6 µg g^{-1} in fish samples from Malaysia (Mazlin *et al*., 2009).

Table 2: Mean concentrations (µg g^{-1} wet weight) of Cu, Fe and Zn in edible muscle of commercial fish samples from markets in Monrovia, Liberia (2013)

Scientific Name	**Local Name(s)**	**n**	**Cu** (µg g^{-1})	**Fe** (µg g^{-1})	**Zn** (µg g^{-1})
Albula vulpes	Morlay	1	0.211	2.128	3.811
Arius latiscutatus	Catfish	3	0.937	2.122	2.591
Cephalopholis taeniops	Rock fish	2	0.189	2.823	1.783
Chloroscombrus chrysurus	Porjoe	2	0.572	4.300	2.093
Elops lacerta	Shinny lady	2	0.533	3.172	2.735
Elops senegalensis	Tenpound	2	0.212	4.002	3.242
Epinephelus goreensis	Black grouper	1	1.813	5.711	4.972
Euthynnus alletteratus	Blood fish	1	0.613	4.241	4.113
Galeoides decadactylus	Butter Nose	3	0.152	2.349	3.466
Harengula jaguana	Zipper fish	2	0.348	2.466	2.772
Lepomis gibbosus	Pumpkin fish	2	0.128	3.272	3.922
Lutjanus campechanus	Red Snapper	3	0.821	2.814	2.144
Pagrus caeruleostictus	Snapper	3	0.257	2.704	2.251
Pomadasys rogerii	Grunter	3	1.025	3.278	1.992

Priacanthus arenatus	Chicken soup fish	3	0.379	2.841	2.757
Pseudotolithus elongatus	White boy	1	0.105	3.210	4.621
Pseudotolithus senegalensis	Cassava fish	2	0.460	3.108	4.271
Sardinella aurita	Sardine fish	3	2.990	6.538	3.840
Sardinella maderensis	Bonny	3	2.598	6.804	4.015
Scomber colias	Sea Mackerel	1	0.423	2.503	5.021
Scomberomorus tritor	Mackerel fish	2	0.218	3.337	6.013
Selene setapinnis	Big head Porjoe	2	1.331	2.871	3.242
Seriola carpenteri	Judusloyah, Wakie	2	0.142	4.061	4.986
Stromateus fiatola	Marry fish	2	0.692	3.963	5.721
Thunnus obesus	Tuna fish	3	0.542	2.734	2.578
Trachinotus goreensis	Small Corvally	1	0.101	2.391	4.902
Trachinotus maxillosus	Pompano	1	0.281	2.200	5.922
Trichiurus lepturus	Silver fish	2	0.873	2.427	2.396
Tylosurus crocodilus crocodilus	Penten, Gar fish	2	0.268	2.497	2.268

Note: n (sample size) = 60; Local name(s): name(s) of fish species in Monrovia, Liberia

IV. CONCLUSION

The levels of the tested metals (Cu, Fe and Zn) in all the fish species analyzed were below acceptable guideline limits. This suggests that, at the moment, the fish sold in markets in Monrovia are safe for human consumption with respect to the tested metals. Increase in the levels of these metals could however pose health risk to the fish consuming populace. There is thus a need for routine analysis of commonly consumed fish species in order to avert residual effects.

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