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Research Article

Heavy Metal Concentrations in Gills and Muscle of Local and Imported Tilapia in Port Harcourt, Nigeria

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Abstract: The concentrations of Arsenic (As) and Cadmium (Cd) were measured in the gills and muscle of *Sarotherodonmelanotheron*(a locally available species) and *Tilapia zilli* (imported from China) in Port Harcourt in 2012 to establish their suitability for consumption as food. The samples *S. melanotheron* and *T. zilli* were derived from Creek Road market and a cold-room in Mile One Market respectively.The heavy metal analysis was performed using Flame Atomic Absorption Spectrophotometer AAS model GBC Avanta Pm. The levels of metal varied in the organs and in the fish species. Mean concentrations of As in *S. melanotheron* were 0.74±0.06 mg/kg and 0.68±0.07 mg/kg in gill and muscle respectively. Cd was 0.098±0.001 mg/kg in gill and 0.026±0.015 mg/kg in muscles. In *T. zilli* As concentration was 0.64±0.04 mg/kg in gills and 0.53±0.04 mg/kg in muscle. Cd concentration was 0.18±0.009 mg/kg in the gills and 0.17±0.063 in the muscles. The concentration of As in *S. melanotheron* was not significantly different from that in *T.zilli*, while Cd was significantly higher ($p<0.01$) in *T. zilli*. Concentrations of As and Cd in *T.zilli* and As in *S. melanotheron* were above WHO (1981) permissible limit. The implication of these levels was discussed.

Keywords: Arsenic, bioaccumulation, cadmium, *Sarotherodon melanotheron*, *Tilapia zilli*

INTRODUCTION

Heavy metals are present in the aquatic environment where they biomagnify along the food chain. For this reason, determination of the chemical quality of aquatic organisms, particularly the contents of heavy metals is extremely important for human health. Therefore, the problem of food (including fish) contamination by toxic metals is becoming a concern. As a result the accumulation of heavy metals in fish and other aquatic organisms have been extensively studied and well documented (Nnaji *et al*., 2007; Agbozu *et al*., 2007; Raja *et al*., 2009; Edem *et al*., 2009; Ruelas-Inzunza *et al*., 2010; Anim *et al*., 2011; Ugbomeh and Jaja, 2013). Large amounts of some metals from the water can be concentrated in fish high up the food chain (Mansour and Sidky, 2002) which can bioaccumulate and reach toxic levels in the consumers.

Lead (Pb), Barium (Ba), Cadmium (Cd), Mercury (Hg), Chromium (Cr^{4+}) and Arsenic (As) are classified as toxic heavy metals and maximum residual levels have been suggested for humans in Nauen (1983) and FDA (2001). Depending on the amount ingested, As can be beneficial (as animal studies suggest that low levels of As in the diet are essential) or adverse (high levels can be toxic). The acute lethal dose to humans can be about 2 to 20 mg/kg body weight per day (mg/kg^{-day}). Ingesting small amounts of As overtime produces chronic effects such as skin darkening and formation of corns, damage to peripheral nerves, cardiovascular system effects, hair and appetite loss and mental disorders.

In Nigeria, fishes are imported to subsidize the overfished rivers and estuaries as well as to increase our protein source. *T. zilli*, a cichlid is one of such imported species marketed frozen in ice in 10 kg and 20 kg packs. There is a general preference for local species as they are considered fresher and healthier. However, these fish consumers may be exposed to relatively higher levels of heavy metals by eating fish from local rivers, ponds lakes and seas or from the imported fish. Edible fish which are often contaminated with heavy metals could affect human health and cause chronic disease (Zyadah and Abdel-Baky, 2000). Most consumers in Port Harcourt depend on the consumption of fish from the Creek Road Market for their protein requirement while others prefer the imported tilapia as they are readily available and larger in size. This study therefore aims to establish the level of heavy metals (As and Cd) in *S. melanotheron,* a common and local food

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fish available in the local market and the readily available imported *T. zilli* to ascertain which is safer for consumption by comparing with known permissible limits.

MATERIALS AND METHODS

Sample collection: Twenty fresh samples of *S. melanotheron*were bought from the Creek Road Market in Port Harcourt in June 2012, placed in polyethylene bags and transported to the laboratory in an insulated thermox box containing ice. A 10 kg pack of imported *T. zilli* was purchased from a Cold room in the Port Harcourt mile one market. The fish production date was 30th May 2012 and expiration date was 30th May 2013 imported from one of the Asian countries into Nigeria. The *T. zilli* samples were therefore assumed as fresh when purchased in June 2012. The fishes were then kept in the deep freezer until analysis.

Sample preparation and analysis: The frozen fresh fish samples were thawed at room temperature and the gills and muscles were cut out for heavy metal analysis. The muscle and gills were homogenized, dried to a constant weight and then burnt at 500°C for about 30 min until it turned into ash. The samples were allowed to cool in the desiccator and then crushed into fine powder by using a porcelain mortar and pestle. Portions of the sample (0.5g DW) in powdered form of both muscle and gill were digested in a closed microwave oven using ultra pure nitric acid (10%) in hydrochloric acid. The completely digested samples were allowed to cool to room temperature and analyzed for heavy metals using atomic absorption spectrophotometer AAS model GBC Avanta Pm. The metals assessed were As and Cd and the concentrations were expressed as mg/kg DW of fish. Statistical analyses were conducted to determine the differences in the heavy metal concentration of the sampled fishes and in the different organs using t-test paired two sample means and Analysis of Variance (ANOVA) and the results were presented in histograms using Microsoft Office 2010 Excel.

RESULTS AND DISCUSSION

S. melanotheron used in analysis were between 16.7 to 19.9 cm in length and *T. zilli* between 20.1 to 23.5 cm in length. In *S. melanotheron* the mean concentration of As was 0.74±0.06 (ranged from 0.544-0.94 mg/kg) in the gills and 0.68±0.07 (ranged from 0.408 to 0.82 mg/kg) in muscle. Cd concentration was 0.098±0.01 (range of 0.076 to 0.148 mg/kg) in the gills and 0.026±0.015 (range of 0.001-0.084 mg/kg) in muscles. In all samples of *S. melanotheron*, As concentration was significantly higher than that of Cd (Fig. 1). In *T. zilli* As in gills ranged from 0.54-0.76 mg/kg with a mean of 0.64±0.04mg/kg and in muscle from 0.45-0.70 mg/kg with mean of 0.53±0.04mg/kg. Cd concentration in gills ranged from 0.15-0.21 mg/kg with mean of 0.18±0.009mg/kg and in muscles 0.036 – 0.396 mg/kg with a mean of 0.17±0.063mg/kg. As concentrations were significantly higher than Cd in both gills and muscles of *T. zilli* (Fig. 1). The concentration of As was not significantly higher in the gills than in the muscle although higher concentrations were recorded in the gills. Cd concentration was also higher in the gills than in the muscle and this was significant at $p = 0.01$ (Table 1).

As and Cd were detected in all samples of *S. melanotheron* and *T.zilli*analysed. The major source of heavy metals in fish is from food and water (Pentreath,

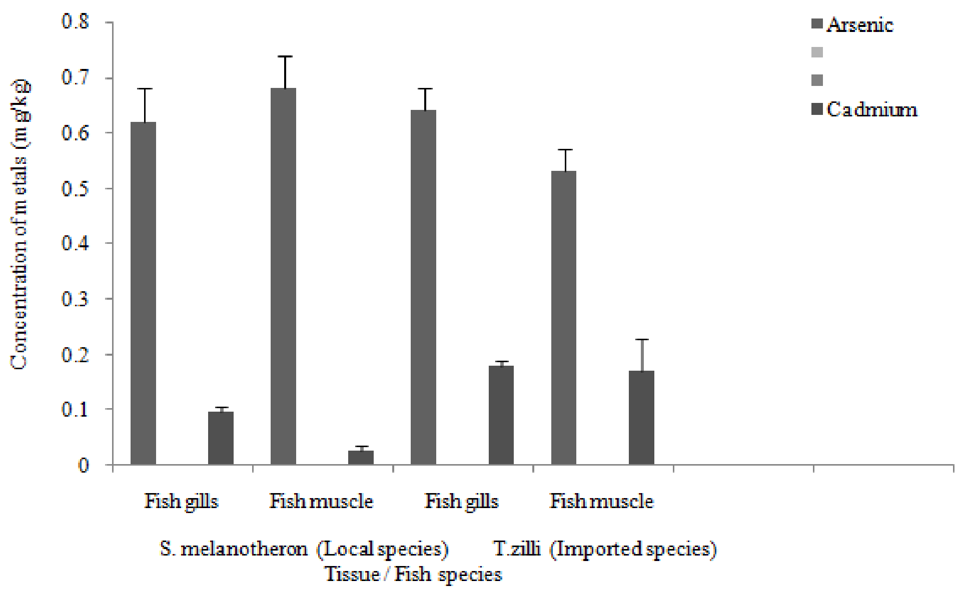

Fig. 1: Concentrations (mean±S.E) of the heavy metals in gill and muscle for As and Cd in the two fish species

Table 1: Summary of the t-test of paired sample means using concentrations of As and Cd in gill and muscles of *S. melanotheron* and *T. zilli* in Port Harcourt

Groups	t-stat	p-value	t-crit	Level of significance ($p<0.01$)
As in gills and muscle(*S. melanotheron)*	1.29	0.13	2.57	NS
Cd in gills and muscle(*S. melanotheron)*	5.11	0.002	2.57	S
As and Cd (gills and muscle in all samples *S. melanotheron*)	11.3	4.73×10^{-5}	2.57	S
As and Cd in *T.zilli* gills	14.13	1.6×10^{-5}	2.57	S
As and Cd in T.zilli muscles	4.9	0.002	2.57	S
As in gills vs As Muscles (*T.zilli*)	1.73	0.071	2.57	NS
Cd in gills vs Cd in muscle (*T.zilli*)	0.3	0.388	2.57	NS

Legend: NS = Not significantly different;S= Significantly different

Table 2: Mean concentration of As and Cd compared to Naeun (1983) and WHO (1981) limits

Mean conc. of metals (mg/kg)	Fishmuscle	Fishgill	Naeun 1983	WHO 1981	Inference
S. melanotheron (local species)					
Arsenic (As)	0.68±0.07	0.62±0.06	0.03	-	Above limit
Cadmium (Cd)	0.026±0.015	0.098±0.01	0.05	0.05	Above limit in gills
T.zilli (Imported species)					
Arsenic (As)	0.53±0.04	0.64±0.04	0.03	0.03	Above limit
Cadmium (Cd)	0.17±0.06	0.18±0.01	0.05	-	Above limit

1973) and it is therefore believed that the As and Cd in the fish samples came from its environment through its food and water and across the gills during respiration. Heavy metals after uptake, are known tobind to sites with highest affinity (Ruelas-Inzunza *et al*., 2010) and as a result certain tissues have higher metal levels than others. The gills are the respiratory and osmoregulatory organ in fish, whiletheintestines are for food intake and absorption. They are the main barriers that control absorption of metals from the environment and contaminated preys (Andres *et al*., 2000) and as a result, the concentrations of metals are usually higher at the gills and intestines than other tissues. This trend is reflected in this present study where the level of Cd contamination in gill of *S. melanotheron* was significantly higher than in the muscles.However, As concentrations were not significantly different in gills and in muscles although higher in the muscle suggesting similar binding affinity of As to both the gills and muscle tissues of *S. melanotheron*. There was no significant difference in the metal concentration in the sexes; therefore it appears that sex may not significantly influence variation of metal concentrations, so data was pooled.

Concentrations of heavy metals were higher in gills than muscles as was observed by Edem *et al*. (2009) and Ruelas-Inzunza *et al*. (2010) who concluded that muscles were safer for human consumption than the gills, as they contain lower amounts of the metals. Therefore the consumption of gills of fish together with the muscles as is commonly done in Nigeria should be discouraged. As was detected in both gills and muscle of the tilapias used in this study but not in another tilapia (*Oreochromi sniloticus*) by Edem *et al*. (2010). This suggests differential metal uptake which may be influenced by its availability in the environment.This implies that the environment of the fish in this study was polluted with As and Cd that was available for the fish to take in either as food or from the water. Although the samples were market derived, the sellers claim the local samples of *S. Melanotheron* were collected by fishermen in the Bonny River. Previous studies in the Bonny River have also shown high levels of heavy metals in water, sediment and biota (Ekweozor *et al*., 1987; Chindah and Braide, 2003; Moslen, 2008; Ugbomeh, 2013; Ugbomeh and Jaja, 2013).

In considering the limits of the heavy metals in the local species *S. melanotheron* and imported *T. zilli* for human consumption, standards of WHO (1981) and Nauen (1983) were used. This is presented in Table 2. As in both their gills and muscles exceeded the permissible limit of 0.03 mg/kg (Nauen, 1983) posing a health risk from chronic accumulation from the consumption of the fish. Arsenic is a known toxin and may damage the brain, central nervous system, kidney, liver and the reproductive system (FDA, 2001). Cd was above permissible limit in the gills and not in the fish muscle. This notwithstanding it is bio-accumulative and regular exposure to high levels in food can cause bone disorders, occasional renal failure and may affect women with multiple risk factors (FDA, 2001).

Also in *T.zilli* As and Cd in gill and muscle were above the FAO and WHO limits posing a health risk to its consumers. Cd was significantly higher in *T.zilli* than in *S. melanotheron*.

In conclusion, the heavy metals As and Cd were found in all samples investigated suggesting that the environment from which the fish samples were obtained is contaminated with these metals. Also it is erroneous to assume the local species of tilapia is safer than the imported variety or vice versa as both species have As and Cd concentrations above the permissible limits. There is however need for more investigation to determine the source of pollution especially in the local species *S. melanotheron as* Cd levels were significantly higher in the gills than in the fish muscle. In As, there was no significant difference between concentrations in gills and that of fish muscle suggesting similar binding sites in gills and muscles of the fish. As levels however, were significantly higher than Cd in all fish samples and above the permissible limits suggesting a potential health risk associated with the consumption of muscle of this local species. The imported tilapia had heavy metal concentrations above permissible limit and it is suggested that there should be some regulations on the heavy metal concentration of fish imported in to

Nigeria. The consumption of both the local *S. melanotheron* and imported *T. zilli* should be moderate or reduced as bioaccumulation over time of As and Cd could result in increased risk of cancer.

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