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Assessment of Toxic Trace Metals in Selected Fish Species and Parts of Domestic Animals

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Abstract: The Cd, As, Pb, Cr and Se contents of fillets of ten fish species and As, Cd and Pb contents of some parts of cow and goat meats were determined by Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES), after wet digestion of powdered samples with 1:1 HNO_3,/H_2O_2. The ranges obtained for the metals analyzed in fish (mg/kg, dry weight) are as follows; As (0.02-4.58), Se (0.66-1.66), Pb (0.45-4.78), Cd (0.22-2.02) and Cr (0.18-1.96). While the ranges obtained for the metals analyzed in cow meat (mg/kg, dry weight) are as follows: As (0.82-2.09), Cd (0.28-1.50) and Pb (0.80-1.42) and the range of metals analyzed in goat meat are as follows: As (0.02-4.88), Cd (0.04-0.93) and Pb (0.02-1.36). Of all the samples analyzed, the goat intestine contained the highest amount of As (4.88±0.015). Mean Pb concentrations (mg/kg) in *Hydrocynus forskahlii* (3.51±0.06), *Clarias anguillaris* (3.43±0.021), *Scomber japonicus* (4.61±0.043) and *Scomber scombrus* (4.78±0.045) exceeded the recommended limits specified by most food regulatory bodies. It is concluded that fish samples in the study area have heavy metal accumulations a little above recommended safety standards.

Key words: Assessment, toxic metals, fish, domestic animals

INTRODUCTION

Animal protein intake remains the surest way to furnish the body with a complete assay of all the needed amino acids required for proper tissue formation, growth and repair. The common animal protein sources in Nigeria include fish, beef and mutton. The habitat of these animals are continually been polluted with heavy metals discharged as a result of industrial activities. These metals find their way into the food chain of these animals and consequently build up in these animal products. When these animal products are consumed, the heavy metals in them produce pathologies relative to quantity and period of time consumed. This explains why the presence of heavy metals in animal products has continued to receive a lot of attention from nutritionists and environmental scientists. The main threats to human health from heavy metals are associated to exposure to lead, cadmium, mercury and arsenic (Lars, 2003). Excessive intake of these toxic heavy metals can lead to several diseases such as organ failure, cancer and retarded mental development, most especially in children and foetus in pregnant women. It has been reported that acute large dose of arsenic causes gastrointestinal damage with profuse watery diarrhea, bleeding and death (Dodd, 1984). Pratter, 1981 observed that cadmium is not a biological essential or beneficial element, but it is associated with various deleterious effects. Cadmium has been found to be teratogenic, carcinogenic and possibly mutagenic (Young and Bevins, 1981). Hauser and Hauser, 2009 reported that high doses of cadmium can lead to kidney failure, damage to testicles and liver. Acute lead poisoning usually manifest itself in gastro intestinal effects, anorexia, dyspepsia, constipation, attack of colic with intense paroxysmal abdominal pain, bone pain, brain damage, confusion, convulsions, dizziness drowsiness, fatigue, headaches, hypertension, memory difficulties, inability to concentrate, indigestion and irritability (Blood, 1969; Anonymous 2002a,b). Excessive intake of lead can also lead to damage to the brain, liver, kidney and reproductive systems (Hauser and Hauser, 2009). The present study was carried out to assess the levels of Cd, As, Pb, Cr and Se in some fish samples and Cd, As and Pb in parts of cow and goat meats consumed in the study area.

MATERIALS AND METHODS

The meat samples which include the liver, heart, muscle, intestine and kidney of goat and cow meats were purchased from Abattoirs in Nsukka and Enugu, Nigeria while the fish samples were purchased from the banks of River Niger at Onitsha or the Onitsha market, Nigeria. Ten species of fish viz: Osteogloid (*Heterotis niloticus*), moon fish (*Citharinus citharus*), grass eater (*Distichodus rostratus*), catfish (*Hemisynodontis membranaceus*), African carp (*Labeo coubie*), tilapia (*Oreochromis niloticus*), tiger fish (*Hydrocynus forskahlii*), mudfish (*Clarias anguillaris*), mackerel

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Table 1: Mean concentration (mg/kg) of heavy metals in cow meat parts

Metals	Heart	Kidney	Muscle	Liver	Intestine
As	N.D	1.40^{b}±0.016	0.82^{c}±0.010	1.23^{b}±0.015	2.09^{a}±0.046
Pb	0.80^{b}±0.055	1.16^{a}±0.012	0.29^{c}±0.023	0.87^{b}±0.020	1.42^{a}±0.017
Cd	0.28^{d}±0.018	1.50^{a}±0.015	0.81^{c}±0.010	0.88^{c}±0.014	1.25^{b}±0.010

[abcd]Row means with different superscript are significantly different (p<0.05), ND = Not-detectable

Table 2: Mean concentration (mg/kg) of heavy metals in goat meat parts

Metals	Heart	Kidney	Muscle	Liver	Intestine
As	N.D	0.02^{c}±0.010	2.22^{b}±0.011	1.53^{b}±0.070	4.88^{a}±0.015
Pb	0.56^{b}±0.50	0.04^{d}±0.061	N.D	0.44^{c}±0.040	0.93^{a}±0.070
Cd	0.76^{b}±0.041	0.02^{c}±0.070	0.55^{b}±0.060	1.30^{a}±0.031	1.36^{a}±0.012

[abcd]Row means with different superscript are significantly different (p<0.05), ND = Not-detectable

(*Scomber scombrus*) and mackerel (*Scomber japonicus*) were analyzed along with the parts of cow and goat meats.

Sample preparation: Samples (fillets) for analysis were extracted from descaled (where necessary) fish after other necessary treatment. Meat and fish samples were dried to a constant weight at 105°C. The dry samples were ground using plastic mortar and pestle and thereafter stored in desiccators. Wet digestion of samples was done using method reported in literature (FAO, 1983). This was done by digesting 10.00 g of dried samples in 60.00 cm^3 of freshly prepared 1:1 HNO_3/ H_2O_2 solution at 160°C on a hot plate for about one hour untill the contents came to about 5.00 cm^3. This was transferred to a standard flask and made up to 25.00 cm^3 with distilled water. The solution were aspirated into an optima 2000DU Perkin Elmer ICP-OES for the determination of the concentrations of the relevant metals. Appropriate standards supplied by Perkin Elmer were used for all metals determined.

Statistical analysis: The data obtained were subjected to a one-way Analysis of Variance (ANOVA) according to the procedure of Steel and Torrie (1980). Significantly different means were separated using the methods of Duncan (1955). The values obtained were presented as Least Significance Differences (LSD) of means at ($p<0.05$).

RESULTS AND DISCUSSION

Results showed that the highest accumulation of As and Pb in cow occurs in the small intestine whereas Cd had a higher significant (p<0.05) accumulation in the kidney. The concentration of As in the small intestine was 2.09±0.046 which differed significantly from the values observed for the other cut parts. The least concentration of As was found in the muscles. These concentrations differ significantly from the quantity of As found in the kidney (p<0.05). The intestine also had a Pb concentration of 1.42±0.017 which was significantly (p<0.05) higher than values found in the other parts. In goat parts, mean concentration of As, Pb and Cd were statistically higher (p<0.05) in the intestine. The least values of all these heavy metals were recorded in the kidney. The observed high concentration of As, Pb and Cd found in the small intestine of cow and goat may be related to the physiological role of the small intestine as the active site of digestion. The small intestine is lined up with finger like projections called villi. The villi allow the assimilation of digestive end products to the body. It appears there is a 'trap' in the small intestine that accumulates heavy metals. The mean concentration of As was significantly (p<0.05) higher in *Clarias anguillaris* (4.58±0.14). Cd concentration was significantly (p<0.05) higher in *Hemisynodontis membranaceus* (2.02±0.019). *Scomber scombrus* and *Scomber japonicus* had significantly (p<0.05) higher accumulation of Pb. Se concentration in *Labeo* coubie was significantly (p<0.05) higher than concentration found in *Heterotis niloticus, Hemisynodontis membranaceus, Oreochromis niloticus, Hydrocynus forskahlii* and *Scomber scombrus*. *Heterotis niloticus* had highest concentration of Cr (1.96±0.011), which did not differ significantly (P>0.05) from the value of 1.63±0.014 observed for *Districhodus rostratus*. The habitat and feeding pattern of the fish could account for varying concentration of metals. *Hydrocynus forskahlii* feeds on phytoplankton, insects, water beetle, larvae and plants. *Clarias anguillaris* is an omnivore which can feed on anything found in the river for example fish, mud, rotten vegetable, insects and even occasionally zooplankton while *Hemisynodontis membranaceus* is a voracious, predatory, bottom dwelling fish and thrives more in dirtier waters where more food is available (Welcome, 1955). The level of Pb obtained for the fish in the present study are below the levels reported in previous works by Okoye (1994) and Odoemelam (2005). However the concentrations of Cd reported in this study were close to previously reported values for fish in Oguta lake (Odoemelam, 2005). The concentrations (mg/kg) of Pb recorded for *Hydrocynus forskahlii* (3.51), *Clarias auguillaris* (3.43), *Scomber japonicus* (4.61) and *Scomber scombrus* (4.78) were above the MAFF and the Australian National Health and Medical Research Council recommended limits of 2.0 mg/kg as observed by Bebbinton *et al.* (1977). Of all the fish species studied only *Hemisynodontis*

Table 3: Mean concentration (mg/kg) of heavy metals in fish samples

Metals	Osteoglid (*Heterotis niloticus*)	Moonfish (*Citharinus citharus*)	Grasseater (*Districhodus rostratus*)	Catfish (*Hemisynodontis membranaceus)*	Africancap fish (*Labeo coubie)*
As	0.58^{c}±0.010	0.02^{d}±0.092	0.26^{d}±0.071	0.06^{d}±0.012	0.16^{d}±0.011
Cd	0.60^{c}±0.013	0.61^{c}±0.017	0.43^{d}±0.020	2.02^{a}±0.019	0.92^{c}±0.010
Pb	0.74^{d}±0.014	0.45^{c}±0.015	0.49^{c}±0.010	0.97^{b}±0.013	0.68^{c}±0.011
Se	1.12^{d}±0.010	1.61^{a}±0.121	1.60^{a}±0.011	1.32^{b}±0.010	1.90^{a}±0.011
Cr	1.96^{a}±0.011	0.50^{c}±0.014	1.63^{a}±0.010	1.00^{ab}±0.101	0.78^{b}±0.015
Metals	Tilapia (*Oreochromic niloticus*)	Tiger fish (*Hydrocynus forskahllii*)	Mud fish (*Clarias auguillaris*)	Mackerel (*Scomber japonicusl*	Mackerel (*Scomber scombrusl*)
As	0.39^{d}±0.012	1.58^{b}±0.060	4.56^{a}±0.014	0.60^{c}±0.015	1.10^{b}±0.011
Cd	0.28^{e}±0.014	0.55^{d}±0.013	0.22^{e}±0.011	1.00^{b}±0.010	1.06^{b}±0.015
Pb	0.28^{d}±0.013	3.51^{ab}±0.011	3.43^{ab}±0.021	4.61^{a}±0.043	4.78^{a}±0.045
Se	0.66^{c}±0.012	1.00^{b}±0.010	1.66^{a}±0.012	N.D	1.20^{b}±0.010
Cr	0.92^{b}±0.017	0.52^{c}±0.013	0.18^{e}±0.011	0.71^{b}±0.010	0.38^{d}±0.021

^{abcd}Row means with different superscript are significantly different ($p<0.05$), ND = Not-detectable

membranaceus recorded concentration of Cd exceeding the Australian National Health and Medical Research Council Recommended limits of 2.0 mg/kg. Most of the fish had concentration of Cd exceeding the Codex Committee of Food Additives and Contaminants draft guideline of 0.05 mg/kg. The levels of Cr recorded for fish in this study are below the values reported for fish caught from rivers in Ikot-Ekpene, Nigeria (Ibok *et al*., 1989). A concentration of 2.86 mgCr/kg was reported for *Auchenoglanis occidentalis* in a previous study (Odoemelam, 2005). The highest concentration of Cr in the present study is 1.96 mg/kg recorded for *Heterotis niloticus*. The results of the present study have not shown that there is great danger of heavy metal poisoning from the studied fish and meats. This is evident from the fact that heavy metal accumulation in the studied samples merely exceeded recommended limits by negligible amount. However periodic surveillance of heavy metals levels in fish and meats is highly necessary, since heavy metals tend to accumulate in these foods.

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