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Assessment of Heavy Metal Load in Meat Parts From Nigerian Market and the Health Implication on Humans

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ABSTRACT

There has been increased awareness of the effect of some toxic trace metals in the environment and their adverse effect on human health. This has led to more research with respect to determination of trace metals levels in food, water and the environment. The present research work measured the concentration of seven trace metals arsenic (As), Nickel (Ni), Zinc(Zn), Chromium(Cr), Lead(Pb), Cadmium(Cd), and Iron(Fe). In beef, goat and chicken from Ile-Ife (west) and Nsukka (east).The meat samples were analysed, using Atomic Absorption Spectrophotometer (AAS), with air- acetylene flame. Results obtained showed that all the trace metals were detectable in the samples at varying levels the highest concentrations in mg/kg of Chromium (2.26), lead (42.74), iron (146.75),zinc (3.03), manganese(22.34),and cadmium (5.80) were found in goat. While chicken had the highest values of arsenic15.44, nickel2.10, and mercury 13.15. Beef had the lowest concentrations of these trace metals. When the values of trace metals obtained in this study were compared with values reported for meat samples from other countries, the levels of lead were higher in Nigerian meats of Pakistani origin.

Keywords: Heavy Metals, Health, AAS, Meat Samples, Environment, Concentration

INTRODUCTION

In Nigeria, just like in the rest of the world, rapid urbanization and population growth have brought about a proportional increase in the amount of waste that is generated. The inability to manage these wastes effectively in most developing and some developed countries becomes an issue of great concern because apart from the destruction of aesthetics of landscape by the

waste dumpsites, some of the municipal solid waste contain both organic and inorganic toxic pollutants (such as heavy metals) that threaten the health of humans and the entire ecosystem [1]. Animal protein intake remains the surest way to furnish the body with a complete assay of all the needed amino acids for proper tissue formation, growth and repair. The common animal protein sources in Nigeria include fish, beef, goat, chicken and mutton. The habitats of these animals are continually being contaminated with heavy metals discharged from natural, domestic and industrial activities. These metals find their ways into the food chain of these animals and consequently build up in these animals and finally get to human beings who consume meat and other animal products. It has been estimated that at the present time man's load of these elements in comparison to the last century has quadrupled [2]. When animal products are consumed, the heavy metals in them produce pathologies relative to quantity and the length of time. This explains why the presence of heavy metals in animal products has continued to receive a lot of attention from nutritionists and environmental scientists [3]. Excessive uptake of both essential and non-essential metals may result in adverse effects on soil biota; plants can transfer via the food chain, on mammals, birds and human consumers [4]. Potential hazards associated with trace elements pertain to their accumulation in soils which may lead to a plant toxicity condition or result in increased uptake of metals into the food chain. Many of the trace metals are amplified in the food chain.

The chemical composition of plants is generally related to the elemental contact of nutrient solutions or soils. Absorption processes are very complex; the main pathway of trace elements to plants is via the roots. Foliar uptake can occur but this is only a major pathway in relation to aerial sources of pollutants. Root uptake is dependent upon the dissolved forms in the soil solution (ionic, chelated, complexes) pH, the presence of other ions, redox potential and temperature [5]. There is a wide variability in the bioacummulation of trace elements among different plants species. Some elements such as B,Cd, Rb, Cs are readily taken up, where as Fe and Se are only slightly available to plants. Trace elements absorption by plants roots is also influenced by mycorrgizal fungi, which enhance uptake from soil solution in exchange for carbohydrates from the host plants. Evolutionary changes have also resulted in metal tolerant plant species which are able to accumulate very high concentrations of specific metals (Ni, Zn, Cr, Co, Se, Cu,

Hg).Accumulation of elements in a plant can have major effects on key plants metabolic processes such as respiration, photosynthesis and fixation or assimilation of major nutrients[6]. Plant uptake of trace elements is generally the first step of their entry into the agricultural food chain. Plant uptake is dependent on (1) movement of elements from the soil to the plant root, (2) elements crossing the membrane of epidermal cells of the root, (3) transport of elements from the epidermal cells to the xylem, in which a solution of elements is transported from roots to shoots, and (4) possible mobilization, from leaves to storage tissues used as food (seeds, tubers, and fruit), in the phloem transport system. After plant uptake, metals are available to herbivores and humans both directly and through the food chain. The limiting step for elemental entry to the food chain is usually from the soil to the root [7].

Besides soil and water, food is also contaminated with trace metals by the introduction of mechanized farming, ever increasing use of chemicals, sprays, preservatives, food processing and canning. In order to get the minimum adverse impact, it is important to measure and continuously monitor their levels in various food items, total diet, water and inhaled air [8]. Heavy metals are ubiquitous in the environment as a result of both natural and anthropogenic activities, and humans are exposed to them through various pathways, especially food chain. Food consumption had been identified as the major pathway of human exposure to heavy metals, accounting for more than 90% compared to other ways of exposure such as inhalation and dermal contact. Hence, the accumulation of heavy metals in the environment is of increasing concern due to the food safety issues and potential health risks [9]. Plants are important component of ecosystem as they transfer elements from abiotic into biotic environments. The primary sources of elements from the environment to plants are: air, water and the soil. Crops can take up toxic elements through their roots from contaminated soils, and even leaves can absorb toxic elements deposited on the surface [10], thereby transferred in to primary consumers. In addition to the potential they accumulate in different animal source foods such as meat and milk [11].

METHOD AND MATERIALS

Samples of beef, goat and chicken were bought at markets in Nsukka and Ile-Ife in Enugu and Osun states respectively at various times. The

parts of the meat collected from each of the animals included; kidney, liver, intestine and muscle. These were stored in HCl –treated polythene bags, and labeled appropriately. The samples were each weighed and dried in an oven regulated at 105°C to a constant weight. They were stored in desiccators, after which they were all pulverized and homogenised separately using washed laboratory mortar and pestle [12]. 2g of the homogenized samples were weighed into porcelain crucibles and ashed in a muffle furnace set at 500oC for 4hrs. The resulting white ashes were allowed to cool down and later dissolved in 5ml 6M HCl and quantitatively filtered into 100ml standard flasks through Whatman No 1 filter papers. The solutions were made up the mark with distilled water. Porcelain crucibles (2) containing no samples were also placed in the oven and allowed to stay in the furnace for the same time as the sample. Five militres of 6M HCl was measured into each of the empty porcelain crucible and the solution filtered through whatman No1 filter paper. The solution was made up to mark with distill water and marked blank. The concentrations of metals in the sample were read against those of the blank using ALPHA- 4 model Atomic Absorption Spectrophotometer with air – acetylene flame [13].

RESULTS AND DISCUSSION

The average moisture contents in all parts is 70.8 ±21.3% and fall within the range 65 - 83%. Goat had the lowest moisture content with the muscle having the least level. In cow the intestine had the highest moisture content followed by the kidney. The results of the metal analysis for the samples are presented in tables 1 – 4, while tables 5 and 6 represents the overall average metal concentration in the animals and ranges of heavy metals levels in Nigerian meat compared with data on Pakistani meat respectively.

Table 1: Average Trace Metals Concentrations and Ranges in the Liver ($mgkg^{-1}$)

Metals	Cow	Goat	Chicken
Cd	0.04 nd – 0.11	1.56 nd - 3.58	0.67 nd - 1.75
As	0.59 0.13 - 1.32	3.58 nd - 5.78	0.60 nd - 1.19
Cr	0.22 nd - 0.66	nd	0.35 nd -1.04
Fe	112.4 6.62 - 187.11	436.33 15.73 - 816.96	138.88 14.88 - 221.52
Pb	7.71 0.13 - 21.24	13.26 2.50 - 22.7	2.60 nd - 5.05
Mn	1.72 1.37 -2.07	4.63 4.14 - 5.12	1.17 0.22 - 2.11
Zn	0.41 nd - 0.62	0.63 nd - 1.92	1.17 0.22 -2.11
Ni	0.53 0 - 0.53	0.41 0 - 0.41	1.61 0 - 1.61

Table 2: Average Trace Metals Concentrations and Ranges in the Kidney ($mgkg^{-1}$)

Metals	Cow	Goat	Chicken
Cd	0.20 nd – 0.34	0.28 nd - 2.77	nd
As	0.14 nd - 0.42	2.52 nd - 4.82	10.51 8.48 - 12.53
Cr	0.36 0.18 - 0.57	nd	nd
Fe	148.11 9.65 - 380.69	208.56 21.35 - 462.20	76.15 43.2 - 109.10
Pb	5.06 nd - 10.90	9.62 nd - 23.07	13.83 nd - 27.65
Mn	2.33 0.58 - 4.07	3.58 1.64 - 5.52	3.05 0 - 3.05
Zn	0.33 nd - 0.67	0.32 nd - 0.95	0.73 0.98 - 1.37
Ni	0.70 0 - 0.70	nd	nd

Table 3: Average Trace Metals Concentrations and Ranges in the Intestine ($mgkg^{-1}$)

Metals	Cow	Goat	Chicken
Cd	0.30 nd – 0.83	2.02 nd - 5.59	1.23 nd - 2.38
As	1.03 nd - 3.08	0.41 nd - 1.23	2.79 1.13 - 5.60
Cr	0.24 nd - 0.72	0.91 0.73 - 1.08	0.49 nd - 15.03
Fe	303.60 15.87 - 874.60	208.56 13.60 - 1269.6	103.77 9.73 - 221.20
Pb	1.04 nd - 2.60	12.91 nd - 25.97	6.83 nd - 20.48
Mn	3.79 0 - 7.34	3.58 4.05 - 12.89	1.89 1.42 - 2.36
Zn	0.40 nd - 0.67	1.70 nd - 3.44	nd
Ni	nd	nd	0.49 0 - 0.49

Table 4: Average Trace Metals Concentrations and Ranges in the Muscle ($mgkg^{-1}$)

Metals	Cow	Goat	Chicken
Cd	0.57 nd – 1.06	1.94 nd - 4.16	0.76 nd - 0.53
As	0.12 nd - 0.37	2.21 nd - 4.87	1.54 0.36 - 2.42
Cr	0.26 nd - 0.76	1.35 nd - 3.02	0.59 0.20 - 0.68
Fe	36.49 22.75 - 46.91	260.09 14.94 - 534.34	20.31 16.52 - 22.22
Pb	4.73 0.74 - 11.32	6.95 nd - 20.00	2.78 nd - 5.07
Mn	0.50 0.46 - 0.53	5.66 4.59 - 6.72	1.26 .18 - 0.33
Zn	0.19 nd - 0.30	0.33 nd - 0.99	nd
Ni	nd	nd	nd

Table 5: Overall Average of Trace Metals Concentrations in Beef, Goat and Chicken ($mgkg^{-1}$)

Metals	Cow	Goat	Chicken
Cd	1.11	5.80	2.16
As	1.88	8.72	15.44
Cr	1.08	2.26	1.35
Fe	600.61	1461.75	339.11
Pb	18.54	42.74	26.04
Mn	8.34	22.34	6.37
Zn	1.33	3.03	0.78
Ni	1.23	0.41	2.10

Table 6: Ranges in Heavy Metals Levels in Nigerian Meats Compared with Pakistani Meats [14]

Metals	Cd	As	Cr	Hg	Fe	Pb	Mn	Zn	Ni
Nigerian meat Beef Goat Chicken	nd – 1.06 nd – 4.16 nd – 0.53	nd – 0.37 nd – 4.87 0.86–2.42	nd – 0.76 nd – 0.02 0.20–..68	nd – 6.65 nd nd–3.22	22.75 - 46.91 14.94-534.34 16.52 - 22.22	0.74 - 11.32 nd – 20.0 nd – 5.07	0.46 - 0.53 0.59 - 6.72 0.18 - 0.33	nd - 0.3 nd - 0.99 nd	nd nd nd
Pakistani meat Beef Goat Chicken					2390 - 2415 6975 - 7015 585 - 610	nd – 3 nd - < 3 nd - 3	1 – 3 3 – 4 < 1 - 1	<1 – 2 nd – 1 nd - 1	nd-1 <1-2 1

The average concentrations of heavy metals in liver are shown in Table 1. Some metals namely iron, arsenic, lead manganese and nickel were detected in the liver of all the animals. Essential heavy metals like zinc, iron and manganese occurred in highest quantity in goat liver compared to the livers of other animals. Zinc concentrations were highest in the liver than the muscle and the kidney. Manganese concentration was lowest in chicken than goat and cow. Nickel has the highest concentrations in chicken liver than cow and goat liver. Cadmium, lead, arsenic and mercury concentrations were relatively higher in the liver especially in goat and chicken than cow. The high concentration of these metals in chicken could be as a result of the feeding habit of chicken. For cows, their habit of feeding on grasses and leaves, which might have been covered with lead emitted from motor car exhaust, may count for high concentration of lead in the cow meat samples. On the average concentrations of heavy metals were highest in goat followed by chicken and lastly cow.

Table 2 showed the average concentrations of heavy metals in the kidney of the animal studied. The kidney of chicken lack one essential trace metal (Cr) and contain almost all the toxic heavy metals (Pb==. 13.83mg/kg, and As==. 10.51mg/kg) Cadmium, known for its accumulation in liver especially kidney was not detectable in the kidney of chicken but was present in the kidney of cow and goat. Mercury was not found in both cow and chicken kidney but was detected in goat kidney. This could be as a result of the level of exposure of the analysed samples of the metals. The average trace metal concentrations in the intestines are shown in Table 3, Mercury and nickel were not detectable in the cow and goat intestines. The intestines contain less trace essential metals. e.g. zinc, chromium, and nickel, than iron. The differences in the levels of cadmium, lead and mercury in the animals may be a reflection of their feeding habits and age [14]. In addition, cow and goat were transported from the north to the southern part of the country. The length of time these animals were kept before they were slaughtered may have affected the levels of trace metals in their intestine. Those slaughtered immediately after long journey may show low metal concentration in the intestine due to lack of food during the long Journey southwards .The goats roam about and feed on leaves and grasses, which may contain some levels of Pb.

The concentrations of the trace metals in muscles are shown in Table 4. It also contained all the trace

essential metals except nickel. In mutton mercury was not detectible but it contained other toxic trace metals at a level higher than in beef Incidentally the chicken contained all the toxic trace metals with lead in the highest concentration, (Pb = 2.78mg/kg), but lacked some essential trace metals namely zinc and nickel. The feeding habits of the animals and environmental pollution level may have contributed to the type and levels of these trace metals in the samples analyzed. Local chicken that feeds from dirty environment and is always found around the house pecking indiscriminately, can easily acquire most of these metals. Generally, it has been reported that contamination of meat depends on nature and age of animal, environment, dietary habits, slaughtering, and transportation method and duration of exposure to dust particles etc. [14]. Table 5 showed that the highest concentrations of Cd, Cr, Fe, Pb, Zn, and Mn are found in goat, while As, Ni, and Hg were highest in chicken. The least concentration of the trace metals occurred in Beef.

In Table 6, the overall concentrations in the Nigerian meat samples are compared with data for Pakistani meat, by Azad (2003) [14]. With the exception of lead, the other metals, Fe, Mn, Zn and Ni were higher in the Pakistani samples. This is likely an indication of higher lead contamination in Nigeria than in Pakistan. This trend must be viewed with seriousness considering that the maximum permissible concentration of lead in meat, set at O.5ppm.[15]. The values of the metal in some of the samples analyzed in the current study were therefore outrageous and seem to confirm what Ihedioha and Okoye (2012) concluded in their study of lead levels in Nigerian goat meat samples.[16]. With respect to cadmium with maximum permissibility concentration of 0.1ppm. is in line with the findings of Okunola *et al* and Ayodele *et al* [17],[4]. Zinc with maximum permissible concentration of 150ppm [18] is very low in the Nigerian meat samples.

CONCLUSION

The result of this study has shown that Pb and Cd were found above permissible level in the meat samples studied. This was attributed to high level of these elements in the Nigerian environment. Under these circumstances, there is need for increase environmental awareness for the populace through the body 'responsible for proper disposal of wastes; some measures should be taken to control emission of these metals into the environment (effluents from industries and motor cars) especially lead, and cadmium. Animals especially chicken and goat

should be confined to avoid much contamination from the surrounding. High consumption of cow and goat kidney and liver obtained from the sources studied may result to lead toxicities. Therefore, for growth, health, and fertility of the animals and by extension that of man to remain unimpaired, the functional and structural integrity of tissues should be safeguarded.

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