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Heavy Metal Levels in Animal Muscle Tissue: A Case Study of Nigerian Raised Cattle

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Abstract: The increasing level of pollution in both aquatic and terrestrial environment with which some animals which form part of human diet are constantly in contact has been a global concern, minding the contamination of aquatic and terrestrial organisms especially in countries which are prone to severe environmental pollution due to the lack of appropriate waste management system and technologies. In Nigeria as well as several other countries, meat from cattle is the most common hence, the need to assess the level of heavy metals in cow muscle tissue. The levels of Pb, Cd, Co, Zn, Cu and Fe were determined in the muscle tissue of 15 cattle at slaughter during 3 different seasons. The samples were digested and analyzed with atomic absorption spectrophotometer. The values ranged from ND-14.80 mg kg^{-1} at the on-set of rainy season; 0.01-3.53 mg kg^{-1} at the peak of rainy season and 0.005-3.90 mg kg^{-1} during the dry season.

Key words: Cattle, heavy metals, muscle, pollution, metal levels, season

INTRODUCTION

The increasing levels of environmental pollutions by toxic metals from various sources have generated a great concern on the impact on human health. Humans are prone to several routes of exposure and hence the need to evaluate the levels in human diet which is one of the easiest routes of exposure. While the occurrence of toxic metals in some aquatic organisms which form human diet have been of great concern in that they could accumulate the metals at a level exceeding the proportion that occur in the environment, bioaccumulation by animals raised for human consumption has been dreaded as a great risk to humans (Hashmi *et al*., 2002). Urban run-off sediments in some parts of Nigeria, Particularly Lagos where environmental pollution takes various forms have been evaluated for the levels of heavy metals and Zn, Fe and Cd were found in very high concentrations (Adekola *et al*., 2002) while water samples of 72 rivers, streams and waterways in southern Nigeria analyzed for Pb, Cr, Cd, Fe, Zn, Mn and Cu were found to contain higher levels of these pollutants at concentrations exceeding the guidelines of WHO (Asonye *et al*., 2007).

Humans consuming vegetables grown in contaminated soils and animals raised in such area stand at a risk (Sedki *et al*., 1995). Plants growing around major highways are prone to contamination by aerial deposition of metal-containing particulate matter from automobile exhaust this is exemplified by some studies carried out by Atayese *et al*. (2008) on heavy metal contamination of Amaranthus grown along major highways in Lagos, Nigeria. The effects of moderate pollution on toxic and trace metal levels in calves from a polluted area of northern Spain were studied by Miranda *et al.* (2005) and the results indicated contribution of anthropogenic pollution to toxic metal residues in cattle in an industrialized area of Asturias. The results of metal levels in body tissues, forage and fecal pellets of elk living near the ore smelters at Sudbury, Ontario, exceeded the WHO guidelines and Canadian regulatory standards, implying significant health risk for human consumption (Parker and Hamr, 2001). In the determination of heavy metal contents in Egyptian meat, Abou-Arab (2001) observed that the Pb, Cd, Zn, Cu, Mn and Fe contents in muscle, liver, kidney, heart and spleen in industrial areas were higher than in the same organs for rural areas. Bovines grazing on the municipal wastewater spreading field of Marrakech City (Morocco) were found to be seriously contaminated by toxic metals (Sedki *et al*., 2003). In the evaluation of metal accumulation in cattle raised in a serpentine-soil area, Miranda *et al.* (2009) observed that tissue accumulation in animals was related to concentrations of the metals in soils and forage. Concentrations of some heavy metals in animal tissues were correlated with the heavy metal content in the soil (Lopez-Alonso *et al*., 2002). Apart from being in contact with polluted soil environment and grazing on contaminated plants, cattle could as well be exposed to heavy metals through contaminated feeds

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(Miranda *et al*., 2005). In some instances, high concentrations of Cu and Zn are added to pig and poultry feeds; application of pig and poultry manures as fertilizers may then result in pollution of agricultural lands by these metals (Poulsen, 1998) and uptake by plants; these then pose risks to grazing cattle.

Diet and season have been identified as factors determining the transfer of metals from the surrounding environment to terrestrial animals (Hunter *et al*., 1987). Also, there have been indications of industrial pollution in the forest ecosystems (Medvedev, 1995). In all tissues analyzed in gray whale carcasses from the Northern Pacific Mexican Coast, Fe, Cu, Zn and Mn were present in the highest concentrations (Mendez *et al*., 2002).

Some essential elements, though necessary for life and are particularly involved in some metabolic processes, if taken in excess could be toxic (Spears *et al*., 1986). Concentration of a metal may affect the level of others in animal tissues (Blanco-Penedo *et al*., 2006). Exposure of humans to some heavy metals have indicated risk factors for breast lesions (Siddiqui *et al*., 2006). In Nigeria as well as several other countries, meat from cow is the most common and the part mostly processed for consumption is the muscle.

Some heavy metals are present mainly in muscle tissue (Storelli and Marcotrigiano, 2003). Though caution is exercised to ensure that a very healthy cow is processed for consumption, a cow with high levels of toxic metals may not show any obvious symptoms of illness and thereby posses hidden potential health risk to humans. Food chain contamination has been a common route of exposure to heavy metals for humans (Ferner, 2001). This study assesses the levels of Pb, Cd, Co, Zn, Cu and Fe in the muscle tissue of cow at slaughter during three different seasons.

MATERIALS AND METHODS

Portions of muscle tissue from fifteen cows at slaughter were collected from Awka abattoir, five cattle in each of the three different seasons of the year: on-set of rainy season (April-July, 2004), peak of rainy season (July-October, 2004) and dry season (January-April, 2005); the samples were collected in contaminant-free sample bags and preserved in refrigerator pending the time of analysis.

About 10.0 g of each muscle sample was placed in conical flasks, 5 mL of phosphoric were added it was then heated on a heating mantle for about 1 h, until heated to dryness; 100 mLs of distilled water were added and thoroughly shaken. It was filtered into a 100 mL standard flask and the filtrate was made up to mark with distilled water. Aliquots of this were analysed for Pb, Cd, Co, Zn, Cu and Fe using atomic absorption spectrophotometer, model Shimadzu AA-6800 (Nwude *et al*., 2010).

Correlations were made between the concentrations of one metal and the other to establish any possible relationships in the accumulation of the metals in the muscle tissue using the RSQ worksheet function.

RESULTS AND DISCUSSION

The results of the determination of levels of heavy metals in cow muscle tissue during the three seasons are shown in Table 1. At the on-set of rainy season (April-July), the values ranged from ND-4.80 mg kg^{-1} at the peak of rainy season (July-October), 0.01-3.53 mg kg^{-1} during the dry season (January-April), 0.005-3.90 mg kg^{-1}. Figure 1 shows the average concentration in April-July, the values ranged from 0.03-7.95 mg kg^{-1} in July-October (Fig. 2), 0.01-3.25 mg kg^{-1} and in January-April (Fig. 3),

Table 1: Levels (mg kg^{-1}) of heavy metals in cow muscle tissue in April-July (2004), July-October (2004) and January-April (2005)

Time period	Pb	Cd	Co	Zn	Cu	Fe
April-July						
A	4.98±0.02	0.01±0.0000	0.84±0.03	2.80±0.10	0.03±0.03	-
B	2.24±0.02	0.01±0.0100	1.10±0.03	7.20±0.02	0.08±0.12	-
C	2.05±0.02	0.10±0.0300	0.60±0.20	5.73±0.02	0.10±0.01	-
D	ND	0.02±0.0000	0.60±0.10	14.80±0.03	0.04±0.05	-
E	4.50±0.04	0.004±0.471	1.00±0.10	10.00±0.02	0.10±0.00	-
July-October						
A	2.16±0.01	0.02±0.0200	0.84±0.03	3.05±0.02	0.97±0.00	1.40±0.02
B	1.10±0.22	0.01±0.1000	0.20±0.80	3.53±0.01	1.90±0.01	1.15±0.03
C	1.20±0.08	0.01±0.0400	0.60±0.10	3.30±0.02	0.10±0.01	1.10±0.02
D	0.60±0.14	0.01±0.0100	0.91±0.01	2.95±0.03	0.50±0.30	1.30±0.02
E	1.42±0.02	0.01±0.0100	0.65±0.02	3.44±0.01	0.44±0.06	0.92±0.01
January-April						
A	1.09±0.04	0.01±0.0400	0.50±0.04	3.70±0.04	0.90±0.02	0.70±0.01
B	0.60±0.10	0.01±0.0200	0.90±0.10	3.70±0.00	0.91±0.04	0.71±0.03
C	0.80±0.10	0.02±0.0200	0.40±0.20	3.80±0.01	1.02±0.00	0.71±0.00
D	0.63±0.01	0.005±0.120	0.21±0.10	3.90±0.00	2.04±0.00	1.30±0.02
E	0.22±0.53	0.01±0.0100	0.24±0.60	3.90±0.02	1.52±0.01	1.50±0.01

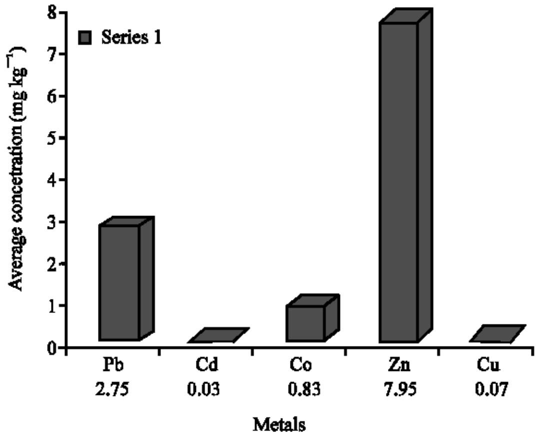

Fig. 1: Average concentration of metals in cow tissue in April-July

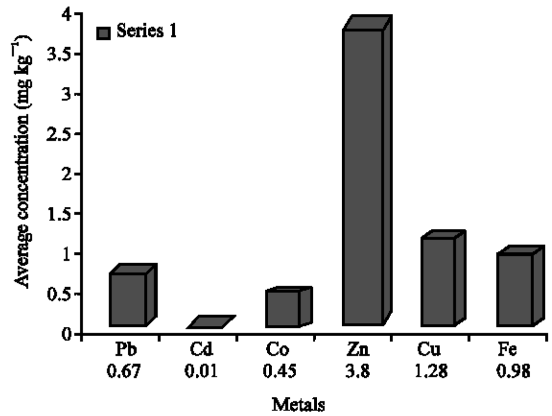

Fig. 3: Average concentration of metals in January-April

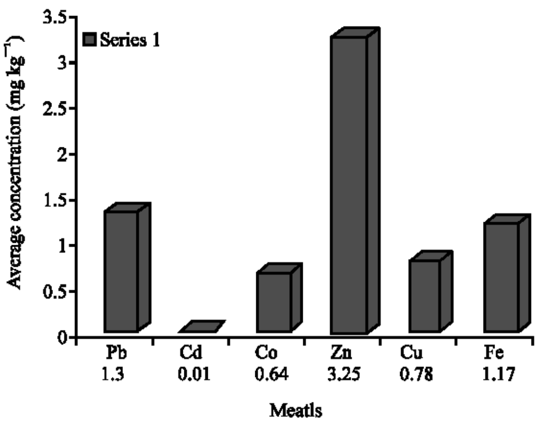

Fig. 2: Average concentration of metals in July-October

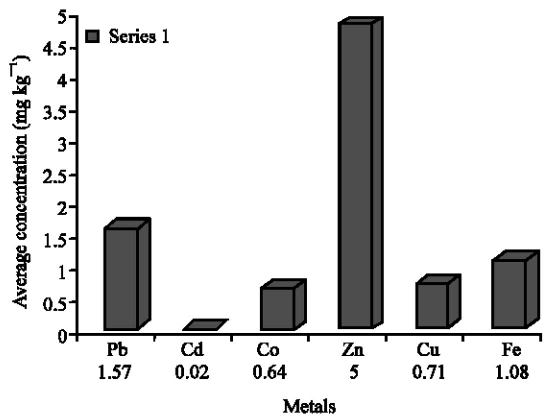

Fig. 4: Average concentration of metals in the three seasons

0.01-3.8 mg kg^{-1}. Figure 4 shows the average concentration in the three seasons, the values ranging from 0.02-5.00 mg kg^{-1}. Levels of heavy metals in muscle tissues of various animals to compare with the results in this study are shown in Table 2 while the results of correlations between levels of the various metals are shown in Table 3.

At the on-set of rainy season, Zn level was the highest followed by Pb while the least was obtained for Cd. The same pattern was observed at the peak of rainy season.

During the dry season, the level of Zn was followed by that of Cu. In the aggregate of the metal levels for the three seasons, the accumulation of Zn in the cow muscle tissue was the highest followed by Pb and the least being Cd.

The varying levels of corresponding metals in the different seasons indicate the effect of season as a factor influencing the accumulation of heavy metals by cattle.

The leading levels of Zn and Pb in the muscle tissue during the different seasons may indicate inherent potential in cattle to accumulate Zn and Pb in the muscle tissue or an indication of the degree of environmental pollution by these metals.

The level of Pb observed in this study was ND-4.98 mg kg^{-1}; literatures are not available on the level of Pb in cattle muscle tissue; the available literatures cover the levels in sheep, goat, calves, elk and fur seal: 0.081±0.03 mg kg^{-1} for sheep and 0.084±0.04 mg kg^{-1} for goat (Abou-Arab, 2001); ND-150 μg kg^{-1} calves (Miranda *et al*., 2005) and 1.09±0.06 mg kg elk (Parker and Hamr, 2001).

The results fairly compare with the references. While the range of Cd levels (0.004-0.1 mg kg^{-1}) is slightly lower than that observed by Sedki *et al.* (1995) (0.25-1.0 mg kg^{-1}) which may imply higher level of pollution in the region of study by Sedki *et al.* (2003) the values are comparable to those observed in sheep (0.02±0.01 mg kg^{-1}), goat (0.041±0.03), calves

Table 2: Levels (mg kg^{-1}) of metals in the muscle tissue of various animals

Animal	Pb	Cd	Co	Zn	Cu	Fe
[a]Cattle	-	0.25-1.0	-	89-154	2.6-6.0	-
[b]Sheep	0.081±0.03	0.02±0.01	-	46.9±16.4	1.40±0.70	39.1±11.5
[b]Goat	0.084±0.04	0.041±0.03	-	41.4±20.4	1.20±0.90	51.1±2.2
[c]Calves*	ND-150	ND-20.7	-	29.2-66.5	0.46-3.35	18.3-94.7
[d]Elk	1.09±0.06	0.17±0.02	0.54±0.05	70.65±8.66	2.99±0.50	156.07±22.62
[e]Northern fur seal**	-	0.04-0.36	-	16.0-47.4	1.02-2.34	44.0-191

[a]Sedki *et al.* (2003); [b]Abou-Arab (2001); [c]Miranda *et al.* (2005); [d]Parker and Hamr (2001); [e]Noda *et al.* (1995); * (µg Kg^{-1}); **(µg g^{-1}); ND: Not Determined

Table 3: Results of correlations between levels of the metals in cow muscle tissue

	April-July		July-October		January-April	
Metals	Equation	R^2	Equation	R^2	Equation	R^2
Pb/Cd	y = -15.672x+3.2053	0.0972	y = 108x-2E-15	0.7212	y = 12.583x+0.5296	0.0472
Pb/Co	y = 4.6978x-1.1358	0.2804	y = 0.2472x1.1378	0.0146	y = 0.2817x+0.5412	0.0610
Pb/Zn	y = -0.2987x+5.1757	0.4532	y = -0.0005x+1.2976	5E-080	y = -2.1x+8.648	0.4385
Pb/Cu	y = 4.4773x+2.4406	0.0054	y = 0.0835x+1.2307	0.0105	y = -0.3109x+1.0653	0.2364
Pb/Fe	-	-	y = 0.639x+0.5458	0.0434	y = -0.681x+1.3177	0.5305
Cd/Co	y = -1148x+0.1238	0.4228	y = 0.0065x+0.0078	0.1622	y = 0.0023x+0.01	0.0132
Cd/Zn	y = -0.0019x+0.0443	0.0466	y = 0.0083x+0.0389	0.2107	y = -0.0125x+0.0585	0.0521
Cd/Cu	y = 0.504x-0.0065	0.1732	y = 0.001x+0.0112	0.0227	y = -0.0065x+0.0193	0.3458
Cd/Fe	-	-	y = 0.0164x-0.0073	0.4643	y = -0.0072x+0.0181	0.2605
Co/Zn	y = -0.0117x+0.9226	0.0544	y = -0.9894x+3.8595	0.7843	y = -2.375x+9.475	0.7297
Co/Cu	y = 1.6818x+0.7103	0.0599	y = -0.2602+0.8435	0.4277	y = -0.4119x+0.9764	0.5399
Co/Fe	-	-	y = 0.6559x-0.13	0.1920	y = -0.516x+0.9577	0.5140
Zn/Cu	y = -2.9545x+8.3068	0.0005	y = 0.134x+3.1492	0.1417	y = 0.1778x+3.5727	0.7780
Zn/Fe	-	-	y = -1.0303x+4.4635	0.5911	y = 0.2329x+3.5709	0.8092
Cu/Fe	-	-	y = 0.8541x-0.2207	0.0515	y = 1.0798x+0.2155	0.7072

(ND-20.7 µg kg^{-1}), elk (0.17±0.02 mg kg^{-1}) and fur seal (0.04-0.36 µg g^{-1}) by Abou-Arab (2001), Miranda *et al.* (2009), Parker and Hamr (2001) and Noda *et al.* (1995), respectively. Report on Co levels in animal tissues is available only for elk (Parker and Hamr, 2001), the value being 0.54±0.05 mg kg^{-1} and the results obtained in this study ranged from 0.20-1.10 mg kg^{-1}. The results compare well with the reference.

The values for the levels of Zn in this study are closer to that observed for fur seal by Noda *et al.* (1995) disparity exists with those observed by the others; higher level of pollution may be inferred for the higher levels observed by the other and while the levels of Cu in this study agree with the references for Fe, disparity exists. The results of correlations show little or no relationships between the levels of the various metals as observed at the on-set of rainy season.

Some significant relationships exist between the levels of Pb and Cd and between Co and Zn at the peak of rainy season between Co and Zn, Zn and Cu and Cu and Fe during the dry season.

CONCLUSION

The levels of heavy metals in cow muscle tissue as observed in this study vary with season. The references selected to compare with the results in this study are those of studies carried out in some polluted regions. Hence, where the results of this study agree with those references, pollution may be inferred.

REFERENCES

Abou-Arab, A.A.K., 2001. Heavy metal contents in Egyptian meat and the role of detergent washing on their levels. Food Chem. Toxicol., 39: 593-599.

Adekola, F.A., O.A. Eletta and S.A. Attanda, 2002. Determination of the levels of some heavy metals in urban run-off sediments in Ilorin and Lagos, Nigeria. J. Applied Sci. Environ. Manage., 6: 23-26.

Asonye, C.C., N.P. Okolie, E.E. Okenwa and U.G. Iwuanyanwu, 2007. Some physico-chemical characteristics and heavy metal profiles of Nigerian rivers, streams and waterways. Afr. J. Biotechnol., 6: 617-624.

Atayese, M.O., A.I. Eigbadon, K.A. Oluwa and J.K. Adeosun, 2008. Heavy metal contamination of *Amaranthus* grown along major highways in Lagos, Nigeria. Afr. Crop Sci. J., 16: 225-235.

Blanco-Penedo, I., J.M. Cruz, M. López-Alonso, M. Miranda and C. Castillo *et al*., 2006. Influence of copper status on the accumulation of toxic and essential metals in cattle. Environ. Int., 32: 901-906.

Ferner, D.J., 2001. Toxicity of heavy metals. eMed. J., 2: 1-1.

Hashmi, M.I., S. Mustafa and S.A. Tariq, 2002. Heavy metal concentrations in water and tiger prawn (*Penaeus monodon*) from grow-out farms in Sabah, North Borneo. Food Chem., 79: 151-156.

Hunter, B.A., M.S. Johnson and D.J. Thompson, 1987. Ecotoxicology of copper and cadmium in a contaminated grassland ecosystem. III Small mammals. J. Applied Ecol., 24: 601-614.

Lopez-Alonso, M., J.L. Benedito, M. Miranda, C. Castillo, J. Hernandez and R.F. Shore, 2002. Cattle as biomonitors of soil arsenic, copper and zinc concentrations in Galicia (NW Spain). Arch. Environ. Contam. Toxicol., 43: 103-108.

Medvedev, N., 1995. Concentrations of cadmium, lead and sulphur in tissues of wild, forest reindeer from North-West Russia. Environ. Pollut., 90: 1-5.

Miranda, M., J.L. Benedito, I. Blanco-Penedo, C. Lopez-Lamas, A. Merino and M. Lopez-Alonso, 2009. Metal accumulation in cattle raised in a serpentine-soil area: Relationship between metal concentrations in soil, forage and animal tissues. J. Trace Elements Med. Biol., 23: 231-238.

Miranda, M., M. Lopez-Alonso, C. Castillo, J. Hernandez and J.L. Benedito, 2005. Effects of moderate pollution on toxic and trace metal levels in calves from a polluted area of Northern Spain. Environ. Int., 31: 543-548.

Mendez, L., S.T. Alvarez-Castañeda, B. Acosta and A.P. Sierra-Beltrán, 2002. Trace metals in tissues of gray whale (*Eschrichtius robusts*) carcasses from the Norhtern Pacific Mexican Coast. Mar. Pollut. Bull., 44: 217-221.

Noda, K., H. Ichihashi, T.R. Loughlin, N. Baba, M. Kiyota and R. Tatsukawa, 1995. Distribution of heavy metals in muscle, liver and kidney of northern fur seal (*Callorhinus ursinus*) caught off Sanriku, Japan and from the Pribil of Islands, Alaska. Environ. Pollut., 90: 51-59.

Nwude, D.O., P.A.C. Okoye and J.O. Babayemi, 2010. Assessment of heavy metal concentrations in the liver of cattle at slaughter during three different seasons. Res. J. Environ. Sci. (in Press).

Parker, G.H. and J. Hamr, 2001. Metal levels in body tissues, forage and fecal pellets of elk (*Cervus elaphus*) living near the ore smelters at Sudbury, Ontario. Environ. Pollut., 113: 347-355.

Poulsen, H.D., 1998. Zinc and copper as feed additives, growth factors or unwanted environmental factors. J. Anim. Feed Sci., 7: 135-142.

Sedki, A., N. Lekouch, S. Gamon and A. Pineau, 2003. Toxic and essential trace metals in muscle, liver and kidney of bovines from a polluted area of Morocco. Sci. Total Environ., 317: 201-205.

Sedki, A., Pineau, A., Pihan, J.C., 1995. Lead in childrens hair, as related to exposure in wastewater spreading field of Marrakech (Morocco). Trace Met. Electrolytes, 13: 18-21.

Siddiqui, M.K.J., Jyoti, S. Singh, P.K. Mehrotra, K. Sing and R. Sarangi, 2006. Comparison of some trace elements concentration in blood, tumor free breast and tumor tissues of women with benign and malignant breast lesions: An Indian study. Environ. Int., 32: 630-637.

Spears, J.W., R.W. Harvey and L.J. Samell, 1986. Effects of dietry nickel and protein on growth, nitrogen metabolism and tissue concentrations of nickel, iron, zinc, manganese and copper in calves. J. Nutr., 116: 1873-1882.

Storelli, M.M. and G.O. Marcotrigiano, 2003. Heavy metal residues in tissues of marine turtles. Mar. Pollut. Bull., 46: 397-400.