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Heavy Metal Contents of Poultry Feeds and Liver Tissues of Chicken Fed With Different Poultry Feeds

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ABSTRACT

The purpose of this research was to determine the mean concentration of some heavy metals in liver tissues of chickens with possibility of transfer to the food chain through chicken consumption. Mature chickens fed different locally formulated commercial poultry feeds: Top, Guinnea, Sanders, Livestock and Vital poultry feeds from Uyo, Eket and Ikot Ekpene municipalities in Akwa Ibom State, Nigeria were analysed for concentrations of arsenic (As), cadmium (Cd), iron (Fe), nickel (Ni) and lead (Pb). Chickens fed with Top Poultry Feed (TPF) contained 0.720±0.068 ug/g Pb; those fed with sanders poultry feed (SPF) and Vital poultry feed (VPF) had the highest mean concentrations of 1.408±0.347 ug/g As and 13.305±0.903 ug/g Fe. Mean total metal concentrations (μgg^{-1}) in chicken liver tissues were 0.888±0.45 for As, 0.664±0.08 for Cd, 11.726±1.96 for Fe, 4.609±1.14 for Ni and 4.377±0.72 for Pb.

INTRODUCTION

The increasing awareness of the dangers of heavy metals in the environment has been on for more than two decades. Such awareness especially in developing countries needs to be intensified because environmental disturbance and careless disposal of heavy metals have great adverse effects on the environment. Some mineral elements are essential for plants and animals. These essential minerals are classified into macro and trace elements.

Macro elements are required in higher amount than the trace elements. The trace elements include; Fe, Mn, Zn, Se, I, Co, Cr, V, Ni, Sn, Pb, B and As (Underwood, 1998). Among these trace elements are heavy metals, which are often toxic to organisms and have a relative density of 5.0 or higher. Those metallic elements generally classified by nutritionist are As, Cd, Cr, Cu, Pb, Ni, Se and Fe (Tucker et al, 2003).

The soil is the ultimate sink for heavy metals that bio-accumulate in agricultural produce and aquatic biomass. These metals in agricultural produce and aquatic animals are consequently passed up through the food chain to human consumers. A contaminant is said to bio-accumulate when its uptake rate exceeds its elimination rate (Ibok et al, 1989). For any element or compound to accumulate in an organism, the exposure must be over an extended period of time particularly in the food chain. The presence of these metals and their concentrations in poultry products is the focus of our study.

Although, studies have been conducted to determine levels of heavy metals in the environment, most have focused on soil, sediments and plants (vegetables) as sources of environmental monitoring. Heavy metal pollution in the soil is a common phenomenon; metal concentration in soil and its absorption by plant have been widely studied (Udosen, 1998; Beavington, 1975; McGrieght and Schroeder 1971; Warent and Delavault 1989). Concentrations of heavy metals in fishes were also determined (Ibok et al.,1989; Nijoke and Danuete, 1999). Okoye et al. (2002) studied metal concentration in marine crab. Edward (1987) showed high concentrations of some heavy metals in plants. Thus, raw materials for poultry feed formulation such as cereals and sea foods have considerable levels of heavy metals, which should be routinely monitored and evaluated as a food safety measure. Our objective was to determine the concentrations of some heavy metals in both poultry feeds and poultry product (meat).

MATERIALS AND METHODS

Fresh chickens randomly selected from the three senatorial districts (Eket, Ikot Ekpene and Uyo) of Akwa Ibom State and fed with different poultry feeds: Top poultry Feed (TPF), Guinea Poultry Food (GPF), Sanders Poultry Feed (SPF), Livestock Poultry Feed (LPF) and Vital Poultry Feed (VPF) were slaughtered and their liver tissues extracted into labeled plastic container after being washed thoroughly with deionized water. Each sample (liver tissue) and feed type was separately dried to a constant weight in an oven temperature of 50 - 60 °C for forty-eight hours (48 hrs). Concentrations of trace metals in poultry feeds and water samples from Ikot Ekpene (W_1), Uyo (W_2) and Eket (W_3) are given in Tables 1 - 2.

Table 1: Heavy metals concentration (μgg^{-1}) in poultry feeds fed to matured chickens.

Poultry Feed	Heavy metal (μgg^{-1})				
	As	Cd	Fe	Ni	Pb
Top (TPF)	0.02	0.10	199.2	3.10	1.30
Guinea (GPF)	0.02	0.08	311.2	2.40	2.12
Sanders (SPF)	0.02	0.18	403.2	3.22	1.66
Livestock (LPF)	0.02	0.10	197.6	3.00	2.58
Vital (VPF)	0.02	0.14	342.0	2.90	1.90
Mean	0.02±0.0002	0.12±0.04	290.7±90.4	2.92±0.32	1.91±0.48
C.V(%)	1.00	33.33	31.10	10.80	25.21

Table 2: Heavy metals concentration in the water supplied to the matured chickens.

Water Sample	Heavy metal (μgg^{-1})				
	As	Cd	Fe	Ni	Pb
W_1 (Ikot Ekpene)	0.06	0.02	1.00	0.05	0.05
W_2 (Uyo)	0.05	0.02	1.00	0.04	0.07
W_3 (Eket)	0.06	0.02	1.20	0.06	0.05
Range	0.05-0.06	0.01-0.02	1.0-1.2	0.04-0.06	0.05-0.07
Mean	0.057±0.0058	0.02±0.002	1.10±0.1	0.05±0.01	0.057±0.012

The dried samples were milled into powder using an electric blender and stored in appropriately labeled containers. Each sample (1.0 g) was weighed into a crucible and ashed at 650 °C until the ash was devoid of traces of carbon (AOAC, 1975). The white residue was removed from the muffle furnace after ashing, allowed to cool and leached with 5ml of 20% nitric acid (HNO_3). This was then heated in a steam bath until the volume was reduced to about one-third of the original volume. The solution was transferred into a 20ml volumetric flask and made up to mark with deionized water (AOAC, 1975). The water given to the chickens were also collected and analyzed.

Heavy metals in the solution were analysed with an atomic absorption spectrophotometer (Buck 210, Buck Scientific, Inc, East Norwalk, USA). Duplicate analysis of the samples and reagent blanks were carried out to ensure accuracy and precision. The detection limit of the instrument used for the analysis was 0.001 mg/1. Data obtained were analyzed using statistical software, MATLAB to calculate the standard deviation, coefficient of variation and t-test.

RESULTS

The results of heavy metal concentrations in the liver tissues of chickens fed with different poultry feeds are summarized in Table 3. Arsenic (As) concentrations (μgg-^{1}) ranged between 0.12 - 0.72 in TPF, 0.26 - 1.22 in GPF, 0.94 - 1.80 in SPF, 0.12 - 1.82 in LPF and 0.18 - 1.22 in VPF. Sanders Poultry Feed had the highest mean level of 1.41 μgg-^{1} As. The overall mean trend among samples was SPF> LPF> GPF> VPF> TPF. Cadmium, iron, nickel, and lead were also identified in all the samples analyzed. The highest mean concentration (0.718±0.60 μgg-^{1}) of Cd was noted in liver tissues of chicken fed with TPF, followed by the mean concentrations of 0.680±0.135 μgg-^{1} Cd in SPF, 0.673±0.135 μgg-^{1} in LPF, 0.663±0.084 ugg-^{1} in VPF and 0.586±0.084μgg-^{1}Cd in GPF.

Table 3: Mean concentrations and ranges of heavy metals in the liver tissues of chickens.

Poultry Feed	Heavy metal (μgg^{-1})				
	As	Cd	Fe	Ni	Pb
Top	0.350±0.22 (0.12– 0.72)	0.718±0.06 (0.62– 0.80)	11.06±1.45 (8.66–12.82)	5.903±1.93 (4.18 - 9.60)	5.230±0.53 (4.80-5.80)
Guinea	0.925±0.56 (0.26-1.22)	0.586±0.08 (0.54-0.76)	11.863±2.18 (8.44-14.42)	2.650±0.53 (2.06-3.38)	3.413±0.67 (2.53-4.26)
Sanders	1.47±0.31 (0.94-1.80)	0.680±0.14 (0.50-0.86)	10.710±2.98 (6.02-14.24)	5.267±0.35 (4.96-5.94)	4.86±0.35 (4.38-5.40)
Livestock	0.988±0.72 (0.12-1.82)	0.673±0.05 (0.60-0.72)	11.683±2.39 (8.38-14.42)	4.615±2.24 (3.38-9.44)	4.650±1.33 (3.32-7.10)
Vital	0.707±0.42 (0.18-1.22)	0.663±0.09 (0.54-0.80)	13.307±0.81 (12.20-14.42)	4.612±0.64 (3.40-5.24)	3.734±0.70 (2.94-4.74)
Mean	0.888±0.45	0.664±0.08	11.726±1.96	4.609±1.14	4.377±0.72

Iron concentrations (ugg-^{1}) in liver tissues were 8.66 – 12.82 for chicken fed with TPF, 8.44 – 14.24 for chicken fed with GPF, 6.02 – 14.24 for chicken fed with SPF, 8.38 – 14.42 for chicken fed with LPF and 12.20 – 14. 24 for chicken fed with VPF. The highest mean Ni concentration was recorded in liver tissues of chickens fed with TPF (5.903±2.928 μgg-^{1}) while GPF produced the lowest concentration of 2.650±0.530 μgg-^{1}. Also, the highest mean concentration (5.230± 0.56 μgg-^{1}) of Pb was found in liver tissues of chickens fed with TPF, followed by SPF with 4.86±0.345 μgg^{-1}, LPF (4.6000±1.497 μgg^{-1}), VPF (3.734±0.695 μgg^{-1}) and GPF with the lowest concentration of 3.413±0.670 μgg^{-1}.

The relationship between heavy metal concentrations in liver tissues of chickens fed with different poultry feeds using t-test analysis is presented on Table 4. The content of As in the liver tissues of chickens fed with SPF versus VPF was most significant, while chickens fed with TPF versus SPF showed a negative relationship, indicating more As content in Sanders than both Vital and Top feeds.

Similarly, Cd and Fe had a negative significant difference in the liver tissues of chickens fed with GPF versus LPF, TPF versus VPF; $t = -2.600$ and -4.488, respectively, showing lower content of Cd in Guinea than Livestock feeds and lower content of Fe in Top than Vital feeds. Also, there was a significant difference in Ni content of liver tissues of chickens fed with Top versus Guinea feeds, Top versus Livestock feeds and Sanders versus Vital poultry feeds, t = 4.865, 3.701 and 3.753, respectively. This indicates that Top feed contained more Ni than Guinea and Livestock feeds. However, GPF versus SPF and GPF versus VPF had negative relationships ($t = -9.627$ and -5.536), showing less Ni content in Guinea feed than both Sanders and Vital feeds.

Lead content in liver tissues of chickens fed with Top versus Guinea feeds, Top versus Vital and Sanders versus Vital feeds were significantly different (Table 4), while Guinea versus Sanders and Guinea versus Livestock feeds had negative significance at ($p<0.001$), indicating higher content of Pb in Top feed than Guinea and Vital feeds, and a lower level of Pb in Guinea feeds than those of Sanders and Livestock feeds. Possible sources of Pb in liver tissues of the chickens were feeds, water and air-borne Pb in the environment (Merian, 1991).

Table 4: Independent t-test of heavy metals in liver tissues of chicken fed with different poultry feeds.

Paired	Heavy metal (μgg^{-1})				
Samples	As	Cd	Fe	Ni	Pb
Top vs Guinea	-2.108	1.200	-1.247	4.865***	5.300***
Top vs Sanders	-10.230***	0.721	0.235	0.815	1.938
Top vs Livestock	-2.221	1.904	0.845	3.701***	0.808
Top vs Vital	-1.665	1.780	-4.488***	1.706	8.581***
Guinea vs Sanders	-1.172	-2.120	0.615	-9.627***	-5.559***
Guinea vs Livestock	-0.130	-2.600**	0.133	-2.207	-3.614***
Guinea vs Vital	1.888	-1.559	-1.604	-5.536***	-1.156
Sanders vs Livestock	0.241	0.167	-0603	0.645	0.292
Sanders vs Vital	3.188***	0.238	-2.277	1.663	4.587***
Livestock vs Vital	0.671	0.215	-2.249	3.753***	1.464

*** Significant at $p<0.001$; ** Significant at $p<0.01$

DISCUSSION

Our mean concentration of arsenic (0.350 μgg^{-1}) in liver tissues of chicken fed with TPF was consistent with the normal range from Canada and U.S Environmental protection Agency (EPA) of 0.33 - 0.43 ppm and 0.10 – 0.51 ppm of As/Kg/day (Korsurud et al., 1985; Salisbury et al., 1991). In contrast, the arsenic concentration in liver tissues of chickens fed with SPF, VPF, GPF and LPF exceeded the Canadian and US EPA daily dietary intake. Hermayer et al, (1977) observed that chickens fed with 1–50 μgg^{-1} of arsenic pentoxide suffered no adverse effect, possibly because the maximum tolerable levels in poultry were 50 ppm for inorganic and 100 ppm for organic arsenic (Henry and Miles, 2001).

The greatest potential sources of arsenic in poultry may be drugs such as phenylarsenoxide acid and 3–nitro-4–hydrophenylarsenic acid sometimes used as coccidiostats. Another possible source is the exposure to arsenical insecticides. The coefficient of variation for As in liver tissues of chicken fed with SPF was the most stable (C.V = 22.07%), compared with that of VPF (C. V= 58.98 %), GPF (C.V= 60.00 %), TPF (C.V of 61.52 %) and LPF (C.V = 72.67 %).The stability of these metals in the samples indicates the ability of the tissues to bioaccumulate over a period of time until they become bio-concentrated and subsequently carried to consumers through the chain. This may result in toxicosis and various health symptoms that may ultimately lead to dead in man (CalEPA, 1997; ATSDR, 2000).

For all our tissue samples, the content of cadmium was considered unsafe based on German Federal Health Agency limits (0.1 $\mu gg\text{-}^{1}$) for cadmium in foodstuff, including chicken meat (Merian, 1991). Although the maximum tolerable Cd level for poultry was 0.50 ppm (Merian, 1991), concentrations above 0.10 ppm increased the risk of toxicity to consumers. The high mean Cd content (0.12 $\mu gg\text{-}^{1}$) in the poultry feeds may have negative consequences on the environment when poultry manure is used for fertilizing plants or as soil amendment in combination with other organic materials. Analysis of the drinking water used indicated a Cd concentration of 0.02 $\mu gg\text{-}^{1}$, which may also contributed to the high Cd content in the liver. However, there was a highly significant difference between the Cd content observed in liver tissues of chickens fed GPF and LPF (t = 2.600). This suggests high Cd contents in raw materials used for the feed formulation.

The analysis of the poultry feeds indicated a mean concentration of 290.7±90.4 $\mu gg\text{-}^{1}$ while the drinking water contained 1.10±0.1 $\mu gg\text{-}^{1}$ Fe. However, Iron is considered as a threat since the maximum tolerable level of Fe in poultry is 100 ppm (NRC, 1980). Comparatively, iron was most stable (C.V of 6.07 %) in liver tissues of chickens fed with VPF than those fed TPF (C.V = 13.13 %), GPF (C.V=18.39 %), LPF (C.V = 20.42 %) and

SPF (C.V of 27.76 %). These variations were possibly due to differences in the iron content of feed ingredients.

The observed concentration of Ni in the chicken samples was low compared with the 300 ppm Ni reported in NRC (1980). The overall stability trend varied in the order SPF>VPF>GPF> TPF> LPF. The Ni level in liver tissues of chickens fed with TPF differed significantly (p,0.01) from those fed GPF (t= 4.865); those fed VPF also differed significantly from those fed LPF. These differences reflect those in Ni concentrations in feeds.

The concentration of lead in our liver tissues (Table 3) was much lower than the maximum tolerable level (300 - 1000 μgg^{-1}) in poultry (NRC, 1980; Hermayer, 1977). The German Federal Health Agency guideline limit was 0.25 ugg^{-1} Pb daily dietary intake in chicken meat by human (Merian, 1991). The possible sources of Pb which contributed to differences in liver tissues were feeds, water and air-borne Pb in the environment. The coefficient of variation showed that liver tissues of chickens fed with TPF were least stable while the content tissues of chickens fed with SPF with were most stable. The stability of Pb follows the trend SPF> TPF> GPF> LPF.

CONCLUSION

The liver tissues of chickens fed with the different poultry feeds accumulated toxic metals through ingestion in their feeds and water, with a strong possibility of transfer to humans through the food chain. Thus, constant monitoring and regulation of quality of feed ingredients and chicken meat are advocated.

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