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Short communication

HEAVY METAL RESIDUES OF CHICKEN MEAT AND GIZZARD AND TURKEY MEAT CONSUMED IN SOUTHERN NIGERIA

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Summary

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The concentrations of iron (Fe), copper (Cu), zinc (Zn), nickel (Ni), manganese (Mn), cadmium (Cd), lead (Pb) and chromium (Cr) in chicken meat, chicken gizzard and turkey meat consumed in southern Nigeria were determined after nitric acid/perchloric acid digestion using graphite furnace atomic absorption spectrophotometry. The order of the elements in the chicken meat, chicken gizzard and turkey meat was as followed: Fe>Zn>Ni>Cu>Cr>Pb>Cd>Mn. The concentration ranges of the elements were: 23.59–97.72 mg.kg^{-1} Fe; 0.01–5.15 mg.kg^{-1} Cu; 4.95–48.23 mg.kg^{-1} Zn; 0.13–7.93 mg.kg^{-1} Ni; 0.01–1.37 mg.kg^{-1} Mn; 0.01–5.68 mg.kg^{-1} Cd; 0.01–4.60 mg.kg^{-1} Pb and 0.01–3.43 mg.kg^{-1} Cr. The concentrations of iron, manganese, copper, zinc were below the permissible limits while those of cadmium, nickel, chromium and lead in some samples were at levels above the permissible limits. The body burden with these elements is very dependent on the concentration of the various elements in major sources of animal protein, namely turkey meat, chicken meat and gizzard, the frequency of consumption of these foods and the rate of detoxification in the human body.

Key words: chicken meat and gizzard, heavy metals, turkey meat

Meat and meat products are important for human diet because they provide a great part of nutrients, including the necessary trace elements. Heavy metals from man-made pollution sources are continuously released into aquatic and terrestrial ecosystems and therefore, the concern about the effect of anthropogenic pollution on the ecosystems is growing. Contamination with heavy metals is a serious threat because of their toxicity, bioaccumulation and biomagnifications in the food chain (Demirezen & Uruc, 2006). These pollutants often have direct physiological toxic effects because they are stored or incorporated in tissues, sometimes permanently (Bokori *et al*., 1996; Mariam *et al*., 2004). In recent years, much attention has been focused on the levels of heavy metals in fish and other seafoods with little attention on the levels of heavy metals in chicken gizzard, chicken and turkey meats.

In Nigeria, chicken meat, gizzard and turkey meat are a major source of protein to the population and are widely consumed. The main source of metals in chicken and turkey meat arises from contamination of poultry feeds, and drinking

water source and processing. In view of the fact that there are very little or no available original data on content of metals in tissues of domestic and wild animals in Nigeria, studies were undertaken in order to determine these levels in chicken meat, chicken gizzard and turkey meat in southern Nigeria, with emphasis on hygienic and toxicological aspects.

A total of 210 random chicken meat, gizzard and turkey meat samples were collected in January–April 2007 from sales outlets situated in seven widely spread localities in southern Nigeria. The age, sex and feeding habits of these animals were not taken into consideration during sampling but it was assumed that they were up to 6 months, locally processed and packaged or imported. The samples (chicken muscles, chicken gizzard and turkey muscles) were collected in polyethylene bags and stored at −18 °C and analyzed as soon as possible. The digestion of the samples for determination of Cd, Pb, Mn, Ni, Cr, Fe and Zn was done using a mixture of HNO_3, $HClO_4$ and hydrogen peroxide (H_2O_2). The samples (2.00 g) placed in a digestion tube were predigested in 10 mL concentrated HNO_3 at 135°C until the liquor was clear. Next, 10mL of HNO_3, 1 mL $HClO_4$ and 2 mL H_2O_2 were added and temperature was maintained at 135 °C for 1 h until the liquor became colourless. The digest was slowly evaporated to near dryness (avoiding prolonged baking), cooled and dissolved in 1M HNO_3. The digests were subsequently filtered through Whatman filtre No 1 and diluted to 25 mL with 1M HNO_3. The content of Cd, Pb, Mn, Ni, Cr, Fe and Zn in the sample solution was analyzed using graphite furnace atomic absorption spectrophotometry (GBC scientific equipment Sens AAs 1175, Australia).

Appropriate quality assurance procedure and precautions were carried out to ensure reliability of the results. In all metal determinations analytical blanks were prepared in a similar manner. All glassware was carefully cleaned with a solution of 10% nitric acid for 48 h followed by rinsing with deionized water. In order to determine the reliability of instruments, a blank and known standard were run after every 6 samples. In addition, a recovery study of the total analytical procedure was carried out for metals in selected samples by spiking analyzed samples with aliquots of metal standards and then reanalyzed the samples. A recovery of greater than 92.4% was achieved.

The statistical analysis of data was done by the Student's *t* test .

The results for determination of metals in wet weight are shown in Table 1. The values measured in this study were compared with literature data referring to other meat types from different areas of the world and with international permissible limits. Daily consumption of chicken meat, turkey meat and chicken gizzard was set to 100 g/day/person. The results for the trace elements Cu, Fe, Mn and Zn indicated that Fe and Zn were present at higher concentrations than copper and manganese. Iron occurs naturally in plants and animals.

The concentrations of iron in the samples showed significant variability ($P<0.05$) among the different locations. In all locations the concentrations of iron in the chicken meat were significantly higher ($P<0.05$) than levels in the turkey meat and chicken gizzard except for turkey meat samples from Ughelli zone. The results indicated that chicken meat (22.07–97.72 $mg.kg^{-1}$) contained the highest concentrations of iron, followed by chicken gizzard (19.28–45.72 $mg.kg^{-1}$) and turkey

Table 1. Concentration ($mg.kg^{-1}$) of iron, copper, zinc, manganese, cadmium, lead and chromium in turkey meat (n=10), chicken meat (n=10) and chicken gizzard (n=10) collected from 7 different localities in southern Nigeria. The values are presented as mean ± SD

Location	Sample	Fe	Cu	Zn	Ni	Mn	Cd	Pb	Cr
Agbor	Turkey meat	14.32 ± 0.27	0.01±0.00	16.25±0.17	6.62±0.18	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00
	Chicken meat	92.72±4.61	0.33±0.17	6.12±0.15	7.30±0.11	0.01±0.00	0.23±0.10	0.98±0.15	0.33±0.14
	Chicken gizzard	32.88±5.70	0.46±0.58	10.19±0.11	6.03±0.12	0.05±0.03	0.01±0.00	3.22±0.20	1.05±0.11
Asaba	Turkey meat	15.75±1.70	1.00±0.27	15.41±0.23	7.93±0.26	0.01±0.00	0.18±0.11	0.01±0.00	0.99±0.21
	Chicken meat	48.90±8.00	0.25±0.12	10.93±0.69	5.31±0.14	0.13±0.08	0.01±0.00	4.60±0.92	0.29±0.08
	Chicken gizzard	20.49±3.21	1.95±0.43	12.62±0.08	2.25±0.09	0.01±0.00	0.30±0.15	0.01±0.00	2.02±0.28
Onitsha	Turkey meat	14.14±0.51	0.01±0.00	17.66±0.30	0.91±0.20	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00
	Chicken meat	30.74±3.85	0.01±0.00	10.81±0.11	1.20±0.16	0.01±0.00	0.16±0.13	0.01±0.00	0.01±0.00
	Chicken gizzard	19.38±3.67	1.93±0.58	21.42±5.25	5.33±0.11	0.01±0.00	0.14±0.10	0.01±0.00	2.30±0.12
Ughelli	Turkey meat	35.03±1.58	0.05±0.04	4.95±7.51	0.13±0.07	0.01±0.00	1.29±0.22	1.55±0.32	0.03±0.02
	Chicken meat	23.59±1.24	5.15±0.50	32.31±0.78	8.30±0.14	0.01±0.00	1.27±0.24	0.01±0.00	4.58±0.91
	Chicken gizzard	33.64±2.04	2.05±0.50	26.50±0.19	2.07±0.15	0.75±0.21	1.02±0.14	0.01±0.00	2.17±0.26
Sapele	Turkey meat	22.07±0.40	0.53±0.11	48.23±1.62	1.69±0.20	0.28±0.12	0.01±0.00	0.01±0.00	0.45±0.14
	Chicken meat	22.92±0.82	5.10±0.15	19.86±0.72	5.38±0.21	0.90±0.21	0.73±0.19	0.01±0.00	4.83±0.22
	Chicken gizzard	45.72±1.10	1.61±0.18	37.03±0.19	3.55±0.11	0.07±0.04	0.01±0.00	0.77±0.01	1.49±0.11
Warri	Turkey meat	15.79±1.66	3.36±0.21	33.30±1.75	20.78±14.42	1.37±0.21	5.68±0.29	1.26±0.29	3.43±0.17
	Chicken meat	27.41±0.94	2.91±0.15	21.42±0.24	9.02±0.12	0.01±0.00	0.30±0.15	0.01±0.00	2.88±0.19
	Chicken gizzard	31.17±2.11	2.55±0.28	9.63±0.21	4.48±0.20	0.07±0.06	0.01±0.00	0.01±0.00	2.33±0.18
Benin	Turkey meat	33.93±1.81	0.65±0.19	6.90±0.40	0.66±0.12	0.20±0.12	0.41±0.20	0.01±0.00	0.75±0.17
	Chicken meat	43.77±0.66	1.75±0.22	33.21±43.34	6.50±0.53	0.45±0.17	0.11±0.08	0.01±0.00	1.65±0.29
	Chicken gizzard	27.40±0.81	0.23±0.08	28.17±36.88	6.67±0.14	0.01±0.00	0.31±0.11	0.01±0.00	0.30±0.08

meat (14.14 to 35.03 mg.kg^{-1}) and therefore it could be used as a better source of this element. The levels of iron in the studied locations in Nigeria were lower than those reported by Demirezen and Uruc (2006) for certain meat and meat products in Turkey.

In this study, concentrations of Zn ranged between 4.95–48.23 mg.kg^{-1}; 6.12–33.21 mg.kg^{-1} and 10.19–37.03 mg.kg^{-1} for turkey meat, chicken meat and chicken gizzard, respectively. The mean Zn levels in samples collected within the same locality showed no significant difference except higher values found in chicken meat and chicken gizzard in comparison to turkey meat collected from Benin zone. The highest mean Zn level was observed in turkey meat samples collected from the Sapele zone. Mariam *et al*. (2004) reported mean levels of 28.53± 3.39 mg.kg^{-1} Zn in lean meat of poultry in Lahore. The levels of zinc we found in the present study are similar to those of Mariam *et al*. (2004). All the values in the studied samples were below the permissible limit (150 mg.kg^{-1}) set by the Australia-New Zealand Food Authority (ANZFA).

It should be highlighted that food is a principal source of copper (Cu) as an essential element for humans. In this study, the average Cu levels ranged between 0.01–3.36 mg.kg^{-1}, 0.01–5.15 mg.kg^{-1} and 0.46–2.55 mg.kg^{-1} for turkey meat, chicken meat and chicken gizzard, respectively. The chicken meat containedd more Cu compared to the gizzard and turkey meat in regions of Ughelli, Sapele and Benin. There was no significant difference in Cu levels between samples collected from the same locality except for gizzard samples coming from the Agbor zone. Mariam *et al*. (2004) reported higher concentration of copper in mutton, beef and poultry meat from Lahore region. Although Cu is an essential element, it is toxic and the maximum limit intake was set from 1 to 10 mg/day (WHO, 1996). Our data about Cu in turkey meat, chicken meat, and gizzards were below the permissible limit.

Nickel (Ni) can cause respiratory problems and is a carcinogen (Anonymous 2003; Agency for Toxic Substance and Disease Registry, 2004). The upper tolerable Ni intake for children (1–3 years old) and adults (19–70 years old) is 7 and 40 mg/day, respectively. The highest mean level of Ni was found in turkey meat samples collected from Warri zone (20.78 mg.kg^{-1}). The levels of Ni found in these samples did not exceed the upper tolerable intake levels of this element.

The concentrations of manganese (Mn) in samples were generally low compared to other metals studied. The highest Mn level was found in turkey meat samples from the Warri zone. Upper tolerable intake of Mn for people is 2–11 mg/day (Anonymous, 2003). The Mn levels in this study were below the upper tolerable intake for humans in all studied regions.

Excess lead (Pb) is known to reduce the cognitive development and intellectual performance in children and to increase blood pressure and cardiovascular disease incidence in adults (Commission of the European Communities, 2001). The Pb concentrations in this study varied between 0.01–4.60 mg.kg^{-1} for chicken meat; 0.01–3.22 mg.kg^{-1} for gizzards and 0.08–1.55 mg.kg^{-1} for turkey meat. The Pb content in chicken meat from the Asaba zone was significantly higher ($P<0.05$) than levels in chicken meat from any other locality. Excessive amount of Pb in chicken meat could not be attributed to industrialization alone. High levels of metals in poultry products emanate mainly

from contamination of feeds and water sources. Mariam *et al*. (2004) reported mean levels of 2.18 $mg.kg^{-1}$, 4.25 $mg.kg^{-1}$ and 3.15 $mg.kg^{-1}$ for lead in beef, mutton and poultry, respectively. The levels found in this study were much lower than these values and were under the permissible limits of 1 $mg.kg^{-1}$.

Food is one of the principal environmental sources of cadmium (Baykov *et al.,* 1996). All samples collected from Ughelli zone and turkey meat samples from the Warri zone showed higher Cd levels in comparison to the samples from other regions. Gonzalez-Weller e*t al*. (2006) reported mean levels of 1.68 $\mu g.kg^{-1}$ Cd in chicken meat, 5.49 $\mu g.kg^{-1}$ Cd in pork meat, 1.90 $\mu g.kg^{-1}$ in beef meat and 1.22 $\mu g.kg^{-1}$ Cd in lamb meat. Higher values of Cd were found in meat products consumed by the population in Teneriffe Island, Spain: 4.15 $\mu g.kg^{-1}$ Cd in chicken meat products, 6.50 $\mu g.kg^{-1}$ Cd in pork meat products, 4.76 $\mu g.kg^{-1}$ Cd in beef meat products; and 5.98 $\mu g.kg^{-1}$ Cd in turkey meat products. Mariam *et al*. (2004) reported Cd content of 0.33 $mg.kg^{-1}$, 0.37 $mg.kg^{-1}$ and 0.31 $mg.kg^{-1}$ for lean meat of beef, mutton and poultry respectively. Cd levels found in our study were comparable to levels reported by Mariam *et al*. (2004) and much higher than those reported by Gonzalez-Weller *et al.* (2006). The permissible limit of cadmium in meat is 0.5 $mg.kg^{-1}$ (Anonymous 2000; 2001b). The concentrations of cadmium exceeded the permissible limits in all samples from the Ughelli region, in turkey meat from Warri region and chicken meat from Sapele region.

Chromium (III) is an essential element at low concentrations and at the same time chromium (VI) is carcinogenic; the daily requirement for adults is estimated to be between 0.02 and 0.5 mg/day (Tarley *et al.*, 2001). In general, the total concentrations of chromium in meat and fish ranged from 0.01 to 1.3 $mg.kg^{-1}$ (Anonymous, 1996). However, in the current study, variations between 0.01 and 3.43 $mg.kg^{-1}$, 0.01 and 4.83 $mg.kg^{-1}$; and 0.38 and 2.33 $mg.kg^{-1}$ were observed for turkey meat, chicken meat and chicken gizzard, respectively. The Cr concentrations followed the order: chicken meat>chicken gizzard> turkey meat. The concentrations of this element varied significantly ($p<0.05$) between localities. The Cr levels recorded in this study were lower than those reported by Demirezen and Uruc (2006) for certain fish, meat and meat products in Turkey. The levels of chromium in this study met the estimated daily requirement for this trace element provided that daily meat intake was no more than 100 g.

In general, chicken meats contained higher levels of these metals compared to chicken gizzard and turkey meat. These levels of trace elements in samples could result from contamination of the feed, water source, the environment, the processing and the packaging. Therefore people that consume chicken meat in preference to turkey meat and chicken gizzard are likely to be exposed to higher metal levels. The information provided herein will be essential to frame guidelines and standards for heavy metals in meat and meat products in Nigeria.

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