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Analysis of Arsenic, Cadmium, Chromium and Lead Residue in Commercial Eggs in Damaturu Local Government, Yobe State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Authors HBG and IBMG designed the study and managed the literature review. Authors MB, HIA and MMG wrote the first draft of the manuscript, manage the analyses of the study and performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

Poultry egg is a self-contained unit for starting a new life, it is the most consumable animal protein in the world and so the safety of this important food for its role in the daily diet is paramount. The objectives of this study were to determine the sources of table eggs and to detect the residue of cadmium, lead, chromium and arsenic in commercial eggs meant for human consumption in Damaturu Local Government, Yobe state. Sixty table egg samples were collected using convenient

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sampling method. After preparation and processing the samples in the laboratory the concentration of these metals has been determined in whole egg, using digital calorimeter. Data were analysed using SPSS statistical package (Version 21). There are 2 major source of commercial eggs in Damaturu Viz: Damaturu farms and Jos, plateau state. The mean residue concentrations of these metals in the whole egg was as follows: Damaturu farms include 0.023 mg/kg, 0.043 mg/kg, 0.032 mg/kg and 0.002 mg/kg for cadmium, lead, chromium and arsenic respectively. Jos include 0.054 mg/kg, 0.023 mg/kg, 0.007 mg/kg and 0.008 mg/kg for cadmium, lead, chromium and arsenic respectively. The mean residue concentration of Cadmium sourced from Jos farms and Chromium from both Damaturu and Jos farms have exceeded the Maximum residue limit for these metals in table eggs. Therefore, it is cause for concern. It can be prevented or control through Farmers' awareness on the danger of heavy metal residue, adopting the principle of hazard analysis and critical control point and legislation by the government.

Keywords: Table eggs; digital calorimeter; cadmium; lead; chromium and arsenic.

1. INTRODUCTION

Food and agricultural organization classification of poultry production management system in Nigeria include Sector 1: an Industrial integrated system with a high level of biosecurity and birds/products marketed commercially. Sector 2: Commercial poultry production system with moderate to high biosecurity and birds/products usually marketed commercially, Sector 3: Commercial poultry production system with low to minimal biosecurity and birds/products entering live bird markets. Sector 4: Village or backyard production with minimal biosecurity and birds/products consumed locally [1]. The poultry industry is now the largest agricultural sector throughout the world [2,3]. Poultry is critical to Nigerian economy, providing income for small scale farmers and a source of quality protein for the population of Nigeria [4]. The poultry egg contains many essential nutrients, as it is a 'self-contained unit for starting a new life [2]. In 2008 the annual production capacity of commercial eggs in Nigeria is estimated at 8, 216, 208, 000 eggs equivalent to 273, 873, 600 crates of eggs [1].

Metallic elements are found in all living organisms where they play an important role, as structural, components of control mechanisms and enzyme activator. Some metals are essential as copper (Cu), zinc (Zn), calcium (Ca) and chromium (Cr) if present in permissible limits play a perfect role in the intrinsic mechanisms regulating vital biological processes [5]. Whereas nonessential metals especially lead (Pb) and cadmium (Cd) are toxic even in trace amount [6]. Global environment is polluted with heavy metal which leads to an increased interest in metals contamination of food stuffs and amongst them eggs which represent an important part of human's diet especially in children [7]. Lead is a chronic and cumulative poison, and affects enzymes, provokes anemia, renal toxicity, carcinogenicity, cardiovascular and neurobiological impact and negative consequences on the reproductive system [8]. Since lead is primarily deposited in cortical bones, the carry-over to edible tissues, eggs or milk is low [9,8]. Lead can be found in eggs at levels ranging from < 0.003 to 0.259 mg/kg according to surveys made in different European countries [10]. Cadmium occurs as a result of volcanic emissions and is found in the soil in variable concentrations, and can be absorbed by plants via roots [8]. It can be also present in impurities in mineral feed material. Cadmium toxicity is largely related to long-term exposure and results in pathologic changes in kidney, bones, neurotoxicity, carcinogenic and teratogenic [10]. Arsenic is a major constituent of many minerals in the earth crust, and is deposited in the soil from emissions from coal fired power plants, smelters, use in wood preservation and arsenical pesticides, which are not used anymore. Water can have high levels of arsenic in territories with thermal activities and with arsenic-rich rocks. Arsenicals have been used as feed additives for disease control and performance enhancers, but their use is discontinued in Europe. The toxic effects in humans are skin lesions and neurological effects and is also reported to be genotoxic to humans [9] Chromium in very low dose are nutritionally important elements but above safe level may be toxic either to animals or humans [9].

Detection of the heavy metals such as Arsenic, Cadmium, Chromium and Lead in the poultry eggs is very important due to their cumulative and carcinogenic effect on the consumer which can pose serious threats to liver and kidney [11].

In spite of public health interest in metal residue in food of animal origin available data in commercial eggs are scarce in Damaturu Local Government Yobe state and also there is lack of information on the source of table eggs for human consumption. Therefore, the present study was conducted to quantify the residue of Arsenic, Cadmium, Lead and Chromium residue in commercial eggs in Damaturu Local Government area, Yobe state.

Table 1. Permissible limits of cadmium, chromium, Lead and Arsenic in commercial eggs

Metals	Permissible limit (mg/kg)
Cadmium	0.05a
Chromium	0.002b
Lead	0.5a
Arsenic	0.5c

Source: [a11, b12, c13]

2. MATERIALS AND METHODS

2.1 Study Area

The study area is Damaturu Local Government, Capital of Yobe State, Nigeria. The climate of Damaturu is characterised by a long dry season with high evaporation rate from October to May and a short Wet season for the remaining part of the year. Generally, the mean monthly temperature is always above 20°C, but the daily extremes vary in a wide range reaching up to 47°C in April [14]. Poultry egg production enterprise in the study area is patronized by women than men [15]. Poultry production is a profitable venture [15].

2.2 Study Design

Sixty table egg samples were collected using a random sampling method. Thirty samples were collected from Fanzar farm within Damaturu, while 30 samples were collected from retailers. Information on the sources of eggs was obtained from the retailers. The determination of sample size for table eggs collection was based on convenience. The Table eggs collected were arranged in a clean crate, labelled and transported to the Yobe State University laboratory immediately for processing.

2.3 Sample Preparation

2.3.1 Sample Pre-treatment

The egg samples were removed from their shells and transferred quantitatively into separate clean 50 mL plastic containers and covered. The samples were then homogenised using a universal flask shaker, by agitating continuously for 2 minutes.

2.4 Sample Digestion

0.5 g of each sample was weighed into a thoroughly clean plastic container (microwave tube), 6ml of 65% HNO_3 and 2 ml of hydrogen peroxide (3:1) was added and then allowed to stand for a while. The plastic container (microwave tube) was then covered and placed into microwave digester (Master 40) and digested. A blank was also prepared in the same way as the sample.

The microwave digester was programmed to digest the sample at a temperature of 95°C for 30 min and then ramped at 5°C per min to 120°C and hold for 5 minutes. Total time taken for the digestion was 40mins and then followed by a cooling to room temperature in the microwave. The digested samples were diluted with deionized water to a total volume of 25 ml.

2.5 Sample Analysis

The potential presence of heavy metal in chemicals used in digestion was determined. Blanks were used simultaneously in each batch of the analysis to authenticate the analytical quality. The analysis was performed using digital colorimeter (HACH). The concentration of lead, cadmium, arsenic and chromium was determined in absorption mode. A calibration standard (of each heavy metal) was prepared ranging from 0.1 ppm to 15 ppm and the absorbance was taken. This absorbance were used to plot the calibration curve from which the sample concentrations were extrapolated.

2.6 Statistical Analysis

The statistical analyses was conducted using Microsoft excel Software (2007 version) to determine the level of heavy metal concentration in the samples. The absorbance of the samples, blank and calibration standards were taken and the corresponding concentrations were subsequently determined.

NOTE: The standard calibration curve was plotted for the absorbance of the standards against the corresponding concentrations (absorbance on Y-axis against Concentration on X-axis). The linear regression was determined

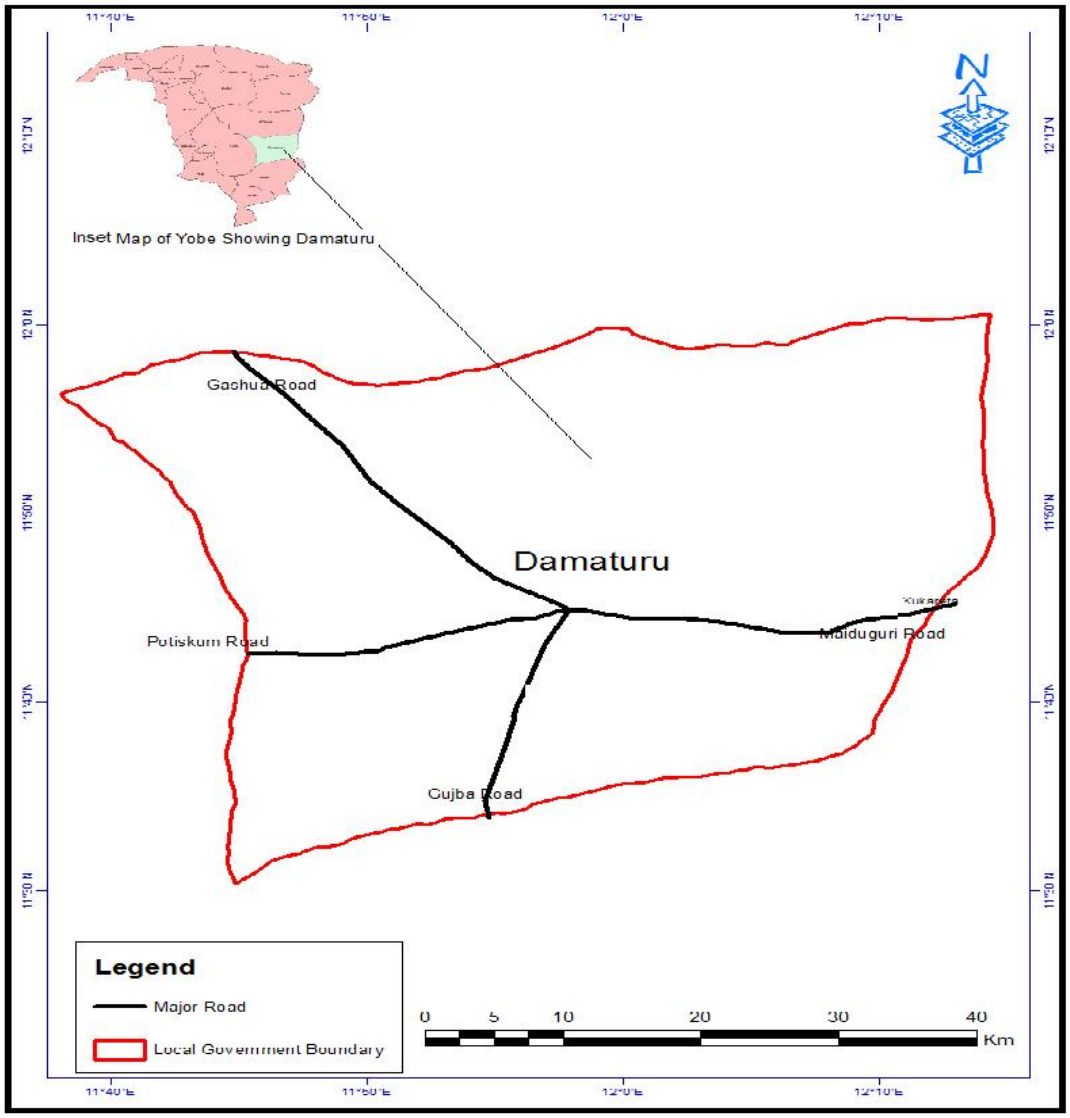

Fig. 1. Map of Yobe state, showing Damaturu Local Government, the study area

And the concentrations of the samples were calculated from the straight line equation, y = mx + c. Where y, is the sample absorbance and x is the corresponding concentrations. M and c are all constants.

3. RESULTS AND DISCUSSION

Out of the 30 egg samples from Damaturu farm, 16 (53.7%), 27 (90%) 23 (76.7%) and 16 (53.7%) were positive for arsenic, Cadmium, Lead and Chromium respectively (Table 2). Out of the 30 table egg sample from retail outlet 20 (66.7%), 21 (70%), 17 (56.7%) and 21 (70%) were positive for arsenic, cadmium, lead and chromium residue respectively.

The mean residue concentrations of metals in the whole egg was as follows: Damaturu farms include 0.023 mg/kg, 0.043 mg/kg, 0.032 mg/kg and 0.002 mg/kg for cadmium, lead, chromium and arsenic respectively (Table 3). Jos include 0.054 mg/kg, 0.023 mg/kg, 0.007 mg/kg and 0.008 mg/kg for cadmium, lead, chromium and arsenic respectively (Table 3).

There is a significant difference between the mean residue concentration of Arsenic,

Table 2. Percentage positive sample of commercial eggs for arsenic (As), cadmium (Cd), lead (Pb) and chromium (Cr) residues in Jos and Damaturu

Metal	Damaturu Number +ve (%)	Jos Number +ve (%)	Total +ve (%)
As	16 (53.7)	20 (66.7)	36 (60)
Cd	27 (90)	21 (70)	48 (80)
Pb	23 (76.7)	17 (56.7)	40 (66.7)
Cr	16 (53.7)	21 (70)	37 (61.7)

Table 3. Mean residue concentration of arsenic (As), cadmium (Cd), lead (Pb) and chromium (Cr) in commercial eggs from Jos and Damaturu

Location	As (mg/kg) Mean±SEM	Cd (mg/kg) Mean±SEM	Pb (mg/kg) Mean±SEM	Cr (mg/kg) Mean±SEM
Damaturu	0.002 ± 0.00	0.023 ± 0.01	0.043 ± 0.01	0.032 ± 0.01
Jos	0.008 ± 0.00	0.054 ± 0.02	0.023 ± 0.01	0.007 ± 0.00
Maximum residue limit (MRL)	0.5 mg/kg	0.05 mg/kg	0.5 mg/kg	0.002 mg/kg
Sig (p<0.05)	0.03	0.03	0.07	0.00

Cadmium, and Chromium in table eggs collected from Damaturu and Jos farms (Table 3).

All the samples used for the study were obtained from layer farms and retail outlets which source their eggs from Jos in order to compensate for the short fall from local production in the study area. Short fall is connected with low production in the study area.

Analysis of metal residue in commercial eggs is critical to poultry industry because of the importance of egg in dietary supplements. This study aimed to provide a base line data of Arsenic, cadmium, chromium and lead residue in commercial eggs, as such information hitherto is lacking in Damaturu, Yobe State, Nigeria. The mean residue concentration of Cadmium in table eggs sourced from Jos farms (0.054 ± 0.02 mg/kg) and Chromium in table eggs from both the 2 sources (0.032 ± 0.01 mg/kg Damaturu farms and 0.007 ± 0.00 mg/kg Jos farms) was higher than the Maximum residue limit (Table 1). A high residue of cadmium and Chromium above maximum residue limit might not be unconnected with the high intake of these elements by the birds from feed and water. This study on cadmium is in concord with the research of Islam et al*.* [4], Fakayode and Olu-Owolbi, [16], which reported residue above permissible or safe level. According to Zmudzki and Szkoda, [11], Surai et al*.,* [17], Kan and Meijer [18]: An increase in cadmium residue in egg is directly proportional to the increased cadmium content of feed. Study by Waegeneers et al*.,* [19], Al-Ashmawy, [20] disagree with the finding of this research that cadmium concentration was below the limit of quantification for the majority of egg samples. The result related to lead in this study is below the Maximum residue limit (Table 1), similar to the findings of Al-Ashmawy, [20] and disagree with the findings of Islam et al., [4], Ferguson et al*.,* [21], Hui, [22] they reported residue above acceptable daily intake. Lead has been shown to be associated with impaired neurobehavioral functioning in children. Impaired neurobehavioral development was considered to be the most critical effect [23]. Inorganic lead compounds are classified by The International Agency for Research on Cancer (IARC) as a probably carcinogenic to humans [24]. The arsenic residue in this study is below the permissible level which disagrees with the findings of Salwa et al*.,* [25], Nisianakis et al*.,* [26] who reported that arsenic burden was found in high concentration in chicken eggs. Chromium residue concentration in this research is alarming which is far above the maximum residue level (Table 1), this might not be unconnected with the feed, water or environmental contamination where the poultry layer are located. Finding in this regard is not in agreement with research of Islam et al*.,* [4], Salwa et al., [25], Nisianakis et al*.,* [26], Fakayode and Olu-Owolbi, [16]. They all reported negligible residue concentration of chromium. The difference in residue concentration of these metals from the two source of commercial eggs might be due to the level of environmental pollution with these elements from the farms where the eggs were sourced. International dairy federation, [7,8], Surai et al*.,* [17] made similar reports that is reminiscent of the finding of this study.

4. CONCLUSION

It is concluded that the Cadmium and Chromium residues concentration commercial eggs in this study is above the maximum residue level while Arsenic and Lead residues concentration were below the maximum residue limits.

5. RECOMMENDATION

Because of the importance of poultry egg in our dietary regimen, public awareness is critical to layer poultry production farmers with regards to metal residue and its public health hazard. Commercial farmers should adhere to the maximum residue limit of various metals in table eggs by adopting the principle of hazard analysis and critical control point or principle of quality assurance. Hazard analysis and critical control point concept on poultry layer production farming will ensure that commercial eggs made for human consumption is safe and wholesome.

DISCLAIMER

This paper is based on preliminary dataset. Readers are requested to consider this paper as preliminary research article, as authors wanted to publish the initial data as early as possible. Authors are aware that detailed statistical analysis is required to get a scientifically established conclusion. Readers are requested to use the conclusion of this paper judiciously. Authors also recommend detailed statistical analysis for similar future studies.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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