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RESEARCH ARTICLE

Egg consumption risk due to different metal residues: An estimation from two chicken egg types (exotic and local) collected from Sokoto, Nigeria

AI Umar[1*], Yusuf Sarkingobir[2], Kasimu Abubakar Shagari[3], Yalli Abu Abdulkarim[4]

[1]Department of Biochemistry, Sokoto State University, Sokoto, Nigeria
[2]Department of Environmental Education, Shehu Shagari University of Education Sokoto, Nigeria
[3]Department of Biology, Shehu Shagari University of Education Sokoto, Nigeria
[4]Department of Biology, Shehu Shagari College of Education Sokoto, Nigeria

[*]**Corresponding author:** supperoxidedismutase594@gmail.com

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Abstract

Eggs are important component of human diet worldwide. They provide the human body with diverse array of substances including metal elements. Due to pollution the eggs can incorporate metals at levels that are harmful. Thus, the objective of this work was to determine the levels of Ca, Mg, Fe, Zn, Cd, Pb, and Cr in eggs in Sokoto, Nigeria and health risk therewith. The metals were determined using atomic absorption spectroscopy. The results reveal, significantly ($p<0.05$) different concentrations of metals in commercial/ exotic and local chicken eggs in Sokoto, Nigeria as follows: The zinc (Local: 35.0 ± 1.5 ppm, Exotic: 30.12 ± 2.6 ppm) metal is the most elevated metal, followed by magnesium (Local:15.0 ± 0.05 ppm, Exotic:10.02 ± 1.5 ppm), then iron (Local: 7.0 ± 0.001 ppm, Exotic: 4.02 ± 0.001 ppm), then calcium (Local: 6.21 ± 0.01 ppm, Exotic: 5.01 ± 0.005 ppm). Others lower levels of metals are recorded by chromium (Local: 3.01 ± 0.05 ppm, Exotic: 4.51 ± 0.05 ppm), cadmium (0.061 ± 0.001 ppm detected in Exotic), and lead (Local: 0.05 ± 0.002 ppm, Exotic: 0.20 ± 0.002 ppm). The levels of essential metals found in eggs in this study are low, and levels of Cr, Cd, and Pb in exotic eggs are elevated. Similarly, health risk assessment result shows a public health concern. Care needs to be taken when consuming eggs by the public.

Keywords: Egg, Poultry, Zinc, Iron, Cadmium, Toxic, Essential.

INTRODUCTION

Poultry is a rich source of income in many countries and to many farmers' throughput the world. Poultry is among the famous agricultural sectors that is prominent in its role as producer of eggs that are used for a variety of purposes (Kabir et al., 2019). Eggs are a common source that provide us with important proteins, vitamins, lipids, and minerals among other things (Siddiqui et al., 2011;

Rokanuzzaman et al., 2022). Metals are present all over the environment to be used for the circle of the ecosystem substances and for industrial development. The surf for resources that are applicable in various human endeavours lead to excess disgorgement of metals in the environment in contact with man and consequent effects result. Moreover, some metals play essential roles as structural components in biological systems (such as in nerve), and at least in enzymes activations. These metals such as Fe, Zn, Ca, and Mg are essential, always need to be taken from food in optimum concentration. Excess or low intake can result in effects (Siddiqui et al., 2011; A. Umar, Sarkingobir, Umar, et al., 2022; A. Umar, Sarkingobir, and Dikko, 2022). Parable, zinc plays an important function in protein synthesis, wound healing, immunity, cell division, growth and development, and DNA synthesis. Iron is a major component of haemoglobin essential for oxygen transport in the body. Calcium is needed for bone making and muscle contraction. Magnesium is needed in the synthesis of ATP, the energy currency of the biological system (Siddiqui et al., 2011; Olagunju et al., 2020; Tschinkel et al., 2020).

Nevertheless, feeds and medicines which contain metals of various amounts are used in the course of poultry production. This practice coupled with pollution has been a concern, because there is possibility of incorporating excess of low amounts of metals in the poultry products at our midst that in turn can spur public health challenges (Dr. Krishna Mishra, 2020; Sarkingobir et al., 2020) Certainly, presence of toxic metals in poultry products is a great concern. Parable, lead metal has no known nutritional role and act to cause effects on almost all the major organs and systems of the body. Cadmium affects reproduction, bone synthesis, brain, kidney, blood, heart, and lungs (Labbo et al., 2021) Unfortunately, there is scarce information regarding the levels of metals in poultry products in the country. The study is imperative to laid foundation for further studies, give a recipe as baseline data, and inform the public or policy makers on decisions to improve public health. The objective of this work was to determine the levels of Ca, Mg, Fe, Zn, Cd, Pb, and Cr in eggs in Sokoto, Nigeria and estimated health risk therewith.

MATERIALS AND METHODS

Sample Collection

Three different chicken eggs from local and exotic sources were bought in Sokoto, Nigeria. The analysis of every element was carried out in thrice.

Procedure for Digestion

Fifty 50cm^3 of each sample was transferred into a beaker and 5cm^3 of concentrated HNO_3 was added into each beaker. The samples were heated on a hot plate until the solution appears pale yellow colour indicating the digestion was completed. After which solution allowed to cool and transferred to a 50cm^3 volumetric flask and distilled water was added to the mark and transferred into a sample bottle for atomic absorption spectroscopy (A. Umar, Sarkingobir, Umar, et al., 2022; A. Umar, Sarkingobir, and Dikko, 2022).

Principle of Atomic Absorption Spectroscopy (AAS)

In Atomic Absorption Analysis, the absorption of light uses an instrument called Atomic Absorption Spectrophotometer (AAS). In This process, flame system is generally employed to dissociate element from their chemical bonds. The atoms absorb light at characteristic wavelength when present in their ground state. A mixture of air and acetylene produce a flame which is of a sufficient high temperature to ensure the presence of free atoms of most elements. The use of nitrous oxide in place of air result in a higher temperature and this is necessary for the estimation of certain elements. The narrow spectral line of the sample necessitates the use of light source as well as high resolution monochrometer. This helps to prevent interference from adjacent spectral lines of other species on the sample matrix. AAS in conjugation with flame atomizer was used to determine specific metals in a

sample. The availability of a spectrometer equipped with a lamp turret will facilities the measurement of multiple metals in a sample (A. Umar, Sarkingobir, Umar, et al., 2022; A. Umar, Sarkingobir, and Dikko, 2022).

Procedure for Atomic Absorption Spectroscopy (AAS)

After the digestion has been completed, the AAS machine was used to determine the presence and concentration in the sample containing the metals analyte. The analyte is then aspirated into air-acetylene flame and in turn causing evaporation of the solvent and vaporization of free metal atoms. This method is called atomization, therewith, a light source (hallow cathode lamp) operating in the Uv-visible spectra region was used to cause electronic excitation of the metal and the absorbance was measured with a conventional Uv-visible dispersive spectrometer with photomultiplier detector (A. Umar, Sarkingobir, Umar, et al., 2022; A. Umar, Sarkingobir, and Dikko, 2022).

The descriptive statistics and one-way analysis of variance (ANOVA) were carried out at ($p<0.05$) significance level using Microsoft excel version 7.

Health Risk Estimation

Health risk due metals consumption in eggs were estimated using estimated daily intake (EDI), hazard quotient (HQ), and target cancer risk (TCR). EDI is given by QMC (average egg consumed by people daily, 132g, equivalent to three eggs daily) X C (concentration of metal in egg)/ Bw (body weight, 60kg for adult and 30kg for children). HQ= EDI/ RfD (reference oral dose, RfD for Fe= 0.700, Zn= 0.300, Cd= 0.001, Pb= 0.0035, Cr= 0.003). While, TCR= EDI x CSF (Cancer slope factor) (Njoga et al., 2021; Olagunju et al., 2020).

RESULTS AND DISCUSSION

Significantly ($p<0.05$) different concentrations of metals determined in commercial/ exotic and local chicken eggs in Sokoto, Nigeria were shown in Table 1. The zinc (Local: 35.0 ± 1.5 ppm, Exotic: 30.12 ± 2.6 ppm) metal is the most elevated metal, followed by magnesium (Local:15.0 ± 0.05 ppm, Exotic:10.02 ± 1.5 ppm), then iron (Local: 7.0 ± 0.001 ppm, Exotic: 4.02 ± 0.001 ppm), then calcium (Local: 6.21 ± 0.01 ppm, Exotic: 5.01 ± 0.005 ppm). Others lower levels of metals are recorded by chromium (Local: 3.01 ± 0.05 ppm, Exotic: 4.51 ± 0.05 ppm), cadmium (0.061 ± 0.001 ppm detected in Exotic), and lead (Local: 0.05 ± 0.002 ppm, Exotic: 0.20 ± 0.002 ppm).

Eggs are important as the poultry due their nutritional contents and uses in some areas of human endeavours. Embedded in the egg matrix there are proteins, minerals elements, vitamins and other useful components for human consumption (Silva et al., 2019). As animals, the chicken requires metallic elements for diverse array of purposes within the biological system and import these metals from the diet (Semple et al., 1968). However, due to the current spate of anthropogenic activities there is anxiety among the experts and the populations that the chicken could take in much essential metals and toxic metals and deposit them in their body parts and products such as egg (Okoye et al., 2011). Consequently, the consumption of eggs could spur toxicity of essential or non-essential metals in the human consumer when care is not taken (Irenosen, 2019; A. Umar, Sarkingobir, Umar, et al., 2022). Therefore, it is pertinent to bio-monitor the amounts of both essential and non-essential metals present in eggs to safeguard public health (Abduljaleel and Shuhaimi-Othman, 2011).

In the same vein, Fe is needed for synthesis and stocking of neurotransmitters, for haemoglobin synthesis and other purposes. Iron deficiency is seen in anaemia, and poor brain development (Mohammed et al., 2017). Zinc is essential for animal nutrition. However, excess zinc can result in diarrhoea, weakness, anaemia, gastrointestinal problems, vomiting, decreased immunity etc (Mohammed et al., 2017). Zn and Fe in local chicken (LC) are more concentrated than in exotic chicken (EC). However, they are lower than recommended daily intake for humans. Fe determined (Table 1) is lower than the values reported by a study from Kano (Mohammed et al., 2017) determined

in egg samples. Likewise, (Rokanuzzaman et al., 2022) found higher Fe in chicken in a Bangladesh study, but comparatively lower zinc in chicken eggs. Indeed, the presence of these metals can be attributed in most cases to their diets (ul Islam et al., 2014; Saad Eldin and Raslan, 2018; Rokanuzzaman et al., 2022).

Non-essential metals (lead, cadmium, and chromium) are more concern and need more monitoring in foods like egg from poultry, because at slight increase they can cause effects (Akter et al., 2020). Lead determined in this work is lower than the findings of Saad Eldin and Raslan, 2018 in Pakistan chicken eggs. Cadmium in exotic is higher than levels obtained from Pakistan study in eggs and is above the maximum permissible limit set by FAO/ WHO of 0.1 ppm (Saad Eldin and Raslan, 2018). The concern is, excess level of cadmium causes severe toxicity such as associated mutation, cancers, malfunction, Itai-Itai diseases, fractures, osteomalcia, thyroid dysfunction, and renal dysfunction among others both in man and poultry (Saad Eldin and Raslan, 2018). The chromium determined in this work (Table 1) was lower than the results of a study from an Indian study (Dr. Krishna Mishra, 2020). Additionally, the calcium is essential for bone formation; likewise, magnesium is an essential element needed in many purposes such as in the enzymes activation (Kabir et al., 2019). The values of calcium and magnesium obtained in eggs by this study is extremely lower than the outcome of a study from Bangladesh, and extremely lower than the required amounts in poultry feed (Kabir et al., 2019). The results showing levels of some metals in egg collected from Sokoto, Nigeria were shown in Table 1.

Table 1. Different concentrations of metals determined in commercial/ exotic and local chicken eggs in Sokoto, Nigeria

No	Metals	Local Chicken Egg (ppm)	Commercial/ Exotic Chicken Eggs (ppm)	Permissible Limit	Acceptable Limit
1	Iron	7.0 ± 0.001	4.02 ± 0.001		
2	Zinc	35.0 ± 1.5	30.12 ± 2.6	20	70
3	Chromium	3.01 ± 0.05	4.51 ± 0.05		
4	Cadmium	n.d	0.061 ± 0.001		
5	Lead	0.05 ± 0.002	0.20 ± 0.002	0.05	0.07
6	Calcium	6.21 ± 0.01	5.01 ± 0.005	0.5	0.5
7	Magnesium	15.0 ± 0.05	10.02 ± 1.5		

Table 2. Showing the Estimated daily intake (EDI) of different concentrations of metals determined in commercial/ exotic and local chicken eggs in Sokoto, Nigeria

		Local chicken egg		Exotic chicken egg	
No	Metals	Adult	Children	Adult	Children
1	Iron	15.4	30.8	8.844	17.688
2	Zinc	77.0	154	66.264	132.528
3	Chromium	6.622	13.244	9.9222	19.8444
4	Cadmium	0.0	0.0	0.1342	0.2684
5	Lead	1.1	0.44	0.44	0.88
6	Calcium	13.662	11.022	11.022	22.044
7	Magnesium	33.0	66.0	22.0	44.0

Table 3. Showing Hazard quotient (HQ) of different concentrations of metals determined in commercial/ exotic and local chicken eggs in Sokoto, Nigeria

		Local chicken egg		Exotic chicken egg	
No	Metals	Adult	Children	Adult	Children
1	Iron	22.0	30.8	8.844	17.688
2	Zinc	110	154	66.264	132.528
3	Chromium	2207.33	13.244	9.9222	19.8444
4	Cadmium	0.0	0.0	0.1342	0.2684
5	Lead	314.29	11.022	11.022	22.044

Table 4. Showing Target Cancer Risk (TCR) of different concentrations of metals determined in commercial/ exotic and local chicken eggs in Sokoto, Nigeria

		Local chicken egg		Exotic chicken egg	
No	Metals	Adult	Children	Adult	Children
1	Chromium	3.311	6.622	4.9611	9.222
2	Cadmium	0.0	0.0	0.05099	0.101992
3	Lead	0.0088	0.0176	0.000352	0.000704

Health risk due to consumption of metals (Pb, Cr, Cd, Fe and Zn) was estimated using some measurements of EDI, HQ, and TCR as shown in Tables 2-4. The estimated EDI for the determined metal residues in the two egg types (local and exotic) were shown in Table 2. Therein, the EDI when compared with provisional tolerable daily intake (PTDI) (the amounts of metals that can be taken daily without eliciting significant health risk) for Cd, and Pb shows that, the PTDI for cadmium 90.001 mg/kg/day) and lead (0.002 mg/kg/day) are lower than the values in Table 2. The EDI values for children might be more affected. The observation of excess EDI (especially in children) is similar to another finding that determined heavy metals in goat carcass in Southern Nigeria study (Njoga et al., 2021). The elevated levels of EDI could be mostly attributed to the increased rate of environmental; pollution where the chicken lives (Friday et al., 2011). Indiscriminate anthropogenic activities such as waste disposal, agrochemical addition, etc pollute soils, water, and plants. Since the chicken is nutritionally herbivore, it takes polluted plants laced with heavy metals, takes in water polluted with heavy metals, takes in feed polluted with heavy metals, and pick food from heavy metals contaminated soils (Akter et al., 2020; Njoga et al., 2021; Sarkingobir et al., 2022; Sarkingobir et al., 2023; Y. Umar et al., 2023). The HQ for Fe, Zn, Cr, Cd, and Pb metals residues in eggs in Sokoto was shown in Table 3. The values observed are all above the 1, except in the respect of Cd in local eggs. Thus, it ca be predicted that, there is possibility of risks due to the intake of the metals concentrations in the observed eggs (Njoga et al., 2021; Y. Umar et al., 2023). In Table 4, the cancer risk estimation due to metals consumption (TCR) shows that, Cr values are above 1, and in turn shows likelihood of cancer related effects (Labbo et al., 2021; Olagunju et al., 2020). Therefore, public health agencies should put more efforts in ensuring the safety of eggs being consumed by the public.

CONCLUSIONS

Eggs are important component of human diet worldwide. They provide the human body with diverse array of substances including metal elements. Both essential and toxic metals are needed to be properly monitored in eggs to safeguard public health, because little or excess intake of essential metals such as Ca, Mg, Z, and Fe can cause effects. Likewise, excess intake of toxic metals such as cadmium, chromium, and lead can elicit effects detrimental to health; therefore, have to closely monitored in our diet. The levels of essential metals found in eggs in this study are low, and levels of Cr, Cd, and Pb in exotic eggs are elevated. Care need to be taken when consuming eggs by the public.

Author contributions

AI Umar: Conceptualization, writing draft, writing review dan editing; Yusuf Sarkingobir, Kasimu Abubakar Shagari, Yalli Abu Abdulkarim: Data curation, formal analysis.

Conflict of Interest

There is no conflict of interest in this study.

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Data availability

We thank all respondents involved in this research project.

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