Global Journal of Scientific Research Publications
Published by: Sangotra Publishing House *ISSN (Online): 3139-5821*

Assessment of Heavy Metals in Commonly Consumed Snacks Sold Within Higher Institutions in Nigeria

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Abstract—*This study assessed the concentrations of cadmium (Cd), copper (Cu), lead (Pb), and iron (Fe) in two commonly consumed snacks, chinchin and peanuts, sold by vendors within the Air Force Institute of Technology (AFIT), Kaduna, Nigeria. Snack samples were randomly collected from selected vendors, oven-dried, digested with nitric acid, and analyzed using atomic absorption spectrophotometry. Mean metal concentrations in chinchin were 0.019 ± 0.001 ppm Cd, 0.027 ± 0.001 ppm Cu, 1.832 ± 0.698 ppm Pb, and 0.395 ± 0.105 ppm Fe, while peanuts contained 0.022 ± 0.013 ppm Cd, 0.153 ± 0.125 ppm Cu, 0.079 ± 0.012 ppm Pb, and 0.555 ± 0.144 ppm Fe. Although all measured metals (except Pb) were generally within permissible limits, lead was notably higher in chinchin and may warrant concern with habitual consumption. The findings suggest that routine monitoring of informal snack foods remains important for food safety and consumer protection, especially in institutional environments where vending is common.*

Keywords*— Heavy metals, snacks, AAS, concentrations, environment.*

I. Introduction

Food contamination by heavy metals is a persistent public health concern because contaminants can enter food during production, handling, packaging, storage, and distribution (Orecchio and Papuzza, 2009; Iwegbue *et al*., 2015; Arigbede *et al*., 2019). In many developing settings, informal food vending plays an important nutritional role, especially for students and workers who depend on affordable ready-to-eat snacks. Chinchin and peanuts are widely consumed in Nigerian tertiary institutions because they are cheap, convenient, and easy to store, but their safety depends on hygiene, raw materials, and processing conditions. Heavy metals such as Cd and Pb are toxic even at low concentrations, while Cu and Fe are essential but harmful in excess. Recent review evidence confirms that dietary exposure to toxic metals remains a global concern, particularly for vulnerable groups such as children and pregnant women (WHO, 2015).

Ready-to-eat snacks serve as a vital food source for students and urban dwellers; however, they are often produced in informal, unregulated environments, raising concerns about potential contamination (Oyelola *et al*., 2013). Improper packaging, unsanitary preparation, and contaminated raw materials can all lead to the introduction of heavy metals like Fe, Pb, Cu, and Cd into the food chain (Iwegbue et al., 2015). Given the high consumption rate of these snacks at AFIT, this study was conducted to evaluate the metal content of chinchin and peanuts and assess the associated dietary and health risks.

Rietjens *et al*. (2025) note that contaminants may be introduced at any stage of food handling, and that maximum levels are intended to protect human health while keeping contaminant levels as low as reasonably achievable. In this context, assessing heavy metals in commonly consumed snacks is important for documenting exposure risks and supporting preventive food safety measures (Iwegbue, 2011; 2012). The present study therefore examined Cd, Cu, Pb, and Fe in chinchin and peanuts sold within AFIT, Kaduna, Nigeria.

II. Materials and Methods

Study Area, Sample Collection, Sample Preparation and Analysis

The study was conducted at the Air Force Institute of Technology (AFIT), Kaduna, Nigeria. Two snack types, chinchin and peanuts, were purchased from three randomly selected outlets within the institution's market and transported to the laboratory for analysis. Samples were oven-dried at 60–70°C for 24 hours, milled, and sieved through a 2 mm mesh to achieve uniformity.

For digestion, 1.0 g of each sample was treated with diluted nitric acid, heated in a fume cupboard until digestion was complete, cooled, filtered, and made up to volume with deionized water. Atomic absorption spectrophotometry (AAS model FS280AA) was utilized to determine the concentrations of Fe, Pb, Cu, and Cd. Analytical blanks and standard calibration curves were prepared to support the analysis. Data were summarized descriptively, and mean concentrations were compared between snack types using an independent samples t-test in GraphPad Prism version 10.4.2.

III. Results

The mean concentrations of heavy metals found in the snacks are summarized in the table below:

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TABLE 1: Mean concentrations of heavy metals found in the snacks

Snack	Cd (ppm)	Cu (ppm)	Pb (ppm)	Fe (ppm)
Chinchin	0.019 ± 0.001	0.027 ± 0.001	1.832 ± 0.698	0.395 ± 0.105
Peanuts	0.022 ± 0.013	0.153 ± 0.125	0.079 ± 0.012	0.555 ± 0.144
FAO/WHO & NAFDAC (Max limit)	0.050 – 0.100	1.000 – 5.000	0.100 – 0.200	-

Cadmium, copper, lead, and iron were detected in both snack types. Mean concentrations in chinchin were 0.019 ± 0.001 ppm Cd, 0.027 ± 0.001 ppm Cu, 1.832 ± 0.698 ppm Pb, and 0.395 ± 0.105 ppm Fe. In peanuts, the corresponding values were 0.022 ± 0.013 ppm Cd, 0.153 ± 0.125 ppm Cu, 0.079 ± 0.012 ppm Pb, and 0.555 ± 0.144 ppm Fe (Table 1).

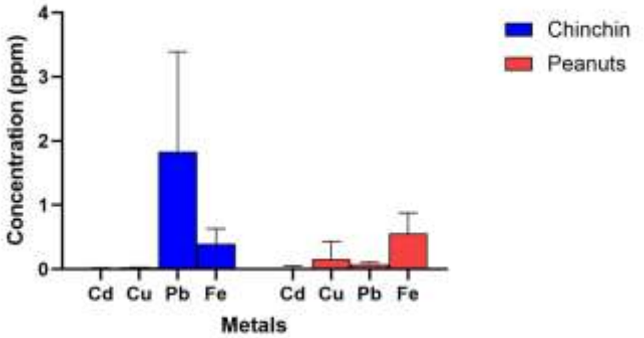

Fig. 1. Mean concentration of heavy metals in chinchin and peanuts

Cd and Cu were within allowable limits when compared to the FAO/WHO (1996) and National Agency for Food and Drug Administration and Control (NAFDAC) limits, while Pb in chinchin was higher than the benchmark and significantly higher than that in peanuts. Overall, the recorded levels suggest low contamination for most analytes, but the elevated lead level in chinchin is highly alarming for a processed snack, and this deserves attention because chronic dietary intake can increase cumulative exposure.

IV. Discussion

The presence of heavy metals in snacks is consistent with evidence that contaminants may be introduced through raw materials, environmental deposition, utensils, packaging, and poor processing conditions. The higher Pb concentration in chinchin (Figure 1) may reflect contamination during preparation, handling, storage, or exposure to combustion-related emissions around vending sites. Lead is especially concerning because it is a cumulative neurotoxin with no known safe exposure threshold for routine dietary intake (Wani *et al*., 2015). In general, the contamination of food and snacks by metals in areas with high anthropogenic pressure is widespread, and it is a major determinant of food quality (Iweala *et al*., 2014). The concentration of Pb in chinchin samples was found to be higher than that of peanut samples and exceeded the permissible limit of 0.200 mg/kg set by FAO/WHO (1996). The concentration of lead in this study is similar to a previous report on metals in ready-to-eat foods (Iwegbue *et al*., 2013). The presence of lead in the snacks may be due to processing, ingredients, handling, and preparation methods, which usually involve the burning of wood. The point of sale of flours could also be a contributing source in which lead from motor vehicle exhaust gets deposited on the snacks. The health issues associated with lead accumulation in humans include abdominal pain, renal disease, interference with the peripheral nervous system in adults, central nervous system in children, and cardiovascular diseases (Adefemi *et al*., 2012). However, the level of Pb recorded in this vended snack (chinchin) may pose a severe threat to the health of students who are major consumers of these products since the value exceeds the borderline.

Cadmium levels in both snack types were low, which is reassuring given cadmium's toxicity to the kidneys and bones with long-term exposure. Cadmium exposure occurs through food, which represents a major route. The data obtained for Cd revealed that the level of the metal in the vended snacks was lower and fell within the previously reported concentrations in food (Salama and Radwan, 2005; Ojo *et al*., 2015; Iweala *et al*., 2014). Cadmium content of the snack samples was found to be lower than the 0.02 mg/kg permissible limit set by FAO/WHO (1996). Copper and iron were present at low concentrations and are not unexpected because both are essential micronutrients; however, excessive intake can still be problematic depending on total dietary exposure. Low Cu concentration was recorded in this study when compared with the values reported by previous researchers (Mustafa *et al*., 2012; Iwegbue *et al*., 2013; Mohammed *et al*., 2016). However, the concentrations recorded in the present study showed that the Cu content in the snack samples fell below the permissible limit of 10.00 mg/kg set by WHO/FAO. Iron is an essential nutrient for both plants and animals, and its importance lies in the fact that many body functions are linked to iron-containing enzymes (Abbaspour *et al*., 2014). Water and processing utensils may have contributed to the high concentration of Fe in the peanut control sample. The side effects of consuming excess Fe in humans include vomiting, diarrhea, abdominal pain, iron overload, and organ damage (Ingleson, 2017). The overall pattern suggests that while the snacks may not pose an immediate major toxicological threat, continuous consumption could contribute to long-term exposure, particularly when multiple dietary sources are considered (Salahel Din *et al*., 2025).

These findings align with Codex guidance (Codex Alimentarius Commission, 2024) emphasizing preventive control of contaminants in food and ongoing monitoring throughout the food chain. The study supports the wider literature, which suggests that toxic metal contamination of the food chain is still relevant in daily diets, particularly in environments with informal processing and vending systems. For institutional food environments, routine surveillance and improved hygiene are essential to reduce avoidable contamination (Azevedo *et al*., 2024).

While all measured metals were generally within the FAO/WHO (1996) permissible limits, the study found that the levels of lead (Pb) in chinchin were significantly higher and exceeded the threshold of 0.200 mg/kg. Potential sources of this contamination include motor vehicle exhaust emissions near sales points, as well as handling and processing methods. While the current levels may not pose an immediate health threat, the potential for chronic accumulation underscores the need for routine surveillance of informal snack production to protect the health of students.

V. Conclusion and Recommendations

This study found generally low levels of Cd, Cu, and Fe in chinchin and peanuts sold within AFIT, Kaduna, Nigeria, with lead (Pb) being the main metal of concern in chinchin. Although the detected concentrations were mostly within the permissible limits set by regulatory bodies, the results support the need for routine monitoring, improved hygiene, and better handling practices in snack production and vending. In conclusion, the snacks analyzed may be generally safe for consumption, but the significant presence of lead in chinchin necessitates cautious monitoring. It is recommended that regulatory bodies and institutional authorities encourage hygienic practices at all stages of snack production and sale to mitigate heavy metal exposure.

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