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An Assessment of the Metal Concentrations in Maize (*Zea Mays*) Cultivated in Karu Local Government Area, Nasarawa State, Nigeria

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Abstract

The study aimed to assess the levels of heavy metal content in milled Maize (*Zea mays*) and Maize bran in Uke Local Government Area, Nasarawa State, Nigeria. Three communities were selected for the study using a sampling technique. Laboratory analysis was conducted to determine the Fe, Co, Pb, Mn, and Cu levels in the milled and bran maize samples. The data obtained underwent statistical analyses using ANOVA and regression. The results showed that the concentration of Pb was highest in milled maize (0.555 mg/kg), while Mn (0.21 mg/kg) had the lowest concentration among all combinations. These findings were within the acceptable consumption limits of the World Health Organization (WHO). It is recommended that routine monitoring of heavy metals is conducted in food to prevent excessive accumulation upon consumption.
Keywords: Heavy metals, Trace elements and Bioavailability

1. Introduction

Maize (Zea mays) is pivotal in Nigeria's agricultural sector, serving as a staple crop for millions of people. Its significance spans nutritional, economic, and cultural dimensions, making it indispensable to the country's food security and livelihood. It is a significant source of carbohydrates, providing essential calories for the Nigerian population. It also contains substantial amounts of protein, vitamins (such as vitamin A and B-complex vitamins), and minerals (including iron and zinc), which contribute to the overall nutritional status of consumers (Bello *et al*., 2022).
According to Adewale *et al*. (2021), Maize contributes significantly to the daily caloric intake of many Nigerian households, particularly in rural areas where access to diverse food sources is limited. However, contamination of Maize by heavy metals poses significant health risks to consumers. Heavy metals can accumulate in crops through soil, water, and atmospheric deposition, leading to potential toxic effects. Heavy metal contamination of food crops is an issue of global concern, and a significant cause for worry in Nigeria, which is the most populous country in Africa with a population of 220 million (World Population Review, 2024), as it ultimately results in toxicity and diseases in humans and animals through the consumption of contaminated soils and food crops, leading to environmental pollution from high levels of heavy metal accumulation in the environment and food crops (Saxena *et al*., 2024).
Heavy metals have atomic densities higher than 4 g/cm³. These include lead (Pb), cadmium (Cd), zinc (Zn), mercury (Hg), arsenic (As), silver (Ag), chromium (Cr), copper (Cu), iron (Fe), and platinum (Pt). The high level of environmental contamination by these metals is dangerous because their uptake in

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plants and subsequent accumulation in food crops consumed by humans and animals causes harm to health (Onakpa *et al*., 2018). Harmful metals are introduced by several sources, such as through the soil, which releases these toxic substances into food, air, and water. Other sources of metal contamination are through anthropogenic activities, such as applying fertilizer, usng pesticides, herbicides, and irrigation in agriculture. Additional sources are automobile emissions, paints, cigarette smoking, industries, and sewage and waste disposal. Evidence shows that heavy metals contaminate vegetables and other food crops consumed in Nigeria, and this is associated with adverse health issues, such as cancer, which is currently on the rise in Nigeria, leading to the need to monitor the levels of these harmful elements in food crops (Joseph *et al*., 2020). Understanding the metal content in Maize is crucial for assessing potential consumer health risks and environmental impacts. This study evaluates the concentration of heavy metals in Maize (*Zea mays*) cultivated in Karu Local Government Area, Nasarawa State, Nigeria.

2. Materials and Method

The study was conducted in January 2023 at Uke (Lat 9.0 ° N and Long 7.75° E) in Karu Local Government Area, Nasarawa State, Nigeria. Karu LGA lies in the western part of Nasarawa State and shares borders with the Federal Capital Territory (FCT) to the west, which makes it part of the Abuja metropolitan area.

Sample collection and preparation

Through sampling, four samples of unmilled maize and maize bran were collected from three farming communities in Uke town. The samples were packed in nylon bags and transported to the Muhammadu Buhari Research Institute Laboratory for analysis. The concentrations of metals such as Fe, Co, Pb, Mn, and Cu were analyzed using atomic absorption spectrophotometry (AAS). The results were compared with international standards to determine the safety of maize consumption and the implications for sustainable agricultural practices.

Apparatus and Reagents used

Weighing balances, Conical flasks, Beakers, Filter papers, Funnels, a Measuring cylinder, Nitric acid, and Hydrochloric acid. Laboratory analysis was conducted following the method of Hamon *et al.* (1998), and data were collated. The mean values obtained for Fe, Co, Pb, Mn, and Cu from the samples were compared by ANOVA at the 95% level using regression to compare levels of heavy metals from maize grains.

3. Results and Discussion

Analysis of the samples were carried out in the laboratory and the following results were obtained (Table 1).

Table 1: Result for metal analysis in milled maize.

Sample	Pb (mg/kg)	Mn (mg/kg)	Co (mg/kg)	Cu (mg/kg)	Fe (mg/kg)
Milled red maize	0.555 ± 0.003	0.210 ± 0.040	0.239 ± 0.004	0.323 ± 0.003	0.111 ± 0.004
Unmilled red maize	0.398 ± 0.002	0.207 ± 0.012	0.459 ± 0.003	0.340 ± 0.002	0.889 ± 0.010

* 0.05 Significant difference

The findings from our research, as presented in Table 1, are paramount in food safety. They reveal a consistent trend: unmilled Maize consistently has lower heavy metal (Pb, Mn, Fe, Cu, Co) content than the milled variety. Notably, Pb was highest in milled Maize Maize (0.555 mg/kg), while Mn (0.21 mg/kg) had the lowest concentration among all combinations. Importantly, all values obtained for both milled and unmilled Maize were within the FAO/WHO permissible value limits, underscoring the safety of both.

The observation that unmilled Maize has lower metal content than milled Maize can be attributed to several factors, such as contamination during the milling process and metals from the machinery that can leach into the Maize during grinding and milling. This contamination is often due to wear and tear of the equipment or inadequate cleaning and maintenance practices; Dust and other particulates in the milling facilities might contain heavy metals, which can settle on the Maize during processing. The handling and transport of milled Maize involve more steps and potential contamination points. Each stage in the supply chain can introduce heavy metals through contact with contaminated surfaces or exposure to polluted environments. After milling, Maize is often stored in different conditions compared to unmilled Maize. Storage containers, bags, and environments for milled Maize may not be as controlled, leading to higher chances of contamination from metals. Another challenge is residual contamination as Milling facilities often process multiple batches of grains. If heavy metals are present in one batch, residues can remain in the equipment and
contaminate subsequent batches of Maize. These results were consistent with those obtained by Saxena *et al*. (2024), who comprehensively examined the intricate interplay between heavy metal contamination, the food chain, and the associated health risks to human populations. The investigation encompasses a multifaceted exploration of the sources, pathways, and mechanisms involved in bioaccumulating heavy metals within the food web. They established that metals can seep into food during the processing stage.
This position was also supported by Joseph *et al*. (2020) who carried out similar studies and proposed that during the milling process, both surfaces of the plates having small ridges run from the edge to centre, grinding by power rotating one mobile plate against a stationary plate. In the process, grains that pass between the plates are crushed to powder. The cast iron materials, produced from the amalgamation of iron with nickel, chromium, copper, molybdenum and silicon, are expected to increase the tensile strength of the milling plate and prevent or resist wear and tear. However, due to the varying qualities of milling plates on the market, studies have established the presence of contamination with some metals in milled products.

Long-term accumulation of heavy metals in soils results in contamination of food crops, and studies have proven that heavy-metal-contaminated food crops, fruits, and vegetables can contain levels higher than the recommended tolerable values proposed by the European Union (EU), USEPA, FAO, and WHO (FAO/WHO, 2022) .The implication of these results is clear: there is a pressing need to monitor the post-harvest of food just as much as precautions taken during field activities. This underscores the importance of continuous vigilance in ensuring food safety (Bello and Aladesida, 2022).

Table 2: Recommended Dietary Allowances for Selected Trace Elements Established by the Food and Nutrition Board, Institute of Medicine, National Academy of Sciences.

Age	Copper (µg/day)	Iodine (µg/day	Iron (µg/day)	Selenium (µg/day)	Cobalt (µg/day)	Zinc (µg/day)
0–6 mts	-	-	-	--	-	-
7–12mts	-	-	11	-	-	3
1–3 yrs	340	90	7	20	0.9	3
4–8 yrs	440	90	10	30	1.2	5
9–13 yrs	700	120	8	40	1.8	8
14–18 yrs	890	150	11M/15F	55	2.4	11M/9F
19–50 yrs	890	150	8M/18F	55	2.4	11M/9F
51 and above	900	150	8	55	2.4	11M/8F
In Pregnancy						
≤ 18 years	1,000	220	27	60	2.6	13
19 – 50 years	1,000	220	27	60	2.6	13
During Lactation						
≤ 18 years	1,300	290	10	70	2.8	14
19 – 50 years	1,300	290	9	70	2.8	12

Key: F, female; M, male Culled from Jarup. (2021)

Table 2. shows the Recommended Dietary Allowances for Selected Trace Elements Established by the Food and Nutrition Board, Institute of Medicine, National Academy of Sciences. It serves as a guide to avoiding serious health problems that can result from excessive exposure to heavy metals, as the consumption of contaminated foodstuffs can seriously deplete some essential nutrients in the body, leading to decreased immunological defences, intrauterine growth retardation, impaired psychosocial behaviours, disabilities associated with malnutrition, and a high prevalence of gastrointestinal cancer.

4. Conclusion

The consumption of contaminated food crops can lead to the prolonged accumulation of heavy metals in the body. The adverse effects of this accumulation may manifest only after several years of exposure, contributing to the onset of various health disorders. Research has shown that locally available foodstuffs in different regions of Nigeria are a significant source of heavy metal exposure, posing a public health concern (Bello, 2022). Maize, a fundamental dietary component of a substantial portion of the Nigerian population, necessitates diligent oversight due to the scarcity of food intake records in Nigeria for monitoring the presence of heavy metals and their concentrations in blood and urine. More data is needed to reflect the imperative for more comprehensive monitoring protocols (Usman and Abdulrahman, 2020). Implementing soil management practices such as routine soil testing for heavy metal concentrations is advisable to detect contaminated areas and monitor changes over time. Additionally, utilizing organic fertilizers, practising organic farming, and implementing crop rotation are recommended. Public awareness and education can be raised through farmer training programs, community engagements, and educational initiatives. Furthermore, conducting post-harvest activities, continued research, and enforcing appropriate food policies and regulations can significantly mitigate the risk of heavy metal contamination in maize, thereby ensuring a safer food production process. and contributing to sustainable agricultural practices.

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