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The Levels of Heavy Metal in Some Selected Grains Sold in Makurdi Markets, Benue, Nigeria

***Yusuf, E. Y., Joshua, G. A. and Yusuf, M. A.**
Federal University of Agriculture Makurdi, Gombe State University, Gombe State University
Email: *emmanuelyila@uam.edu.ng, Gayusa01@gmail.com; Sirmaina90@gmail.com

ABSTRACT
This research was conducted to determine the concentrations of heavy metals in different cereal crops (rice, beans, and soya beans). Two different samples each were bought in two different markets (Wurkum and North band) in Makurdi and were analyzed, using atomic absorption spectroscopy (BK-AA320N). The result of the analysis from both markets ranged as follows: Magnesium (Mg) 0.458 – 0.999ppm; Nickel (Ni) 0.227 – 0.543 ppm; Calcium (ca) 0.192 – 0.716 ppm; Iron (Fe) 0.314 – 0.730 ppm; Lead (Pb) 0.317 – 0. 501 ppm and Chromium (Cr)0.139 – 0.852 ppm, for soya beans, beans and rice. The levels of heavy metals determined in the analyzed cereal samples were found to be below the permissible limit set by WHO; hence, the concentration of these heavy metals in the selected analyzed cereals, may not presently pose a health hazard in the population.
Keywords: Atomic Absorption Spectroscopy, Cereals, Heavy Metals, Makurdi

INTRODUCTION
The proliferation of heavy metal contamination poses a significant environmental health hurdle, carrying potential dangers due to bioaccumulation along the food chain [1]. This phenomenon stems from rapid industrial expansion, increased utilization of agricultural chemicals, and urbanization. Consequently, heavy metals are dispersed throughout the environment, leading to compromised public health, primarily through the consumption of contaminated food crops [2]. The absorption and subsequent accumulation of heavy metals by plants pose a potential hazard to the health of animals and humans [3]. The type and quantity of heavy metals present in food vary from one type of food to another, influenced by factors such as the type of soil, agricultural inputs, growing season, and other environmental conditions. Additionally, the accumulation of heavy metals is contingent upon plant species, with the effectiveness of metal absorption determined by either plant uptake or soil-to-plant transfer factors [4]. Cereals stand as a primary nutrient source in northern Nigeria and hold the status of being the most prevalent food consumed in the region. They are cultivated and dispersed across the country through retail channels, providing a reliable energy and mineral source, especially for humans [5]. Cereals boast richness in carbohydrates, *trace* elements, vitamins, oil, and protein [6]. However, the contamination of food crops by heavy metals is a pressing global concern, leading to toxicity and illness in both humans and animals upon the consumption of contaminated soils and crops. The population endures environmental pollution due to elevated levels of heavy metal accumulation in both the environment and food crops. The substantial environmental contamination by these metals poses a significant threat, as their absorption by plants and subsequent accumulation in crops consumed by humans and animals can have detrimental health effects. It is in light of these concerns that the researcher aims to assess the concentration of heavy metals in specific grains within two markets in Makurdi, Benue State.

MATERIAL AND METHODS

Sample Area
The work was carried out in Makurdi, Benue State. Makurdi is the capital of Benue State of Nigeria. The city is located 7.73 latitude and 8.52 longitudes, alongside River Benue. It has a population of 422,159 according to the 1996 population census.

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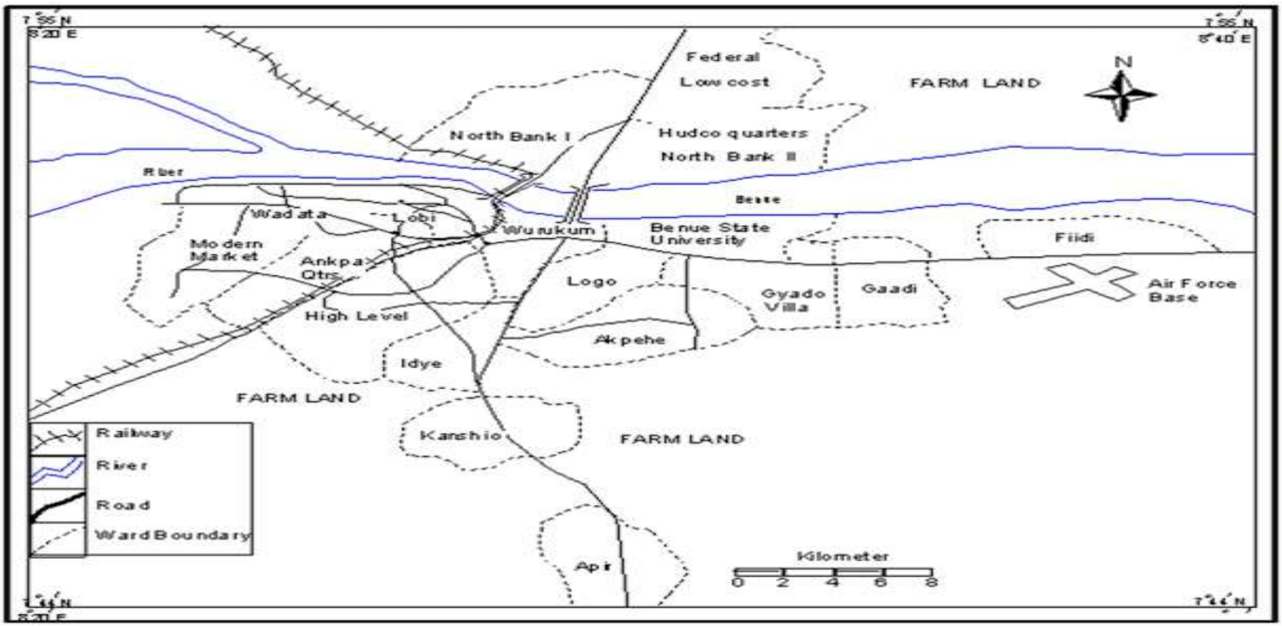
Table 1: Sample Code labeling.

S/N	Sample Code	Sample	Area	Name of Place
1	A	Soya Beans wkm	Wurkum	Wurkum
2	B	Soya N/B	North bank	North bank
3	C	Beans N/B	North bank	Northbank
4	D	Beans WKM	Wurkum	Wurkum
5	E	Rice N/B	North bank	Northbank
6	F	Rice WKM	Wurkum	Wurkum



Sample Collection and Preparation

Rice, beans, and soybeans were acquired from Wurkum and North band markets, then packed in polythene bags with appropriate labeling upon purchase, as they were already dried. Due to the presence of dust and other undesirable particles, the samples were washed with distilled water. These samples represented the seeds of three cereal crops: rice (Oryza sativa), beans (Phaseolus vulgaris), and soybeans (Glycine max). An electric blender was utilized to mill the samples, and a suitable sieve made of high-density polyethylene (HDPE) was employed for sieving.

Sample Digestion and Analysis

2.5 g of the sample, previously dried to constant weight was placed in a 100 ml reflux flask. 15 ml of concentrated HNO_3 and 5 ml of concentrated H_2O_2 were mixed with the sample. The mixture was allowed to stand for about 48 hours at room temperature. It was then refluxed on a heating mantle at 90°C until brown fumes ceased to evolve, 4-6 h, and allowed to cool. 5 ml of 60% (v/v) $HClO_4$ was added to the mixture and further refluxed for 30 min. The digest was allowed to cool at room temperature. It was filtered into a 100 ml volumetric flask with a Whatman NO. 42 filter paper and made to the mark with de-ionized (DI) water. This was repeated for all the samples, blank was also prepared similarly and then ready for AAS analysis (Haware and Pramode, 2011). Concentrations of Pb, Mn, Ni, Fe, Cr, Ca was determined using an Atomic Absorption Spectrophotometer (AAS).

RESULTS AND DISCUSSION

Table 2: Level of Heavy Metals in Cereals Sample from Wurkum Market

Serial number	Sample Code	Cereals	Source	Manganese (ppm)	Nickle (ppm)	Calcium (ppm)	Iron (ppm)	Lead (ppm)	Chromium (ppm)
1	A	Soya Beans	Wurkum Market	0.659	0.227	0.373	0.314	0.501	0.256
2	D	Beans	Wurkum Market	0.623	0.484	0.716	0.730	0.317	0.442
3	F	Rice	Wurkum Market	0.998	0.531	0.290	0.360	0.428	0.464
			Mean	1.614	1.185	1.185	1.164	0.960	0.852

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Table 3: Level of Heavy Metals in Cereals Sample from North Bank Market

Serial number	Sample Code	Cereals	Source	Manganese (ppm)	Nickle (ppm)	Calcium (ppm)	Iron (ppm)	Lead (ppm)	Chromium (ppm)
1	B	Soya Beans	North Bank	0.767	0.506	0.676	0.425	0.429	0.613
2	C	Beans	North Bank Mk	0.671	0.475	0.192	0.611	0.377	0.352
3	E	Rice	North Bank Mk	0.458	0.543	0.417	0.726	0.456	0.139
			Mean	1.590	1.162	1.007	1.278	1.034	1.034

Based on the results presented in the above (Table 1 and 2), the manganese concentration ranged from 0.458 to 0.999 ppm. Notably, rice from Wurkum exhibited a higher concentration compared to all other samples. In previous studies, the mean concentration for rice was lower, specifically 13.30±4.56 [9]. Conversely, the amount detected in beans from the Kafur market was 0.049 ppm lower than in this study, whereas soybeans surpassed this study by 16.88 mg/kg (Ahmed and Mohammed, 2005). Upon comparison with the World Health Organization (WHO) standard, it was determined that the manganese concentration fell within the permissible level of 0.2 mg/kg [7].

The mean concentrations of nickel ranged from 0.227 to 0.543 ppm in beans, rice, and soybeans. For rice, the mean nickel concentrations were lower than 0.81±0.72, as reported by [1]. In beans from the Kafur market, nickel was detected at 0.002 ppm [8], while in another study, nickel levels in soybeans ranged from 4.08 to 22.37 ppm [9]. All nickel levels found in this study were below 1.0 ppm, which aligns with the permissible level set by the World Health Organization [7]. Research indicates that certain forms of oral nickel intake exceeding 0.6 ppm can be acutely toxic to humans [6], thereby confirming that the nickel levels in the samples are at non-toxic concentrations.

The calcium concentrations in beans, rice, and soybeans varied from 0.192 to 0.716 ppm. Previous research indicates that rice and beans had mean calcium levels of 1.3 ppm and 1.52 ppm, respectively [3]. Additional studies have shown varying calcium contents in soybeans, ranging from 3000.36 mg/kg [10] to 780 mg/kg [8]. [11] found that soybean seeds grown in southwestern Poland contained 1700 mg/kg of calcium. The recommended daily allowance of calcium for adults in the US is 1000-1200 mg/day. Based on the results obtained, there is no apparent risk of calcium toxicity.

The average lead concentration varied between 0.317 and 0.501 ppm. In other studies, the mean lead concentration in rice was below 0.94 ppm [6]. Additionally, [10] reported lead concentrations ranging from 4.084 to 14.475 mg/kg. [12] found the maximum lead concentration in beans to be 1.52 mg/kg, while in soybeans, it ranged from 0.015 to 1.18 ppm [6]. According to this research, lead concentrations in grains remain below the WHO standard limit of 0.2 ppm.

Chromium was detected in all examined cereal samples and its values ranged from 0.139 to 0.852 ppm. From other studies, the mean concentration of Cr for rice was less when compared to a study carried out by [12] and it was observed also that beans ranged from 0.189 - 0.586 ppm [5], while soybeans were 1.58 ppm [8]. When compared to the WHO standard it was found to be above the permissible level of 0.5 ppm [7].

The disparity between this study and others may stem from heavy metal toxicity, which can arise from various sources such as contaminated irrigation water, fertilizer and pesticide use, industrial emissions, harvesting practices, transportation, storage, or sales. Additionally, variations in heavy metal concentrations between this study and others might be attributed to differences in the geographical locations of the cereals. Farmlands located in industrialized areas are susceptible to pollution from chemical releases, potentially contaminating plant crops.

CONCLUSION

This study analyzed cereal samples purchased from two different markets for their heavy metal (Mg, Ni, Ca, Fe, Pb, and Cr) content. The findings indicated that the majority of the analyzed grains did not surpass the WHO permissible limits. Hence, these cereal samples can be deemed safe for consumption and could potentially provide trace metals to the population.

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