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Assessment of Some Heavy Metals Concentrations in Selected Cereal Grains in Adamawa State, Nigeria

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ABSTRACT

Cereals are the most widely consumed food and a major source of nutrients. Grown and sold nationwide through retail outlets, cereals are especially important to humans as a consistent source of energy and minerals**.** Hence the aim of this paper was to assess the level of heavy metals concentration in cereal grains in Hong Local Government Area (LGA), Adamawa State, Nigeria. The samples were crushed, sieved, and digested and were analyzed using atomic absorption spectrophotometer (AAS). The heavy metals, Pb, Cu, Cr, Zn and Cd, were detected in rice, maize, millet, and guinea corn. The concentration in the samples ranged as follows: 30.299-1.382 mg/kg (Zn), 1.233-0.063 mg/kg (Pb), 0.260-0.003 mg/kg (Cd), 16.770-0.517 mg/kg (Cu) and 0.652-0.013 (Cr). Cd was not detected in millet and guinea corn at Garha Larh and also in rice and millet at Waja. The concentration of Pb, Cd and Cr in cereal grains in certain locations contained high concentration of the metals, whereas the levels of other metals remained within WHO permissible limits . These findings underscore the urgent need for regular monitoring and intervention to ensure food safety and protect public health in Hong LGA.

Keywords: Atomic Absorption Spectrophotometer, Cereal Grains, Heavy Metals, Adamawa State

INTRODUCTION

In northern Nigeria, cereals are the most widely consumed food and a major source of nutrients. Grown and sold nationwide through retail outlets, cereals are especially important to

humans as a consistent source of energy and minerals [1]. According to Doe et al [2], they are high in protein, oil, vitamins, carbohydrates, and trace minerals. However, Okaka [3] found that grain protein is deficient in lysine.

The term "food safety" refers to the absence or presence of pollutants, adulterants, naturally occurring poisons, or any other material that could provide a short-term or long-term risk to human health. Food quality is a multifaceted attribute that influences the value and acceptance of food among consumers. Plant species, genetics, soil and metal kinds, soil conditions, weather, environment, maturity stage, and supply route to the market all affect how much metal accumulates in plants [4,5].

According to Haware et al [6], heavy metals are environmental pollutants that can have a negative impact on human health if consumed in excess through food. They are persistent, non-biodegradable, have long biological half-lives, and can accumulate through biological chains. Contamination of irrigation water, fertilizer and metal-based insecticides, industrial emissions, harvesting, transportation, storage, and sale are all potential causes of heavy metal toxicity. According to Bempah et al [7], crops and vegetables cultivated in heavy metal-contaminated soils accumulate more than those grown in uncontaminated soils. This is due to the fact that farms located in industrialized areas are vulnerable to pollution from chemical releases into the fields, which can contaminate crops [8, 9]. While Fe, Cu, Mn, Zn, and Ni are regarded as necessary trace elements, elements like Cd, Cr, and As are thought to be carcinogenic. Elements such as Cd, Cr, and Ni are considered carcinogenic, but Fe, Cu, Mn, Zn, and Ni are considered vital trace elements. Eating cereal grains tainted with heavy metals may be harmful to human health [6, 10]. Although trace elements do not contain calories, if they are present in the necessary levels, they are crucial to the human body's ability to regulate metabolism. For instance, they are co-enzymes and co-factors in the human system, and they have many functions in the development of the immune system, metabolism, and growth [11]. However, these vital components become hazardous to our health if their amounts are higher than what is considered appropriate [12]. According to Oti [13], Pb poisoning can have an impact on the body's musculoskeletal, renal, ophthalmic, immune system, and reproductive systems. When plants are produced on or close to hazardous sites, it is crucial to take attention

of the possibility of heavy metal contamination in food. Food quality control includes metal analysis as a crucial component [11].

Research work carried out by Muhammed and Ibrahim [14] on assessment of heavy metals concentration in some doil and irrigated cereals in Mubi, Adamawa State, Nigeria obtained a results ranging from (0.004-0.34 mg/kg) for Pb, (0.11-0.18 mg/kg) for Cd, (7.19-33.5 mg/kg) for Cu and (8.72-29.3 mg/kg). Similarly, Sulyman et al [15] carried out studies concentration of heavy metals in some selected cereals sourced within kaduna state, Nigeria and obtained a result 1.58, 0.98, 5.23, 0.90 and 2.41 mg/kg for Cu, 0.70, 2.01, 4.51, 2.04 and 11.32 mg/kg, for Zn and 8.24, 5.99, 10.54, 18.97 and 13.61 mg/kg for Fe.

The novelty of this work is to assess the level of heavy metals in cereal grains cultivated in Hong LGA, of Adamawa State in which little or no work has been done on cereal grains cultivated in those locations.

This work was aimed to assess the level of heavy metals in cereal grains in Hong LGA, Adamawa State Nigeria. It focuses on cereal grains (maize, rice, millet and guinea corn).

MATERIALS AND METHODS

Sample Collection and Sample Preparation

A total of sixteen cereal grains samples was collected form four villages namely, Shashau, Munga, Garha Larh and Waja in Hong Local Government Area of Adamawa State Nigeria. The cereal grains samples which include maize, rice, millet and guinea corn were picked randomly from various locations on the sample farm land and was mixed for analysis. The hard samples were ground using a wooden pestle and mortar, whereas the soft samples were ground using a porcelain pestle and mortar. Before being subjected to wet digestion, the powdered samples were kept in an airtight container [16].

Digestion of Samples for Heavy Metal Analysis

Exactly 1 g sample was weighed using a weighing balance and placed in 250 ml beakers separately and 15 ml of aqua regia (HCl and HNO_3 concentrated in 3:1 ratio) was added. The mixture was digested on a hot plate at 70 °C till the solution became transparent. The resulting solution was filtered through filter paper and transfer into a sample bottle and diluted to the

mark with distilled water. The sample solution was analyzed for concentrations of Cr, Zn, Cd, Cu and Pb using an atomic absorption spectrophotometer Model Alpha Star 4 (ChemTech Analytical) at the central laboratory, Modibbo Adama University, Yola. [17].

RESULTS AND DISCUSSION

The concentration of Pb, Cd, Cr, Cu and Zn in cereal grains were studied. The result of the levels of these heavy metals in cereal grains showed that some of the samples in some locations contained all the heavy metals while others do not or were below the detection limit. The heavy metals vary in concentrations in all the locations as presented in Table 1 below.

Table 1. Concentrations of Heavy Metals in Cereal Grains in (mg/kg)

Sample Location	Metals	Maize	Rice	Millet	Guinea corn	Safe limit WHO [18]
SHASHAU	Pb	0.311±0.002	0.282±0.004	0.278±0.031	0.130±0.006	0.3
	Cd	0.018±0.000	0.020±0.001	0.059±0.001	0.027±0.002	0.2
	Cr	0.141±0.001	0.129±0.001	0.144±0.003	0.067±0.003	2.3
	Cu	1.674±0.011	2.671±0.038	16.770±12.470	1.808±0.133	73.3
	Zn	3.519±0.024	2.739±1.218	1.382±0.042	3.366±0.510	99.4
MUNGA	Pb	0.565±0.007	1.233±0.025	0.074±0.004	0.178±0.001	0.3
	Cd	0.041±0.000	0.260±0.003	0.016±0.002	0.003±0.000	0.2
	Cr	0.046±0.001	0.652±0.016	0.018±0.001	0.047±0.001	2.3
	Cu	1.526±0.022	12.652±1.833	0.517±0.380	1.435±0.009	73.3
	Zn	1.565±0.696	9.928±0.214	1.491±0.225	7.039±0.047	99.4
	Pb	0.590±0.009	0.413±0.004	0.650±0.005	0.063±0.010	0.3

GARHA LARH	Cd	0.037±0.001	0.011±0.00	ND	ND	0.2
	Cr	0.125±0.002	0.085±0.001	0.130±0.001	0.013±0.002	2.3
	Cu	6.271±0.096	4.214±0.031	6.501±0.044	0.630±0.095	73.3
	Zn	29.244±0.446	19.771±0.146	30.299±0.204	12.625±1.911	99.4
WAJA	Pb	0.257±0.002	0.181±0.001	0.284±0.001	0.326±0.009	0.3
	Cd	0.024±0.000	ND	ND	0.082±0.007	0.2
	Cr	0.070±0.001	0.039±0.001	0.060±0.001	0.044±0.003	2.3
	Cu	1.743±0.021	1.188±0.007	1.869±0.011	1.178±0.040	73.3
	Zn	5.225±3.641	4.879±0.036	7.474±0.050	5.783±0.876	99.4

THE RESULTS FOR ANALYSIS OF HEAVY METALS IN CEREAL GRAINS

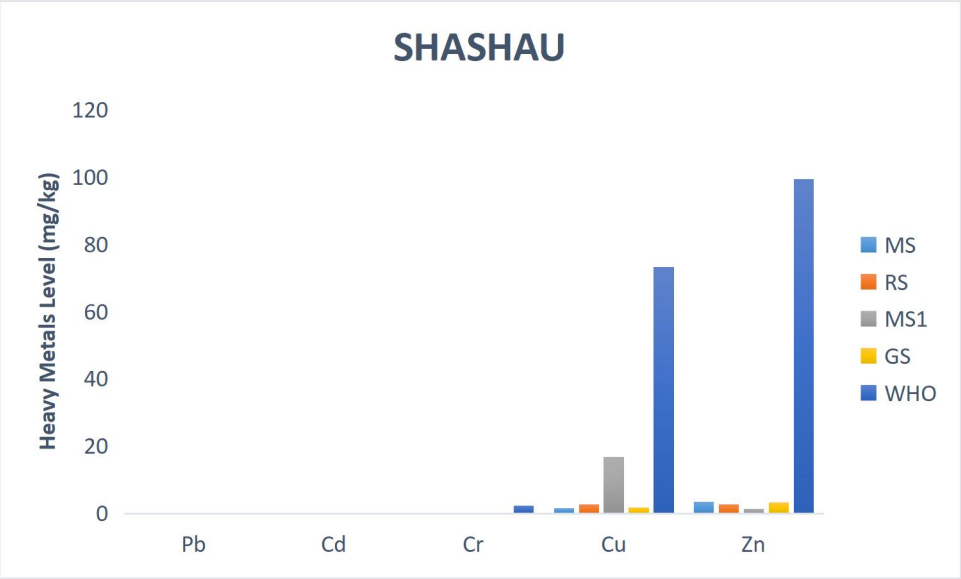

Fig 1. Heavy metals concentration of cereal grains at Shashau.

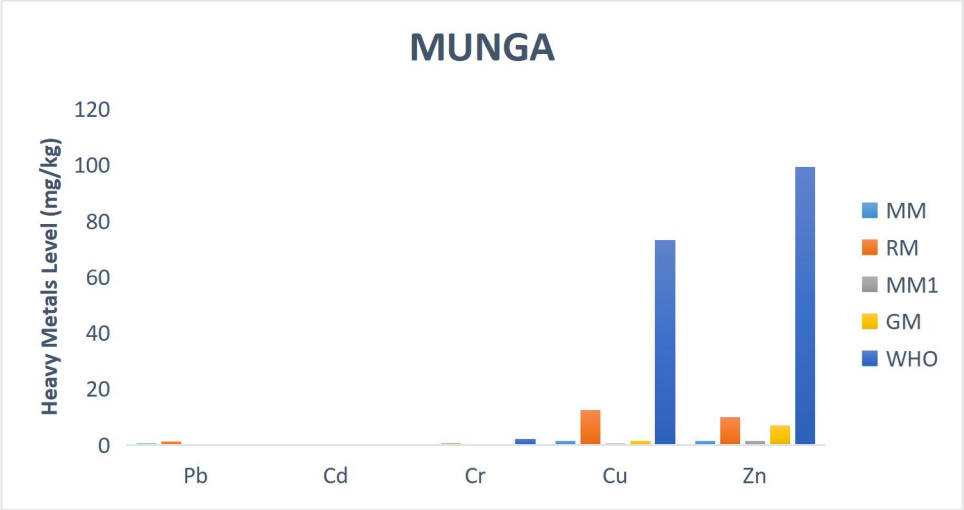

Fig 2. Heavy metals concentration of cereal grains at Munga

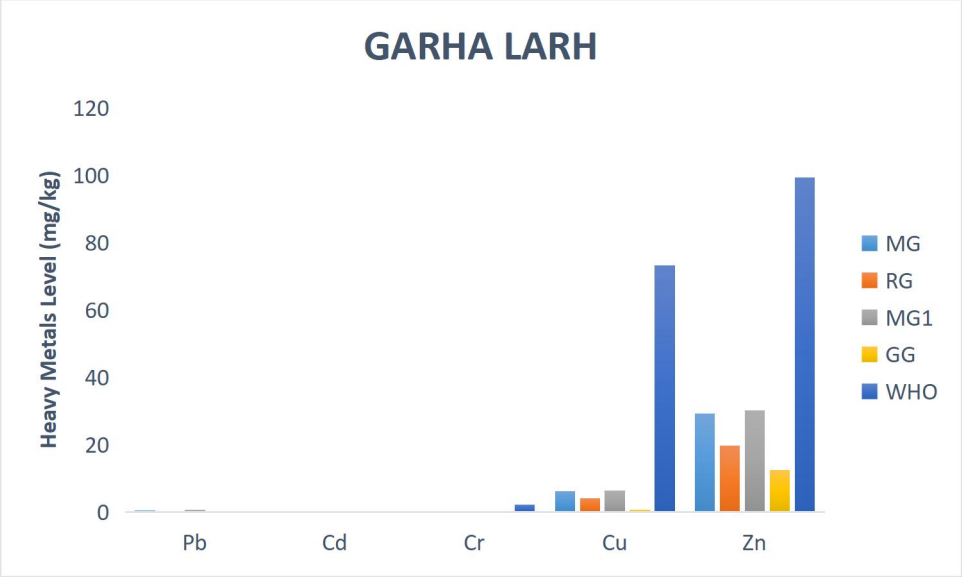

Fig 3. Heavy metals concentration of cereal grains at Garha Larh

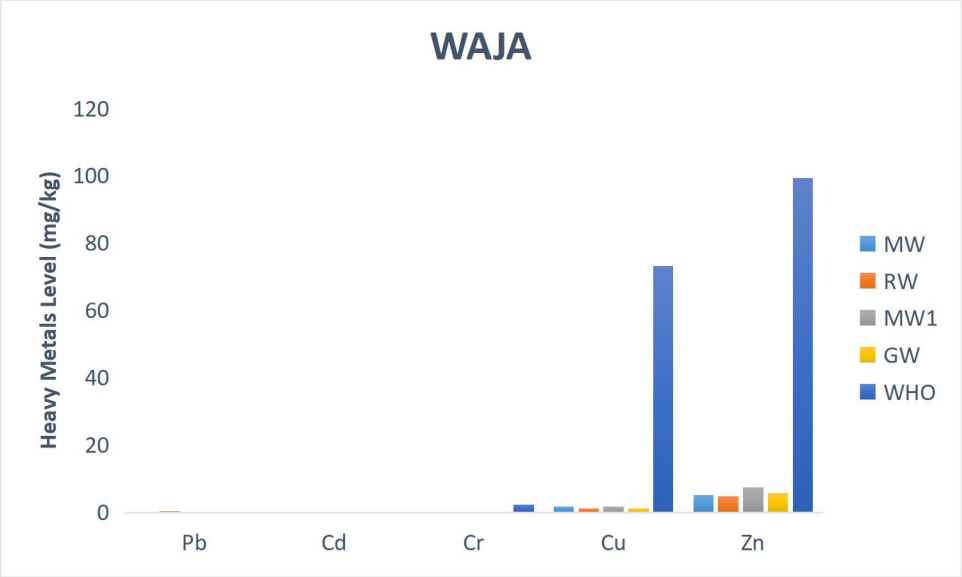

Fig 4. Heavy metals concentration of cereal grains at Waja

HEAVY METALS IN CEREAL GRAINS AT SHASHAU

Fig 1. has shown that Cu has the highest concentration over all the metals analyze in cereal grains with concentration which ranges from 16.770-1.674 mg/kg. High concentration of Cu was detected in millet while a low concentration was detected in maize, All the various concentrations were within the WHO permissible limit.

Pb was also detected in the sample which ranges from 0.311-0.130 mg/kg the high concentration of lead was detected in maize, Pb was found to be high in maize 0.311 mg/kg which was slightly higher when compared to WHO [18] safe limit 0.30 mg/kg while the concentration of Pb in rice, millet and guinea corn were all within the permissible limit.

Cd was also detected in the samples which ranges from 0.059-0.018 mg/kg and the concentrations were all within the permissible limit.

Cr was also detected in all the sample and it ranges from 0.144-0.067 mg/kg. All were within the permissible limit.

Zn was also within the range of 3.366-1.382 mg/kg. The concentration of Zn found in the sample was also within the permissible limit.

HEAVY METALS IN CEREAL GRAINS AT MUNGA

Fig 2. revealed that Cu has the highest concentration over all the metals analyze in cereal grains. The concentration of Cu ranges from 12.652-0.517 mg/kg. The high concentration was found in rice and the low concentration was found in millet respectively.

Pb was also detected in the sample which ranges from 1.233-0.074 mg/kg the concentration of Pb was found to be high in rice which was above the permissible limit.

Cd was also detected in the samples and the value ranges from 0.260-0.003 mg/kg. Cd was also found to be high in rice which was slightly above the maximum permissible limit,

Cr was also detected in the sample which ranges from 0.652-0.018 mg/kg. The concentration of Cr was found to be within the permissible limit.

Zn was also detected in the samples which ranges from 9.928-1.491 mg/kg and the concentration of Zn was found to be within the safe limit.

HEAVY METALS IN CEREAL GRAINS AT GARAHA LARH

Fig 3 has shown that Zn was found to be in higher concentration over all the metals analyzed in cereal grains. The concentration of Zn ranges from 30.299-12.625 mg/kg. The highest and lowest concentration of Zn was found in millet. The concentration of Zn was within the safe limit.

Pb was also found in the samples and it ranges from 0.650-0.063 mg/kg. The concentration of Pb was found to be higher in maize, rice and millet and was within the safe limit in guinea corn. The various concentrations in rice, maize and millet were above the safe limit. Cd was also detected in maize (0.037 mg/kg) and rice (0.011 mg/kg) but was not detected in millet and guinea corn.

The concentrations of Cr in the sample were within the safe limit. Cu was detected in the sample which ranges from 6.271-0.630 mg/kg and were all within the permissible limit.

HEAVY METALS IN CEREAL GRAINS AT WAJA

Fig 4 revealed that Zn was also found to be higher in concentration over all the metals analyzed in cereal grains at Waja. The concentration of zinc ranges from 7.474-4.878 mg/kg.

The high concentration was found in millet and low concentration was found in rice. The concentration of these heavy metals was all within the safe limit.

Pb was also detected in the samples which ranges from 0.326-0.181 mg/kg. The concentration of Pb in guinea corn was above the safe limit while the concentrations in maize, millet and rice were within the safe limit.

Cd was found in maize (0.024 mg/kg) and guinea corn (0.326 mg/kg) and was not detected in rice and millet. The concentrations of Cd were within the safe limit.

Cr was also detected in the samples and it ranges from 0.070-0.039 mg/kg. The concentrations of these metals were within the permissible limit.

Cu was also detected in the samples and it also ranges from 1.188-1.178 mg/kg the various concentration of copper all falls with the safe limit.

Zinc was also found in all the samples and it ranges from 4.879 mg/kg-7.474 mg/kg. The concentrations of zinc in the sample were all within the safe limit.

The results show variation in concentrations of metals analyze in all the sample obtained from the study areas which could be as a result of differences in geographical locations and heavy metal toxicity. Contamination of irrigation water, fertilizer and metal-based insecticides, industrial emissions, harvesting, transportation, storage, and sale are some of the causes of heavy metal poisoning. [7]. Pb was high concentration in maize (0.311 mg/kg) from Shuahau, 0.326 mg/kg in guinea corn from Waja and 0.590 mg/kg, 0.413 mg/kg and 0.650 mg/kg in maize, rice and millet from Garaha Larh respectively, while the low concentration of Pb was detected in guinea corn. Pb concentration in cereal grains was in agreement with Salihu et al [1] who reported similar value. Pb contamination in this study area is higher in the cereal grains when compared to the WHO [18] safe limit. The levels of lead concentration in maize, rice, guinea corn and millet in Shashau Waja and Garaha Larh indicate a potential hazard to consumers. Musculoskeletal, renal, ophthalmic, neurological, immunological, reproductive, and developm ental effects are all known to result from lead exposure [19].

Cr(III) is a necessary element needed for healthy metabolisms of fat and sugar. It works well with insulin to control diabetes and is a cofactor in insulin. Cr(III) and its

derivatives are not thought to pose a health risk, however Cr(VI) has long been known to be poisonous and carcinogenic [20]. Cr was detected in all the cereal grains samples in all the locations but they were all below the safe limit, which was also in agreement with Wadoje [21], who also reported similar range of values of these metals in the cereals analyzed.

Cd was also detected in high concentration of 0.260 mg/kg in rice from Munga which is higher when compared with the WHO safe limit while it was not detected in rice and millet at Waja and in millet and Guinean corn at Graha Larh, The absence of Cd in rice and millet was in agreement with the study conducted by Sulyman et al [15]. Cd is a highly hazardous non-essential metal that has no function in a living organism's biological processes. Therefore, a high cadmium concentration may be detrimental to living things [19]. Cd poisoning in humans can result in anemia, kidney damage, birth defects, and lung cancer [22]. The high concentrations of Pb and Cd indicate that heavy metal pollution is present at the river's main source. This pollution was caused by the widespread use of lead products in storage batteries, as well as by human activities such as burning leaded gasoline, improper waste disposal, excessive fertilizer and pesticide use, and ongoing agricultural land cultivation in both the rainy and dry seasons.

High concentration of Cu was found in millet at Shashau, and the lowest concentration of Cu was recorded at Munga. The concentration of Cu in cereal grains was higher than that reported by Sulyman et al [15]. A high concentration of Cu suggests the availability of important micronutrients, and artificial or organic fertilizer should be used to ensure that there is a sufficient supply for plants to flourish [23].

Zn was high in all the cereal grains in Garaha Larh. The highest concentration of Zn was recorded in millet from Garaha Larh and the lowest concentration in millet at Shashau. The concentration of Zn in cereal grains was higher than that reported by Sulyman et al [15]. Zn is a vital component for all living things, playing a crucial part in growth, development, metabolism, and overall health. It is also a necessary co-factor for numerous enzymes within the body. Zinc deficiency causes a variety of metabolic disorders and coronary heart disease [24].

CONCLUSION

The study's objective was to assess the levels of heavy metals in the rice, maize, millet, and guinea corn found in Hong, Adamawa State, Nigeria. The heavy metals, Pb, Cu, Cr, Zn, and Cd, were detected using atomic absorption spectrophotometry. The results showed that these metal amounts varied throughout the cereals and geographical areas. Some samples had high concentrations of Pb, Cd, and Cr, while others were within the permissible limit. Cd was missing from rice and millet from Waja as well as from guinea corn and millet from Garha Larh. The study emphasizes that in order to guarantee food safety, heavy metal levels in cereals must be monitored.

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