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HEAVY METALS CONTAMINATION IN SELECTED VEGETABLES CONSUMED IN DORAYI-BABBA, KANO AND THEIR TOXICITY TO HUMAN HEALTH

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ABSTRACT
Health implications to the populace due to consumption of heavy metals contaminated vegetables have been a great concern all over the world. This research is aimed to assess the level of some heavy metals (Fe, Mn, Pb, Cd, Co, and Cr) in selected vegetables (Garlic, Onion bulb, Onion leaves, Lettuce, Spinach, and Carrot) obtained in Dorayi Babba, Gwale L.G.A, Kano State. In this study, the levels of heavy metals have been determined using atomic absorption spectrophotometer. The average concentrations of the metals determined were in the range of 0.685 – 4.312, 0.108 – 1.049, 0.009 – 0.329, 0.002 - 0.018, 0.026 - 0.096 and 0.079 - 0.662 mg/Kg for Fe, Mn, Pb, Cd, Co, and Cr respectively. Cadmium is not detected in lettuce, this implies that, either its concentration was below the detection limit by the machine or is not present at all. Garlic was found to contain the highest concentration of lead (0.329 mg/kg), while the onion leaves contained the lowest concentration (0.009 mg/kg). The FAO/WHO maximum permissible limit for lead in vegetable is 0.03 mg/kg. The concentration of lead in garlic and carrot were above tolerable limit set by world regulatory bodies. All other heavy metals were within the safety baseline levels/tolerable limits for human consumption. The results obtained were comparable with those available in the literature.

Keywords: Atomic Absorption Spectrophotometer, Dorayi Babba, Heavy and Vegetables.

INTRODUCTION

Recently, vegetables and food safety are becoming a great challenge to the general public due to lack of proper management of industrial and household waste materials. Furthermore, toxic materials are being accumulated that are harmful to human health. Vegetables are widely used as food or for cooking purposes and are very important in the human diet because of the presence of vitamins and minerals. They contain water, calcium, iron, Sulphur and potash. They also act as neutralizing agents for acidic substances forming during digestion. Therefore, the heavy metals contaminated vegetables will no longer serve as a nutritional source only but also introduce dangerous pollutants into the human body. (Nur Illia, and Azura, 2020).

Vegetable consumption is a significant route to elevate the concentrations of potentially toxic heavy metals. (Bashdar and Rasul 2023). Therefore, vegetables are very useful for the maintenance of health as a preventive treatment of various diseases. Vegetables, which are integral part of human diet, contain several minerals, essential metals and vitamins that aid in illness prevention, cell repair, and immune system stimulation through the production of blood cells. However, vegetables, especially leafy vegetables, accumulate higher amounts of heavy metals because they absorb these metals in their leaves (Joseph *et al.,* 2022).

The consumption of vegetables contaminated with heavy metals may lead to their accumulation in the kidney and liver of humans, causing disruption of numerous biochemical processes that may cause cardiovascular, nervous, kidney, and bone diseases (Sharma *et al.,* 2009). The bio-toxic effects of heavy metals will depend upon the concentration and oxidation states of heavy metals, the mode of deposition, chemical composition of vegetables, physical characterization, and the consumption rate. A high concentration of toxic metals in groundwater enters the food chain and causes substantial risk (Ghazala, *et al.,* 2021).

Long-term consumption of vegetables contaminated with heavy metals can seriously diminish some of the essential nutrients in the body that may cause a reduction in immunological defenses, impaired physico-social behavior, intrauterine growth retardation, and disabilities associated with malnutrition (Arora *et al*., 2008). Neurotoxic, carcinogenic, mutagenic, or teratogenic effects that may be acute, chronic, and sub-chronic have also been reported due to metal poising. Renal disorders were similarly reported (Kadir *et al.,* 2008). The quality of marketed vegetables cannot be guaranteed as many of them has been contaminated with toxic metals These heavy metals can act as either growth supporter or threat depending on their kinds and concentration absorbed by the plants. (Nur Illia, and Azura, 2020).

Metal poisoning has also been linked to neurotoxic, carcinogenic, mutagenic, or teratogenic consequences, which might be acute, chronic, or sub-chronic. Some employees also were examined having kidneys problems (Kadir, *et al.,* 2008; Rai, *et al.,* 2019).

The detrimental effects of heavy metals during pregnancy and fetal development has been widely established. Heavy metals have the potential to harm the reproductive system of females by causing damage to the ovary, hormone production and its release (Sankhla, *et al.,* 2019).

It should be noted that, a condition known as biological concentration would occur where bioaccumulated heavy metals in the living systems will increase in their concentrations as they are passed from organism of lower trophic level to organism of higher trophic level (Nur, *et l.,* 2020).

Pb in the body of the host has been linked to lower birth weightiness, preterm birthing, stillbirths, spontaneous abortions, as well as hypertension, whereas, Cd exposure is linked to low birth weight. Bayissa and Gebeyehu (2021) reported the significantly

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elevated levels of lead (Pb) and cadmium (Cd) were also detected in cabbage and tomato samples.
The objectives of this research are; To determine the concentration of some heavy metals in commonly consumed vegetables in Dorayi Babba using Atomic Absorption Spectrophotometer and also to raise awareness among the people about the risk for consuming vegetables contaminated with toxic metals.

EXPERIMENTAL

Sampling Area

Dorayi Babba is a residential area in Dorayi ward under Gwale Local Government in the city of Kano. The geographic coordinates of Dorayi Babba is Latitude (width): 11˚ 57' 13.6"N and Longitude (length): 8˚ 28' 06.2" E.

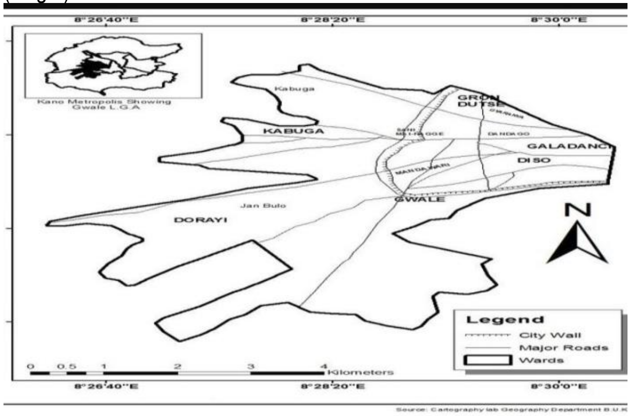

Figure 1: Map of Gwale Local Government Area Kano State Showing Dorayi.
Source: Department of Geography, Bayero University, Kano.

Figure 2: Map of Dorayi Babba, Gwale Local Government Area

Chemicals and Reagents

All the chemicals and reagents were of analytical grade and were purchased from Sigma Aldrich.

Materials

Perkin-Elmer PinAcle 900H Atomic Absorption Spectrophotometer (AAS) was used for this analysis. Certified Atomic Absorption Spectroscopic standard stock solutions (1000 mg/L) of Fe, Mn, Pb, Cd, Co and Cr were prepared using Iron (II) chloride hexahydrate ($FeCl_2.6H_2O$), Manganese (II) chloride tetrahydrate ($MnCl_2.4H_2O$), Lead (II) chloride ($PbCl_2$), Cadmium (II) chloride ($CdCl_2$), Cobalt (II) chloride hexahydrate ($CoCl_2.6H_2O$) and Chromium (II) chloride hexahydrate ($CrCl_2.6H_2O$). Working standard solutions of 2, 4, 6, 8 and 10 mg/L were prepared by appropriate dilutions of the stock solution. Deionized water was used in the preparation of all the solutions.

Sampling

Samples of fresh vegetables were collected from different vendors at Dorayi Babba. (Three samples for each vegetable) in order to estimate the total heavy metal content (Fe, Mn, Pb, Cd, Co and Cr) in the samples.

Sample Preparation and Treatment

A reasonable amount of each edible portions of the vegetable samples were used for analysis while damaged or rotten samples were removed. The samples were stored in polythene bags until analysis under refrigerated condition (<10 °C). The samples were thoroughly washed and then dried using oven dry method at 105 °C for 48 h to determine the moisture content (Sadi *et al.*, 2021). Dried samples were powdered in a manual grinder and were used for heavy metal analysis. Powdered samples (3 g each) with three replicates for each vegetable were accurately weighed and placed in a porcelain crucible and two drops of concentrated nitric acid were added to the solid as an ashing aid. Dry ashing process was carried out in a muffle furnace by stepwise increase of temperature up to 550 °C and then left to ash at this temperature for 6 hours. The ash was dissolved in 20 mL of freshly prepared aqua regia (3:1, HNO_3: HCl) and stirred very well. The ash suspension was filtered in a 100 mL plastic bottle with Whatman No 1 filter paper and the volume was made up to the mark with more deionized water. (Bashdar and Rasul 2023)

Statistical Analysis

In the analysis of the data, IBM SPSS Statistics Software Version 23 was used and the results were expressed as Mean $\pm$ Standard deviation (SD). Parametric tests of one-way analysis of variance (ANOVA), confidence level of 95% and significance level of 0.01 were considered in comparing the average concentration of the metals in the vegetable samples.

Results and Discussion

Table 1: Percentage of moisture in the vegetable samples

Samples	Weight of Fresh Sample (g)	Weight of Dried Sample (g)	Weight of Water (g)	Percentage of Moisture
Garlic	121.127	44.175	76.952	63.53
Onion bulb	185.190	8.945	176.245	95.17
Onion leaves	155.595	11.46	144.128	92.63
Lettuce	139.413	10.749	128.664	95.29
Spinach	149.358	20.880	128.478	86.02
Carrot	175.690	11.174	164.516	93.64

The percentage of moisture in the selected vegetable samples were in the range of 63.53 to 95.29 %. The water content of the fresh samples was in the order Lettuce > Onion bulb > Carrot > Onion leaves > Spinach > Garlic. This shows that, in all the samples analyzed, lettuce has the highest amount of water (95.29%) while garlic has the least (63.53%) as shown in Table 1.

This result is comparable to the one reported by Sadi *et al.,* (2021).

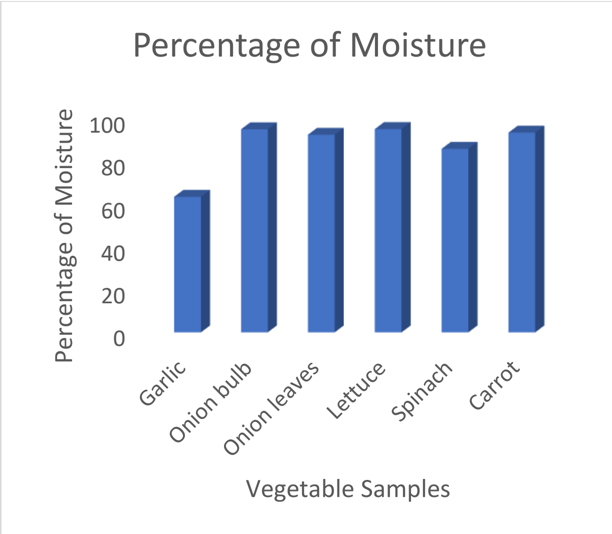

Fig. 3: Percentage of moisture in the vegetable samples

Table 2: Mean Concentrations of the Heavy Metal ions in the Samples

Vegetables	Scientific Name	Mean Concentration (mg/Kg) ± SD Fe	Mn	Pb
Garlic	*Aliun sativa*	0.828 ±0.0120	0.167 ±0.0008	0.329 ±0.0062
Onion bulb	*Alium cepa*	2.075 ±0.0047	0.108 ±0.0043	0.029 ±0.0490
Onion leaves	*Alium cepa*	3.164 ±0.0074	0.117 ±0.0015	0.009 ±0.0054
Lettuce	*Lactuca sativa*	1.577 ±0.0016	0.199 ±0.0028	0.012 ±0.0063
Spinach	*Spinacia oleracia*	4.312 ±0.0233	0.627 ±0.0061	0.025 ±0.0133
Carrot	*Dagus carota*	0.685 ±0.0026	1.049 ±0.0057	0.094 ±0.0226
*FAO/WHO		**42.5**	**50**	**0.03**

Key: *FAO/WHO Maximum permissible limits of the metals in vegetables (mg/Kg) dry weight

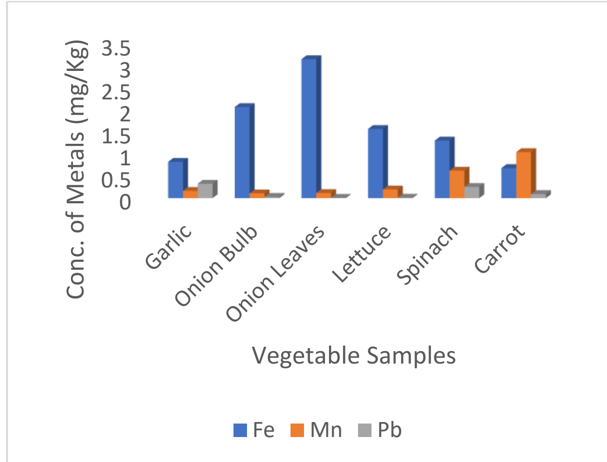

Fig. 4: Chart showing the mean concentration of Fe, Mn and Pb ions in the samples

Table 2, shows the mean concentration of iron in the analyzed vegetable samples were found between 0.685 – 4.312 mg/kg. Spinach the highest amount of iron (4.312 mg/kg) followed by onion leaves (3.164 mg/kg) then onion bulb. Garlic and lettuce contain lesser amount of iron, but carrot contain the lowest (0.685 mg/kg). (Rayhan and Mosummath, 2021). Iron is an essential element for humans. It is a constituent of hemoglobin, myoglobin and a number of enzymes, and as much as 30% of the body iron is found in storage forms such as ferritin and hemosiderin, in the spleen, liver, and bone marrow, and a small amount is associated with the blood transport protein transferin. Iron deficiency results in anemia (Neriman, *et al.,* 2010). But consuming too much iron makes the body harder to absorb zinc. Over time, excess accumulation of iron can damage liver and other organs and may lead to arthritis and heart problems (Jessica, 2018). The maximum allowable limit for iron in vegetables set by FAO/WHO is 42.5 mg/kg, hence, the concentration of iron in all the samples were found to be within the tolerable level.

The average concentrations of manganese in the samples were in the range of 0.108 – 1.049 mg/kg. Carrot was found to contained the highest concentration of manganese, whereas the onion bulb contained the lowest. The maximum allowable limit for manganese in vegetables set by WHO is 50 mg/kg. The concentrations of manganese in all the analyzed samples were far below the set limit. This agrees with the results reported by Nur, *et l.,* (2020). Therefore, all the vegetables are safe for public consumption with regard to manganese toxicity. However, manganese toxicity can result in a permanent neurological disorder known as manganism with symptoms that include tremors (dystonia), difficulty walking (bradykinesia), and facial muscle spasms (Keen and Zidenberg-Cherr, 2013).

The mean concentrations of lead in the selected vegetables were in the range 0.009 – 0.329 mg/kg. Garlic was found to contained the highest concentration of lead (0.329 mg/kg), while the onion leaves contained the lowest concentration (0.009 mg/kg). The FAO/WHO maximum permissible limit for lead in vegetable is 0.03 mg/kg. The concentration of lead in garlic and carrot were above tolerable limit set by world regulatory bodies, as such peoples consuming these vegetables in Dorayi Babba are prone to or at risk of lead toxicity. However, lead concentration in onion bulb is at the threshold level (0.029 mg/kg) as it is close to maximum permissible/tolerable limit. But the concentration of lead in onion leaves, lettuce and spinach are within the allowable range. This result is in good agreement with the results reported by Sadi *et al.*, (2021)

Lead is well known for its toxicity and adverse effects on human health. Absorption of ingested lead may constitute a serious risk to public health. Some chronic effects of lead poisoning are stomachache, heartburn, constipation and anemia (Bolger, 2000). The excessive lead in blood may cause hypertension, nephropathy, and cardiovascular disease and will influence the intelligence development of children. These toxic metals have been long regarded as serous environmental contaminants even at smaller concentration because of their detrimental effect to public health (Bayissa and Gebeyehu 2021).

Table 3: Mean Concentrations of the Heavy Metal ions in the Samples

		Mean Concentration (mg/Kg) $\pm$ SD		
Vegetables	**Scientific Name**	**Cd**	**Co**	**Cr**
Garlic	*Aliun sativa*	0.013 $\pm$0.0017	0.086 $\pm$0.0085	0.137 $\pm$0.0206
Onion bulb	*Alium cepa*	0.018 $\pm$0.0005	0.069 $\pm$0.0018	0.124 $\pm$0.0197
Onion leaves	*Alium cepa*	0.007 $\pm$0.0005	0.073 $\pm$0.0025	0.159 $\pm$0.0037
Lettuce	*Lactuca sativa*	ND	0.086 $\pm$0.0056	0.173 $\pm$0.0056
Spinach	*Spinacia oleracia*	0.002 $\pm$0.0006	0.026 $\pm$0.0011	0.662 $\pm$0.0079
Carrot	*Dagus carota*	0.004 $\pm$0.0005	0.032 $\pm$0.0072	0.079 $\pm$0.0084
*FAO/WHO		**0.2**	**50**	**1.3**

Key: ND = Not Detected; *FAO/WHO Maximum permissible limits of the metals in vegetables (mg/Kg) dry weight.

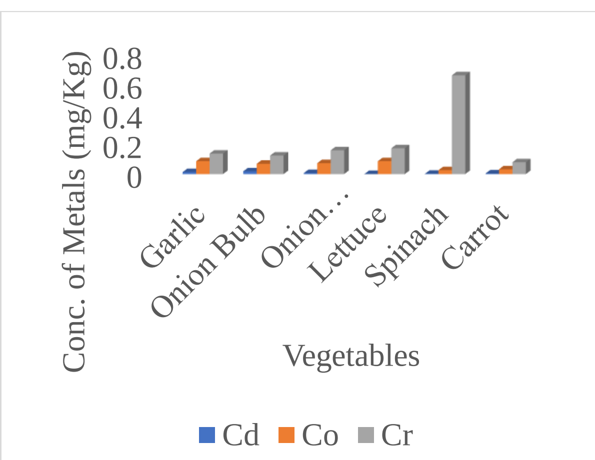

Fig. 5: Chart showing the mean concentration of Cd, Co and Cr ions in the Samples

Table 3, show the average concentrations of Cd, Co and Cr ions in the selected vegetables. The mean concentration of cadmium was in the range of 0.002 to 0.018 mg/Kg which are far below the maximum tolerable limit set by FAO/WHO (0.2mg/Kg). Onion bulb has the highest concentration of Cd^{2+} (00.18 mg/Kg) whereas spinach has the least (0.002 mg/Kg). Cadmium is not detected in lettuce, this implies that, either its concentration was below the detection limit by the machine or is not present at all. This result was in good agreement with the results reported by Ogunkunle *et al.,* (2014). Cd has been found to cause negative impacts on several important enzymes, harmful effects may range from painful bone disease known as ostemalacia to destruction of red blood cells and kidney damage (Navas *et al*., 2007).

Similarly, cobalt and chromium ions were obtained in the range of 0.026 - 0.096 mg/Kg and 0.079 to 0.662 mg/Kg respectively. Spinach has the lowest amount of cobalt (0.026 mg/Kg) but contain the highest amount of chromium (0.662 mg/Kg) this is comparable to the result reported by Ray, *et al.,* (2010). Accumulation of cobalt and chromium over a long period of time can lead to cardiomyopathy (Heart become big and floppy with problem pumping blood), deafness, thickening of the blood, thyroid and vision problems (Gebeyehu and Bayissa 2020).

CONCLUSION AND RECOMMENDATION

The results revealed that the mean concentrations of lead in some of the vegetables were higher than the set standards and all other heavy metals were within the safety baseline levels/tolerable limits for human consumption. No matter how low levels of heavy metals are present in vegetables, their presence is undesirable. This is due to businesses, economic, industrial, and other development activities, heavy metals concentrations are increasing in irrigation water, agricultural soils and vegetables that were grown in and outside cities. The farmlands and land spots along the river banks are intensely used in vegetable production. Based on the results of this study, there would be a significant health risk (both carcinogenic and non-carcinogenic) to the consumers regarding the consumption of vegetables obtained in the study area due to high amount of lead. The results have provided valuable baseline data for further investigation of heavy metals accumulation in vegetables, thereby improving food safety and more efficient health protection for people who live at the examined territory. But still, more information is required regarding level of heavy metals in irrigation water and vegetables, as such environmentalists, administrators and public health workers are hereby encouraged to create public awareness to avoid the consumption of vegetables grown in contaminated areas, hence reducing potential toxicity of heavy metals. Therefore, this study recommends a strict regulatory control on the safety of vegetables originated from the contaminated areas, regular scrutiny and monitoring of the heavy metals present in vegetables and irrigating water to avoid extreme accumulation in the food chain and hence get away human health risks.

Conflicts of Interest

All the authors declared that, they have no competing interest with regard to publication of this article.

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