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Assessment of Selected Metals in Onion Bulbs and Leaves Collected from Samaru Market, Zaria, Kaduna State, Nigeria

Onoja D Emmanuel[1], Itodo D Adukwu[2], Ejila A Odeh[2] and Adejo E Ogweye[1]

[1] Department of Medical Physics, Federal University of Health Sciences, Otukpo, Benue State, Nigeria
[2] Department of Chemistry, Federal University of Health Sciences, Otukpo, Benue State, Nigeria

Corresponding E-mail: emmanuel.onoja@fuhso.edu.ng

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Abstract

This study examined the levels of metals (Mg, Al, Si, P, S, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Zr, Nb, Mo, Ag, Sn, Sb, Ta, Pt, Au, Pb, and Bi) in onion bulbs and leaves in light of the latent toxicity, unsolvable character, and snowballing behaviour of heavy metals. The onion bulbs and leaves were randomly selected from the Samaru market chopped, dried, and ground into a powder for X-Ray Fluorescence Spectrometer (XRF) measurement. Except for concentrations of Si, Ti, Zr, and Ag, with the value of 9.996, 4.051, 2.047 and 2.082 mg/kg in the onion bulbs and 20.23, 5.861, 1.175 and 1.538 mg/kg in the onion leaves respectively, which were higher than the permissible level of 0.800, 0.530, 0.000005 and 0.014 respectively, all the metals analysed were at or below the World Health Organization's (WHO) permissible limit. The findings generally indicated that Si, Ti, Zr, and Ag poisoning could result from eating onion bulbs and leaves from the Samaru market due to the Si, Ti, Zr, and Ag health risks. To avoid metal poisoning and subsequent bioaccumulation of the metal in the systems of consumers and the ecosystem at large, there is a need for a quarterly examination of the metal content in the onion bulb and onion leaf in the Samaru market.

Keywords: Concentration; onion bulbs; onion leaves; metal poisoning; XRF.

I. INTRODUCTION

Vegetables are considered one of the main food supplements because of their important constituents of minerals, vitamins, fibre and protein (in the form of amino acids) that enhance food metabolism, hence the name "protective supplements" [1,2].

The onion (Allium cepa), one of the most significant and popular vegetables in Nigeria and throughout the world, is used as a condiment in a variety of cuisines due to its high vitamin A and C content and abundance of other essential minerals [3].

Onions are a key component in many delectable dishes, but they also improve digestion and control the body's anti-cancer activities [4, 5]. Heavy metals are ingested by onion leaves and bulbs through irrigation water, soil, nutrient solutions, and air [6, 7]. Heavy metals are any metallic chemical elements with a high relative density that, even in small amounts, are poisonous and bad for human health [8, 9, 10]. The natural weathering of rocks, trash disposal, fertilizer, pesticide, and herbicide use, as well as the use of industrial effluent, can all cause an increase in the amounts of these metals [11]. The primary cause is the streams where heavy metals are discharged (leached) from the soil and ingested by the roots of crops. Heavy metals can build up in agricultural soils because they are disseminated again if plants decay. Bioaccumulation, geo-accumulation, and biomagnification may take place as these heavy metals enter the ecosystem. As a result, extended wastewater irrigation can result in higher levels of heavy metals in the soil and crops used for human consumption [12].

Industrialization is influenced by human inputs such as atmospheric deposition, waste incineration, urban sewage, traffic discharge, fertilization, and long-term wastewater use in farmland to grow food crops. These human inputs enhance the build-up of heavy metals, which in turn has an impact on food crops [13].

Numerous researchers from around the world claim that metals in water and food have been a big worry for years due to their toxicity towards aquatic life, people, and the environment.

Experimental studies have been conducted to assess and determine the levels of heavy metals in onion bulbs, onion leaves, and many other vegetables, but the studies have mainly focused on the same metals (Na, K, Ca, Mg, Cu, Co, Cr, Mn, and Zn) and the same experimental apparatus (Flame Atomic Absorption Spectroscopy (FAAS)) [1, 2, 3, 5, 6, 9, 11, 12, 13]. Considering the potential toxicity, recalcitrant nature, and cumulative behaviour of heavy metals, it was worthwhile to assess and determine other heavy metals in onion bulbs and leaves that are toxic, carcinogenic, and hazardous to human health using an X-ray fluorescence Spectrometer (XRF) instead of the conventional FAAS. This study is aimed at Assessing and comparing the concentration of Selected Metals (Mg, Al, Si, P, S, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Zr, Nb, Mo, Ag, Sn, Sb, Ta, Pt, Au, Pb and Bi) in Onion Bulbs and Leaves Collected from Samaru Market, Zaria, Kaduna State, Nigeria.

II. MATERIALS AND METHODS

A. Study Area

The onion bulbs and leaves were collected randomly from the Samaru market and brought in from the nearby Bomo village where they were cultivated. Zaria is in the Guinea savannah area of the northern hemisphere of Kaduna state Nigeria on latitude 110 09' 41" N and longitude 70 43' 29"E with an altitude of 676 m above sea level [15].

B. Materials

A knife and Chopping board were used to cut the onion bulbs and leaves into uniform sizes, while the flat tray was used to sun-dry the chopped samples. A mortar and pestle were used to mash the chopped samples to powdered form while measuring cylinders and pipettes were used to measure the quantities of the volume of the sample solutions. XRF was used to determine the concentration of heavy metal in the sample solutions.

C. Sample Collection and Preparation

Ten (10) fresh samples of the same species each of onion bulbs and leaves were purchased randomly from Samaru Market and brought together for composite. The samples purchased were washed with distilled water in other to remove every soil particle. The Onion bulbs and leaves were then separated and labelled accordingly. The samples were cut into pieces using the knife and the chopping board putting the sizes into consideration and then sun-dry for days to remove the moisture content. The dry samples were crushed with mortar and pestle and then sieved with a 210 mm micro sieve to remove other strenuous particles from the powdery form required for the analysis.

D. Sample Analysis

The concentration of metals present in the filtrate obtained after the sieving was estimated using XRF. The XRF has an advantage over FAAS because of its precision analyses of major and minor elements in a wide variety of samples and does not need a decomposer before analysis [16].

III. RESULTS AND DISCUSSION

A. Characteristics of Onion bulb and Onion leaf samples

Table I shows the concentrations of metals obtained from onion bulbs and leaves as recorded after the XRF analysis.

Table I: Concentration of metals in onion bulbs and onion leaves in mg/kg

Element	Concentration		Permissible Limit	References
	Onion bulb	Onion leaf		
Mg	ND	ND	350.000	[17, 20]
Al	15.738	16.936	1.000	[17, 20]
Si	9.996	20.23	0.800	[17]
P	1.302	1.407	40.000	[17]
S	1.424	2.076	3.000	[17]
Ti	4.551	5.861	0.530	[17]
V	ND	ND	0.030	[17]
Cr	ND	0.572	2.300	[17, 19]
Mn	0.957	1.722	500.000	[17, 20]
Fe	28.021	22.468	15.000	[17, 19]
Co	0.174	0.123	50.000	[17]
Ni	ND	ND	67.900	[17]
Cu	0.297	0.231	73.300	[17]
Zn	1.621	0.884	99.400	[17]
As	ND	ND	0.0003	[17, 19]
Se	ND	ND	0.005	[17]
Zr	2.047	1.175	0.000005	[17]
Nb	ND	ND	-	-
Mo	0.185	ND	5.000	[17]
Ag	2.082	1.538	0.014	[18]
Sn	23.516	11.944	100.00	[21]
Sb	8.091	12.832	36.000	[17]
Ta	ND	ND	-	-
Pt	ND	ND	-	-
Au	ND	ND	-	-
Pb	ND	ND	0.300	[17, 19, 20]
Bi	ND	ND	-	-

*ND: Not Detected

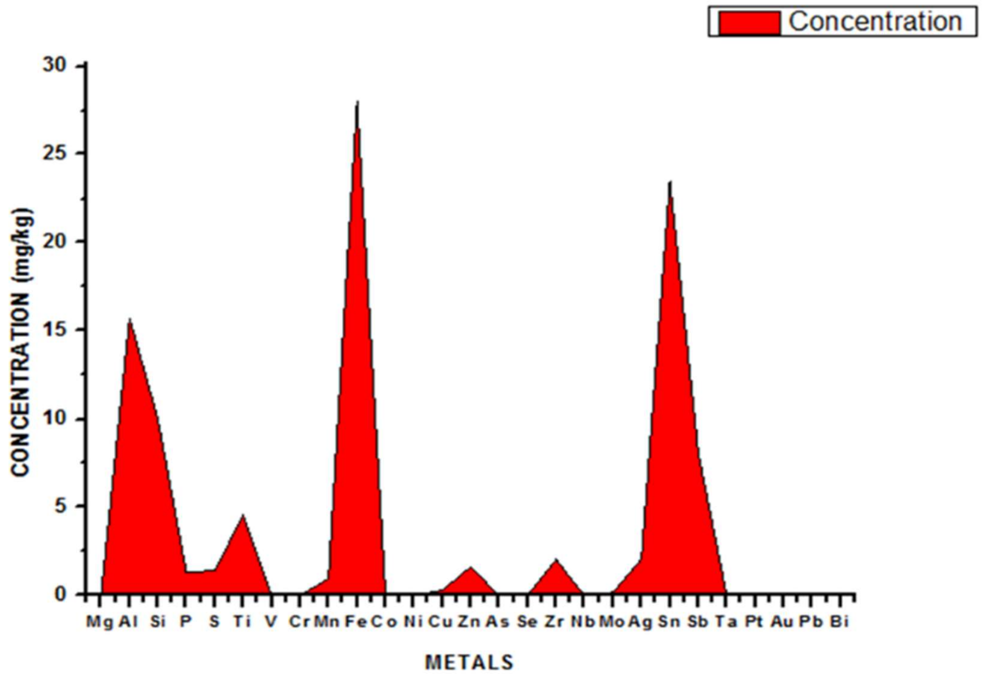

Fig. 1 Graph of the concentration of heavy metals in Onion bulbs against Metals

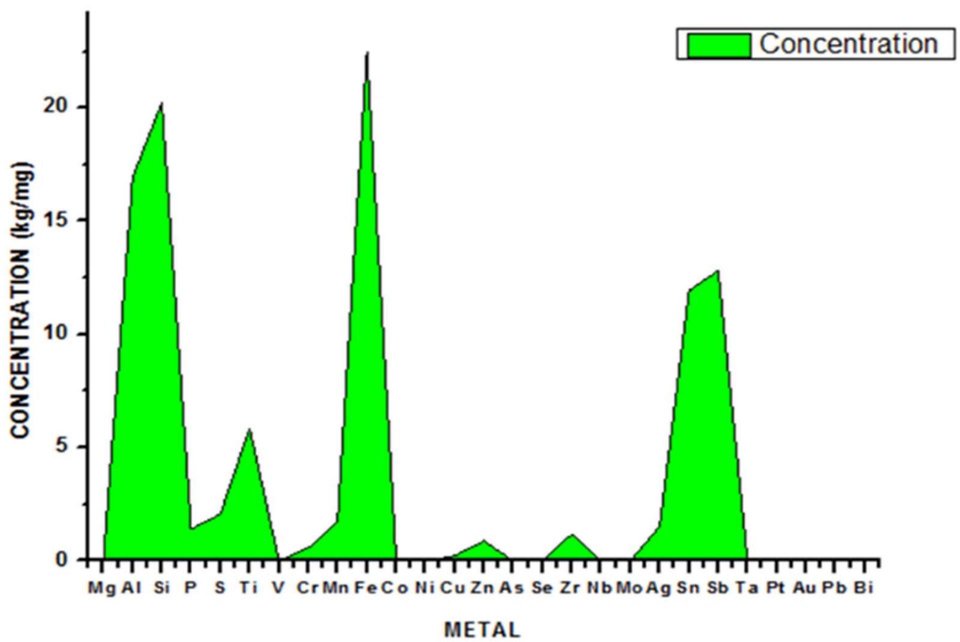

Fig. 2 Graph of the concentration of heavy metals in Onion leaves against Metals

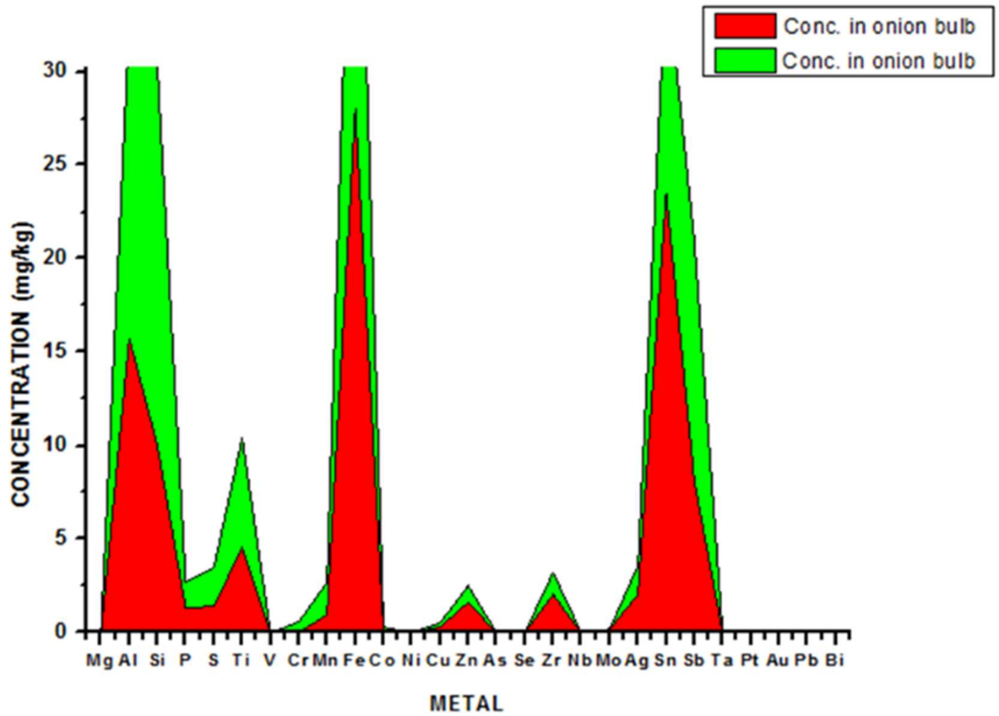

Fig. 3 Graph of the concentration of heavy metals in Onion bulb and onion leaf against Metal

1) Magnesium (Mg)

The concentration of Mg was not detected in the samples of the onion bulbs and leaves analysed by the XRF as depicted in Table I and Fig. 1 compared to [3].

2) Aluminium (Al)

There was a significant concentration of aluminium in the analysed onion bulbs and leaves samples as shown in Table I, and Fig. 1- 3, but it's at the permissible limit set by WHO though higher in the onion leaf sample [17, 120].

3) Silicon (Si)

There was a significant concentration of Si in the onion bulb and onion leaf analysed with the XRF as shown in Table I and Fig. 1-3, which is far higher than the permissible limit set by WHO [17], though the concentration of Si is far higher in onion leaf than the bulb because Si is one of the essential elements for the formation of chlorophyll and enhances the growth of onion plant. Hence, the presence of a silicon concentration higher than the set standard in onion bulbs and leaves when taken by humans when taken as a delicacy could cause silicosis. When in excess in the human body, this could cause the formation of scar tissue which makes it difficult for the lungs to take in oxygen [23].

4) Phosphorus (P)

There was a presence of P in the analysed onion bulbs and onion leaves as depicted in Table I and Fig. 1-3, but it’s at the permissible limit set by WHO [17].

5) Sulphur (S)

Sulphur was detected in the analysed onion bulbs and onion leaves as shown in Table I and Fig. 1-3, but it’s at the limit set by WHO.

6) Titanium (Ti)

The concentration of Ti in the sample of the onion bulbs and leaves samples collected and analysed with RXF was found to be higher than the permissible limit set by WHO as depicted in Table I and Fig. 1- 3 [17]. Since the concentration of Ti is higher than the permissible limit in the sampled onion bulbs and leaves, when taken as a delicacy by humans, the recipient tends to suffer from tightness and pain in the chest, coughing and difficulty in breathing [22].

7) Vanadium (V)

V was not detected in any of the analysed onion bulbs and leaves as shown in Table I and Fig. 1-3.

8) Chromium (Cr)

There was no trace of Cr in the sample of the onion bulb analysed, whereas there were traces of Cr in the sample of onion leaves analysed but at the permissible limit set by WHO as depicted in Table I and Fig. 1-3 [17, 19] contrary to the research carried out by [9], where the concentration of Cr in onion bulbs and onion leaves is higher than the permissible limit set by WHO [9].

9) Manganese (Mn)

In the samples of onion bulbs and leaves, the concentration of Mn is very low compared to the permissible limit set by WHO as depicted in Table I and Fig. 1-3 [17, 20]. However, the concentration of Mn is higher in the onion leaves than in the bulbs due to the process of translocation from the root to the shoot.

10) Iron (Fe)

Fe is one of the essential elements in delicacies but when in excess can be dangerous to humans. There were traces of Fe in both samples of the onion bulbs and leaves analysed with XRF but at the permissible limit set by WHO as shown in Table I and Fig. 1- 3 [17, 20].

11) Cobalt (Co)

There was a low concentration of Co in the samples of onion bulbs and leaves analysed using XRF but at the permissible limit set by WHO [17].

12) Nickel (Ni)

There was no trace of any concentration of Ni in the samples of onion bulbs and leaves analysed by the XRF.

13) Copper (Cu)

There was a trace of Cu in the sample of the onion bulbs and leaves analysed with XRF but at the permissible limit set by WHO [17].

14) Zinc (Zn)

Zn is one of the essential elements needed in the human body that aid growth, development, immune system building and metabolic function [8]. However, in excess can be very dangerous to human health. There were minor traces of zinc in the onion bulbs and onion leaves analysed but at a moderate and permissible limit set by WHO [17].

15) Arsenic (As)

As was not detected in the samples of onion bulb and onion leaf analysed by the XRF.

16) Selenium (Se)

Se was not detected in the samples of onion bulb and onion leaf analysed by the XRF.

17) Zirconium (Zr)

The concentration of Zr in the sample of the onion bulb and onion leaf samples collected and analysed with RXF was found to be higher than the permissible limit set by WHO as depicted in Table I and Fig. 1-3 [17]. Since the concentration of Zr is higher than the permissible limit in the sampled onion bulbs and leaves when taken as a delicacy by humans, there's a high tendency of the recipient to suffer adrenal insufficiency, parasympathetic dominance, hyperparathyroidism, poor digestion, Acne, hypothyroidism, fatigue, hypoglycaemia, transient hypertension, carpopedal spasms, cardiac irregularities, and skin irritation [24].

18) Niobium (Nb)

Nb was not detected in the samples of onion bub and onion leaf sampled and analysed by XRF.

19) Molybdenum (Mo)

The concentration Mo was not detected in the sample of the onion leaf analysed whereas it was discovered in the onion bulb sample analysed but at a limited permissible limit set by WHO [17].

20) Silver (Ag)

The Ag concentration in the onion bulb and leaf samples collected and analysed with RXF was higher than the permissible limit set by WHO as depicted in Table I and Fig. 1-3 [18]. Since the concentration of Ag is higher than the permissible limit set by WHO in the sampled onion bulbs and leaves when such onion bulbs or leaves are taken as a delicacy by humans there's a high tendency for the recipient to suffer from decreased blood pressure and decreased respiration.

21) Tin (Sn)

The concentration of Sn was detected in the samples of Onion bulb and onion leaf analysed by XRF but is at the permissible limit set by WHO [21].

22) Antimony (Sb)

The concentration of Sb was found in both onion bulb and onion leaf but was not more than the limit set by WHO [17].

23) Tantalum (Ta), Platinum (Pt), Gold (Au), Lead (Pb), Bismuth (Bi):

Ta, Pt, Au, Pb, and Bi were not detected in the sample of onion bulbs and onion leaves collected from the Samaru market and analysed by XRF as shown in Table I and Fig. 1-3. Unlike the research carried out by [9] in Ethiopia where a significant concentration of Pb was detected in the onion bulb sampled and analysed using a flame atomic absorption spectrometer (FAAS).

IV. Conclusion

In this research, the concentration of metals (Mg, Al, Si, P, S, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Zr, Nb, Mo, Ag, Sn, Sb, Ta, Pt, Au, Pb and Bi) were analysed using XRF. The concentration of metals analysed in onion bulbs was in the array, Mg, V, Cr, Ni, As, Se, Nb, Ta, Pt, Au, Pb, Bi $<$ Co $<$ Mo $<$ Cu $<$ Mn $<$ P $<$ S $<$ Zn $<$ Zr $<$ Ag $<$ Ti $<$ Sb $<$ Si $<$ Al $<$ Sn $<$ Fe), while the concentration of the metals in onion leaves was in the array Mg, V, Ni, As, Se, Nb, Ta, Pt, Mo, Au, Pb, Bi $<$ Co $<$ Cu $<$ Cr $<$ Zn $<$ Zr $<$ P $<$ Ag $<$ Mn $<$ S $<$ Ti $<$ Sn $<$ Sb $<$ Al $<$ Si $<$ Fe). From all the metals detected, the concentration of Ag, Zr, Ti and Si were discovered to be above the permissible limit set by WHO, which suggests that the consumption of onion bulbs and onion leaves obtained from the Samaru market used in the preparation of delicacies could post a very serious health risk to humans. Since the concentration of some of the metals detected in the onion bulbs and onion leaves is higher than the permissible limit set by WHO, routine monitoring and assessment of how the onion bulbs and onion leaves had such high metal concentration should be carried out and how to remediate it should be proscribed to avoid further accumulation of the metals.

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