Heavy Metal Concentrations in Cassava Leaves and Tubers Harvested from Some Communities in Gokana, Rivers State, Nigeria

Nwineewii, Jack D.

Department of Chemistry, Ignatius Ajuru University of Education, Rumuolumeni, P.M. B. 5047 Port Harcourt, Rivers State, Nigeria

Abstract: **- The concentration of heavy metals in parts of edible plants and food crops is becoming a cause of concern to human beings. Samples of cassava leaves and tubers were collected from four communities in Gokana Local Government Area in Rivers State, Nigeria in the months of July and October 2019. The samples were analyzed for heavy metal concentrations after laboratory treatment. The results showed that the mean concentrations of the heavy metals in the leaves of cassava were; 0.127±0.110, 1.297±0.124, 2.410±0.736, 2.536±0.284, 98.566±9.767 and 2.306±0.480 mg/Kg for Cd, Pb, Cr, Cu, Fe and Ni in July, while the mean concentrations in the month of October were; 0.132±0.105, 1.287±0.210, 2.471±0.811, 2.571±0.291, 100.712±12.614 and 2.087±0.726 mg/Kg for Cd, Pb, Cr, Cu, Fe and Ni respectively. The mean concentrations of the examined heavy metals for July in the tubers were; 0.019±0.019, 0.377±0.341, 1.126±0.067, 1.567±0.304, 96.600±7.137 and 0.654±0.654 mg/Kg for Cd, Pb, Cr, Cu, Fe and Ni, while that of October were; 0.020±0.020, 0.364±0.300, 1.294±0.115, 1.872±0.119, 99.861±10.869 and 0.710±0.674for Cd, Pb, Cr, Cu, Fe and Ni respectively. All the Heavy metal concentrations showed higher values in the leaves than the tubers of cassava. The concentrations of heavy metals in the leaves were in the order; Fe > Cu > Cr > Ni >Pb> Cd and in the tubers, the order were, Fe > Cu > Cr > Ni >Pb> Cd. There is the need for adequate monitoring and implementing of necessary measures to reduce the levels of heavy metals in the cassava parts, so as to curb excessive intake by local consumers who consume the tuber as food and the leaves as medicine.**

I. INTRODUCTION

Plants require minerals and nutrients to grow. Presently, there is a sudden rise in concerns on the levels of absorption of heavy metals by plants and the level that is retained in the different parts of the plant. The retention of the metals taken up by plants leads to bioaccumulation of these metals in plant. The release of trace metals to the surface of the earth's crust (land, air, water and biota) is the aftermath effect of human activities which include quarrying, manufacturing, manure or fertilizer, pesticide, atmospheric deposition, metropolitan and industrialized dumpsite (Alloway and Ayres, 1993; Hajar *et al*., 2014).

Several investigations on the toxic potentials of heavy metals give consideration to animals and lower plants such as bacteria, while neglecting their effects on higher plants. The buildup of metals in higher plant gives a very high degree of exposure to human (Oliveira, 2012). Due to the fact that plants through the process of transportation and absorption take up metals from the soil and then transfer these metals to herbivorous animals (Al-Farraj and Al-Wabel, 2007). The aftermath of plant eating animals in some cases have been identified to be the major causes of some diseases namely spongiform encephalopathy or prion disease (Rasaq *et al*., 2015).

Metals whether essential to plant and animal life or not has a limit to which the body will not require it. At very high concentrations, they result in either plant or animal toxicity. The condition of excessive accumulation of heavy metals in plants originated from excess concentrations of those metals in the soil. In such situation, they constitute health risk to both plants and animals in the interdependence chain of consumption (food chain) (Singh *et al*., 2012). The rate of retention of heavy metals in plant parts varies from one plant to the other. Despite the fact that in most cases these heavy metals do not inhibit the growth of these plants, yet crops reaped from such contaminated soil or lands pose health risks to humans. These risks are as a result of high concentrations of the individual contaminants above the required standard for food (Singh *et al*., 2015).

Plant life grows through the supply of nutrients taken up from the environment (soil, water and air). The uptake of plant nutrients is not selectively done to take up only the required minerals but also other chemical components which may be toxic or poisonous found within the environment (Arora *et al*., 2008). The soil is the final sink for environmental contaminants and as such accumulates pollutants to levels that may be unacceptable and hazardous to the environment (Boke *et al*., 2015). These chemicals or metals in particular are dispersed through natural means or human factors or activities. Other forms of soil pollution originate from human exploration and exploitation activities of which the petrochemical industry is a major contributor **(**Nwineewii and Neeka,2017).

Plants take up minerals components by its root. This is due to the fact that the root is the part of plant that has direct contact with the soil. The uptake of nutrients by plants is also accompanied with water which allows the entrance of many metals into plant tissues, with the concomitant exchange of ions in the cell through complex metabolic activities. When minerals or any chemical component is absorbed by the root and transferred to other parts of plant for storage or further transfer. When plants take up metals, they are accumulated in the different parts, which may either be consumed or not. These stored up or accumulated chemical components (metals) might reach levels that may be as high to possibly cause threats to animals and man that consume them (Sulaiman and Hamzah, 2018).

II. MATERIALS AND METHODS

Collection of Cassava Samples

Cassava samples were collected at the points where the soil samples were collected. The tubers were separated from the leaves and placed individually into separate plastic bags. They were immediately transported to the Chemistry Laboratory, Ignatius Ajuru University of Education, Rumuolumeni, Port Harcourt for proper preservation.

Preparation of Cassava samples for Analysis

The cassava samples obtained from the various sites were initially washed with borehole water to remove all dirt and soil particles attached to them. Thereafter, they were washed again with de-ionized water obtained from the laboratory. The leaves were immediately put into the oven and dried at a temperature of 60 ^{O}C for six hours to a constant weight. The cassava tubers were first peeled to remove the outer covering and the white edible part cut to small sizes. After which, they were dried for between eleven to twelve hours to a constant weight.

The dried leaves and tuber samples were pulverized in an electrical grinder to fine powder. The powdered cassava samples were removed and placed in nitric acid pre-cleansed plastic bottles and stored until time for digestion.

Digestion of Cassava Samples and analysis

Accurately weighed 2.0 g of each sample were transferred to digesting vessels previously acid washed and 7 ml of 70% nitric acid, 2 ml of (35%) hydrogen peroxide and 1ml of HCl were added to the individual vessels. All vessels were firmly sealed and placed in a steam bath operated at a temperature of 60 ^{o}C. The vessels were heated for one and half hours for a clear colour of the digest to appear. Thereafter, 20 ml of water was added and heated for 30 minutes. The vessels were removed from the digester and the digested samples were allowed to cool. They were then transferred to 50 ml volumetric flasks. Then appropriate volume of de-ionized water was added to 50 ml mark. The digested samples were filtered using whatman filter paper into 50 ml plastic sample bottles. These were stored in a refrigerator maintained at 4 ^{o}C until time for analysis. The preserved solutions of the digests were determined using atomic absorption spectrometry (AAS), model 71906. Triplicate measurements were done for all the samples.

III. RESULTS AND DISCUSSION

The concentrations of heavy metals in the leaves and tubers of the cassava plant from the different study locations are shown in Tables 1 - 4. The concentrations of Cd in the cassava leaves in July varied from 0.031 – 0.314 mg/Kg, with a mean value of 0.127±0.110 mg/Kg, while that of October varied from 0.044 - 0.311 mg/Kg, with an average value of 0.132±0.105 mg/Kg. In the tubers of the cassava from the various stations, the concentrations of Cd varied from undetected - 0.041 mg/Kg with a mean value of 0.019±0.019 mg/Kg in July, but October values ranged from undetected - 0.040 mg/Kg and a mean of 0.020±0.020 mg/Kg. The concentrations of Cd in the leaves were either lower or higher than the FAO/WHO (2011) value of 0.1 – 0.2 mg/Kg in consumable crop. The values obtained indicated that Cd was more accumulated in the leaves than the tubers of the cassava plant.

The concentrations of Cd in the cassava parts in this study is at variance with the observation of Idodo-Umeh and Ogbeibu (2010), who did not detect Cd in both soil and the parts of cassava and plantain examined, but lower than the values observed in the leaves of millet and maize in Abare and Dareta, Zamfara State, Nigeria, where concentrations of Cd were high to the value of 5.74±0.133 and 5.34±0.08 mg/Kg respectively (Ogunlesi*et al*., 2017) and fell within the range of values observed in *Commelina Africana*, where values were observed within the range of 0.150 - 0.750 mg/Kg (Benson *et al*., 2016). The presence of the Cd in the cassava plant is as a result of transfer from the soil to the different parts of the cassava, which also may have different accumulation capacities

Cd is a known carcinogen and therefore its presence in a staple food as cassava, that is highly consumed within the Gokana Local Government Area and also sold in the market patronized by the Rivers populace has the potential to cause risk and health challenges and environmental worries or concerns to the consuming population (Luo *et al*., 2012).

The concentrations of Pb in the cassava leaves from the sampled locations were in the range of 1.092 – 1.417 mg/Kg, with an average concentration of 1.297±0.124 mg/Kg in the month of July, while in October, the concentrations ranged from 1.063 - 1.631 mg/Kg and a mean concentration of 1.287±0.210 mg/Kg. In the tubers, the observed concentrations ranged from 0.032 - 0.943 mg/Kg and a mean concentration of 0.377±0.341 mg/Kg in July, while in October, the concentration ranged from 0.041 - 0.854 mg/Kg and a mean of 0.364±0.300 mg/Kg. The concentrations of Pb were observed to be higher in the leaves than the tubers of cassava examined. The concentrations of Pb observed from this work are within that of WHO/FAO (2011), which is stipulated between 0.1 - 2.0 mg/Kg in food.

Table 1: Heavy metal concentrations (mg/kg) in Cassava Leaves from some communities in Gokhana L.G.A. in July

Heavy Metals (mg/Kg)	Stations				Mean±SD
	Yege	Bodo	B-Dere	K-Dere	
Cd	0.071	0.031	0.091	0.314	0.127±0.110
Pb	1.311	1.417	1.369	1.092	1.297±0.124
Cr	1.211	3.102	2.911	2.414	2.410±0.736
Cu	2.506	2.118	2.912	2.607	2.536±0.284
Fe	112.432	87.604	91.418	102.811	98.566±9.767
Ni	1.897	2.861	2.699	1.767	2.306±0.480

Table 2: Heavy metal concentrations (mg/kg) in Cassava Leaves from Some Communities in Gokana L. G. A. in October

Heavy Metals (mg/Kg)	Stations				Mean±SD
	Yege	Bodo	B-Dere	K-Dere	
Cd	0.073	0.044	0.101	0.311	0.132±0.105
Pb	1.242	1.631	1.210	1.063	1.287±0.210
Cr	1.192	3.310	3.001	2.381	2.471±0.811
Cu	2.491	2.193	3.005	2.594	2.571±0.291
Fe	121.321	90.001	90.865	100.661	100.712±12.614
Ni	1.094	2.855	2.701	1.696	2.087±0.726

The observed concentrations of Pb in the present study are lower than the concentrations of Pb observed in the leaf, stem and root of *Myriophyllumspicatum* with concentrations of Pb in the range of 3.05 ± 0.43 - 17.04 ± 2.21 mg/Kg dry weight of the plant (Yabanlı *et al*., 2014), but were either lower, or within the range observed in the works of Hind *et al*., (2015) in various parts of the plant *Diplaziumesculentum*. However, Pb has been considered as a major chemical pollutant in the environment.

The presence of Pb (an unwanted metal) in the parts of cassava plant most especially the tuber is not good for the cassava consuming populace. This is based on the fact that cassava is used for production of garri, tapioca and fufu which are highly consumed foodstuff in the southern part of Nigeria. Continuous consumption of the food item (which was not subjected to laboratory analysis) can lead to cumulative effect of Pb in the tissues of human and animals, which can be detrimental to the well-being or health of the consumers (Van Vuren and Nussey, 1996). The effects of Pb on consumers are known to be numerous, which include among others; damage of placenta, abortion, damage of the brain of foetus and reduction in the immune potentials of human (thus making him vulnerable to disease attack). This situation where the person's immune system attacks its own cells which can cause diseased conditions as rheumatoid arthritis, diseases of kidneys, nervous system and circulatory system (Casarett and Doull, 1996;Fosu-Mensah et *al*., 2017). Furthermore, its presence in the human system can lead to nervous ailments, destruction of CNS and malignancies of several body tissues (Casarett and Doull, 1996). The presence of Pb in plant parts have been documented to cause dwarfing of and reduction in harvest of plants (Balba *et al*., 1991).

The concentrations of Cr in the cassava leaves fall within the range of 1.211 - 3.102 mg/Kg and mean concentration of 2.911 mg/Kg in July and in October, the range was 1.192 - 3.310 mg/Kg and a mean concentration of 2.471±0.811 mg/Kg. In the tubers, the concentrations of Cr were in the range of 1.061 - 1.236 mg/Kg and a mean concentration of 1.126±0.067 mg/Kg in July and those of October ranged from 1.143 - 1.439 mg/Kg and a mean concentration of 1.294±0.115 mg/Kg.

Panda *et al*. (2003) have reported Cr induced chlorosis in young leaves of wheat, damage to root cells, impaired photosynthesis, altered enzymatic function, stunted growth, and consequently plant death. Also, Sangwan *et al*. (2014), observed Cr induced decline in growth of bunch bean due to seizure in the activities growth regulatory enzymes such as nitrogenase, nitrate reductase, nitrite reductase, glutamine synthetase and glutamate dehydrogenase.

Additional, study revealed that Cr stress decreased the size in barley plants through affecting the structure order in leaves by irregular thickening and swelling of chloroplast, increased amount of plastoglobuli and degenerated thyroid tissue which was consequent in the total decline in net stomatal conductance, concentration of carbon dioxide in the cell, the rate of respiration, and distortion of other light based reactions such as photochemical effectiveness and net rate of photosynthesis (Ali *et al*., 2013).

Cr controls carbohydrate, nucleic acid, and lipoprotein uptake. Cr also potentiates insulin action (Yap *e al*., 2010). Further to this, Cr is involved in the activation of several enzymes. Nevertheless, prolonged contact with Cr could harm the liver, kidney, and lungs (Malaysian Food Regulation, 1996). Lack of Cr causes reductions in the proficiency of insulin and causes a rise in sugar and cholesterol levels in the blood. Cr deficiency also causes insulin resistance, impairs glucose tolerance, and possibly functions as a risk factor of atherosclerotic diseases (Shedded *et al*., 2006).

The concentrations of Cu in the samples of cassava leaves from the stations were observed to fall within the range of 2.118 - 2.912 mg/Kg, with an average concentration of 2.536±0.284 in July and in the month of October, the concentrations were in the range of 2.193 - 3.005 mg/Kg and a mean concentration of 2.571±0.291 mg/Kg. The concentration observed in the tubers from the different locations varied between 1.410 - 1.897 mg/Kg and a concentration of 1.567±0.304 mg/Kg in July, while the recorded concentration in October ranged from 1.683 – 2.001 mg/Kg and a mean of 1.872±0.119 mg/Kg. The concentrations of Cu observed in both leaves and tubers of cassava from the sampled stations were lower than the 40 mg/Kg for food (WHO/FAO, 1984). The amount of Cu permitted by WHO in therapeutic plants is 10 mg/kg and that of daily consumption from food is pegged at 23mg/day (WHO, 2005).

The obtained concentrations of Cu from the different parts of the cassava plant may not pose health threat to its consumers. The concentrations in the leaves were slightly higher than those of the tubers. Cu concentrations in the present study were within the range of concentrations observed in rice, wheat and onion from heavily impacted industrial area in Isfahan, Iran (Moradi *et al*., 2013), but were generally lower than those obtained from different fruits and edible plants in Misurata Area of Libya (Elbagermi *et al*., 2012). However, the observed concentrations of Cu in the present work is higher than those observed in selected vegetable crops in Dar es Salaam, Tanzania (Kacholi and Sahu, 2018).

Table 3: Heavy metal concentrations (mg/kg) in Cassava Tubers from Some Communities in Gokana L. G.A in July

Heavy Metals (mg/Kg)	Stations				Mean±SD
	Yege	Bodo	B-Dere	K-Dere	
Cd	-	-	0.036	0.041	0.019±0.019
Pb	0.237	0.943	0.032	0.294	0.377±0.341
Cr	1.090	1.117	1.061	1.236	1.126±0.067
Cu	1.812	1.148	1.897	1.410	1.567±0.304
Fe	103.436	99.728	84.632	98.604	96.600±7.137
Ni	0.149	-	0.811	1.656	0.654±0.654

Table 4: Heavy metal concentrations (mg/kg) in Cassava Tubers from Some Communities in Gokana L. G. A. in October

Heavy Metals (mg/Kg)	Stations				Mean±SD
	Yege	Bodo	B-Dere	K-Dere	
Cd	-	-	0.040	0.039	0.020±0.020
Pb	0.261	0.854	0.041	0.301	0.364±0.300
Cr	1.143	1.439	1.231	1.362	1.294±0.115
Cu	1.936	2.001	1.867	1.683	1.872±0.119
Fe	114.293	98.563	83.905	102.681	99.861±10.869
Ni	0.189	0.021	0.903	1.726	0.710±0.674

Beside the function of Cu as a biocatalyst, Cu is very important in body skin-colouring, effective or proper care of the wellness of central nervous system, prevention of anemia and helps in boosting the functions of Zn and Fe in animal body system (Akinyele and Osibanjo, 1982). As an important element required for normal functioning of plant and human cells, it is indispensable for the proper functioning of several enzymes, regular growth and development. Elevated levels of Cu can cause metal vapours fever, change in the colour of hair and skin, dermatitis, breathing tract ailments and other deadly ailments in humans (Khan *et al*., 2008).

The concentrations observed for Fe in the various samples of cassava leaves ranged from 87.604 - 112.432 mg/Kg, with a mean of 98.566±9.767 mg/Kg in July, while the obtained concentrations in October ranged from 90.001 - 121.321 mg/Kg, with a mean of 100.712±12.614 mg/Kg. In the tubers, the concentrations of Fe were within the range of 84.632-103.436 mg/Kg with mean concentration of 96.600±7.137

mg/Kg in July while in October, the obtained concentrations ranged from 83.905 – 114.293 mg/Kg and a mean concentration of 99.861±10.869 mg/Kg. The concentrations of Fe in the leaves and tubers of cassava were not significantly different. The concentrations in both parts were higher than the FAO/WHO (1996) requirement in edible or consumable crops stipulated at 42.5 mg/Kg.

The observed concentrations of Fe in parts of cassava in the present work is higher than those of Kacholi and Sahu (2018) in selected vegetables commonly eaten in Dar es Salaam, Tanzania and those of Shah *et al*., (2013) in selected medicinal plants, but were lower than the concentrations of Fe observed in selected plants (*Athyriumesculentum*, *Chromolaenaodorata*, and *Lantana camara*) from roadside of Maran district, in Pahang, Malaysia (Sulaiman and Hamzah, 2018) and also lower than those of Hajar *et al*., (2014) in leaves, stems and flowers of *Steviarebaudiana* plant obtained from the countryside of Malacca, Malaysia.

Fe is an indispensable element required for the growth of plant and mostly taken as one of the macronutrient. Iron is considered the key metal in energy transformations needed for syntheses and other life processes of the cells (Thompson and Troeh, 1973). Despite the fact that Fe as a metals is not counted to be lethal, yet its environmental status is very important due to its interrelationship with other metals that are known to be toxic to man, animals and plants. The oxides of Fe are adsorbed to several elements and which partake in the reduction of many trace or heavy metals. When Fe is in appreciable or large quantity in the soil, it prevents the uptake of many trace metals by plant, but the reverse is the case when little of Fe is present and the others are in larger quantity. In the reverse situation, the rate of synthesis of chlorophyll by plants is greatly inhibited. The ratio of Fe to Mg present in a plant is an important factor in their utility for metabolic processes and very important to the plant rather than their concentrations. When their ratio is balanced, the different tissues of plant responds favourably to growth signals (Kabata-Pendias and Pendias, 1992).

The concentrations of Ni observed in the cassava leaves from the sample stations varied from 1.767 - 2.861mg/Kg with mean concentration of 2.306±0.480mg/Kg in July, whilein October, the concentrations ranged from 1.094 – 2.885 mg/Kg with mean concentration of 2.087±0.726 mg/Kg. The obtained concentrations of Ni in the tubers was within the range of undetected - 1.656 mg/Kg and a mean concentration of 0.654±0.654 mg/Kg in July, while the concentrations observed in October ranged from 0.021 - 1.726 mg/Kg and a mean of 0.710±0.674 mg/Kg. The concentrations of Ni in the cassava leaves were higher than the WHO/FAO (1984) permissible limit of 1.63 mg/Kg in consumable plants. The observed concentrations of Ni were higher than those observed in plants at Korle Bay area in Accra, Ghana (Fosu-Mensah *et al*., 2017) and those of Mee-Young *et al*., (2013) in yam powder sold in South Korea. The presence of Ni in the parts of cassava plants in the studied area might be ascribed to the used of heavy exploration equipment which contain Ni in the alloy compositions which was transferred from the soil to the plant. Elevated concentration of Ni in an edible plant can lead to the development of health challenges among consumers.

Ni uptake by plants is achieved through unmotivated transmission and dynamic transference. This is achieved through minor transport of proteins called permeases. The entry of Ni bound complexes or compounds into plant roots and other parts is achieved principally by endocytosis and transported to other parts of the plant via the xylem tissue where they get accumulated. The transfer of Ni is controlled through metal-ligand complexes (Ahmad and Ashraf, 2011).

Lack of Ni in plants is associated with some growth and metabolism associated problems in plants such as: stunted growth, stimulation of aging characteristics, stem and leaf diseases, reduction in the absorption of Fe. Other effects of Ni deficiency are the reduction of activity of some Ni bound stimulated enzymes such urease, superoxide dismutase, nickel, nitrogen uptake, metabolism of hydrogen (Ahmad and Ashraf, 2011).

Despite its metabolic importance to plants, at high concentrations, it becomes poisonous to many species of plants and thus reduces the capacity of plants and seeds to germinate by interfering with enzymes responsible for germination and growth in the plant. It also affects the development of root and shoots, thus affecting branch formation, produce irregular shape of flowers, produce spot in leaf, reduces yield and productivity, and inhibits photosynthetic capacity of plants and transpiration and absorption of nutrients by the roots (Ahmad and Ashraf, 2011).

IV. CONCLUSION

Cassava is an important dietary component of Nigerian food system. However, the present research has revealed that parts of cassava (leaves and tubers) have the tendency to accumulate heavy metals in them. Further to this, is the fact that some of the metals were in concentrations above FAO/WHO limits in edible plants. This observation therefore, call for adequate processing methods of cassava tubers before consumption and the leaves before being used as medicine to avoid situations of toxicity arising from consumption.

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