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Heavy Metal Concentrations in Various Species of Onion Bulbs in (*Allium Spp.)* Lapai Market, Niger State, Nigeria

Hauwa, I. Muhammad, M. Musah and S. Abdulfatai
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Abstract: *In order to evaluate the levels of heavy metal concentration in various species of onions, this study was implemented using three varieties of onion bulbs (Bermuda onion, Spring onion, Vidalia onion), gotten from some local markets within Niger State, They were analysed for their content of Cd, Cr, Pb, Cu, Zn and Fe using dry ashing and wet digestion methods. Variation in trend of mean concentrations of heavy metals obtained in the order: Fe (312.57ppm) > Zn (18.50 mg/kg) > Cu (13.50 mg/kg) > Cr (12.88 mg/kg) > Cd (4.85 mg/kg) and Fe (312.12 mg/kg) > Zn (17.98 mg/kg) > Cu (13.10 mg/kg)> Cr (12.15 mg/k) > Cd (4.71 mg/kg) for results obtained after dry and wet ashing digestion methods respectively. There was no significant difference between the concentrations of heavy metals obtained both digestions method and between the concentrations of metals among the three species of onions. However, concentrations of Cd and Cr were above the FAO/WHO recommended limits for metals concentrations in vegetables.*

Key Words: *Onion bulbs, various species, heavy metal, determination, wet and dry*

Hauwa, I. Muhammad*
Department of Chemistry, Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria
Email: hauwalarai2010@gmail.com
Orcid id: 0000-0002-0426-7269

Monday Musah
Department of Chemistry, Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria.
Email: mkkoro22@gmail.com
Orcid id: 0000-0002-3224-1664

Sheriff Abdulfatai
Department of Chemistry, Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria.
Email: abdulfataisheriff@gmail.com
Orcid id: 0000-0001-7353-1150

1.0 Introduction

The contamination of food crops by heavy metal ions is a serious environmental problem that has severe the health of the present environment including man (Bedassa *et al*., 2017; Gebregziabher and Shiferaw, 2014). Heavy metal ion can accumulate in plant tissue through foliar absorption from the soil and the impact is normally magnified to higher organism through bio magnification (Bedassa *et al*., 2017). Heavy metals are those metals that have density greater than 5 g/cm^3 and are toxic above certain concentration (Uchechukwu, *et al*., 2018; Umoren *et al*., 2017). They include metals such as Cd, Cu, Pb, Zn, Hg, As, Ag, etc (Eddy *et al*., 2004).

Toxic impart of heavy metal ions manifest in man after ingestion through the consumption of food. Several studies have reported incidences of food poisoning through the consumption of heavy metal contaminated food. Rai *et al*. (2019) reported that heavy metal ions have significant toxic effects on some food crops and transferable or magnified impact on man through the food chain and there was a strong correlation between the concentration of heavy metals in the soil and in the crops. Onakpa *et al*. (2018) also stated that the contamination of the environment by metal ions is dangerous because their uptake by plants and subsequent accumulation in food crops consumed by humans and animals is deleterious to health. In

Bangladesh, Hezbullah *et al*. (2016) observed contamination of several food materials by arsenic. Gerberding (2005) also stated that above certain concentrations, most heavy metals can be harmful to living organisms and may be responsible to several health challenges including anemia, learning disorder, and cardiovascular disease in human. However, some heavy metals such as Fe, Cu, Mn and Zn are required in trace concentration for several biochemical functions in the living system (Lane *et al.*, 2005).

Plants can absorb toxic elements deposited on their leaves or from the soil through the root. The concentration of heavy metal in different parts of plants is a function of the species of plant, heavy metal concentration in the soil, type of soil and some of its prevailing activities ((Duran *et al.,* 2007; Francis, 2005; Queirolo *et al.,* 2000) . Literatures have revealed that heavy metals tend to be more concentrated in soft tissues of plants compared to other organs (Nwajuaku and Nweke, 2019). Also, the tendency of different plant species to accumulate heavy metal ions in their tissues can be influenced by genetic differences between plants (Nwajuaku and Nweke, 2019). Din *et al* (2013) reported high concentrations of Fe, Zn, Mn, Cu, Pb, Cr, Ni, Cd and Co ions in onions and potatoes from Pakistan and Afghanistan. Nwajuaku and Nweke (2019) revealed that onion bulb is an excellent bio-indicator for heavy metal concentrations in the soil because its tissue has a strong tendency to concentrate heavy metal ions in their tissue. Bedassa *et al*. (2017) reported significant high concentrations of Fe and Cr ions in onion bulbs and leaves from Central Rift Valley of Oromia region in Ethiopia and found that the concentrations of these ions were higher than the recommended limits.

In view of the high tendency of onions to concentrate significant levels of heavy metal ions in their tissues and the fact that it is a basic component of all types of food in most countries of the world (including Nigeria), it is necessary to investigate the level of concentrations of heavy metal ions in edible portion of onion produced in Lapai, Niger state. Therefore, the aim of the present study is to investigate level of concentrations of cadmium, chromium, lead, copper, zinc and iron ions in onions produced in Lapai, Niger State, Nigeria.

2.0 Materials and Methods

2.1 Study area

The study was carried out in Lapai, a Local Government Area in the south-eastern part of Niger state Nigeria. It has a coordinate; 9° 3' 0'' North, 6° 34' 0'' East.

2.2 Collection and preparation of samples

The samples used for the study consisted of 36 onion bulbs, selected evenly from three species (Bermuda onion, Spring onion and Vidalia which were labeled as BO, SO and VO respectively). All samples were purchased from Lapai market, Niger State, Nigeria.

2.3 Sample treatment

The onion bulbs were washed with 20 % (v/v) nitric acid to remove dirt and rinsed with distilled water. The samples were cut into pieces with a clean knife and air-dried to constant weight in the laboratory at 80 °C. The samples were crushed into powder using a blender, sieved with a 2 mm sieve and transferred into a labeled and sterile polyethylene bags for analysis (Shuaibu *et al.*, 2013). The samples were digested using dry and wet ashing methods (Alam *et al.*, 2003). 0.5 g of powdered sample was transferred into a clean crucible and was heated in a muffle furnace by stepwise increase of temperature up to 600 °C until they were completely converted to ash. The produced ash was wetted with 1 cm^3 distilled water and 2.5 cm^3 concentrated HCl was added and allowed to cool before filtration with Whatman filter paper No. 41. The digest was made up to a 1000 cm^3 mark in the volumetric flask using distilled water. Wet ashing was carried out according to the method reported by Alam *et al.,* (2003).

2.4 Determination of concentration of heavy metal ion

The concentration of heavy metals in the samples were determined using Atomic

Absorption Spectrophotometric (AA-6300 model) equipped with a digital read-out system. Working standards were used, after serial dilution of 1000 ppm metal stock solution in each case. Calibration curves were constructed by plotting absorbance values versus concentrations. By extrapolation, the concentrations of the metals in sample digests were determined. The instrument was fitted with specific lamp of every given metal.

3.0 Results and Discussion

Measured concentrations of heavy metal ions in onion bulb samples that were digested by wet and dry methods are presented in Tables 1 and 2 respectively.

Table 1: Mean concentrations of heavy metal ions in three species of onion bulbs analyzed through dry ashing digestion

Sample	Cd^{2+} (mg/kg)	Cr^{3+} (mg/kg)	Pb^{2+} (mg/kg)	Cu^{2+} (mg/kg)	Zn^{2+} (mg/kg)	Fe^{2+} (mg/kg)
BOD	5.79	16.02	ND	21.20	15.31	357.93
SOD	6.91	9.73	ND	9.07	22.63	446.51
VOD	1.84	16.88	ND	9.17	17.52	133.26
Mean	4.85	12.88	ND	13.50	18.49	312.57
Range	1.84-6.91	9.72-16.88	ND	9.07-21.20	15.31-22.63	133.26-446.51
FAO/WHO safe limit	0.2	2.3	0.3	73.3	99.4	425.50

Table 2: Mean concentrations of heavy metal ions in three species of onion bulbs analyzed through wet digestion

Sample	Cd^{2+} (mg/kg)	Cr^{3+} (mg/kg)	Pb^{2+} (mg/kg)	Cu^{2+} (mg/kg)	Zn^{2+} (mg/kg)	Fe^{2+} (mg/kg)
BOW	5.67	15.97	ND	21.17	14.80	357.72
SOW	6.79	9.68	ND	8.98	22.13	446.15
VOW	1.68	16.80	ND	9.14	17.02	132.95
Mean	4.71	14.15	ND	13.10	17.98	312.09
Range	1.68-6.79	9.68-16.80	ND	8.98-21.17	14.80-22.13	132.95-446.15
FAO/WHI safe limit	0.2	2.3	0.3	73.3	99.4	425.5

Mean concentration of cadmium ion in the onion samples is 4.85ppm and ranged from 1.84 to 6.91 mg/kg. The ranges obtained for concentrations of chromium, copper, zinc and iron ions were 9.72 to 16.88, 9.07 to 21.20, 15.31 to 22.63 and 133.26 to 446.51 mg/kg. There was no significant difference between Cd^{2+} concentrations obtained through dry and wet digestion methods. However, the results obtained indicated the presence of relatively high levels of cadmium ion compared to the recommended permissible limit of 0.2 mg/kg (FAO/WHO, 1998). This implies that the onion samples are contaminated by cadmium and may have constituted severe threat to public health through its consumption. Several health risk attributed to cadmium have been confirmed for example, Cd^{2+} can displace Ca^{2+} from the bone and cause creates toxicity (Ambedkar & Muniyan, 2012). Anthropogenic generation of Cd^{2+} can be transported between environmental matrices and the food chain. Cadmium content of food crops is a consequence of bioaccumulation of cadmium in the soil. Chronic impart of cadmium ion has been linked to chronic kidney disease, osteoporosis, diabetes, cardiovascular disease and cancer (Chunhabundit, 2016). Mean concentrations of chromium ions obtained from dry and wet digestion analysis were 12.96 and 14.15 mg/kg respectively. There was no significant difference between the concentrations of chromium ions obtained from the two methods. The observed concentrations were above the permissible limit of 2.3 mg/kg (FAO/WHO, 2001). Cr^{3+} is an essential element needed by humans to prevent health problems associated with heart conditions, disruptions of metabolisms and diabetes.

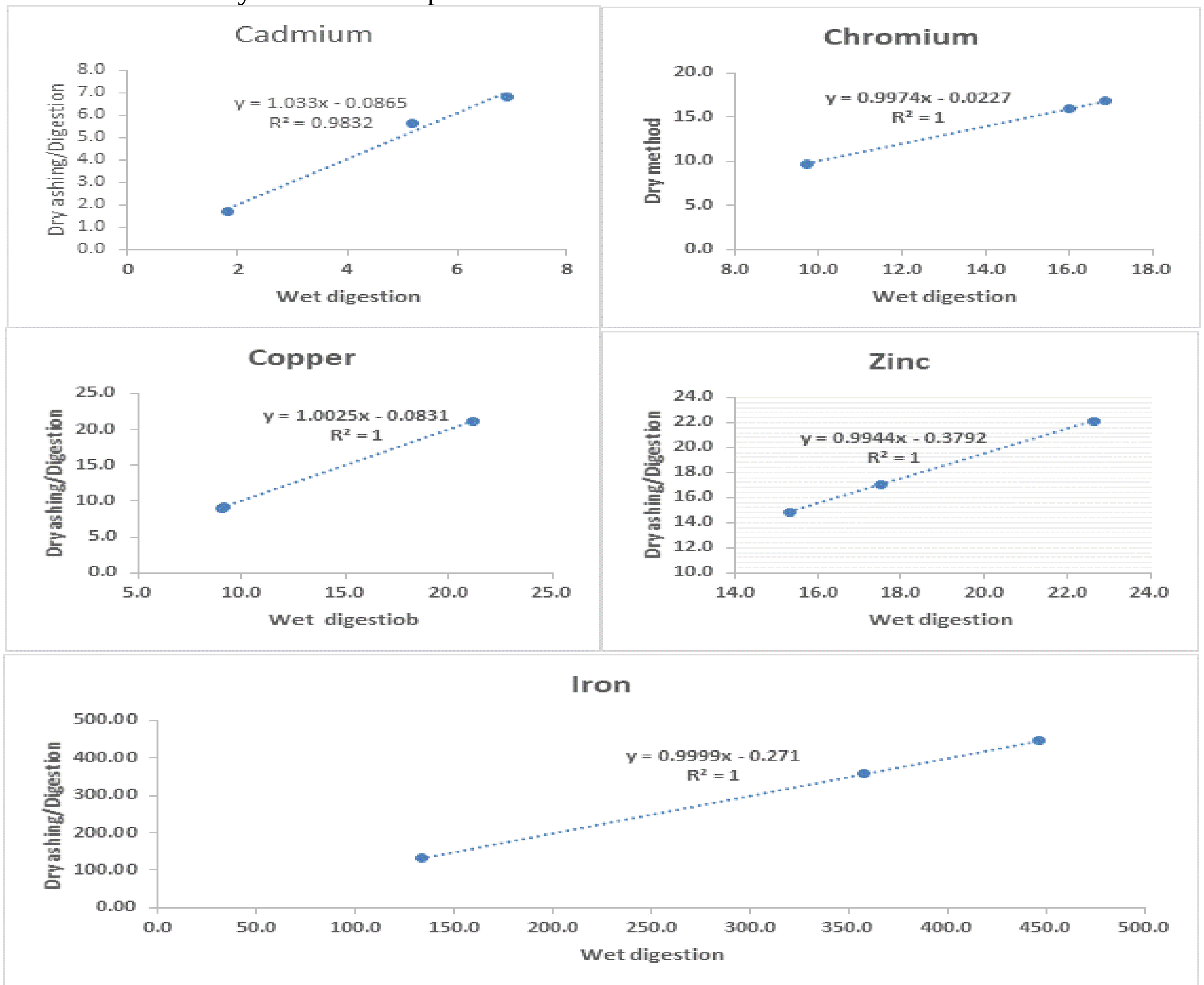

Fig. 1: Regression plots for mean concentrations of heavy metal ions from samples treated through dry ashing and wet digestion methods

However, excessive concentrations of Cr^{3+} can cause skin rashess and other related problems (ref). Cr^{6+} is the most toxic form of chromium that has been indicted as causative agent for skin rashes, stomach ulcers, respiratory problems, weakening of the immune system, kidney and liver problems, alteration of genetic materials, lung cancer and even death (Schönsleben *et al.*, 1995).

Mean concentration of Cu^{2+} in the onion samples (Tables 1 and 2) was relatively low and were below the permissible limit of 73.3mg/kg (FAO/WHO, 2001). Therefore, consumption of these onions may not create copper toxicity.

Mean concentrations of zinc ions in the various onions samples was 18.49 mg/kg which is within recommended safe limit of 99.4 mg/kg in vegetables (FAO/WHO, 2001). Similar deductions were true for iron ions which recorded a mean concentration of 312.57 mg/kg and was still within FAO/WHO acceptable limit of 425.5 mg/kg (FAO/WHO, 2001).

Fig. 1 shows various plots that compare results obtained after dry ashing and wet digestion methods. Values of R^2 obtained in all cases are perfect which indicates that results obtained from the two analytical methods are in good agreement. The results reveal that the concentrations of Zn, Cu and Fe ions were within the permissible limit while those of chromium and cadmium exceeded their respective permissible limits (FAO/WHO, 2001). The observed results are comparable to those reported for onion bulb and onion leaf from Mojo, Meki and Ziway areas of Ethiopia by Bedassa *et al.* (2017). They were also comparable to those reported by Ziway (3.33 mg/kg, 764.33 mg/kg) respectively. Highest concentrations of

Cd^{2+}, Cr^{3+}, Cu^{2+}, Zn^{2+} and Fe^{2+} were observed in SO_D, VO_D, BO_D, SO_D and SO_D respectively while least were observed for VO_D, SO_D, SO_D, BO_D and VO_D respectively.

Analysis of variance (ANOVA) was carried out to test the existent of statistical difference between concentrations among the species and between the method of measurements and the ANOVA parameters obtained are recorded in Table 3.

Table 3: ANOVA parameters for variation in species and analytical methods for onions

Source of Variation	*Sun of square*	*Degree of freedom*	*Mean square*	*F*	*P-value*	F_{crit}
Method	216140.5	4	54035.1344	10.4214	0.0029	3.8379
Species	10839.47	2	5419.73363	1.0453	0.3952	4.4590
Error	41480.21	8	5185.02585			
Total	268460.2	14				

The two sources of variation listed in Table 4 are variation among species and variation in analytical methods. Sine $F_{critical}$ is greater than $F_{Cal'}$, it can be concluded that there is no differences between heavy metal concentrations in the three species of onions studied and that there is no difference between the results obtained from wet and dry digestion analytical methods.

4.0 Conclusion

Result of this study reveals that onion bulbs obtained from Lapai market contain substantial amounts of metals with exception of Pb which was not detected. The general trend for the mean concentrations of the metals studied in the onion samples to be: Fe>Zn>Cu>Cr>Cd. Also, values obtained from dry ashing digestion method were slightly higher than those of the wet digestion method. Concentration of Cd and Cr metals were above the safe limits prescribed by the FAO/WHO. This result is a cause for concern as human health could be directly affected by the consumption of these vegetables.

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Conflict of Interest

The authors declare no conflict of interest.