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Levels of Heavy Metals in Commonly Consumed Vegetables Obtained from Some Markets in Ota, Nigeria

[1]Azeez, R.M.[*], [2]Babayemi, J. O.

[1]Department of Chemical Sciences, Bells University of Technology, Ota
[2]Department of Chemical Sciences, Anchor University Lagos

***Corresponding author:**
E-mail: mopelola008@gmail.com

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ABSTRACT

Background: As a result of increasing environmental pollution in developing countries, Nigeria in particular, assessment of food contamination is necessary.
Objectives: This study aimed at assessing the concentrations of heavy metals in vegetables available in selected markets at Ota, Ogun State.
Method: A total of 75 samples of three edible leafy vegetables: fluted pumpkin leaves *(Telfairia occidentalis)*, Lagos spinach, "Green" *(Amaranthus hybridus*) and Jute Mallow (*Corchorus olitorius*) were obtained from Iyana Iyesi, Ota, Oju-Ore, Sango-Ota and Toll-gate markets in Ado-Odo/Ota local government, Ogun State, Nigeria. The samples were digested and analyzed for heavy metals using Atomic Absorption Spectrophotometer (AAS) following a standard method.
Results: The results showed that all the metals detected were above the WHO/FAO permissible limits. Lead (Pb) was detected in all the vegetables except Jute Mallow from Sango and Fluted Pumpkin in Toll gate. The Pb content in all the vegetables ranged from 0.269±0.36 to 12.601±1.80 mg/kg. Cadmium was also detected in all the vegetables except Lagos Spinach (obtained from Sango Ota) and Fluted Pumpkin (obtained from Iyana Iyesi). The Cd content in all the vegetables ranged from 0.156±0.04 to 0.832±0.03 mg/kg. Chromium (Cr) was not detected in all the vegetables sold at Sango and also in Fluted pumpkin from Iyana Iyesi Market. The Cr content in all the vegetables ranged from 0.508±1.09 to 1.799±1.19 mg/kg.
Conclusion: With regards to the locations or markets, the differences in concentrations were significant ($P<0.05$), while with regards to the metals, the differences in the concentrations were not significant. With significant values of Lead, Cadmium and Chromium observed in samples, vegetable consumers must be wary of vegetables to buy and the source.

Keywords: Heavy metals, vegetables, *Telfairia occidentalis, Amaranthus hybridus, Corchorus olitorius*, Ado-Odo/Ota

INTRODUCTION

At the time of purchase, consumers' choice of vegetables is influenced by the demand for better quality vegetables. Generally, consumers see clean and fresh vegetables as 'better quality". This however may not guarantee safety from contamination. Contaminants in food can be heavy metals (Mapanda *et al.,* 2005) or persistent organic pollutants (Babayemi, 2016). The source of contamination of vegetables with heavy metals can be absorption from contaminated soils or atmospheric deposits on exposed vegetables (Sobukola *et al., 2010*). Mineral composition of plants may depend on the chemical composition of the soil where they grow (Babayemi *et al*., 2017). Hence, the mineral composition of similar vegetables may differ, depending on the source. Generally, contamination of food, particularly vegetables may be expected in industrial cities in Nigeria and in certain communities because of inappropriate waste management resulting in pollution (Babayemi *et al., 2016*). Previous reports have shown contamination of various categories of foods as a result of environmental pollution (Babayemi, 2016).

Vegetables may also contain elevated concentrations of heavy metals through absorption from contaminated soil (Naser *et al.,* 2011). The concentration of heavy metals in plants depends on the species, the concentration and bioavailability of heavy metals in the soil and environmental conditions (Intawongse and Dean, 2006).
With regards to nutrition, metals can be essential (e.g., Zn, Cu, Mn, Cr, Ni), or non-essential and toxic (e.g., Cd, Pb, Hg, As) (Adriano, 2001; Kirkby, 2012). In environmental monitoring, Cd, Cr and Pb are commonly assessed toxic metals. Their toxicity or adverse human health effects have been documented. The

adverse health effects of Cr include cancer, decreased pulmonary function, bronchitis and ulcerations of the septum (Shanker and Venkateswarlu, 2011). Pb toxicity results in cardiovascular problems, decreased kidney function and abnormality in behavior and learning problems in children, and various other health challenges (Skerfving et al., 2015). Cd poses health challenges such as bronchiolitis, impairment of renal function, cancer and genetic disorders (Cartularo et al., 2015; Zang, 2016).

This study aimed at investigating the presence and concentrations of Cd, Cr and Pb in the vegetables sold in some selected markets in Ado-Odo/Ota local government, Ogun State, Nigeria.

MATERIALS AND METHODS

Five (5) different study locations (markets) were selected in Ado-Odo/Ota Local Government Area of Ogun State. The Local Government Area is the second largest in Ogun State and the headquarters being Ota (or Otta) at 6°41′00″N 3°41′00″E to the north of the Area. There are vast agricultural activities in the area. The Local Government Area produces cash and food crops especially cocoa, kolanut, palm oil, coffee, cassava, timber, maize, and abundance of vegetables (Ado-Odo/ota Local Government, 2013).

The method used random sampling technique to collect the vegetable samples of fluted pumpkin leaves (*Telfairia occidentalis*), Lagos spinach, "Green" (*Amaranthus hybridus*) and Jute Mallow (*Corchorus olitorius*) at five (5) major markets in Ota: Iyana Iyesi, Oja Ota, Oju Ore, Toll Gate and Sango at five random points. The leaves of the vegetable samples were separated from the whole plants, washed, oven dried and labelled.

The vegetable samples were washed with tap water and de-ionized water to remove attached particles. The washed samples were oven-dried at 105 ^oC. The dried samples were pulverized, using agate pestle and mortar, and sieved through a 0.5 mm mesh size sieve. The processed samples were labeled and stored in a dry plastic container that had been pre-cleaned with concentrated nitric acid.

Experimental studies were carried out at the Central Research and Teaching Laboratory, Bells University of Technology, Ota, Ogun State, following the procedure of one of the methods of the Association of Official Analytical Chemists AOAC (1990). The seventy-five (75) dried, labeled samples were subjected to dry ashing, which involves the complete combustion of all the organic matter in a muffle furnace at 550 ^oC, followed by dissolution of the residual ash in HNO_3.

Two (2g) of oven-dried samples were weighed into an acid-washed porcelain crucible, and placed in a muffle furnace. The temperature was raised slowly to reach 550 ^oC and the sample ashed for 6 hours. The crucibles were removed from the furnace and allowed to cool. 5 mL of 6M HNO_3 was added, stirred to ensure that the ash dissolves. It was then filtered into a 50 mL volumetric flask; the crucibles were rinsed with de-ionized water into the volumetric flasks and then made up to the mark with deionized water. A blank was prepared by repeating the same procedure without the vegetable.

RESULTS AND DISCUSSION

Data were reported as mean ± standard deviation (SD). One way analysis of variance (ANOVA) was used to determine the significant difference ($p<0.05$) among markets and among heavy metals using SPSS Version 20.00. The results are shown in Tables 1-5.

The results showed that *Amaranthus hybridus* had high concentrations of Cd, Cr and Pb. Analysis of variance showed that the differences in the levels of concentration of these metals were significant ($P<0.05$) with regards to vegetables. On the other hand, with regards to location, especially a market like Oju-ore, analysis of variance showed that the levels of Cd were not significantly different ($P<0.05$).

The mean concentrations in Jute Mallow and Lagos spinach from Iyana Iyesi ranged from 0.205mg/kg to 0.413mg/kg (Cd) and 1.373mg/kg to 1.799 mg/kg (Cr) respectively (Table 1). Chromium and Cd were not detected in fluted pumpkin obtained from this market. Pb was detected in all the vegetables and it ranged from 0.269mg/kg to 5.947mg/kg.

The heavy metals were detected in all the vegetables obtained from Oja Ota market (Table 2). Cd ranged from 0.263±0.035 mg/kg to 0.832±0.029 mg/kg; Cr from 0.694±0.015 mg/kg to 0.958±0.834 mg/kg; and Pb from 0.551±0.025 mg/kg to 6.268±0.139 mg/kg.

In Sango Ota market (Table 3), Cr was not detected in all the samples; Pb was not detected in Jute Mallow and Cd was not detected in Lagos Spinach. The Cd detected ranged from 0.156 mg/kg to 0.393mg/kg and Pb from 0.346 mg/kg to 1.938 mg/kg.

Table 1: Mean concentrations of heavy metals of vegetable samples from Iyana Iyesi Market

Samples	Heavy metals (mg/kg)		
	Cd	Cr	Pb
Fluted pumpkin	ND	ND	1.699±0.018
Jute mallow	0.205±0.005	1.373±0.361	0.269±0.364
Lagos spinach	0.413±0.058	1.799±1.186	5.947±0.080
WHO/FAO	0.1	0.3	0.3

ND: Not detected

Table 2: Mean concentration of heavy metals of vegetable samples from 'Oja Ota' Market

Samples	Heavy metals (mg/kg)		
	Cd	Cr	Pb
Fluted pumpkin	0.263±0.035	0.958±0.834	6.268±0.139
Jute mallow	0.832±0.029	0.951±0.166	1.001±0.203
Lagos spinach	0.367±0.103	0.694±0.015	0.551±0.025
WHO/FAO	0.1	0.3	0.3

Table 3: Mean concentration of heavy metals in the vegetable samples obtained from Sango Ota Market

Samples	Heavy metals (mg/kg)		
	Cd	Cr	Pb
Fluted pumpkin	0.156±0.038	ND	1.938±0.288
Jute mallow	0.393±0.032	ND	ND
Lagos spinach	ND	ND	0.346±0.471
WHO/FAO	0.1	0.3	0.3

ND: Not detected

Table 4: Mean concentration of heavy metals in the vegetable samples obtained from Oju-Ore Market

Samples	Heavy metals (mg/kg)		
	Cd	Cr	Pb
Fluted pumpkin	0.212±0.029	1.267±0.000	5.720±0.191
Jute mallow	0.427±0.029	0.921±0.000	12.601±1.80
Lagos spinach	0.367±0.103	0.694±0.000	1.125±1.542
WHO/FAO	0.1	0.3	0.3

Table 5: Mean Concentration of heavy metals in the vegetable samples obtained from Toll gate Market

Samples	Heavy metals (mg/kg)		
	Cd	Cr	Pb
Fluted pumpkin	0.308±0.000	0.508±1.093	ND±0.000
Jute mallow	0.192±0.119	1.605±0.801	3.306±0.119
Lagos spinach	0.367±0.000	0.707±0.563	4.359±0.000
WHO/FAO	0.1	0.3	0.3

ND: Not detected

In samples from Oju-Ore market (Table 4), all the metals were detected; Cd ranged from 0.2mg/kg to 0.367 mg/kg, Cr 0.694mg/kg to 1.267mg/kg and Pb from 1.125mg/kg to 12.601±1.80.

Pb was not detected in Fluted pumpkin obtained in Toll gate market (Table 5). The non-detection of Pb in some of the samples is similar to the report of Ladipo and Doherty (2011) that Pb was not detected in some vegetable samples at the time of their study. Cd ranged from 0.192±0.119 mg/kg to 0.367±0.000 mg/kg; Cr from 0.508±1.093 mg/kg to 1.605±0.801 mg/kg; and Pb from 3.306±0.119 mg/kg to 4.359±0.000. Some values previously reported for Cd in leafy vegetables include 0.090mg/kg and 0.049mg/kg for flutted pumpkin and for lettuce respectively (Sobukola *et al.,* 2010; Muhammad *et al.,* 2008). For waterleaf sold in some markets at Ota, previous studies revealed the levels of these heavy metals to be Pb (0.35-3.85 mg/kg), Cd (ND), Cr (ND-7.11 mg/kg) (Babayemi *et al*., 2016); which are similar to the present study. In this study, Cd, Cr and Pb were detected at higher concentrations than the FAO/WHO safe limit of 0.1mg/kg for Cd, 0.3mg/kg for Cr and 0.3 mg/kg for Pb consumption in vegetables.

Generally, the levels of Pb in the analysed samples were high when compared with the permissible levels. The route of Pb contamination in the vegetables may include pollutants present in irrigation water, contaminated farm soil or pollution from the highways traffic (Anhwange *et al.,* 2004). Reports have shown that the soil chemical composition may influence the heavy metal uptake by vegetables (Babayemi *et al*., 2017; Sobukola *et al., 2010*). High levels of Pb in food should be of high environmental and human health concern.

Pb possesses toxic properties and the common routes of human exposure include air, water and food and the content in food may not be removed by simply washing the food items (Chove *et al.,* 2003). Cr, Cd and Pb are toxic metals and their human health effects have been documented (Gullfraz *et al.,* 2001; Pehlivana *et al*, 2008). For Cr, some effects include skin rashes, stomach ulcer, kidney, liver damages, lungs and cancer (Kirmani *et al.,* 2011) and osteomalacia (Hashmi, 2007). Kidneys and livers are target organs for Cd (Divrikli *et al.,* 2006).

Anthropogenic activities contribute to the sources of Cd in the environment. The applications include batteries, pigments and fertilizers and may also be present in detergents. In some places in Nigeria (Musa and Ifatimehin, 2013) and some other African countries (Odai *et al.,* 2008; Kihampa *et al.,* 2011), agricultural activities take place around dumpsites particularly for the cultivation of vegetables, taking the advantage of decomposing organic matter since vegetables thrive better on soil with sufficient decomposing organic materials. Significant contamination of vegetables on such land may occur. The high level of heavy metals might be a reflection of severe pollution of soil from the release or emission of pollutants from industries and consequently taken up by the plants growing on the soil (Al-Rashdi and Sulaiman, 2013).

In some places in Nigeria, lands at the banks of drainage channels and around dumpsites are being used to grow vegetables. Some vegetable farms are located along major highways. There can be emissions from the heavy traffic on these roads and the particulate deposits may contain Pb, Cd, Zn and Ni which may result in contamination of soil and plants and adverse effects on food quality (Kirmani, 2011; Doherty, 2007).

CONCLUSION

The vegetables studied contained varying levels of concentrations of heavy metals. Generally, the levels were high in all the markets. High levels of heavy metals in vegetables from the studied locations which exceeded the FAO/WHO permissible limits call for concern and continual environmental monitoring in this highly industrialized city.

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