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Levels of Heavy Metals in Selected Leafy Vegetables from Markets in Owerri, Imo State, Nigeria

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ABSTRACT
The study assessed the concentrations of cadmium (Cd), lead (Pb), mercury (Hg) and arsenic (As) in *Telfairia occidentalis* (fluted pumpkin), *Talinum triangulare* (water leaf), *Occimium grattissimum* (scent leaf), *Murraya koenigii* (curry leaf) and *Gnetum africana* (ukazi)) obtained from the Relief Market, New Egbada Market and Amakohia Market in Owerri, Imo State of Nigeria. The part of each of the leafy vegetables selected for analysis was the leaf. The leaves were prepared by first washing with clean borehole water to remove sand and other dirty materials before they were sun-dried for 6 days and sent to the Spring Board Research Laboratory in Anambra State, Nigeria, for analysis. The determination of the concentrations of the heavy metals in the leaves was done by Atomic Absorption Spectroscopy (AAS), using the standard procedures. Data generated from the samples were subjected to test of significance using Analysis of Variance (ANOVA) at 95% confidence level with SPSS (Statistical Package for Social Science). Results showed that the mean levels of Pb, Hg and As in the leafy vegetables were significantly higher than FAO/WHO (1999 & 2015) safe limits, whereas the mean levels of Cd were lower. Care should, therefore, be taken in the production and handling of vegetables to ensure consumption of toxic free vegetables.
Keywords: Heavy metals, Leafy vegetables, permissible limits

INTRODUCTION

Leafy vegetables are those vegetables that are cultivated and harvested primarily for the consumption of their leaves, either raw or cooked (Thompson and Kelly, 2009). They constitute essential dietary components because they are good sources of vitamins, protein, carbohydrates and other nutrients which are usually in short supply (Thompson and Kelly, 2009). Past reports (Shaibu et al, 2013) have shown that leafy vegetables contain some harmful substances over a wide range of concentrations and these include heavy metals.

Heavy metals are conventional elements with metallic properties. Their atomic numbers and densities are usually greater than 20 and 5 g/cm^3 respectively (Pehlivan, et al, 2009). Iron (Fe), cobalt (Co), zinc (Zn), cadmium (Cd), silver (Ag), mercury (Hg), arsenic (As), chromium (Cr), bismuth (Bi), thallium (Tl), ruthenium (Ru), indium (In) and Osmium (Os) are some of the known and reported heavy metals (Pehlivan, et al, 2009). While some of them (typically Fe, Co and Zn) are either essential plant nutrients or relatively harmless (especially Ru, Ag and In), but can be toxic in larger amounts or certain forms. Other heavy metals such as Cd, Hg and Pd are highly toxic (Lasat, 2000). Toxic heavy metals can be differentiated from other pollutants, since they cannot be biodegraded but can be accumulated in living organisms, thus causing various diseases and disorders even in relatively lower concentrations (Pehlivan, et al, 2009).

The most common heavy metal contaminants are Cd, Cr, Cu, Hg, Pb, and Zn (Lasat, 2000). These heavy metals are natural components of soils. Metal pollution has harmful effects on biological systems and heavy metals with soil residence times of thousands of years pose numerous health dangers to higher organisms (Lasat, 2000). They are also known to have effect on plant growth, ground cover and have a negative impact on soil microflora (Roy et al, 2005). As non-biodegradable and persistent environmental contaminants, these metallic elements may be deposited on the surfaces and then absorbed into the tissues of the vegetables (Suruchi and Pankaj, 2011). They are absorbed by growing vegetable crops from contaminated soils, water or via exposure to polluted air as a result of human/industrial activities such as mining and industrial wastes disposal, vehicle emissions, lead acid batteries disposal, fertilizers application, use of aging water supply-infrastructure and micro plastics floating in the world's oceans (Orisakwe et al, 2015). Hence, there is need to analyze food items to ensure the levels of these metallic elements comply with permissible limits. There is insufficient data on the concentrations of heavy metals in vegetables sold to consumers within Owerri in particular and Imo State in general. This is why this study aimed to assess heavy metals concentration in leafy vegetables obtained from some markets in Owerri, Imo state, Nigeria.

MATERIALS AND METHODS

Five leafy vegetables: Fluted pumpkin (*Telfairia occidentalis*), water leaf (*Talinum triangulare*), scent leaf (*Occimium grattissimum*), curry leaf (*Murraya koenigii*), ukazi (*Gnetum africana*), were bought from three major markets in Owerri: Relief Market, Amakohia Market and Egbeada Market. The three markets served as replicates.

The vegetables procured for the experiment were washed with clean borehole water and sundried for a period of five days until they were completely dry. The samples were bagged separately in black polythene bags, properly labeled and taken to Spring Board Research Laboratory, Anambra State, Nigeria, for analysis.

The determination of the concentrations of the heavy metals (Pb, Hg, Cd and As) was done by Atomic Absorption Spectroscopy (AAS), using the standard procedures reported by Kareem et al. (2016). The metallic contents of the digested samples were quantified using a Varian AA240 Fast Sequential Flame Atomic Absorption Spectrophotometer (AAS) and vapour generation accessory (Varian VGA 77) with closed end cell for mercury. The quality of analytical procedure was confirmed by analyzing standard reference materials of mussel. The concentrations of the heavy metals were expressed in mg/kg.

Data generated from the study were subjected to ANOVA at 95% confidence level. Mean separation was done using Duncan Multiple Range Test (DMRT) on SPSS (Statistical Package for Social Science) version 20.

RESULTS

The levels of the heavy metals in the leafy vegetables studied are presented in Table 1 and illustrated in Fig 1.

Table 1: Concentrations of heavy metals (mg/kg) in the leafy vegetables studied

Plant Samples	Lead (Pb)	Cadmium (Cd)	Mercury (Hg)	Arsenic (As)
Gnetum africana (Ukazi)	$0.596^{b}\pm0.002$	$0.127^{c}\pm0.0110$	$0.820^{b}\pm0.010$	$0.319^{b}\pm0.010$
Telferia occidentalis (Pumpkin)	$0.476^{a}\pm0.100$	$0.060^{ab}\pm0.020$	$0.111^{a}\pm0.001$	$0.099^{a}\pm0.001$
Talinium triagulare (Waterleaf)	$1.158^{e}\pm0.019$	$0.080^{b}\pm0.030$	$0.101^{a}\pm0.001$	$1.242^{e}\pm0.002$
Ocimium gratisimium (Scent leaf)	$0.739^{d}\pm0.010$	$0.038^{a}\pm0.011$	$0.083^{a}\pm0.002$	$0.881^{d}\pm0.100$
Murraya koenigii (Curry leaf)	$0.715^{c}\pm0.003$	$0.064^{ab}\pm0.002$	$0.079^{a}\pm0.010$	$0.342^{c}\pm0.002$
Range	0.476-1.158	0.038-0.127	0.079-0.820	0.099-1.242
Mean+ SD	0.7368±0.2417	0.0738±0.0342	0.2388±0.3011	0.5766±0.437
T (0.05)	P=0.000	P=0.000	P=0.018	P=0.001
FAO/WHO Safe Limit (2015a, 1999b)	**0.30a**	**0.20a**	**0.03b**	**0.10b**

abcd means with same superscripts are not significantly different ($p<0.05$)

As shown in Table 1, the mean concentrations of Pb were significantly different ($p<0.05$) across the leafy vegetables. *Talinium triagulare* had the highest mean concentration of Pb (1.158 mg/kg), while pumpkin leaf had least mean concentration of Pb (0.476 mg/kg). This gave a range of 0.476 - 1.158 mg/kg Pb concentrations in the leafy vegetables assessed. The mean Cd concentrations differed significantly ($p<0.05$) across the leafy vegetables studied. While *Gnetum africana* was significantly different ($p<0.05$) from the other leafy vegetables in its mean Cd concentration, *Ocimium gratisimium* had the least mean concentration of cadmium. The mean Hg concentrations were significantly different across the leafy vegetables and *Gnetum africana* had the highest mean Hg concentration compared to others. The range of mean concentrations of As in the leafy vegetables was 0.099 - 1.242 mg/kg. *Talinium triagulere* and Telferia occidentalis had the highest and the lowest mean concentrations of As respectively.

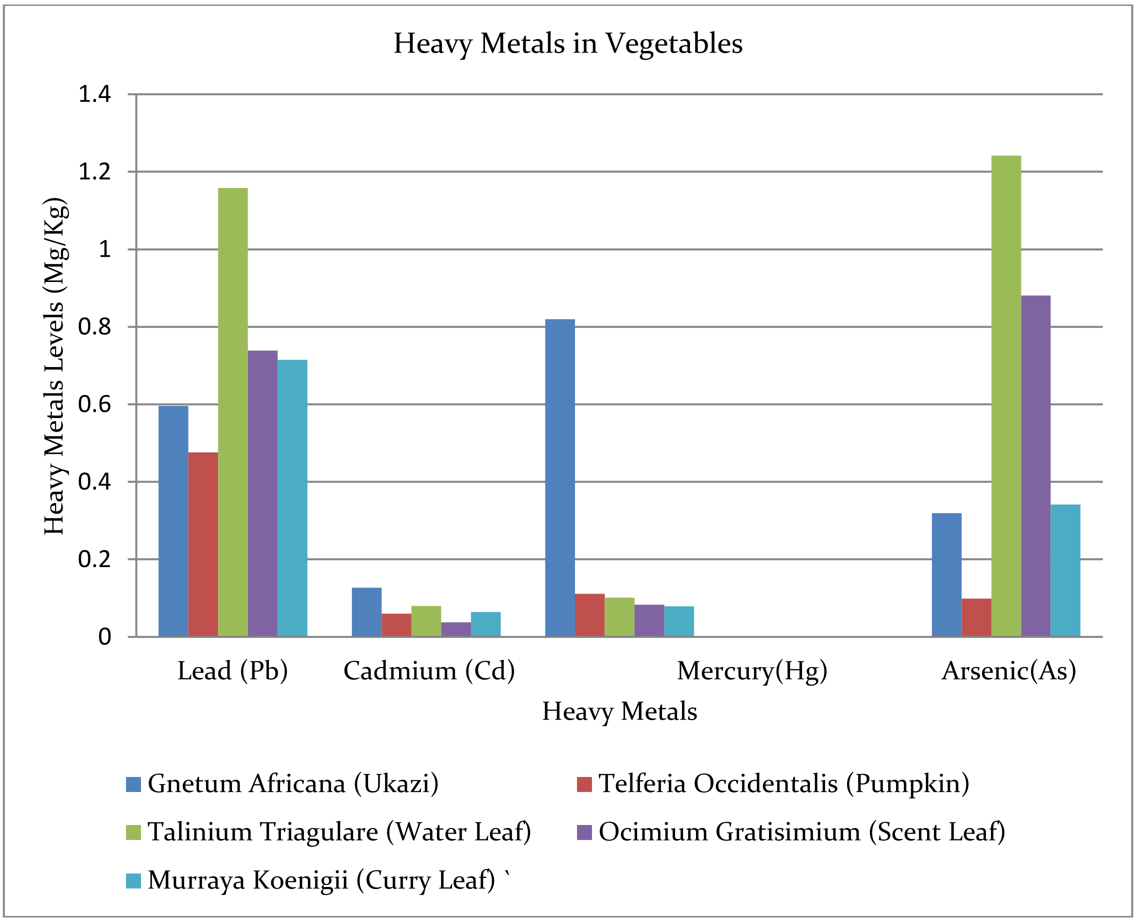

Fig 1: Variations in mean levels of the heavy metals vis-a-vis the leafy vegetables

DISCUSSION OF FINDINGS

It was from the results that the mean levels of Pb and Hg in all the vegetables were higher than the FAO/WHO (1999b, 2015a) safe limits, indicating dangers to the health of the consumers of such leafy vegetables. The mean levels of Arsenic were also higher than the FAO/WHO (1999b, 2015a) safe limits except that of *Telferia occidentalis.* The findings of this study were similar to those reported by past researchers (Maleki and Zarasvand, 2008; Sharma et al., 2009; Yusuf and Oluwole, 2009). Yusuf and Oluwole (2009) reported that urban activities result in elevated levels of heavy metals in leafy vegetables. Contaminants in irrigation water and soils also account for high concentrations of heavy metals in leafy vegetables. Vegetables can absorb metals from soil as well as from deposits on the parts of the vegetables exposed to the air from polluted environments (Khairiah et al., 2004; Al-Jassir et al., 2005; Kachenko and Singh, 2006). Emission of heavy metals from the industries and vehicles may be deposited on the vegetable surfaces during their production, transportation and marketing (Kachenko and Singh, 2006). Al-Jassir et al. (2015) ascribed the elevated levels of some heavy metals in the vegetables sold in a market in Riyadh city, Saudi Arabia, to atmospheric deposition. Sharma et al. (2009) stated that atmospheric deposition can significantly elevate the levels of heavy metals contamination in vegetables commonly sold in markets. In many developing countries, it is a common practice to grow vegetables along banks of rivers passing through urban areas and waters of such rivers have often been reported to be polluted by heavy metals (Mashauri and Mayo, 2010; Othman, 2011). The waters from such rivers are often used for irrigation purposes and account for high levels of heavy metals concentrations in vegetables.

Arsenic is extremely toxic. The concentrations of As in vegetables above the maximum permissible limit of 0.1mg/kg (WHO 1999b) in foodstuff usually cause short term health effects such as nausea, vomiting, diarrhea, and weakness, loss of appetite, cough and headache and long term health effects such as cardiovascular diseases, diabetes and vascular diseases. Mercury is more toxic than Cd and Pb and the concentrations of Hg above the maximum permissible limit of 0.03mg/kg (FAO/WHO, 1999b, 2015a) in foods and foodstuffs cause serious health problems such as loss of vision, hearing and mental retardation and finally death occurs. However, the carcinogenic effects generated by continuous consumption of fruits and vegetables loaded with Cd and Pb have been widely reported (Trichopoulos*et al*., 1997; Turkdogan*et al*., 2002). This may be related to the incidence of gastrointestinal cancer (Trichopoulos*et al*., 1997; Turkdogan*et al*., 2002) and cancer of the pancreas, urinary bladder or prostate (Waalkes and Rehm, 1994).

CONCLUSION AND RECOMMENDATIONS

The results of our study have shown that the levels of Pb, Hg and As in the leafy vegetables bought from markets in Owerri exceeded the safe limits, whereas the Cd levels were below the safe limit.

Based on the result of the findings, the following recommendations were made:

i. There is need for proper soil testing on farms before growing vegetables on such farm lands.
ii. The use of agrochemicals should be deemphasized by relevant authorities.
iii. Vegetables should not be exposed in areas with high vehicular movement.
iv. Emphasis should be on organic agriculture
v. Vegetables should be properly washed before consumption

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