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Comparative Assessment of Selected Heavy Metals in Some Common Edible Vegetables Sold in Yenagoa Metropolis, Nigeria

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Abstract: This study comparatively assessed selected heavy metals in some vegetables (viz: *Gongronema latifolium, Amaranthus hybridus, Piper guineense, Talinum triangulare, Telfairia occidentalis and Ocimum gratissimum*) commonly used for culinary purpose in Yenagoa metropolis, Nigeria. The samples were purchased from Tombia and Opolo market in Yenagoa metropolis, Bayelsa state, Nigeria. The samples were dried, digested and analyzed using flame atomic absorption spectrometery. Result showed that the concentration of lead, cobalt and cadmium were below detection level. The comparative concentration of other heavy metals in the vegetables ranged from 1.85 - 3.55mg/kg (copper), 1.63 – 14.98 mg/kg (zinc), 5.83 – 186.59 mg/kg (manganese), 8.12 – 31.72 mg/kg (chromium), 5.01 – 16.03 mg/kg (nickel) and 307.60 – 1051.31 mg/kg (iron). Analysis of variance showed that there was significance variation (P<0.05) among the various vegetables. The concentrations of the heavy metals in the vegetables were the below Food and Agricultural Organization/World Health Organization maximum limit apart for iron and chromium. As such, the vegetables from the study area should be consumed with considerable level of safety due to high iron and chromium.

Keywords: Heavy metals; Health risk; Vegetables; Yenagoa metropolis.

1. Introduction

Pollution of the ecosystem is affecting environmental sustainability [1]. Environmental contamination is majorly caused by anthropogenic activities and to lesser extent by natural effects. The impacts of human activities affect all forms of environment including water and soil. On water quality, many authors have reported that activities of makeshift refinery, wastes, oil and gas, runoff after rainfall affect water quality [2-10]. In air, studies have also indicated that major human activities such as oil palm processing releases pollutant gases and particulates into the environment [2, 11]. Waste water could also change water and soil quality. For instance, [12]. reported that palm oil processing waste water could alter the physicochemical characteristics of the receiving environment. The soil is not exempted, as it is one of the major repositories of anthropogenic wastes [13].

The type of activities depends on the type of emission released into the environment. For instance, activities such as electroplating, metal finishing, textile, storage batteries, lead smelting, mining, plating, ceramic and glass industries could lead to emission of heavy metals into the environment [14, 15]. Other possible source of heavy metals in the environment include automobile industries, bearing wear, engine part, mining, brake emission [14, 16, 17], waste waters containing pharmaceutical and personal care product, industries like antibiotics, anti-epileptics, tranquilizers among others [14, 18]. The occurrence of heavy metals in the soil leads to contamination and it affect food quality and safety especially in agricultural field [19-21].

Typically, metals that have specific gravity higher than 5 g/cm^3 are often referred to as heavy metals [14, 18, 22]. They are required by living organisms at trace concentration i.e. essential heavy metals (such as iron, copper, zinc, manganese among others). Others such as lead, cadmium, arsenic and mercury have no known biological function hence they are often referred to as non-essential heavy metals [14, 23]. Suruchi and Khanna [24], Asdeo and Loonker [25] reported that the toxicity of heavy metals could be due to the fact that they are not easily biodegraded. They are known to cause several disease conditions in human. For instance, disease conditions such as cardiovascular, hematological, neurological, respiratory, gastrointestinal and birth disorders, dermatitis and cancer could be triggered by arsenic on exposure [12, 14]. Details about the disease conditions caused by other heavy metals such as iron, cadmium, zinc, copper, manganese, mercury, chromium, lead etc have been documented by authors [14, 16, 22, 26, 27].

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Heavy metals are known to bioaccumlate in biological diversity including animals such as fisheries [20, 28-30] and plants [31]. The uptake mechanism of heavy metal from the environment by plants varies depending on the exposure route. One major means through which plant uptake heavy metals is through the root of plants [24]. The metals will then bioaccumulate in different parts of the plants including leaves, shoot, fruit, flowers, root etc. As such, consumption of vegetables that contain high concentration of heavy metals in their edible part could pose a health risk challenge to the consumers [20, 32, 33].

Green vegetables are known to have high nutritional benefits [32]. Vegetables contain several constituents including carbohydrate, fat and oil, protein, amino acids, lipids, water, sugar, energy, vitamins and minerals [24, 34, 35]. As such, they are a major source of diet [1, 32].

Several studies have reported the level of heavy metals in some common vegetables consumed in different part of Nigeria [1, 23, 27, 32, 34-38]. However, information about the heavy metals in vegetables used for culinary purpose such as *Gongronema latifolium, Amaranthus hybridus, Piper guineense, Talinum triangulare, Telfairia occidentalis, Ocimum gratissimum* in Yenagoa metropolis, Nigeria is scanty in literature. Therefore, this study determines the comparative assessment of heavy metals mostly used for culinary purpose in Yenagoa metropolis, Nigeria.

2. Materials and Methods

2.1. Study Area

Yenagoa is the capital of Bayelsa state. Bayelsa state lies in the sedimentary basin and fishing is a major occupation of the indigenous people. Yenagoa is a fast developing city with few industries and several business activities. The region is prone to flooding and has a high water table. Waste in the area is poorly managed. Several types of wastes including municipal, market and sewage are discharged directly into the Epie creek by most residents aligning the creek. The temperature and relative humidity in the area varies between 24 - 37ºC and 50 – 95% respectively all year round.

2.2. Field Sampling

The vegetables including *Gongronema latifolium, Amaranthus hybridus, Piper guineense, Talinum triangulare, Telfairia occidentalis and Ocimum gratissimum* was purchased from Tombia and Opolo market in Yenagoa metropolis, Bayelsa state, Nigeria. The samples were transported to the laboratory using polyethylene vials.

2.3. Sample Preparation

The samples were prepared and digested following the wet oxidation method using perchloric acid [39-41]. A total of 1.0g of the grounded samples was weighed into 125ml Erlenmeyer flask. 4ml, 25ml and 2ml of perchloric acid, nitric acid and sulphuric acid was added under fume hood. The mixture was moderately heated. The heating continued until dense fumes appeared. The heated mixture was allowed to cool and then 45ml of distilled water was added and then boiled for 30 minutes at moderate heat. The mixture was cooled and filtered into 100ml volumetric flask. The mixture was making up by adding distilled water.

2.4. Heavy Metal Determination

The heavy metal content of the digested vegetables were determined using flame atomic absorption spectrometery (FAAS) (Model: GBC Avanta PM A6600) at varying wave length including 213.9nm, 324.70nm, 232.0nm, 248.3nm, 279.5nm, 357.90nm, 228.8nm, 217.00nm and 240.70nm for zinc, copper, nickel, iron, manganese, chromium, cadmium, lead and cobalt respectively.

2.5. Statistical Analysis

SPSS software was used to carry out the statistical analysis. The data were expressed as Mean ± standard deviation. A one-way analysis of variance was carried out at P = 0.05, and Duncan multiple range test statistics was used to determine the source of the observed variation. Detectable metals were correlated using Spearman rho correlation matrix.

3. Results and Discussion

Table 1 presents the concentration of selected heavy metals in some commonly consumed vegetables sold in Yenagoa metropolis, Bayelsa state, Nigeria, while the spearman rho correlation is presented in Table 2. Among all the heavy metal analyzed lead, cadmium and cobalt were not detected. This suggests that no potential health risk accrued to lead, cadmium and cobalt in the consumption of the vegetables. Among the detected heavy metals including copper, zinc, manganese, iron, chromium and nickel, there was significant difference among the various vegetables for each of the metals.

The variation in the heavy metal contents could be due to the differences in bioaccumulation of plants and the industrial activities releasing heavy metals into the environment where they were cultivated. Moreover, the variation among the various plant species could be due to differences in their biochemical constituents as well as the ability to accumulate heavy metals. Dan, *et al.* [34] reported that bioaccumulation and uptake by plants depends on the morpho-physiological nature of the vegetables as well as natural variables (such as direct atmospheric deposition of metals on the leaves surfaces of vegetables by dust, air and rainfall). Furthermore, Umar and Salihu [27] reported that different plants have different potential for the uptake of elements from the soil. In addition, plant could also accumulate heavy metals through the root of vegetables cultivated in heavy metals laden areas [41].

Furthermore, the concentration of copper among the vegetables were significantly different (P<0.05), ranging from 1.85 - 3.55 mg/kg. Copper concentration among the various plants was in the order: *Gongronema latifolium* < *Amaranthus hybridus* ≤ *Piper guineense* ≤ *Talinum triangulare* ≤ *Telfairia occidentalis* < *Ocimum gratissimum.* Copper showed a significant relationship with zinc (r=0.523 P< 0.05) and iron (r=0.777, P< 0.01) and negatively correlated with manganese (r= - 0.676, P<0.01) (Table 2). The concentration of copper reported among the various vegetables is lower than the permissible limit. FAO/WHO maximum limit of copper in vegetables is 73.0 mg/kg [23]. Umar and Salihu [27] also reported WHO MPL of copper in spices as 50mg/kg. The findings of this study suggest that no health risk of copper in the consumption of common vegetables in Yenagoa metropolis, Nigeria.

Table-1. Level of selected heavy metals in some commonly consumed vegetables sold in Yenagoa metropolis, Nigeria

Vegetables	Copper, mg/kg	Zinc, mg/kg	Manganese, mg/kg	Chromium, mg/kg	Nickel, mg/kg	Iron, mg/kg
Amaranthus hybridus	2.47±0.23b	13.09±0.35e	41.46±0.09c	8.08±1.60a	5.36±0.24a	307.60±2.38a
Ocimum gratissimum	8.62±0.24e	14.98±0.68f	35.31±0.05b	37.07±6.38c	16.03±2.71c	1051.31±109.57e
Telfairia occidentalis	3.65±0.03d	7.34±1.13d	25.83±0.71a	8.12±0.96a	6.89±1.58a	589.21±17.03c
Gongronema latifolium	1.85±0.61a	1.63±0.57a	186.59±0.46f	31.72±0.26c	12.79±2.06b	495.34±5.72b
Piper guineense	3.03±0.31bc	5.32±0.57c	67.53±0.75e	8.66±1.05a	5.01±0.90a	427.18±4.15b
Talinum triangulare	3.55±0.26cd	3.52±0.26b	48.17±3.13d	21.47±3.89b	14.65±0.14bc	747.52±11.49d

Data is expressed as mean± standard deviation; Different letters along the column indicate significance variation (P<0.05) according to Duncan Multiple range test statistics

Table-2. Spearman's rho (r)of the heavy metals detected among the various vegetables sold in Yenagoa metropolis, Nigeria

Parameters	Copper	Zinc	Manganese	Chromium	Nickel	Iron
Copper	1.000					
Zinc	0.523*	1.000				
Manganese	-0.676**	-0.771**	1.000			
Chromium	0.232	-0.067	0.174	1.000		
Nickel	0.360	-0.090	0.022	0.810**	1.000	
Iron	0.777**	0.121	-0.350	0.649**	0.742**	1.000

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

The concentration zinc among the vegetables were significantly different (P<0.05), ranging from 1.63 – 14.98 mg/kg. Zinc concentration among the various vegetables were in the order; *Gongronema latifolium* < *Talinum triangulare*<*Piper guineense* < *Telfairia occidentalis* < *Amaranthus hybridus* < *Ocimum gratissimum.* Zinc showed a negative significant relationship with manganese (r= -0.771, P<0.01) (Table 2). The level of zinc reported among the various vegetables in this study is lower than the permissible limit. FAO/WHO maximum limit of zinc in vegetables as 100.0 mg/kg [23].Umar and Salihu [27]also reported WHO MPL of zinc in spices as 100.0mg/kg. The findings of this study suggest no potential health risk associated with zinc in the consumption of common vegetables in Yenagoa metropolis, Nigeria.

The concentration of manganese in the various vegetables under study ranged from 5.83 – 186.59 mg/kg. Basically there was significant difference (P<0.05) among the various vegetables. Manganese concentration among the various vegetables were in the order; *Telfairia occidentalis* < *Ocimum gratissimum* < *Amaranthus hybridus* < *Talinum triangulare*< *Piper guineense* < *Gongronema latifolium.* Manganese plays essential roles in the body. For instance it acts as a cofactor and catalyst to several enzymatic activities during the synthesis of fatty acids, cholesterol, mucopolysaccharide and glycoproteins synthesis [27]. Deficiency in the body leads to skeletal and muscular coordination abnormalities and impairment of glucose tolerance factor [27]. Furthermore, excess concentration could lead to Neurological disorder [42].

The level of chromium among the vegetables ranged from 8.12 – 31.72 mg/kg. There was significant variation (P<0.05) among the various vegetables. Chromium level among the various vegetables were in the order; *Telfairia occidentalis* = *Piper guineense* = *Amaranthus hybridus* < *Talinum triangulare* < *Ocimum gratissimum* = *Gongronema latifolium.* Chromium showed significant relationship with nickel (r=0.810, P< 0.01) and iron (r=0.649, P< 0.01) (Table 2). The level of chromium reported among the various vegetables in this study is higher than the permissible limit. Dio and Madusolumuo [23] reported FAO/WHO maximum limit of chromium in vegetables as 0.10 mg/kg. This suggests potential health risk associated with chromium in the consumption of the vegetables under study. Chromium typically plays an essential role in biosynthesis of glucose tolerance factor in the body [14, 43] and as such they are essential metals. Authors have variously reported that chromium have deleterious effects in human body when the concentration exceeds permissible limits. Some of the notable pathological effects includes liver and kidney damage, cancer, nose and breathing problems [14, 16, 22, 26].

The concentration of nickel among the vegetables ranged from 5.01 – 16.03 mg/kg. There was significant variation (P<0.05) among the various vegetables. Nickel level among the various vegetables were in the order; *Telfairia occidentalis* = *Piper guineense* = *Amaranthus hybridus* < *Talinum triangulare* ≤ *Gongronema latifolium* ≤ *Ocimum gratissimum.* Nickel showed positive significance relationship with iron (r=0.742, P< 0.01) (Table 2). The concentration of nickel reported among the various vegetables in this study is lower than the permissible limit. Umar and Salihu [27] also reported WHO MPL of nickel in spices as 50.0mg/kg. This is an indication that no health risk is posed by nickel. Typically high concentration of nickel in the body could be extremely toxic and carcinogenic [14, 42]. Furthermore, at molecular level, it could substitute other metals in metal dependent enzyme which could lead to alteration in protein function [27].

The concentration of iron in the various vegetables under study ranged from 307.60 – 1051.31 mg/kg. There was significant variation (P<0.05) among the various vegetables. Iron level among the various vegetables were in the order: *Amaranthus hybridus* < *Gongronema latifolium* = *Piper guineense* < *Telfairia occidentalis* < *Talinum triangulare* < *Ocimum gratissimum*. The concentration of iron exceeded the permissible limits. FAO/WHO maximum limit of zinc in vegetables as 425.0 mg/kg [23]. Furthermore, [27] reported WHO MPL of zinc in spices as 300.0 mg/kg. The high iron concentration could be due to geology of the area. Iron has been variously reported in the environment of the Niger Delta in both soil and water. Iron plays an essential role in the body. Some of the notable role of iron in the body include oxygen transport, deoxyribonucleic acid synthesis, electron transport chain and regulation of cell growth and differentiation (biochemical/ metabolic processes) [12, 14, 44-46] and formation of haemoglobin, transferrin, ferritin, and some iron-containing enzymes [12, 14, 47]. Since the concentration is higher than the desirable limits, the consumers may be at risk of iron related diseases. Some pathological effects associated with iron include sclerosis and long cancer [12, 14, 16].

4. Conclusions

This study comparatively assessed the level of heavy metals in the vegetables used for culinary purposes in the Yenagoa metropolis, Nigeria. The study showed that some of the heavy metals such as cadmium, lead and cobalt were not detected in the various vegetables. Furthermore, iron and chromium exceeded the permissible limit specified by FAO/WHO. Meanwhile, copper, zinc and nickel were within the permissible limit. However, the high iron levels may be due to the geology of the area. As such, caution should be exercised in the cultivation of these vegetables especially in contaminated sites/locations.

Author Contributions

This paper was carried out by both authors. Author SC Izah conceived the idea, purchase the samples and Author AO Aigberua carried out the laboratory analysis. Author SC Izah carried the statistical analysis and wrote the initial draft. Author AO Aigberua edited the manuscript. Both authors read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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