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ORIGINAL RESEARCH

Investigating the contents of Heavy Metals in Edible Portion of Leafy Vegetables Grown Within Lagos State University, Ojo Campus

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Abstract
Introduction: Edible plants are the major source of diet, and their contamination with toxic metals may result in catastrophic health hazards. .
Aims: This study was conducted to analyse the heavy metal levels in *Amanranthus viridis, Celosia argentea, and Ocimum gratissimum* grown in selected farmlands around Lagos State University using Atomic Absorption Spectrometers (AAS).
Materials and Methods: Dry ashing method was used to destroy the organic matter to determine the content of the heavy metals. The level of the following heavy metals (Lead (Pb), Copper (Cu), Iron (Fe) and Chromium (Cr).) were determined in the soil and edible portion of the vegetables.
Results: The results showed that the mean concentration of heavy metals dry weight are: Cu(0.072± 0.014 mg/kg), Fe (0.761± 0.140 mg/kg) Pb (0.006± 0.001 mg/kg) and Cr (0.008± 0.002 mg/kg) for *Amaranthus viridis*,0.004± 0.002 mg/kg- Pb, 0.113± 0.158 mg/kg- Fe, 0.032± 0.003 mg/kg- Cu in *Celocia argentea*, 0.025± 0.004 mg/kg- Pb, 0.111±0.002 mg/kg Fe in *Ocimum gratissimum* were recorded in Sport center (site A). The value of heavy metal contamination obtained from School gate (site B) ranged from 0.072± 0.006 mg/kg- Pb to 0.742± 0.066 mg/kg- Fe in *Amaranthus viridis*, 0.007± 0.0 mg/kg- Pb to 0.450± 0.111 mg/kg- Fe in *Celosia argentea*, 0.030± 0.005mg/kg- Fe to 0.051± 0.044 mg/kg- Pb in *Ocimum gratissimum.* The value of heavy metal contamination obtained from PPL (site C) ranged from 0.037± 0.004 mg/kg -Cu to 0.559± 0.080 mg/kg- Fe in *Amaranthus viridis*, 0.011± 0.001 mg/kg Cr to 0.474± 0.151 mg/kg Fe in *Celosia argentea*, 0.007± 0.008 mg/kg Pb to 0.048± 0.017 mg/kg Fe in *Ocimum gratissimum.*
Conclusion: The levels of heavy metals determined in the analyzed Vegetable samples were found to be below the permissible limits set by World Health Organization, thus they are safe for human consumption.
Keywords: Ojo campus, edible plants, permissible limits, human consumption.

All co-authors agreed to have their names listed as authors.

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1. INTRODUCTION

Environmental contamination by heavy metals has become a world-wide problem during recent years due to the fact that heavy metals unlike some other pollutants are not biodegradable [1]. Consequently, they are not detoxified but are bioaccumulated in the environment. Heavy metals are released into the environment through domestic and commercial activities, industrial effluents, pesticides and fungicides as well as manure from poultry farms [2]. Soil pollution by heavy metals has serious health implication especially with regards to crops/vegetables grown on such soils. Heavy metals are ever-present because of their extreme use of their compounds in industrial applications and are very detrimental because of their non-biodegradable nature, long biological half-lives and their potential to accumulate in different body parts. Most of the heavy metals are extremely toxic because of their solubility in water.

Vegetables are known to have positive effects on human health as they play a crucial role in preventing a number of chronic diseases. These protective effects have been attributed to a wide range of compounds present in the vegetables. These are antioxidants such as ascorbic acid, carotenoids, tocopherols, glutathione, phenolic acids and flavonoids [3]. It is known that serious systemic harms can develop as a result of increased accumulation of dietary heavy metals such as lead and cadmium in the human body[4] Major contamination of seeds, plant products with toxic chemical elements due to contaminated soil and water has been observed as a result of release of these toxicants into the sea, rivers, and lakes as well as into irrigation channels. Additionally, the consumption of heavy metal-contaminated food can negatively deplete some essential nutrients in the body leading to decrease in intrauterine growth retardation, immunological deficiencies, disabilities associated with malnutrition, impaired psycho- social behavior, and a high prevalence of upper gastrointestinal cancer[5].

The practice of growing vegetables within and at the edges of cities is extremely aged and most of these cultivated lands are polluted with heavy metals via vehicular emissions, pesticides, fertilizers, industrial effluents and other anthropogenic activities. The yield of vegetable is reduced due to the presence of heavy metal in soil because metabolic processes of plants are disturbed[6]. Generally, the concentrations of heavy metals are higher in soils than vegetables grown on the same soils. This indicates that only a small portion of soil heavy metals is transported to the vegetables and the root acts as a fence to the translocation of heavy metals within plant[7]. In Lagos State, western part of Nigeria, vegetables are heavily cultivated and consumed as food. Lagos is the commercial hub and the industrial nerve center of Nigeria with an estimated population of more than 15 million people and environmental concerns are normally focused on Lagos State [8]. One of the major centers for the cultivation of vegetable crops for major domestic distribution and consumption in Lagos state is located at Ojo Local Government. Lagos State University located at this area is also not left out of all the agriculture activities going on in this area. Large economic farms are situated right within the Lagos state university Ojo campus. Various vegetables are cultivated within the University. The campus which can be refer to as being both residential and commercial areas with high levels of human activities leading to the release of heavy metals into the biosphere.

Conversely, to enhance the yield of these vegetables, application of fertilizers and manures are used on the soil. Therefore, there is possibility of over applications of these fertilizers and manures. Thus, the uptake and storage of some heavy metal pollutants from these wastewater, fertilizers and manures by the vegetables are very likely since these heavy metals are soluble and mobile in ground water.

This study was designed to examine the levels of heavy metals (Pb ,Cu, Fe, and Cr) in edible portions of three different vegetables namely *Ocimum gratissimum, Amaranthus viridis, Celosia argentea* grown within the Lagos State university Ojo campus border and ascertain the suitability or otherwise of the vegetables for human consumption.

2. MATERIAL AND METHODS

2.1 Description of the Study Area

This research was carried out in selected sites of three agricultural locations/farmlands around Lagos State University. Three farming axis were selected, which were Sport Center, PPL axis and School gate axis.

2.2 Sample Collection

The sampling was carried out in the month of October, November and December 2018 and the sampling site was the farmland around the Lagos State University. The vegetable sample was collected from the sample location using clean stainless steel material. The soil sample was collected at 15cm depth around the sample area; it was thoroughly mixed and transferred into clean and labeled polythene bag for onward analysis in the laboratory.

2.3 Sample Preservation

Preservation was necessary to maintain the integrity of the samples. Samples and subsamples were carefully taken and stored in clean sample bottles, at 4°C, until analyses.

2.4 Sample Pre-treatment

The sample was crushed in a mortar and a sub-sample was air-dried. A 5 g portion of the air-dried sample of vegetable was weight into a porcelain crucible and ashed at 550 °C in a muffle furnace (Surgifriend Medicals, England SM 9053) for 2 hr, or until completely ashed. The ash was dissolved in 5 ml of dilute HCl and then made up to a volume of 100 ml, with deionized water. The solution was filtered and the filtrate was saved for the determination of Cu, Fe, Pb, and Cr. Also 5g of the soil samples from each site were prepared and digested using standard methods prior to heavy metal analysis.

2.5 Determination of Metals (Pb, Cu, Cr, Fe)

The metals were determined on filtrate of sample digestate by atomic absorption spectroscopy. Test results were validated with calibration curve obtained with certified metal standards (AccuStandard, Inc, USA). The working calibration standards were prepared from the stock standard by dilutions to concentrations in the range of 0.1 – 1.0 mg/L.

3. RESULTS

Table 1 below shows the mean concentration of heavy metals investigated in leafy vegetable (*Amaranthus viridis, Celosia argentea, Ocimum gratissimum*) consumed within Lagos state University as well as the WHO permissible limits. Iron (Fe) is highest in *Amaranthus viridis* having a mean value of 0.761±0.140 mg/kg at Sport center(Site A) and mean value of the soil detected to be 48.92±5.770 mg/kg. Lowest mean value of Iron (Fe) was detected in *Ocimum gratissimum* to be 0.030± 0.005 in School gate and mean value of soil sample detected to be 29.06± 8.603 mg/kg. Copper (Cu) was detected highest in *Amaranthus viridis* from School Gate (site B) having a mean value of 0.084±0007 mg/kg and soil value of 0.801± 0.077. The lowest value of Copper (Cu) was detected in *Ocimum gratissimum* from School gate (Site B) having the mean value of 0.007±0.002 mg/kg and mean soil value of 0.001±0.001 mg/kg. The level of chromium as shown in Table 1 for all the tested samples varied between 0.007±0.003 mg/kg to 0.066±0.811 mg/kg with *Celosia argentea* from Sport center(site A) having the lowest and *Amaranthus viridis* from PPL(site C) having the highest.The mean soil samples varied between 0.04± 0.010 mg/kg to 0.572± 0.006 mg/kg. The highest concentration of lead was found in *Celosia argentea* from PPL (Site C) with a mean of 0.074± 0.049 mg/kg and soil sample value of 0.060± 0.013 mg/kg. While the lowest concentration of lead was detected in *Ocimum gratissimum* with mean value 0.004± 0.002 mg/kg and soil sample value of 0.018± 0.002 mg/kg.

DISCUSSION

The concentrations of lead (Pb) and chromium (Cr) were observed to be the lowest for all the samples collected from the sites while the level of iron (Fe) and copper (Cu) were the highest. Due to the influence of heavy metal on the nutritive values of agricultural material as well as their negative effect on human beings maximum permissible level of toxic metal in human food were set by National International bodies. For this reason an ever more important feature of food quality must be to control the concentrations of heavy metals in food[9]. The levels of Iron (Fe) in all studied sample are within safe limit of intake standard of 425.5 mg/kg while the Pb content are below the recommended standard levels of 2.0 mg/kg[10].

Lead has been reported to be a serious cumulative body poison which penetrates into the body system via food air and water respectively and cannot be detached by washing the vegetables[11]. The levels of Pb in some of these leafy vegetables may be attributed to pollutants in irrigation water, farm soil or vehicular emission from heavy traffic on the road as lead is present in the fuel as an anti-knocking agent [12]

Copper is an important micronutrient which acts as a biocatalyst, required for body pigmentation in addition to iron, maintaining a healthy central nervous system, prevents anaemia and interrelated with the function of Zn and Fe in the body.. Most plants contain certain amount of copper which is inadequate for normal development and is regularly guaranteed through artificial or organic fertilizers application [13]. It has been reported that copper toxicity induces iron deficiency, lipid peroxidation and membranes destruction.However, the levels of Copper in all studied samples were within 73.3 mg/kg standard safe limit of intake [10]. Likewise, the Cu content in soil sample was lower than the maximum permissible limit of 2.3mg/kg recommended limit. Iron (Fe) is an important mineral. It is needed to help our red blood cells deliver oxygen to the rest of the body. Iron is essential for many proteins and enzymes that maintain good health, transporting oxygen in the blood to all parts of the body as well as essential for proper functioning of the liver. The range of concentration of iron (Fe) in the sampled vegetables were below the maximum limit of 425.5 mg/kg for Iron concentration recommended in food[10]. Reports have shown that high level of iron above the permissible level may lead to leaves chlorosis due to iron toxicity whereas in human it can cause vomiting, upper abdominal pain, pallor, cyanosis, diarrhea, dizziness, shock, haemochromatosis, diabetes[14-15]. Chromium (Cr) is a trace element that is important in the body. It is able to stabilize blood sugar levels, which could prevent diabetes, by using insulin efficiently. It also aids the breakdown of fats in the body and is said to increase the good cholesterol in the body while lowering the bad cholesterol. Cr in all the tested samples varied between 0.007-0.066 mg/kg with *Celosia argentea* from site A having the lowest and *Amaranthus viridis*from PPl (site C)having the highest. These values are lower than the maximum permissible limit of 2.3mg/kg recommended by WHO and this indicates that they suitable for consumption[16]. Generally, the results of this study revealed that Iron (Fe), Copper (Cu) present in the soil and plant samples are in higher concentrations than Lead (Pb) and Chromium(Cr) that are in trace amount.

4. CONCLUSION

All the level of heavy metals are observed to be lower than the recommended standard limit for vegetable which implies that vegetables grown in the studied sites are suitable for consumption. Moreso, iron and copper present in the soil and plant samples are in higher concentrations than Lead (Pb)and Chromium(Cr).

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COMPETING INTERESTS

We declare that there are no competing interests

AUTHORS' CONTRIBUTIONS

Ayotunde Abosede Adu and Oluwatoyin Joseph Aderinola designed the study. Aderinola performed the statistical analysis, managed the literature searches while both authors wrote the draft of the manuscript.

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APPENDIX

Table 1: Levels of heavy metals (mg/kg) in vegetables grown in farmland within LASU

	Sports Centre (Site A)						
	Plant Sample			**Soil Sample**			**WHO LIMIT IN Veg.**
PARAMETER	**A**	**B**	**C**	**A**	**B**	**C**	
Chromium (mg/kg)	0.008± 0.002	0.007± 0.003	0.012± 0.007	0.04± 0.005	0.04± 0.010	0.07± 0.009	2.3
Copper (mg/kg)	0.072± 0.014	0.032± 0.003	0.012± 0.002	0.769± 0.143	0.773± 0.098	0.392± 0.070	73.3
Iron (mg/kg)	0.761± 0.140	0.113± 0.158	0.111± 0.002	48.92± 5.770	45.02± 5.456	32.00± 3.927	425.5
Lead (mg/kg)	0.006± 0.001	0.025± 0.004	0.004± 0.002	0.030± 0.004	0.055± 0.004	0.018± 0.002	2.0
	School Gate (Site B)						
	Plant sample			**Soil Sample**			
PARAMETER	**A**	**B**	**C**	**A**	**B**	**C**	
Chromium (mg/kg)	0.061± 0.007	0.011± 0.002	0.032± 0.004	0.153± 0.018	0.104± 0.003	0.222± 0.007	2.3
Copper (mg/kg)	0.084± 0.007	0.077± 0.010	0.007± 0.002	0.801± 0.077	0.466± 0.113	0.001± 0.001	73.3
Iron (mg/kg)	0.742± 0.066	0.450± 0.111	0.030± 0.005	39.97± 2.960	40.00± 8.772	29.06± 8.603	425.5
Lead (mg/kg)	0.072± 0.006	0.007± 0.001	0.051± 0.044	0.115± 0.005	0.071± 0.004	0.115± 0.009	2.0
	PPL (Site C)						
	Plant Sample			**Soil Sample**			
PARAMETER	**A**	**B**	**C**	**A**	**B**	**C**	
Chromium (mg/kg)	0.066 ± 0.811	0.011± 0.001	0.008± 0.002	0.572± 0.006	0.051± 0.008	0.014± 0.005	2.3
Copper (mg/kg)	0.037 ± 0.004	0.018± 0.003	0.009± 0.003	0.153± 0.051	0.565± 0.094	0.119± 0.016	73.3
Iron (mg/kg)	0.559 ± 0.080	0.474± 0.151	0.048± 0.017	38.93± 0.918	40.46± 4.780	36.17± 10.52	425.5
Lead (mg/kg)	0.056 ± 0.053	0.074± 0.049	0.007± 0.008	0.048± 0.016	0.060± 0.013	0.021± 0.022	2.0

Veg.=Vegetable, A=*Amaranthus viridis*, B=*Celosia argentea*, C=*Ocimum gratiss*