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Analysis of Some Heavy Metal Contents in Selected Vegetables and Fruits from States in Nigeria

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Abstract: The consumption of fruits and vegetables is on the increase as these produce have nutritive values associated to the presence of essential metals that helps boost humans' immune system, thus, avoiding health problems. However, there is also the presence of some non-essential metals in fruits and vegetables that are detrimental to humans. This study was carried out in order to determine the concentrations of some potentially toxic heavy metals namely; Lead (Pb), Cadmium (Cd), Nickel (Ni) and Zinc (Zn) in some leafy vegetables namely; cucumber *(Cucumis sativus)*, watermelon *(Cucurbita lanatus)*, tomatoe *(Solantum lycopersium*) and pepper *(Capsicum annuum)*, brought from Kano state as well as those cultivated in Edo state. 25 samples consisting of 4 different vegetables were each purchased from two major markets known to be a major depot for vegetables in Benin City as well as those produced in Benin City, Edo State, Nigeria. Edible portions of the samples were used for analysis while bruised or rotten samples were removed. Samples for analysis were dried using the oven-dry method at 105°C for 24 hours to obtain the moisture content and then grounded. About 1.0g of the samples were each weighed and digested in a mixture of 10mls Nitric – Perchloric acid in a 250 ml Kjeldahl flask under a fume hood. The content was mixed and heated gently at 120 - 200°C for about 45 minutes on a hot plate. Heavy metals were present in all the vegetables analyse at various levels. Cadmium (Cd) concentration ranges between 0.02 – 0.47 $mgkg^{-1}$, Lead (Pb) was within the range of 0.03 – 11.12 $mgkg^{-1}$, Zinc (Zn) concentration ranges between 0.15 – 73.69 $mgkg^{-1}$, and Nickel (Ni) concentration ranges between 0.07 – 35.54 $mgkg^{-1}$ respectively in all the vegetables from the two states. Cd and Pb were observed to be higher than that of the Maximum Permissible Limit (MPL) stipulated by the World Health Organization (WHO).

Keywords: Vegetables, Heavy Metal Concentration, Maximum Permissible Limits, AAS

1. Introduction

The consumption of fresh fruits and vegetables is increasing as humans (consumers) attempt daily to eat healthy diets and get pleasure from the nutrients and year-round accessibility. Most fruits and vegetables like cucumber *(Cucumis sativus)*, watermelon *(Cucurbita lanatus)*, tomatoe *(Solantum lycopersium*) and pepper *(Capsicum annuum)* are eaten without further processing, that is, in their raw form. This is due to increased awareness of the nutritive value, because of exposure to different cultures and acquiring proper education.

Although, fruits and vegetables constitute a crucial part of the human diet since they are rich sources of carbohydrates, proteins, vitamins, minerals, fibres, as well as trace elements [1-6] essential and toxic elements over a wide range of concentrations [7, 5], but there is associate increasing concern regarding the potential contamination of fruits and vegetables from the appliance of pesticides, chemical fertilizers, herbicides and those cultivated through irrigation from contaminated wastewater. It has been reported that in Kano state, a lot of industrial wastes, residential (defecations, urination, bath, washing) and abattoir wastewater are released into city streams and used for irrigation, for which are present large amounts of toxic heavy metals [8, 9].

Contamination of vegetables with significant metal is additionally due to irrigation with polluted water, industrial emissions, transportation, the gather method, storage or at the

purpose of sale [6]. Ibrahim et. al., suggested that transportation and marketing systems of vegetables play a significant role in elevating the contaminant levels of heavy metals, which can create a threat to the standard of the vegetables [10]. Fernando et. al., also noted that vegetables take up heavy metals and accumulate them in their edible and non-edible parts at quantities high enough to cause clinical problems to both animals and human beings [11]. Furthermore, research has shown that fruits and vegetables have the capacity of accumulating significant levels of heavy metals from contaminated soils through translocation [12]. As an example, the consumption of contaminated food can seriously deplete some essential nutrients within the body inflicting a decrease of immunological defences, disabilities related to deficiency diseases and a high prevalence of upper gastrointestinal cancer [13].

Regular observation of those heavy metals from effluents, sewage, in vegetables and in other food materials is vital for preventing excessive build-up of the metals in the food chain. Heavy metals, such as cadmium, copper, lead and zinc are important environmental pollutants, notably in areas under irrigated with wastewater [7, 5]. Metals like lead, zinc, copper and cadmium are cumulative poisons. These metals cause environmental hazards and are reported to be exceptionally lethal. Heavy metals may enter the human body through inhalation of dust, direct ingestion of soil and consumption of food plants grown in metal contaminated soil [14]. Based on this ground, the knowledge about heavy metals to plants interactions is crucial for environmental safety and human health risk [12].

This study is however important as it sought quantitatively the heavy metal concentrations of some selected vegetables largely consumed in states (Kano and Edo) in Nigeria and comparing these levels with the maximum permissible limit (MPL) stipulated by World Health Organisation (WHO) in order to determine their suitability.

2. Materials and Method

2.1. Sample Collection, Preparation and Treatment

The plants used for this study were four vegetables; cucumber *(Cucumis sativus)*, watermelon *(Cucurbita lanatus)*, tomatoe *(Solantum lycopersium*) and pepper *(Capsicum annuum)*. Vegetables from Kano state, were collected during the period of March 2016 to April 2016, from two different markets (Tenbuga Market and Aduwawa Tomatoes Market) along Upper Mission Road, New Benin, Benin City, Edo state. These vegetables were obtained and transported to Benin City from the following areas in Kano state: Cucumber (Kumbotsu LGA), Watermelon (Albasu LGA), Tomatoe (Kura LGA) and Pepper (Jamari LGA). Similar vegetable samples cultivated in Edo state were obtained from the following areas; Cucumber (Ugbor in Oredo LGA), Pepper and Tomatoe (Uromi in Esan LGA), Watermelon (Osasimwioba in Ovia North East LGA), for the purpose of comparing the heavy metals uptake by vegetables from both states.

These vegetables were thoroughly washed first with tap water followed with double distilled water to remove any possible foliar contaminants, such as pesticides, fertilisers, dust or mud after the bruised and rotten parts were removed; labelled separately, kept in plastic bags and refrigerated. The washed vegetable samples were peeled, sliced to obtain the edible portion for analysis and to increase the surface area for drying. Samples for analysis were dried using the oven dry method at 105°C for 24 hours [15]. The dried samples were ground manually using a porcelain mortar and piston [14]. Ground samples were taken from each food items and accurately weighed to obtain 1g portion of it and placed in a 250ml Kjeidahl flask for digestion [16].

2.2. Sample Digestion

Nitric–Perchloric acid digestion was performed, following the procedure recommended by World Health Organization/Food and Agriculture Organization [12]. A mixture of Nitric acid (Conc. HNO_3) – Perchloric acid (Conc. $HCLO_4$) was prepared in the ratio 10:1. 10mls of the prepared mixture was taken and added to 1g of the ground sample in a 250 ml Kjeidahl flask [17]**.** The content was mixed and heated gently at 120 - 200°C for about 45 mins on a hot plate continuously until the brown fumes disappeared and dense white fumes appeared leaving a clear solution. It was then finally heated strongly for about 20 mins and then allowed to cool.

The cooled sample was filtered (using Whatman filter paper 11cm) into a 100mls volumetric flask and made up to the mark with de-ionized distilled water. From the 100mls flask, filtrate was transferred into a polyethylene bottle and covered to avoid spillage or wastage and so the sample was ready for Atomic Absorption Spectrophotometric analysis. The digestion was done in duplicate to ensure accuracy in the result. This procedure was carried out simultaneously for all the vegetable samples.

2.2.1. Sample Analysis

The heavy metals (Cd, Pb, Ni, and Zn) content of the digested vegetable samples were determined with Perkin-Elmer 3000 Atomic Absorption Spectrophotometer (AAS) [1].

2.2.2. Quality Assurance

Quality assurance procedures and precautionary measures were put in place to ensure reliabilty of results. Samples were subjected to careful handling to avoid contamination of any sort. De-ionized distilled water was used during the study and glasswares were properly cleaned. Also, reagents used were of analytical grades [15]. Digestion of samples was done in a closed system to prevent volatilization of elements, reduction in reagent quantities as well as contamination from external sources [18].

3. Results and Discussion

The most essential constituents of pollution from the

terrestrial environment are considered to be heavy metals. This is due to their toxicity, accumulation in plants and in soil partitioning [12]. Results in Table 1 and Table 2 show the concentration of heavy metals in vegetables sold at Kano state and Edo state together with their respective permissible limits.

Table 1. *Concentrations ($mgkg^{-1}$) of Pb, Ni, Zn and Cd in vegetables obtained from Kano state.*

Vegetables/Metals	Pb	Ni	Zn	Cd
Cucumis sativus	6.15	35.54	19.5	0.04
Capsicum annuum	6.32	4.76	8.49	0.15
Cucurbita lanatus	11.12	16.72	0.51	0.06
Solantum lycopersium	7.32	13.64	10.49	0.05
MPL (WHO)	0.3	67	100	0.1

Table 2. *Concentrations ($mgkg^{-1}$) of Pb, Ni, Zn and Cd in vegetables obtained from Edo state.*

Vegetables/Metals	Pb	Ni	Zn	Cd
Cucumis sativus	0.05	3.23	73.69	0.47
Capsicum annuum	3.83	1.36	92.5	0.07
Cucurbita lanatus	0.85	0.28	0.15	0.04
Solantum lycopersium	2.33	0.35	1.26	0.05
WHO/MPL	0.3	67	100	0.1

It is a known fact that the presence of heavy metals in agricultural produce adversely affects their nutritive values due to their negative influence on humans when consumed. Hence, the maximum allowable limits of heavy metals in fruits and vegetables have been established by standard regulatory bodies such as World Health Organization (WHO), Food and Agricultural Organization (FAO) and Ewers U, Standard Guidelines in Europe [7].

Arising from this study, it is evident that heavy metals were present in all samples obtained from both states. The presence of these metals can be attributed to various processes ranging from agricultural chemicals, laboratories and factories residues, vehicular emissions, battery production and runoffs from roadside mechanics.

From table 1, it was observed that the concentration of Pb in all vegetables was above the permissible limit ($0.3mgkg^{-1}$). Their values ranges from $6.15mgkg^{-1}$ in *Cucumis sativus*, 6.32 $mgkg^{-1}$ in *Capsicum annuum*, 7.32 $mgkg^{-1}$ in *Solantum lycopersium* to 11.12 $mgkg^{-1}$ in *Cucurbita lanatus*. Ni and Zn concentration were below the permissible limits. Cd on the other hand was above the permissible limit (0.1 $mgkg^{-1}$) in *Capsicum annum*, having a value of 0.15 $mgkg^{-1}$ with an exception in *Cucumis sativus* with a value of 0.04 $mgkg^{-1}$; *Cucurbita lanatus* 0.06 $mgkg^{-1}$ and *Solantum lycopersium* 0.05 $mgkg^{-1}$ whose values are below the permissible limits.

From table 2, Pb concentration in *Cucumis sativus* was below the permissible limits, having a value of 0.05 $mgkg^{-1}$. It was observed that the values of most vegetables are above the permissible limit. Their values ranges from 0.85 $mgkg^{-1}$ in *Cucurbita lanatus,* $2.33mgkg^{-1}$ in *Solantum lycopersium* to $3.83mgkg^{-1}$ in *Capsicum annuum*. For Ni and Zn, their values were below the permissible limits for all the vegetables. Cd had a concentration whose value of $0.47mgkg^{-1}$ in *Cucumis sativus* is above the permissible limit with an exception in all other vegetables, having values below the permissible limits stipulated by WHO.

For a population with high consumption of fruits and vegetables, the accumulation of these metals above the permissible limits may suggest health risk to the consumer [12]. For instance, signs and symptoms such as abdominal pain, anorexia, anxiety, and hypertension can be caused by Pb with a concentration level above 0.05 $mgkg^{-1}$ [19]. High concentration of Pb can cause death or permanent damage to the central nervous system, the brain, and kidneys [20, 21]. In low doses, cadmium can produce coughing, headaches, and vomiting. In larger doses, it can replace calcium in the bones and cause a painful disorder. The brain, heart, blood vessels, kidneys, and lungs can be affected by its toxicity [19, 20]. Ni, on the other, although regarded as essential trace metal, becomes toxic at high levels and considered carcinogenic [20].

Lethargy in the brain, risk of prostate cancer, metal fume fever in the respiratory tract are health challenges caused by excessive Zn in the human system [22].

4. Conclusion

The study focused on vegetables grown in Kano state and Edo state. The study has revealed the various concentration of heavy metals (Pb, Ni, Zn, and Cd) in vegetables.

On comparing the permissible limits stipulated by WHO with the values obtained from analysis, it may be inferred that these vegetables are contaminated with heavy metals. Concentrations of Zn and Ni falls below the maximum permissible limits for all the vegetables analysed. Hence, the presence of these metals pose no threat. On the other hand, Pb and Cd are known human carcinogens, their concentrations in these vegetables is high. These results imply that fruits and vegetables bought from both states are not suitable for consumption and may cause health hazards to consumers.

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