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Cadmium and Lead Levels of *Telferia Occidentalis* and *Spinacia Oleracea* Sold in Open Daily Markets in Makurdi, Nigeria

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ABSTRACT

The cadmium and lead contents of *Telferia occidentalis* (pumpkin leaf) and *Spinacia oleracea* (spinach leaf or green tete) purchased from the open daily markets in Northbank, Wadata and Wurukum Areas of Makurdi Township of Benue State were determined using Atomic Absorption Spectrophotometry. Cadmium was detected in the wet extract of spinach leaves at levels ranging from 0.043±0.019mg/kg to 0.055±0.011mg/kg, and at levels from 0.067±0.019mg/kg to 0.075±0.012mg/kg for the pumpkin leaves extract. Lead was also detected at levels ranging from 0.037±0.023mg/kg to 0.057±0.019mg/kg in spinach leaves, and from 0.053±0.020mg/kg to 0.077±0.019mg/kg in pumpkin leaves wet extract respectively. The results obtained were lower than those of previous reports as well as below the FAO/WHO safe limit for green leafy edible vegetables. The results do not seem to suggest any serious clinical implications associated with the consumption of both vegetables.

Keywords: *Crude protein, levels, clinical implications, FAO, WHO.*

I. INTRODUCTION

Vegetables are important components of daily diets in many households. They contribute natural fiber, protein, essential minerals and other nutrients which are in short supply. Green leafy-vegetables contain chlorophyll, fiber, lutein, zeaxanthin, calcium, folate, vitamin C, and carotene. These nutrients help to reduce cancer risks, lower blood pressure and cholesterol levels, normalize digestion time, support retinal health and vision, fight free radicals, and boost immune system activity[1]. Recently, it was proven that the vegetable extract of *Telferia occidentalis* is efficacious in the management of severe anaemia in children and may be useful in paediatric patients with severe anaemia whose parents refuse blood transfusion[2]. The vegetable extract may have an even greater role in the prevention of anaemia if intake is instituted early.

Vegetables contain both essential and toxic elements and other constituents which occur over a wide range of concentrations. While some elements are essential for good health, others such as cadmium, lead and mercury are exceptionally toxic and are regarded as potential environmental pollutants[3]. The harmful effects of cadmium and lead to humans through food consumption are well documented[3].

Research has shown that some common edible vegetables are capable of accumulating high levels of heavy metals from the soil, particularly areas with anthropogenic pressure[4]. Heavy metals uptake also occurs as a result of deposits on different parts of the vegetables exposed to air from polluted environments. However, not all the traces of heavy metals in plants and animals are the results of human activity. Some arise through the absorption processes of naturally occurring soil components. Even foodstuffs grown in completely unpolluted areas are not entirely free of heavy metals; the absorption of very small amounts is therefore unavoidable in principle and has always occurred[5].

Vegetable plants growing on heavy metal contaminated soil can accumulate high doses of such metals, thereby causing serious health risks to consumers. Excessive amount of cadmium and lead ions in food is associated with etiology of a number of diseases, with cardiovascular, kidney, nervous, and bone diseases being more prevalent[6]. Several reports are available on heavy metals contamination of edible vegetables, with the levels of cadmium and lead being higher than the recommended safe limits for some of the cases[7-9].

Benue state is the heartbeat of Nigeria for food production, with edible green leafy vegetables, especially pumpkin and spinach ranking foremost in the list of consumable crops. As a sizeable population of the inhabitants, especially the rural settlers are relatively poor, green leafy vegetables constitute the main source of dietary proteins and other food nutrients, as a result, these vegetables are consumed enormously. The cultivation and harvesting of vegetable crops (especially pumpkin, spinach and okra) go on throughout the year with the months of May through November witnessing a boom. As a cheap source of dietary proteins, the farmers make fortunes from the sale of these vegetables.

This preliminary investigation aims at assessing the levels of cadmium and lead in pumpkin and spinach vegetables, from the open daily markets of Northbank, Wadata and Wurukum Areas of Makurdi Metropolis, and the attendant clinical implications that may be associated with their consumption.

Fig 1: *Telferia occidentalis* (pumpkin leaf)

Fig 2: *Spinacia oleracea* (spinach leaf)

II. MATERIALS AND METHODS

Study Area

The study was carried out in Markurdi town, the regional capital of Benue State, Nigeria. The city is located in central Nigeria along the Benue River and holds the base for the Nigerian Air Force's MiG 21 and SEPECAT Jaguar aircraft squadrons[10]. Its geographical coordinates are 7.44^o N and 8.32^o E, with a population of over 500,000 people[10]. The Benue State is predominantly an agricultural catchment area specialising in cash crops, subsistence crops, and a variety of potentials.

Fig 3: Nigeria Map showing Makurdi in a red patch (Courtesy of Wikipedia the Free Encyclopaedia) [10]

Sampling

Five samples each of fresh and mature pumpkin and spinach vegetable leaves, adequately identified by a competent taxonomist were randomly purchased from anonymous vendors at the open daily markets in Northbank, Wadata and Wurukum areas of Makurdi metropolis. The purchases were made on same day in May, July and September, 2010. The vegetable samples were conveyed straightway to the Postgraduate Research Laboratory of Benue State University, Makurdi, in clean marked polythene bags.

Sample Preparation

The edible portion of the vegetable samples were properly separated and washed with 1% detergent solution to remove surface contaminants like sand and dust[11], and then rinsed with double distilled water. Each sample was chopped into small pieces using a clean stainless table knife and afterward dried to a constant mass in an oven at 80^o C for 48h. Replicate samples of each dried vegetable from the individual markets were combined and pounded to fine powder using a porcelain mortar and pestle. Particle sizes of 0.05 to 0.2mm were obtained using laboratory sieves[11].

2g of each vegetable powder was transferred into a clean dry round-bottomed flask and digested with 30ml of a 5:1:1 solution of analytical grade HNO_3, H_2SO_4 and $HClO_4$ acids. Digestion on a hot plate lasted for 3h under reflux at 120^{o}C. Each digest was filtered through a separate Whatman No.42 filter paper and the resulting solution made up to 50ml with distilled water in a volumetric flask after cooling.

Metal Ions Determination

Solutions of the vegetable extracts were analysed for cadmium and lead concentrations using a UNICAM SOLAAR 32 Atomic Absorption Spectrophotometer AAS). Prior to metal analysis the instrument was calibrated after running five replicate determinations using a blank and standards.

RESULTS AND DISCUSSIONS

The results of cadmium and lead levels in the two vegetable samples from the three markets at the stated months of year are presented in Tables 1-4. The results are given as mean ± SD and the results are means of three replicate determinations.

Table1: Cadmium and Lead levels in vegetable samples vended in May 2010

Market	Cadmium		Lead	
	Pumpkin	Spinach	Pumpkin	Spinach
Northbank	0.072±0.013	0.051±0.013	0.064±0.011	0.043±0.015

Wadata	0.069±0.020	0.047±0.022	0.055±0.018	0.039±0.021
Wurukum	0.067±0.019	0.045±0.018	0.059±0.020	ND
Safe limit	**0.2[a]**		**0.3[a]**	

ND= Not Detected (levels below detection limit)

a = FAO/WHO safe limit form Codex Alimentarius Commission[13]

Table2: Cadmium and Lead levels in vegetable samples vended in July 2010

Market	**Cadmium**		**Lead**	
	Pumpkin	**Spinach**	**Pumpkin**	**Spinach**
Northbank	0.075±0.012	0.055±0.011	0.071±0.012	0.057±0.019
Wadata	0.071±0.022	0.053±0.023	0.068±0.023	0.041±0.017
Wurukum	0.068±0.019	0.0490.020	0.065±0.021	0.037±0.023
Safe limit	**0.2[a]**		**0.3[a]**	

a = FAO/WHO safe limit form Codex Alimentarius Commission[13]

Table 3: Cadmium and Lead levels in vegetable samples vended in September 2010

Market	**Cadmium**		**Lead**	
	Pumpkin	**Spinach**	**Pumpkin**	**Spinach**
Northbank	0.072±0.014	0.053±0.023	0.077±0.019	0.039±0.021
Wadata	0.069±0.020	0.054±0.021	0.053±0.020	ND
Wurukum	0.069±0.020	0.043±0.019	0.066±0.023	ND
Safe limit	**0.2[a]**		**0.3[a]**	

ND= Not Detected (levels below detection limit)

a = FAO/WHO safe limit form Codex Alimentarius Commission[13]

Table 4: Mean levels of Cd and Pb in vegetable samples vended between May and September 2010

Market	**Cadmium**		**Lead**	
	Pumpkin	**Spinach**	**Pumpkin**	**Spinach**
Northbank	0.073±0.013	0.053±0.016	0.071±0.018	0.046±0.018
Wadata	0.070±0.021	0.051±0.022	0.059±0.020	0.040±0.019
Wurukum	0.068±0.019	0.046±0.019	0.063±0.023	0.037±0.023
Safe limit	**0.2[a]**		**0.3[a]**	

a = FAO/WHO safe limit form Codex Alimentarius Commission[13]

III. DISCUSSION

Cadmium exists in low concentrations in all soils. It is spread by air and water far over sea and land, especially in the vicinity of heavy industrial plants. Cadmium is today regarded as the most serious contaminant of the modern age. It tends to be very mobile in soil systems (especially Cd^{2+} ions) and therefore is very available to plants. Absorption or desorption of cadmium is about 10-folds more rapid than for lead[12].

Cadmium is a non-essential element in foods. It accumulates principally in the kidneys, the liver and the lungs. It most frequently results in kidney damage (necrotic protein precipitation) and metabolic anomalies caused by enzyme inhibitions. Various values have been previously reported for leafy vegetables which include 0.090mg/kg for fluted pumpkin and 0.049mg/kg for lettuce[12]. Unlike lead, cadmium contamination cannot be removed from plants by washing them, as it is distributed throughout the organism. It is often difficult to be certain of the cause of a cadmium content found in fruits or vegetables, as the substance in its natural form exists everywhere in the soil and is absorbed by the roots.

The main source of lead pollution in the environment are industrial production processes and their emissions, road traffic with leaded petrol, the smoke and dust emissions of coal and gas fired power stations, the laying of lead sheets by roofers, as well as the use of paints and anti-rust agents. Vegetables and fruits are among the foodstuffs that contribute most to the consumption of lead. Fruits and vegetables mostly acquire their contamination through impurities in the air. Accordingly they are decontaminated to a large extent by simple washing.

Basically, due to their comparatively high affinity for proteins, the lead ions consumed, bond with the haemoglobin and the plasma protein of the blood. This leads to inhibition of the synthesis of red blood cells and thus of the vital transport of oxygen. If the bonding capacity here is exceeded, lead passes into the bone marrow, liver and kidney, leading to serious clinical effects which include encephalopathies in the central nervous system (CNS), kidney and liver malfunction, and damage to the reproductive organs.
Tables 1-3 present the mean concentrations of cadmium and lead in the vegetable samples purchased from the selected markets in May, July and September, 2010. The values for cadmium ranged from 0.043±0.019mg/kg to 0.055±0.011mg/kg in spinach and at levels between 0.067±0.019mg/kg and 0.075±0.012mg/kg for the pumpkin leaves. These results were below the Joint FAO/WHO safe limit for cadmium in edible leafy vegetables which is 0.2mg/kg[13]. Lead was detected at levels from 0.037±0.023mg/kg to 0.057±0.019mg/kg in spinach, and 0.053±0.020mg/kg to 0.077±0.019mg/kg in pumpkin leaves. Lead concentrations in both vegetables were well below those of previous reports as well as the Joint FAO/WHO safe limit for vegetable lead which is 0.3mg/kg[13].

From Tables 1-4 above, it was deduced that no significant difference existed ($p < 0.05$) between the mean concentrations of pumpkin or spinach cadmium in any of the purchases made in May, July or September, 2010, and the mean pumpkin cadmium of the three months of investigation (Table 4). Likewise, no significant difference ($p<0.05$) existed between the mean levels of pumpkin or spinach lead in any of the purchases made in May, July or September, 2010, and the mean pumpkin or spinach lead concentrations of the three months of investigation.

The low levels of cadmium and lead in the vegetable samples could be attributed to the geological morphology of the study area. It is believed that majority of the vegetable cultivations were done in the outskirts of Makurdi township with practically no serious industrial and anthropogenic activities.

IV. CONCLUSION

Heavy metals accumulation in plants have been associated with a number of factors including industrial and anthropogenic activities, application of fertilizers, pesticides and herbicides, vehicular emissions, re-suspended road dust, and waste water irrigation. The results of this investigation revealed no serious clinical implications arising from cadmium or lead contaminations in the vegetables as they occurred at levels lower than those of previous publications and the regulatory standards. This could be attributed to the soil quality of the study area. The authors suggested that these vegetables can be valuable in the food consumption tables for Nigerians and the sub-region of West Africa. Nonetheless the authors have recommended periodical monitoring of the levels of these metals in the selected vegetables as well as other heavily consumed vegetable crops in the study area, for early detection of heavy metals accumulation.

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