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Concentrations of heavy metals in three commonly used medicinal vegetables in Akwa- Ibom state

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ABSTRACT

The concentrations of heavy metals were studied in three medicinal vegetables in Akwa- Ibom State. The plants used in this study were *Gongronema latifolium*; *Telferia occidentalis* and *Vernonia amygdalina*. The heavy metals investigated were lead (Pb), Zinc (Zn), Copper (Cu), Cobalt (Co), Chromium (Cr), Nickel (Ni), Cadmium (Cd), Manganese (Mn) and Iron (Fe). Dry ashing methods were used in obtaining samples for heavy metal analysis. Quantities of the heavy metals were read off using Atomic Absorption Spectrophotometer (AAS). The results of the work showed variations in the concentrations of these metals which ranged from slightly low to high amounts, Zn, Cu, Fe, and Mn had high values, while Pb, Cd, Co, Cr and Ni had relatively low concentrations in the vegetables. The results of the findings are discussed.

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1. Introduction

Fleck (1986) defined vegetables as herbaceous plant, annual, biennials or perennial whose fruits, seeds, roots, tubers, bulbs, stems, leave or flowers are used as food. While Okigbe (1983) defined vegetables as the succulent edible plant parts that may be eaten as supplementary food or side dishes in the raw state or in the cooked form along with staple food. Rice *et al.* (1986) defined vegetables as those plants which are consumed in relatively small quantities as a side dish or as a relish with the staple food. Nutritionally, vegetables are good sources of minerals and other products, and the compositions of some other products. The compositions of some tropical vegetables differ depending on type and species in question. In Africa, green vegetables constitute an important constituent of human diet generally and in West Africa in particular (Oguntona and Oguntona, 1986). They are characterized by high biological quality owing to their high content of antioxidative compounds, such as Vitamin C, Folic acid and Beta-carotene, and are rich sources of basic nutrient constituents as well (Frossand *et al.*, 2000; Kalk, 2005; Kawashima, 2003) are reflected in the WHO/FAO report (2003) recommending increased consumption of this group of products. Plants are bioindicators of heavy metals presence in an environment (Treshow, 1978). In the last decade, a lot of work has been done on vegetables and plant leaves to establish their food and medicinal values and the possible presence of some anti nutrients (Aletor and Adeogun, 1995).

Consumption of vegetables is one of the most important pathways by which heavy metals enter the food chain. Both the farmland and urban environment often suffer from the metals contamination due to the irrigation with waste water and traffic emissions. Therefore human exposure to contaminations of soils and vegetables is a matter of health concern. Thus, it is important for us to inform ourselves about the heavy metals and to take protective measures against excessive exposure. Non- nutrient heavy metals such as cadmium, arsenic, lead, and mercury, which are harmful to both plants and humans, are introduced to agricultural ecosystems from various sources (Diacono and Montemurro, 2010; Gupta *et al.*, 2010). In addition, the interest in chemical composition of medicinal vegetable products is growing because of ongoing development in nutrition and in biochemical surveying and nutrient prospecting (Rodushkin *et al.*, 1999).

Fluted pumpkin (*Telfairia occidentalis* Hoof) belongs to the family Cucurbitaceae (Aregheore, 2009). It is a valuable commercial crop grown across the low-land tropics of West Africa. The largest producers of fluted pumpkin in West Africa are Nigeria; Ghana and Sierra Leone (Nkang *et al.*, 2003; Aregheore, 2007). However, there is no identifiable information on varieties of the crop (Ajibade *et al.*, 2006). It is a tropical vine grown primarily for the leaves and edible seed as an important component of food for many people in West Africa (Fagbemi *et al.*, 2005). Young shoots and leaves are the main parts used in soup. The common names of the plant in Nigeria include that of gourd fluted pumpkin, iroko and ugu. The leaves are low in crude fiber but rich in source of folic acid, calcium, zinc, potassium cobalt, copper, iron, vitamin A, C and K, also have medicinal values (Ajibade *et al.*, 2006). Relative to most vegetables, its protein content is top (Aregheore, 2007). Nutritionally leaves of fluted pumpkin are rich in minerals, antioxidants, vitamins (such as thiamin, riboflavin, ascorbic acid etc (Kayode and Kayode, 2011). Consumption of the leaves assist to combat certain diseases due to the presence of antioxidant and antimicrobial properties, its mineral (especially iron), Vitamins (especially Vit C & A) and high protein content (Kayode and Kayode, 2011).

Bitter leaf (*Vernonia amygdalina*) is a green shrub with petiole leaf of about diameter. The leaf has a characteristics odor and bitter taste. *Vernonia amygdalina* grows under a range of ecological zones in Africa being drought tolerant and produce large fodder biomass for both humans and animals nutrition (Daodu and Babayemi, 2009). Bitter leaf is commonly found around homes in Southern Nigeria as green vegetables or spices “especially in the popular bitter leaf soup” (Igile *et al.*, 1995). They are also widely used for both therapeutic and nutritional purposes. It is excellent source of Vit C and total carotenoid (Ejoh *et al.*, 2005). The plant also acquired anti-helminthic properties as well as anti-tumorigenic properties (Izebigie, 2003). It could be given to patient suffering from hyperglycemia (excessive sugar) as in diabetes mellitus and diabetes insipidus (Nwachukwu *et al.*, 2010). The broad macerated green leaves are used as vegetables and condiments especially in cooking soup. Arhoghro *et al.*, (2009) posits that water extract serves as tonic for the prevention of certain anti-oxidant properties attributed to its flavinoid concentrations as a result of the sesquiterpene lactone present in the leaves (Babalola *et al.*, 2001).

Gongronema latifolium, known as ‘utazi’ in the southeastern and ‘arokeke’ in the South-western part of Nigeria. It is a tropical rainforest plant which belongs to the family of *Aslepiadaceae* (Ugochukwu and Babady, 2002, 2003). It is a climber with tuberous base found in deciduous forest from Guinea Bissau and western Camerouns. Various parts of these plants, particularly the stems and leaves are used as chewing sticks or liquor in

places such as Sierra Leone. The liquor, usually obtained after the plant is sliced and boiled with lime juice or infused with *G. latifolium* is one of such medicinal plants whose therapeutic application has a folkloric background. The plant enjoys widespread reputation as a remedy for inflammation, bacteria, ulcer, malaria, diabetes and analgesic (Morebise et al., 2002).

2. Materials and methods

2.1. The study area

The study was carried out in University of Uyo Ravine in Uyo Local Government Area of Akwa Ibom State. Akwa Ibom State is situated between Latitude 4°31' and 5°30'N and longitude 7°20' and 8°20'E. It has a total land area of about 8,412km² (SLUS, 1989). The topography is plain/undulating, and surrounding lands are cultivated. The area has characteristically two seasons: dry and wet season. Dry season of the area occurs between November and April while the wet season stretches between May and October. Rainfall is heavy and ranges from 3,000mm along the coast, but decreases to 2,000mm along fringe. Mean temperature of the area is usually uniformly high throughout the year with slight variations between 25°C and 28°C, relative humidity is high between 75% and 85%.

The study covers an area of about ten hectares upon which vegetation and soil were sampled. The vegetation is dense and evergreen in some plots. The vegetable plants leaves were collected from three locations in Uyo metropolis.

2.2. Preparation of sample solution

The method of dry ashing (A.O.A.C. 2003) was used in the plant sample preparation for heavy metal contents determination. After removing the leaves from the stems, they were weighed and washed with deionized water to removed dirt, cut into pieces and dried in the oven at 80°C for 48hours. At the specified period of drying, they were removed from the oven and weighed again. The dry leaves were cooled and blended, ground into fine powder with an electric blender and sieved with 2mm- sieve and finally stored in clean tightly sealed sample bottles for analysis. Water samples solutions collected from the ravine were stored in clean sample bottles for the determination of heavy metals using Atomic Absorption Spectrophotometer (AAS). The AAS was standardized with standard solutions, before each metal was read out at different wavelengths using different lamps.

The concentration of each metal was calculated

$$= \text{conc.} \times \text{digestion factor} \times \text{dilution factor}$$

and the result was expressed in mg/kg. Atomic absorption spectrophotometer model used was UNICAM 939.

3. Results

3.1. Heavy metal concentrations in vegetable tissues

Table 1 showed the mean concentrations of the different heavy metals in three commonly used vegetables. From the table, it was observed that the amount of heavy metals found in the vegetables varied from low to high. Gongronema latifolium had the least concentration of Nickel (2.0mg/kg) and it had the highest mean value/concentrations of iron (1045.18mg/kg).

3.1.1. Pb

The value of lead in the plant samples ranged between 5.8mg/kg in Telfairia occidentalis, 7.2mg/kg in Gongronema latifolium, 11.8mg/kg in Venonia amygdalina, 17.5mg/kg

3.1.2. Zn

Zn is one of the highest accumulated heavy metals in this study. Its availability in the plant tissue ranged between 182.1mg/kg in Telfairia occidentalis which is the least in all the species examined, 346.2mg/kg in Gongronema latifolium, 350.7mg/kg in Vernonia amygdalina, 363.4mg/kg

3.1.3. Cu

Table 1

Mean Concentration of Heavy Metals in Plant Samples.

S/N	Species	Pb mg/kg	Zn mg/kg	Cu mg/kg	Co mg/kg	Cr mg/kg	Ni mg/kg	Cd mg/kg	Mn mg/kg	Fe mg/kg
i	<i>Gongronema latifolium</i>	7.2	346.2	106.3	7.3	13.2	2.0	15.0	138.2	1045.18
ii	<i>Telfairia occidentalis</i>	5.8	182.1	117.3	5.0	11.0	8.2	13.5	142.2	450.25
iii	<i>Vernonia amygdalina</i>	11.8	350.7	101.3	9.2	9.7	13.2	20.0	117.0	787.92

Table 2

Showing the Standard Level of Some Heavy Metals in Plants (FEPA, 1991).

S/N	Metal	Standard Range Recommended (PPM)
1	Chromium	200-1200
2	Copper	500-3000
3	Lead	300-1200
4	Nickel	30-500
5	Zinc	1000-10000
6	Manganese	10-500
7	Cadmium	10 -100
8	Cobalt	10 – 100
9	Iron	10-1000

From the least, copper accumulator to the highest was as follows: *Vernonia amygdalina* (101.3mg/kg), *Gongronema latifolium* (106.3mg/kg), but highest in *Telfairia occidentalis* (117.3mg/kg).

3.1.4. Co

Though cobalt is present in all the vegetable samples, its availability is relatively low when compared to the availability of elements like Zn, Cu, Mn and Fe in these vegetables. The phyto-availability of cobalt in this study ranged between 5.0mg/kg in *Telfairia occidentalis* (lowest), 7.3mg/kg in *Gongronema latifolium*, 9.2mg/kg which was highest *Vernonia amygdalina*

3.1.5. Cr

The concentration of chromium in these vegetables ranged from 9.7mg/kg in *Vernonia amygdalina*, 11.0mg/kg in *Telfairia occidentalis*, and 13.2 mg/kg in *Gongronema latifolium*.

3.1.6. Ni

The phyto-availability of Nickel in these vegetables varied slightly and was relatively low when compared to that of zinc and copper. It values ranged from 2.0mg/kg in *Gongronema latifolium*, 8.2mg/kg in *Telfairia occidentalis*, 13.2mg/kg in *Vernonia amygdalina*, which was the highest accumulator.

3.1.7. Cd

Cadmium was available in the three vegetables and its phytoavailability was similar to that of Pb from the result. Apart from the slight lower value observed in *Telfairia occidentalis*

13.5mg/kg, its value ranged from 15.0mg/kg *Gongronema latifolium*, to 20.0mg/kg in *Vernonia amygdalina*.

3.1.8. Mn

The phyto-availability of manganese in the vegetables was relatively high, just like those of Zinc and Copper. The value, ranged from 117.0mg/kg in *Vernonia amygdalina*,. In the remaining two species, the variations were spaced a bit. The value was as high as 138.2mg/kg in *Gongronema latifolium*, 142.2mg/kg in *Telfairia occidentalis*.

3.1.9. Fe

The concentration of Iron in the tissues ranged from 450.25mg/kg in *Telfairia occidentalis*, which was the least accumulator. While *Vernonia amygdalina* had 787.92mg/kg and the highest accumulator was *Gongronema latifolium* with 1045.18mg/kg in the tissue.



PLATE 1. *Gongronema latifolium* (Benth).



Plate 2. *Telferia occidentalis* Hook. F.



Plate 3. *Vernonia amygdalina*.

4. Discussion

The heavy metal contents of the three medicinal vegetables are given in table 1. Their profiles in the vegetables were typical for these types of plants (Sanchez-Castillo et al, 1998). From the result of this work, it is worthy to note that the highest heavy metal accumulation in Fe (iron) was observed and in Gongronema latifolium (up to 1045. 8mg/kg), and the least quantity of heavy metals in Nickel was found among the three vegetables which were in Gongronema latifolium (2.0mg/kg).

Generally, mean value of phytoavailability of Zn and Cu were high. Zinc is nutritionally important due to its role in Immune system (Bonham et al., 2002) insulation secretion in the release of vitamin A from the liver (Hwang

et al., 2002) and as an enzyme activator. Its high concentrations in the vegetables is worthy of note. Also found in the tissues of the plants examined was significant amount of copper.

Copper is naturally present in fruits and vegetables and is very necessary for proper growth and functioning of plants. Previous studies have shown that concentrations of copper in plant tissues tend to increase with increasing copper concentrations in the soil, and that soil properties such as acidity level and organic matter content can affect the amount of copper taken up. Therefore, the high value of copper may be attributed to its present relative abundance in the soils where the samples were picked, although, the soil copper content was not measured.

In the study, it was also observed that Fe (iron) was found in a substantial quality in the three vegetables analyzed. Its phytoavailability value ranged from 450.25 to 1045.18mg/kg.

Fe is a necessary nutrient in plants and in man hemoglobin secretion but its accumulation within cells can be toxic. Plants therefore respond to both iron deficiency and iron excess by expression of different gene sets (Wei and Theil, 2000).

Other heavy metals accumulated in the vegetable tissue were cadmium (Cd), Nickel (Ni), Lead (Pb), chromium (Cr) and Cobalt (Co). The concentrations of these metals were relatively low when compared to that of Zn, Fe, Mn and Cu.

Cadmium, one of these low concentrated non-nutrient heavy metals has been reported to impair plant processes like water transport, Nitrogen metabolism and oxidation phosphorylation (Djebaliet et al., 2005). The effect of cadmium on plant growth and development depends on its concentration in the plant. It is also dependent on the plant genotype, plant part and the duration of exposure. However, long term exposure and accumulation of cadmium has been implicated in some renal and lung dysfunctions (Clemens, 2006).

Naturally, lead (Pb) is the most ubiquitous metal poison and is considered a criterion pollutant. The result of this study, revealed a substantial quantity of Pb in these vegetables tissues (Clemens, 2001).

Chromium was found in the tissues of these vegetables and its phyto-availability values range between 9.7mg/kg, in *Vernonia amygdalina* to 13.2mg/kg in *Gongronema latifolium*. This metal (Cr), though needed in the glucose metabolism enzymes (phosphoglutamase), is implicated in causing certain skin diseases along with cancer in man (Lopez et al., 2009). Nickel is essentially needed by humans, but in low quantity for normal growth but lead and chromium plays detrimental roles in human health (Lopez et al., 2009). From the study, it was also noted that all the vegetables had traces of Nickel in their tissues. The least accumulator of the three vegetables was *Gongronema latifolium* (2.0mg/kg). Nickel, though a heavy metal in small quantities is useful to humans. It is needed by humans in the production of Erythrocytes but in the trace proportion. In large amount, it is mildly toxic (Clemens, 2001). Long-term exposure to Nickel can lead to decreased body weight, heart and hepatic disorders (Bashkim, 2002).

The concentration value for phyto-availability of Cobalt in the vegetable sample was relatively low ranging from 5.0mg/kg in *Telfaria occidentalis*, 7.3mg/kg in *Gongronema latifolium* and was highest in *Vernonia amygdalina* 11.8mg/kg (Nwoboshi, 2000) who reported that Cobalt exerts some married influence on plant metabolism and development. Its irons have been implicated in the activation of some plant enzymes like carboxylases and peptidases and enhancement of the enlargement phase of cell growth on etiolated leaves and certain other tissues.

Another micronutrient element found in the sample was manganese but in high concentrations, 117.0mg/kg in *V. amygdalina* and 142.2mg/kg in *Telfairia Occidentalis*. It has been reported that manganese plays a vital role as a co-factor in various enzymatic reactions, especially those concerned with glycolysis, nitrogen and organic acids metabolism. Manganese is also an essential constituent of the photosynthetic apparatus. Excess concentration of manganese in plant inactivates Cytochrome Oxidase, Catalase, iron intake and the endogenous iron supplies. These eventually lead to the suppression of pigment synthesis and Chlorosis.

Generally, the variations in the values obtained from the analyses of these heavy metals may be due to plant species. The concentration in some of these vegetables may be reduced through washing and rinsing (Akoroda, 1990).

5. Conclusion

From the result of this work, it is obvious that heavy metals in soil do not only contaminate soil surface and underground water bodies in polluted soil but also vegetables, and herbs consequently endangering routes of ingestion. Principal non-nutrient heavy metals such as Pb and Cd have been noted in the samples in rations surpassing national and international recommendations. However, the presence of these heavy metals in these vegetables thus necessitates an urgent and systematic study of the heavy metals content of medicinal and nutritional vegetables across the country. It is also vital to have a good quality control for medicinal herbs in order to protect the consumers from heavy metal poisoning. A wild and cultivated vegetable contributes to food security in times of hunger. Since the role of traditional medicine cannot be undermined in a country like ours and since it contributes immensely to the general state of health of our people, medicinal infusions and decoctives should be properly screened to ensure that they do not pose health risk on our people due to the presence of these toxic metals.

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