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Analysis of Minerals and Heavy metals content in Traditional vegetables in South Eastern Nigeria.

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Abstract: *Vegetables are important sources of minerals that are essential for life processes. Metal toxicity occurs when there is an elevated level of essential minerals or heavy metals in the body. Vegetables take up metals by absorbing them from contaminated soils and polluted environments. The mineral and heavy metal content were determined in ten (10) selected vegetables obtained from south eastern Nigeria. The vegetables include Telfairia occidentalis, Vitex doniana, Pterocapus santahnoides, Ceiba pentanda, Colocasia antiquorum, Curcurbita pepo, Corchorus olitorus, Mucuna Puriens, Amaranthus hybridus and Lecaniodiscus cupaniodes. The mineral content was analyzed using FS240AA agilent Atomic absorption spectrometer while the heavy metal analysis was done using varian AA240 Atomic absorption spectrophotometer. From the mineral analysis, the vegetables are rich in magnesium with appreciable levels of potassium, calcium and phosphate. Heavy metals such as Iron, Zinc, Selenium, Cobalt, Molybdenum and manganese were analyzed. Iron, Cobalt and Selenium content were found to be above the recommended levels while others are within the recommended daily limits. Iron was highest in Corchorus olitorus (61.674ppm) and lowest in Mucuna puriens (3.365ppm). The leaves of Amaranthus Hybridus posses the highest concentration of Zinc (15.380ppm) followed by Corchorus olitorus (10.915ppm) and the lowest was also found in Mucuna puriens leaves (3.010ppm). The highest concentration of Manganese (Mn) was found in Vitex doniana (13.058ppm) and the lowest in Lecaniodiscus cupaniodes (0.459ppm). The Selenium content ranged from 6.233 to 15.627ppm with the highest concentration found in Ceiba pentanda. Cobalt was detected only in Vitex doniana, Amaranthus hybridus and Telfairia occidentalis. The highest concentration was found in Vitex doniana (0.090ppm) and lowest in Telfairia occidentalis (0.011ppm). The highest concentration of Molybdenum was observed in Amaranthus Hybridus (26.050ppm) and was not detected in five vegetable samples. The results from this study indicate that these vegetables are excellent sources of minerals and could serve in alleviating malnutrition. However, care should be taken in consuming them as high intake could be a health risk due to contamination from heavy metals*

Keywords: *Minerals, Heavy metals, Vegetables, South Eastern Nigeria, Trace metals*

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I. Introduction

Vegetables are parts of plants that are consumed by humans and other animals as food. They are referred to as all edible plant matter. Vegetables are important sources of vitamins, minerals, trace elements, carbohydrates and proteins required for human health with consumptions increasing gradually in recent years particularly among the urban communities[1]. They are made up of chiefly cellulose, hemicelluloses and pectin substances that give them their texture and firmness[2]. Incidence of chronic diseases, such as cancer, cardiovascular diseases and other aging-related pathologies are reduced significantly from consumption of vegetables[3]. Vegetables contain minerals such as iron and offer remedies for anemia. Food safety is essential to maintain nutrition and quality, and combat food/waterborne diseases as well as contaminations and toxicity. Of utmost concern is metal toxicity or contamination by heavy metals. Metal toxicity occurs when there is an elevated level of essential minerals or heavy metals in the body. These essential minerals include calcium, potassium, manganese, selenium, zinc, copper, molybdenum, iron, phosphorus, chromium, vanadium and boron. Trace metals such as zinc, ion, Silicon, Copper, Chromium constitute significant health hazards for man and have become an area of particular concern and highest priority in environmental research[4].

There is no unanimous definition of heavy metals. The term heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations. A density of more than 5 g/cm^3 is sometimes mentioned as a common heavy metal defining factor[5]. Heavy metals are natural components of the Earth's crust. The heavy metals essential for life can be toxic if taken in excess; some have notably toxic forms. Trace amounts of some are required for certain biological processes; selenium and zinc are essential to maintain the metabolism of the human body; zinc is involved in hydroxylation[6]; selenium, in antioxidant functioning and hormone production[7]. Iron and copper are required for oxygen and electron transport; cobalt, for complex syntheses and cell metabolism; manganese, for enzyme regulation or functioning. However, at higher concentrations they can lead to poisoning. Soils are the major sink for heavy metals released into the environment through contamination by anthropogenic activities or of natural origin. Anthropogenic activities making major contributions to soil contamination include industry, mining, waste management, traffic, agriculture, artificial fertilisers, metal-based pesticides, municipal sewage wastes, and irrigation[8]. Most metals do not undergo microbial or chemical degradation unlike organic contaminants which are oxidized to carbon (IV) oxide by microbial action[9]. They tend to bioaccumulate. The biodegradation of organic contaminant can be severely inhibited by the presence of toxic metals in soil[10]. Heavy metal contamination of soil may pose risks and hazards to humans and the ecosystem through direct ingestion or contact with contaminated soil, the food chain (soil-plant-human or soil-plant-animal-human), drinking of contaminated ground water, reduction in food quality (safety and marketability) via phytotoxicity, reduction in land usability for agricultural production causing food insecurity, and land tenure problems[11]. Vegetables take up metals by absorbing them from contaiminated soils, as well as from polluted environments[2]. Therefore, the aim of this study was to determine the composition of minerals and heavy metals in some selected traditional vegetables consumed in South Eastern Nigeria.

II. Materials And Method

Sample Collection and Preparation

Ten different neglected and commonly used vegetables were bought from village maket in Mgbowo, Aninri Local Government Area of Enugu State. They include *Telfairia occidentalis*, *Vitex doniana*, *Pterocapus santahnoides*, *Ceiba pentanda*, *Colocasia antiquorum*, *Curcurbita pepo, Corchorus olitorus*, *Mucuna Puriens, Amaranthus hybridus* and *Lecaniodiscus cupaniodes*. The collected samples were washed with distilled water to remove the dust particles. They were room dried for two weeks and thereafter hpmogenized using an electric blender. The ground samples were stored in airtight container for further analysis. The powdered samples were analyzed for minerals such as Magnesium, Potassium, Calcium and Phosphate as well as heavy metals such as Iron, Zinc, Cobalt, Selenium molybdenum and Manganese.

Analysis

The mineral compositions were determined using FS240AA agilent Atomic absorption spectroscopy while the heavy metal analysis was done using varian AA240 Atomic absorption spectrophotometer (Apha 1995; american public health association).

III. Results

Table 1 shows the mineral and heavy metal content of some traditional vegetables consumed in South Eastern Nigeria. The result revealed the presence of the following minerals: Magnesium, Calcium, Potassium and Phosphate. The magnesium levels ranged from 24.884-27.278ppm; the Calcium levels ranged from 1.484-3.839ppm; the Potassium levels ranged from 1.327-3.633ppm while the Phosphate levels ranged from 1.209-3.934.

Table 1: Composition of minerals in the vegetable samples

Sample	Magnesium (ppm)	Calcium (ppm)	Potassium (ppm)	Phosphate (ppm)
Telfairia occidentalis	26.424	1.738	1.462	1.584
vitex doniana	26.748	2.373	2.783	1.209
Lecaniodiscus cupaniodes	27.049	2.839	2.382	3.485
Pterocarpus santahnoides	26.455	2.938	2.562	3.083
Amaranthus hybridus	27.048	3.822	2.727	2.473
Corchorus olitorus	27.278	1.484	1.327	1.765
Mucuna puriens	24.884	2.347	1.576	2.847
Ceiba pentanda	25.049	2.948	2.633	2.007
Colocasia antiquorum	26.238	3.474	2.933	3.910
Cucurbita pepo	26.550	3.839	3.633	1.934

The heavy metal content of the vegetables is shown in table 2. The heavy metals analyzed were Iron, Selenium, Zinc, Cobalt, molybdenum and manganese. Iron content was the highest in all the vegetable samples analyzed and ranged from 3.365-61.674ppm. The Zinc content ranged from 3.369-15.380ppm; Manganese content ranged from 0.459-13.058ppm; Selenium content ranged from 6.233-15.627ppm; Cobalt was not detected in most of the vegetable samples and ranged from 0.000-0.090ppm. Molybdenum was also not present in some vegetable samples and ranged from 0.000-18.375ppm.

Table 2: Heavy metal content of the vegetable samples.

Sample	Iron (ppm)	Zinc (ppm)	Manganese (ppm)	Selenium (ppm)	Cobalt (ppm)	Molybdenum (ppm)
Telfairia occidentalis	29.757	9.559	4.255	8.838	0.011	7.330
vitex doniana	8.660	4.717	13.058	9.481	0.090	0.000
Lecaniodiscus cupaniodes	4.886	3.369	0.459	6.233	0.000	11.273
Pterocarpus santahnoides	9.187	9.555	6.699	9.749	0.000	0.000
Amaranthus hybridus	55.925	15.380	2.865	8.915	0.042	26.050
Corchorus olitorus	61.674	10.915	3.585	11.511	0.000	13.566
Mucuna puriens	3.365	3.010	1.838	9.718	0.000	18.375
Ceiba pentanda	9.442	5.914	0.932	15.627	0.000	0.000
Colocasia antiquorum	15.301	6.295	2.141	14.565	0.000	0.000
Cucurbita pepo	12.947	6.297	1.685	13.151	0.000	0.000

IV. Discussion

The magnesium levels ranged from 24.884-27.278ppm with the highest level obtained in *Corchorus olitorus* leaves and the lowest in *Mucuna puriens* leaves. Low levels of Calcium, Potassium and Phosphate were obtained. Calcium and potassium content was highest in *Cucurbita pepo* (3.839 and 3.633ppm respectively) and lowest in *Corchorus olitorus* (1.484 and 1.327ppm respectively). Calcium functions as a constituent of bones and teeth, regulation of nerve and muscle function[12]. Clinically, Calcium also called “super nutrient” has been proven to be associated with reduced risk of various non-communicable diseases such as osteoporosis, cardiovascular diseases and it also helps to reduce colorectal cancer risk by promoting the apoptosis in human colorectal epithelium that reduce colorectal neoplasm[13]. Potassium is the principal cation in intracellular fluid and functions in acid base balance, regulation of osmotic pressure, muscle contraction and Na^+/K^+ ATPase[14, 15]. For the healthy adult, the recommended dietary allowance (RDA) for potassium intake is set at 4700 mg respectively per day[16]. These values obtained are lower than the RDA value.

Iron, Manganese and Zinc are known as trace elements. Trace element is any substance that when present at low concentration compared to those of an oxidisable substrate significantly delays or prevents oxidation of that substrate[17]. Trace metals constitute significant health hazards for man and have become an area of particular concern and highest priority in environmental research[4]. The exposure of consumers and the related health risks are usually expressed in terms of the provisional tolerable daily intake (PTDI)[18]. Iron content was highest in *Corchorus olitorus* (61.674ppm) and lowest in *Mucuna* puriens (3.365ppm). Iron (Fe) is an essential element in human nutrition. It is a part of the heme of haemoglobin (Hb), myoglobin, and cytochromes[19]. Iron is needed for transporting oxygen and carbondioxide. Minimum daily requirement depend on age, sex, physiological status, and iron bioavailability and range from about 10 to 50 mg/day[20]. Established provisional maximum tolerable daily intake (PMTDI) of 0.8 mg/kg of body weight applies to iron from all sources[21]. Its' deficiency in humans leads to anaemia while excess of iron beyond 45mg/day have critical gastrointestinal side effects[22]. From the values obtained in this study, the iron content for *Corchorus olitorus* (61.674ppm) and *Amaranthus hybridus* (55.925ppm) are higher than the maximum tolerable level daily intake for adults (48mg/day) while others are below.

The leaves of *Amaranthus Hybridus* posses the highest concentration of Zinc (15.380ppm) followed by *Corchorus olitorus*(10.915ppm) and the lowest was also in *Mucuna puriens* leaves (3.010ppm). Zinc is an essential element for plants and animals, but only a small increase in its level may cause interference with physiological processes[23]. Zinc is very useful in protein synthesis, cellular differentiation and replication, immunity and sexual functioins[24]. The Zinc content of all the vegetables anayzed were found to be within the limit given by FAO/WHO of 99.40mg/kg. Impaired zinc absorption, vascular disease and cancer and systemic iron overload may be associated with iron toxicity in human body[20].

The highest concentration of Manganese (Mn) was found in *Vitex doniana* (13.058ppm) and the lowest in *Lecaniodiscus cupaniodes* (0.459ppm). Manganese is part of enzyme involved in urea formation, pyruvate metabolism and the galactotransferase of connective tissue biosynthesis[19]. It is crucial and very important in human physiology, it is essential for haemoglobin formation. Quantity of Manganese requirement in the body is small compared to iron; daily requirement for healthy living is 4.5mg[25] with tolerable daily intake of 12mg/day. Of all the vegetables analyzed, only *Vitex doniana* is above the tolerable daily intake while the rest are below.

The Selenium content ranged from 6.233ppm to 15.627ppm with the highest concentration found in *Ceiba pentanda*. Selenium, which is nutritionally essential, is a constituent of more than two dozen selenoproteins that play critical roles in reproduction, thyroid hormone metabolism, DNA synthesis, and protection from oxidative damage and infection[26]. It is also a constituent of glutathione peroxidase which is a major scavenger of H_2O_2[27, 15]. However, more than five milligrams of selenium is highly toxic; this is roughly ten times the 0.45 milligram recommended maximum daily intake[7]; long-term poisoning can have paralytic effects[28]. The result obtained from this study shows that the Selenium content of all the vegetables analyzed are above the tolerable upper intake level and so excessive consumption may expose people in the community to health risks from selenium. At intakes of 4–8mg/kg, selenium increases the copper contents of the heart, liver, and kidneys but has a detoxifying or protective effect against cadmium and mercury[29, 30]. High selenium intake has also been shown to decrease sperm motility in healthy men[31] and has been related to increased incidence of some forms of cancer including pancreatic and skin cancer.

Cobalt is beneficial to human. It is a key constituent of cobalamin which is known as vitamin B12, the primary biological reservoir of cobalt as an ultratrace element[32]. The minimum presence of cobalt in soils therefore markedly improves the health of grazing animals and an uptake of 0.20 mg/kg a day is recommended for them, as they can obtain vitamin B12 in no other way[33]. Heavy metals like cobalt are toxic because of their solubility in water[34]. Exposure to high levels of cobalt results in lung and heart diseases and dermatitis. Cobalt (Co) induces a rise in hemoglobin in anemic patients with nephritis, cancer and chronic infections. The average daily intake of cobalt is estimated to be 5 to 40 μg per day (0.04mg)[35]. The result from this study showed that Cobalt was found in only three (3) out of the ten vegetables analyzed. The concentration ranged from 0.011ppm-0.090 with the highest concentration found in *Vitex doniana*. The cobalt concentration of *Vitex doniana* and *Amaranthus Hybridus* are above the estimated daily intake. *Telfairia occidentalis* with concentration of 0.011ppm is within safe daily intake limits.

Molybdenum is a rare transition element, well-known for a long time to be an essential micronutrient for microorganisms, plants, and animals[36]. Molybdenum acts as a cofactor for four enzymes which are involved in processing sulfites and breaking down waste products and toxins in the body[37, 38]. A slightly higher daily molybdenum requirement of 100 to 300mg/d for adults has been established[39]. The Food and Nutrition Board established a tolerable upper intake level of 2 mg/d for molybdenum[40]. Although molybdenum can be very toxic to some animals, particularly ruminants, it does not seem to present a severe toxicity risk to humans. In animals, very high levels have been linked to reduced growth, kidney failure, infertility and diarrhea[41]. In humans, increased molybdenum in the blood has also been linked to decreased sperm count and quality[42]. It was observed that circulating testosterone levels were inversely associated with blood molybdenum levels[43]. In the present study, molybdenum was not detected in five vegetable samples out of the ten (10) analyzed. The highest concentration was observed in *Amaranthus Hybridus* (26.050ppm). This is within the recommended daily allowance by WHO but above the tolerable upper intake level of 2mg per day.

V. Conclusion

The result from this study shows that these vegetables are good sources of Magnesium, calcium, potassium and phosphate. They could serve in alleviating malnutrition and meeting up with nutritional requirements. The vegetables also contained different concentrations of heavy metals. Some such as iron and Selenium content are above the recommended levels. One common practice observed in the villages where these vegetables are cultivated is use of wastewater for irrigation and indiscriminate discharge of refuse in the farmlands. Contamination from heavy metals could arise through the use of wastewater for irrigation as wastewater has been reported to contain substantial amounts of toxic metals which create problems[44]. High accumulation of these metals in agricultural soils through wastewater irrigation may not only result in soil contamination but affect food quality and safety[45]. These heavy metals might make the vegetables unfit for human and animal consumption. Educating the general populace on the danger this poses to human health is needed.

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