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Level of minerals in ten leafy vegetables Consumed in Enugu State Nigeria

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Abstract

Background: Vegetables are parts of plants that are consumed by humans and other animals as food and they provide adequate amounts of many vitamins and minerals for human

Objective: To determine the levels of minerals in sun-dried different vegetables sourced locally in the South- East region of Nigeria

Materials and Methods: In this cross-sectional study, leafy vegetables; Telfairia occidentalis (Ugu), Vitex doniana (Uchakiri), Pterocapus santahnoides (Uturukpa), Ceiba pentanda (Akwukwo Akpu), Colocasia antiquorum (Mpoto ede), Curcurbita pepo (Ugbogiri), Corchorus olitorus (Ahihara), Mucuna pruriens (Agbala), Amaranthus hybridus (Inine oji) and Lecaniodiscus cupaniodes (Ukpocha) sourced locally in Enugu State, South Eastern Nigeria were sun-dried and analyzed for minerals using Varian AA240 Atomic absorption spectrophotometer.

Results: In this researchF, the leafy vegetables consumed in the South -East, Nigeria were found to contain minerals in concentrations not significantly different. They are good sources of magnesium (Mg), and would fairly supply calcium (Ca), potassium (K), and phosphate (PO4) which are required for the proper functioning of the body and healthy life. The leafy vegetable also contains (Iron (Fe), Zinc (Zn), manganese (Mn), Cobalt (Co), Selenium (Se), and Molybdenum (Mo) required for specific biochemical functions in living organisms. However, the concentration of the microminerals in the vegetables are higher than the daily recommended limits, Only Vitex donaina and Lecaniodiscus cupaniodes vegetable diets provide Cobalt while Mo deficiency may arise in Telfairia occidentalis, Amaranthus hybridus, Corchorus olitorus, Ceiba pentanda, and Colocasia antiquorum leafy diets from this study. The result indicates that any of these vegetables would provide minerals for maintaining good health and treatment of malnutrition.

Conclusion: The levels of macro minerals in the vegetable studied suggest that there may be a need for supplements to meet the required amount in the body. The vegetables contain microminerals needed at trace levels that may accumulate as toxins with detrimental health effects with time on consumption for a long period.

Keywords: Mineral, Leafy vegetables, Enugu State Nigeria

Introduction

Safe food is required by everyone and all the time. Humans and other animals eat vegetables as food. Green leafy vegetables are essential components of food [1] in Africa generally and West Africa, in particular, and contribute substantially to the quality of the diet [2,3]. Food nutrients are richly sourced from vegetables particularly in rural areas [4]. They supply vitamins, minerals, carbohydrates, and proteins which are usually in short supply in daily diets and required for human health [5]. Consumption of vegetables has been reported to decrease significantly pathological incidences like cancer, cardiovascular diseases, and other aging-related conditions [6]. It is also important in handling anemia since it contains iron.

Biochemically nutrient minerals cannot be produced by living organisms rather they are obtained from the diet. The minerals come from rocks, soil, and water. They're absorbed as the plants grow or by animals as the animals eat the plants [7]. Macrominerals are needed in large amounts while micro minerals are required in small amounts [8, 9]. Minerals control physiological processes of the body and they perform regulatory functions [10]. Good food sources of minerals include nuts, beans and lentils, dark leafy greens, fish, seeds, shellfish, mushrooms, whole grains, low-fat dairy, beef and lamb, avocados, tofu, dark chocolate, cheese, and dried fruits [11]. Mineral deficiency is a lack of dietary minerals and the micronutrients needed for an organism's proper health. The cause may be a poor diet, impaired uptake of the minerals that are consumed, or dysfunction in the organism's use of the mineral after it is absorbed [12]. Any imbalance in the diet might lead to excess or insufficient intake of certain nutrients. Insufficient intake of a particular nutrient can lead to a deficiency disease. Excessive nutrients can, over time, affect metabolic processes and increase the risk of nutritional toxicities. Excessive intake of micronutrients occurs when minerals exceed an upper limits level [13, 14]. The need for essential nutrients in our food in suitable measure for good health led to the present study.

Objective

To determine the levels (concentrations) of minerals in sun-dried different vegetables sourced locally two markets located in Enugu State, of Nigeria

Materials and Method

Sample Collection and Preparation: This is a cross-sectional study [15] in which commonly used vegetable Samples; Telfairia occidentalis, Vitex doniana, Pterocapus santahnoides, Ceiba pentanda, Colocasia antiquorum, Curcurbita pepo, Corchorus olitorus, Mucuna Pruriens, Amaranthus hybridus, and Lecaniodiscus cupaniodes were bought from a village market in Mgbowo, Aninri Local Government Area of Enugu State. The vegetables were collected from two markets - Agbani & Awgu respectively in the Enugu State of Nigeria. Two vegetable samples were collected each to ensure adequate representation.

The leafy samples were washed with distilled water, sun-dried for a week, and later homogenized with an electric blender. Dry Preparation of samples involved 2g of the sample, heated in a furnace for 2hrs at 550^{0}c, diluted with 20ml, 20% H_2SO_4, and filtered with filter paper [16].

Laboratory analysis: The mineral compositions were determined using Varian AA240 Atomic absorption spectrophotometer based on quadrupole mass analyser and octapole reaction system.

(FS240AA Agilent Atomic absorption spectroscopy, USA make) [17]. Collision cell in He-mode was used for elimination of possible polyatomic interferences and instrument was set up by using Tuning solution (Agilent Technologies, Santa Clara, USA).

Data quality: Data quality (18) was confirmed used laid out gold standard to increase the overall reliability, reproducibility, and specificity of data generated for analysis in this study. To be more specific, the calibration solutions were prepared by the appropriate dilution of the single element certified reference materials. Measurement accuracy was verified by using certified reference material of water as was optimized by the Springboard research laboratories. Awka, Anambra State, Nigeria where the samples were analysed.

Statistical analysis: The results were subjected to analysis of variance (ANOVA) using the statistical package Minitab to determine variation between and within result groups.

Results

Table 1 shows the level of macro-mineral contents of ten local vegetables recovered from the local markets in the selected communities of Enugu State in South-Eastern Nigeria. Magnesium, Calcium, Potassium, and Phosphate were present in the result. The magnesium concentration ranged from 0.000-26.415mg/kg; The highest concentration of Magnesium was found in Ceiba pentanda (26.415mg/kg), followed by Telfairia occidentalis (26.332mg/kg) and the lowest was in Lecaniodiscus cupaniodes (8.468mg/kg). Magnesium was not found in Vitex donaina. Calcium concentration in the studied vegetables ranged from 1.473-3.928mg/kg; the highest concentration was in *Amaranthus hybridus and* the lowest in Corchorus olitorus. Potassium concentration ranged from 1.299-4.382mg/kg with the highest concentration in Telfairia occidentalis and the lowest in Corchorus olitorus while the highest level of phosphate (5.893mg/kg) was found Ceiba pentanda and the lowest value of (1.748mg/kg) in Mucuna pruriens. The overall macro mineral composition was not significantly ($p>0.5$) dependent on vegetable samples processed or location from where the vegetables were recovered

The micro-mineral analyzed were Iron, Zinc, manganese, cobalt, selenium, and Molybdenum. Iron content ranged from 2.885-43.083mg/kg as the highest in all the vegetable samples analyzed. Iron (Fe) was highest in Telfairia occidentalis (43.083mg/kg) and lowest in Amaranthus hybridus (2.885mg/kg). The concentration of zinc ranged from 3.042-18.378mg/kg; The leaves of Amaranthus Hybridus possess the highest concentration of Zinc (Zn) (18.378mg/kg) followed by Telfairia occidentalis (11.176mg/kg) and the lowest was also found in Vitex doniana leaves

(3.042mg/kg). Manganese content was in a range from 1.001-7.940mg/kg; The highest concentration of Manganese (Mn) was found in Vitex doniana (7.940mg/kg) and the lowest in Ceiba pentanda (1.001mg/kg). Cobalt was not detected in eight of the vegetable samples and the content ranged from 0.000-0.043mg/kg. Cobalt (Co) was detected only in Vitex doniana (0.043mg/kg) and Lecaniodiscus cupaniodes (0.027mg/kg). The Selenium (Se) content ranged from 6.891-13.022mg/Kg with the highest concentration found in Amaranthus Hybridus and the lowest in Vitex doniana. Molybdenum concentration ranged from 0.000-20.445mg/kg. The level of Molybdenum (Mo) ranges from 4.923 – 20.445mg/kg. The highest was observed in Lecaniodiscus cupaniodes and the lowest was in Mucuna pruriens leaves. It was not detected in five vegetable samples (Table 2). The overall micro mineral composition studied again was not significantly (p>0.5) dependent on vegetable samples processed or location from where the vegetables were recovered

Table 1: Level of macro mineral in the vegetables studied

Samples	Magnesium	Calcium	Potassium	PO4
Telfairia occidentalis	26.332	1.927	4.382	3.738
Vitex donaina	0.000	2.382	1.455	4.865
Lecaniodiscus cupaniodes	8.468	2.927	3.873	3.198
Pterocarpus santahnoides	9.213	3.482	2.083	2.978
Amaranthus hybridus	22.520	3.928	2.983	2.285
Corchorus olitorus	17.465	1.473	1.299	4.754
Mucuna pruriens	17.787	2.372	1.382	1.748
Ceiba pentanda	26.415	2.473	1.728	5.893
Colocasia antiquorum	25.742	2.848	2.272	2.907
Cucurbita pepo	25.708	3.848	2.543	2.009

Using analysis of variance, the result shows no significant difference between and within the groups (P>0.05), Metal concentration=mg/kg

Table 2: Micro mineral contents of the vegetables studied

Samples	Iron	Zinc	Manganese	Cobalt	Selenium	Molybdenum
Telfairia occidentalis	43.083	11.176	6.931	0.000	9.033	0.000
Vitex donaina	42.929	3.042	7.940	0.043	6.891	9.210
Lecaniodiscus cupaniodes	8.205	6.347	1.125	0.027	8.088	20.445
Pterocarpus santahnoides	8.924	6.481	6.566	0.000	9.372	1.500
Amaranthus hybridus	2.885	18.378	4.105	0.000	13.022	0.000
Corchorus olitorus	16.770	7.830	2.350	0.000	10.932	0.000
Mucuna pruriens	11.048	4.259	2.937	0.000	11.286	4.925
Ceiba pentanda	7.806	4.630	1.001	0.000	7.106	0.000
Colocasia antiquorum	10.867	9.217	2.888	0.000	7.019	0.000
Cucurbita pepo	10.426	7.034	2.093	0.000	8.960	13.789

Using analysis of variance, the result shows there is no significant difference between and within the groups (p>0.05) Metal concentration=mg/kg

Discussion

The diversity and great abundance of many vegetables in the forest and in the market consumed by the general public makes it difficult to select what to include in this type of study. Therefore, selected vegetables may not be adequately inclusive if the selection is not diverse and will not be adequately diverse if it is not inclusive [19]. High level of Magnesium found in Ceiba pentanda leaves in this research is higher than the recommended nutrient intake (RNI) of 3.5 – 6.0mg/kg magnesium for infants – Adults [20] and the tolerable Magnesium upper intake limit (UL) of 350mg for adults [21].

Leafy vegetables are very good sources of Magnesium, a cofactor of many enzymes involved in energy metabolism, protein synthesis, RNA and DNA synthesis, and maintenance of the electrical potential of nervous tissues and cell membranes.

The vegetable's (*Telfairia occidentalis* leaves and sun-dried sepals of B. buonopozense) daily supply of calcium in this study is lower than the dietary reference intake (DRI) and upper limit values for adults (22, 23). Calcium plays important role in the formation of bones and teeth, regulation of nerve and muscle function [24]. It has also been shown to be essential in handling various non-communicable diseases such as osteoporosis, cardiovascular diseases and reduce colorectal cancer risk by enhancing the death of cells in the human colorectal epithelium that reduces colorectal neoplasm [25].

Since the concentration of minerals was not significantly ($p>0.05$) dependent on the location, market or method of processing of vegetables, it therefore means that local consumers can buy the vegetables from any of the markets from any of the locations in the studied markets of Enugu State and expect the same level of minerals contents in their food nutrient quality. This is a a promising result to dietary family planners for the ultimate fight against malnutrition

The vegetables analyzed have daily potassium levels lower than the dietary recommended intake (DRI) values for potassium which is 0.4-4.7g/day [19,26]. The highest level was recorded in Telfairia occidentalis. Potassium is essential in; reducing blood pressure, enhancing the healthy balance of body fluid, nerve transmission, and play a critical role in acid-base balance, regulation of osmotic pressure, skeletal and smooth muscles contraction, and Na^+/K^+ ATPase [27]. Family dietary planners must supplement alternative source of potassium to meet the minimum level since the studied vegetables have lower concentration of potassium. Suggested alternative source of potassium in food may include but not limited to Cooked spinach. Cooked broccoli. Potatoes. Sweet potatoes, Mushrooms, Peas and Cucumbers (28)

In this study the phosphate levels of the vegetables are lower than the RDA value of phosphorus (700mg/day) [19]. Intracellular phosphorus is found in biological systems commonly in the form called phosphate even though more than 80% of the total phosphorus is stored in bone and teeth. In the Serum, phosphorus exists as inorganic phosphate, the physiological range is controlled through dietary absorption, bone formation, and renal excretion, and equilibration with intracellular stores [29, 30].

Phosphorus is essentially crucial in different biological functions; cell signaling, breaking and building of minerals, and exchange of energy. To get a balanced diet with enough phosphorus content, Phosphorus supplements such as Organ Meats, Seafood, Dairy, Sunflower and Pumpkin Seeds, Nuts, Whole Grains are recommended for consumers of the analyzed vegetables with low concentration of phosphorus in the studied area (31)

The vegetables analyzed are very good sources of iron. The vegetable contents of iron in descending order is Telfairia occidentalis >Vitec donaina > Corchorus olitorus >Mucuna pruriens > Colocasia antiquorum > Cucurbita pepo > Pterocarpus santahnoides >Lecaniodiscus cupaniodes > Ceiba pentanda> Amaranthus hybridus. From the values obtained in this study, the vegetables will provide daily iron content for a 70kg adult in the range of 201.95 - 3,015.81mg/day which is higher than the minimum daily requirement of 10-50mg/day [32] and the provisional maximum tolerable daily intake (PMTDI) of iron for a 70Kg adult (56mg/day) 0.8 mg/kg of body weight from all sources [33].

The requirement of iron for adult women and men is 18 mg and 8 mg per day [34]. In humans, hemoglobin, myoglobin, and Cytochrome are made up of iron as an essential part [35, 36]. The vegetable diet may reverse the lack of iron condition called anemia while an excess of iron above 45mg/day causes gastrointestinal abnormality [37] or iron overload disorder (Table 2). The Consumer's caution while eating these vegetables for iron supplement is advised

The concentration of zinc daily (212.94 – 1,286.46) mg seen in Amaranthus hybridus studied is higher than; a reference dose of 21 mg zinc/day (0.30 mg/kg-bw-day) for a 70 kg adult [38], the upper level of zinc intake for an adult male set at 45mg/day (690mmol/day) and the average daily zinc intakes of the children in the high-risk (developing) countries between 3.7 and 6.6mg (56–100mmol) [18]. It would also take care of the risk of inadequate zinc intake by 20% of the worlds' population [39]. Zinc is an essential element for plants and animals, but only a small increase in its level may cause interference with physiological processes [40]. Zinc is very useful in protein synthesis, cellular differentiation and replication, immunity, and sexual function [41].

Zinc is a component of a variety of enzymes, including ribonucleic polymerases, alcohol dehydrogenase, carbonic anhydrase, and alkaline phosphatase in humans [42]. Impaired zinc absorption, vascular disease, cancer, and systemic iron overload may be associated with iron toxicity in the human body [32], Deficiency of zinc can result from inadequate dietary intake, impaired absorption, excessive excretion, or inherited defects in zinc metabolism [43].

Zinc is an essential trace element necessary for human health, but high concentrations of zinc can lead to adverse health effects such as anosmia (the loss of the sense of smell) damage to the lungs, liver, kidney, heart, and central nervous system [44]. Zinc helps to speed up the healing process after an injury. In view of the above analogy, Amaranthus hybridus studied provides excellent source of zinc to local consumers in the studied community of Enugu State of South Eastern Nigeria

In this research, the Vegetables were found to have adequate concentration of Manganese (Mn) providing different concentrations higher than the maximum body permissible limit of 5.5mg/kg [45]. Manganese is a co-enzyme that participates in urea, pyruvate, and connective tissue biosynthesis [35].

Cobalt was detected only in Vitex donaina and Lecaniodiscus cupaniodes in this study. Other vegetables did not show the presence of Co. [46] reported Cobalt concentration of 0.011ppm -0.090ppm. The vegetables in this study provided a slightly higher Co level (1.89 - 3.01mg/day) than the average daily intake of cobalt estimated to be 5 to 40 μg per day (0.04mg) [47]. The grazing animals have a recommended value of 0.20mg/kg cobalt [48]. Cobalt is beneficial to humans. It is a key constituent of cobalamin which is known as vitamin B12, the primary biological reservoir of cobalt as an ultra-trace element [49]. Macronutrients like cobalt are toxic because of their solubility in water taken every day, every time by everyone and to high levels of cobalt may results in lung and heart diseases, dermatitis, rise in hemoglobin in anemic patients with nephritis, cancer, and chronic infections [50].

From this research, the order of provision of selenium by the vegetables from the highest to the lowest in concentration is *Amaranthus hybridus* > Mucuna pruriens > Corchorus olitoru > Pterocarpus santahnoides > Telfairia occidentalis > Cucurbita pepo > Lecaniodiscus cupaniodes > Ceiba pentanda > Colocasia antiquorum >Vitex donaina. The level of selenium in the vegetables studied was higher than the maximum daily intake of 0.45mg recommended [51]. Exposure to selenium for long is reported to cause paralysis [52] while a level above 5mg is considered to be highly toxic [51].

Consumers caution while eating these vegetables for selenium is advised. Selenium at 4–8mg/kg intake is reported to decrease sperm motility in healthy men, increase the copper contents of the heart, liver, and kidneys, increases pancreatic and skin cancer cases and it detoxifies or protect against cadmium and mercury complications [53,54].

Nutritionally essential selenium is a constituent of more than two dozen seleno-proteins that play critical roles in reproduction, thyroid hormone metabolism, DNA synthesis, and protection from oxidative damage and infection [55]. It is also a constituent of glutathione peroxidase which is a major scavenger of H2O2 [56,25].

Molybdenum was present in only five vegetable samples analyzed. The provision of molybdenum in descending order is Lecaniodiscus cupaniodes > Cucurbita pepo > Vitex donaina > Mucuna pruriens > Pterocarpus santahnoides. In this study, Pterocarpus santahnoides with a daily Mo intake of 105mg fall within the daily molybdenum requirement of 100 to 300mg for adults [57] while the other vegetables contain higher Mo level. The tolerable upper intake level of Molybdenum is 2 mg/daily [58]. Molybdenum is a micronutrient very important for microorganisms, plants, and animals [59]. Molybdenum is a cofactor for four enzymes involved in the metabolism of sulfites, waste products, and toxins in the body respectively [60,61]. Very high levels of Mo in animals are associated with a reduction in growth, failure in the kidney, infertility, and diarrhea [62]. Reduction in sperm count, quality of sperm, and circulating testosterone levels are associated with a level of molybdenum in the human blood [63,64].

Conclusion

The ten sun-dried local vegetables analysed contain minerals in different concentrations non significantly. The vegetables are good sources of Magnesium Calcium, Potassium, and Phosphate in the body system for healthy functions. Most of the macro minerals are lower in concentration than tolerable upper levels. This indicates that the populace may need mineral supplements or fortified diets to meet appropriate requirements to avoid mineral deficiencies.

The vegetables contain microminerals essential for good health though in values higher than the recommended daily intake. This indicates that continuous consumption of the vegetables may lead to their accumulation in the blood exposing the consumers to health risks associated with excess intake of micronutrients. Eight and five of the vegetables studied do not contain

Cobalt and Molybdenum respectively. Supplements in diets for cobalt and molybdenum may be required to compensate for the lack in the affected vegetables.

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References

1. Fasuyi AO. Nutritional potentials of some tropical vegetable meals: Chemical characterization and functional properties. Afr. J. *Biotech*. 2006, 5: 49-53.

2. Mepha HD, Eboh I. & Banigo EB. Effect of processing treatments on the nutritive composition and consumer acceptance of some Nigerian edible leafy vegetables. Afr. J. Food Agric. Nutr. Dev. 2007, 7(1),23-26.

3.Sobukola OP, Adeniran OM, Odedairo AA and Kajihausa OE. Heavy Metal Levels of Some Fruits and Leafy Vegetables from Selected Market in Lagos, Nigeria. Afr. J. Food Sci. 2010, 4 (2): 389-393.

4.Mohammed MI, and Sharif N. Mineral composition of some leafy vegetables consumed in Kano, Nigeria. Nig. J. Basic. Appl. Sci. 2011, 19(2): 208 - 211.

5.Ihekoronye AI, and Ngoddy PO. Tropical fruits and vegetables. In Integrated Food Science and Technology for the Tropics. Macmillan Publishers, London. pp.292 304. 1985

6.Prakash D, Upadhyay G, Gupta C, Pushpangadan P and Singh KK. Antioxidant and free radical scavenging activities of some promising wild edible fruits. Int. Food Res. J. 2012, 19 (3): 1109-1116.

7."Minerals". Micronutrient Information Center. Linus Pauling Institute, Oregon State University, Corvallis, OR. 2016

8.Berdanier CD, Dwyer JT, Heber D. Handbook of Nutrition and Food, Third Edition. CRC Press. pp. 211–24. 2013

9.Mcintyre T. Phytoremediation of heavy metals from soils. Adv. Biochem Eng. Biotechnol. 2003, 78:97–123.

10.Soetan K. Olaiya, CO, Oyewole OE. The importance of mineral elements for humans, domestic animals, and plants: A review. Afr. J of Food Sci. 2009, 4.

11.U.S. Department of Agriculture - USDA, Agricultural Research Service. FoodData Central. fdc.nal.usda.gov. 2019

12. Johnson LE. Overview of minerals in "Introduction: Mineral Deficiency and Toxicity: Merck Manual Professional". 2020

13. Pike V and Zlotkin, S. Excess micronutrient intake: defining toxic effects and upper limits in vulnerable populations. Ann. N.Y. Acad. Sci. 2019, 1446, 21–43.

14.Girmaye B. Assessment of heavy metals in vegetables irrigated with Awsh river in selected farms around Adma town, Ethiopia. Afr. *J. Environ*. Sci. Technol. 2014, 8(7): 428-434.

15. Scientific and Technical Advisory Council (STAC) of the Special Journals Publisher (SJP): Research Design Innovations in Public Health, Nutrition, and Dietetics. Spec. j. publich helth nutr. diet. 2020; 1 (1):1-21

16.Adrian WJ. A comparison of a wet pressure digestion method with other commonly used wet and dry-ashing methods, Analyst, 1973, 1164

17.American Public Health Association APHA. 3111B, Direct Air- Acetylene Flame Method, Standard Methods for the examination of metals, 20th Edition, APHA, AWWA, WEF. 1998

18. Scientific and Technical Advisory Council (STAC) of the Special Journals Publisher (SJP): Data Integrity in Public Health, Nutrition, and Dietetics Research. Spec. j. publich helth nutr. diet. 2020; 1 (1):1-7

19. Scientific and Technical Advisory Council (STAC) of the Special Journals Publisher (SJP): Inclusion and Diversity in Public Health, Nutrition and Dietetics Research. Spec. j. publich helth nutr. diet. 2020; 1 (1):1-23

20. Jahnen-Dechent W, Ketteler M. Magnesium basics. Clin Kidney J. 2012 Feb;5(Suppl 1):i3-i14.

21. Benjamin Brown, Ciara Wright, Safety and efficacy of supplements in pregnancy, *Nutrition Reviews*, Volume 78, Issue 10, October 2020, Pages 813–826,

22.Idris, S. Compositional Studies of *Telfairia Occidentalis* Leaves. Am J Chem. 2011, 1(2): 56-59

23. Danso J, Alemawor F, Boateng R, Barimah J and Kumah DB. Effect of drying on the nutrient and anti-nutrient composition of Bombax buonopozensesepals, African Journal of Food Science. 2019, 13(1),21-29

24.Brody T. Nutritional Biochemistry. San Diego, C.A; Academic Press, 2nd Edition, pp. 1994, 761- 794.
25. Ng, X. N, Chye, FY and Ismail MA. Nutritional profile and antioxidative properties of selected tropical wild vegetables. Int. Food Res. J. 2012, 19(4): 1487-1496.
26.Food and Nutrition Board. Dietary reference intakes for water, potassium, sodium, chloride, and sulfate. Washington (DC): National Academy Press. 2005
27. Murray RK, Granner DK, Mayes P A and Rodwell, VW (2000). Harper‘s Biochemistry,25th Edition, McGraw-Hill, Health Profession Division, USA. 2000
28. Jakše B, Jakše B, Pajek M, Pajek J. Uric Acid and Plant-Based Nutrition. Nutrients. 2019 Jul 26;11(8):1736.
29. Fukagawa M, Kurokawa K., Papadakis MA. Fluid and electrolyte disorders. In: Tierney LM, McPhee SJ, Papadakis MA, eds. Current Medical Diagnosis and Treatment. New York, NY: McGraw-Hill/Appleton & Lange; 2004: 837–867. 2005
30.Blumsohn A. What have we learned about the regulation of phosphate metabolism? Curr Opin Nephrol Hypertens. 2004, 13: 397–401.
31. Calvo MS, Lamberg-Allardt CJ. Phosphorus. Adv Nutr. 2015 Nov 13;6(6):860-2.
32.Oladele AT and Fadare OO. Heavy Metals and Proximate Composition of Forest leafy vegetables in oil-producing Area of Nigeria. (E.J.E.S.M.) Ethiopian J. of Envt. St. and Mgt. 2015, 8(4): 451-463.
33.JECFA, (2005). Joint FAO/WHO Expert Committee on Food additives, 64th Meeting, JECFA/64/SC, Codex Standard 193- 1995, Pg 47
34.Nieboer E. and Richardson D. "Lichens and 'heavy metals' ", International Lichenology Newsletter; 1978, 11(1): 1–3. 19.
35.Chandra RK. Micronutrients and Immune functions: An overview. Ann. New York Acad. Sci. 1990, 587: 9 -16
36. Hamlin F, Latunde-Dada GO. Iron bioavailibity from a tropical leafy vegetable in anaemic mice. Nutr Metab (Lond). 2011 Feb 3;8:9.
37.Driskell JA. Upper Safe Levels of Intake for Adults: Vitamins and Minerals. University of Nebraska – Lincoln Extension Publication, Institute of Agriculture and Natural Resources. 2009
38.EPA U.S.A. Environmental Protection Agency. Integrated risk information system (IRIS) for zinc. National Center for Environmental Assessment, Office of Research and Development, Washington, 2002,
39.Hotz C, Brown KH. Assessment of the Risk of Zinc Deficiency in Populations and Options for Its Control. International Zinc Nutrition Consultative Group (IZINCG) eds. *Food* Nutr Bull. 2004, 25: S91-S204.
40.Elbagermi MA, Edwards, HGM. and Alajtal AI. Monitoring of Heavy Metal Content in Fruits and Vegetables Collected from Production and Market Sites in the Misurata area of Libya. Anal. Chem. 2012, 12:1-5.
41. Pathak P. and Kapil, P. Role of trace elements zinc, copper, and magnesium during pregnancy and its outcome. Indian J Pediatr. 2004, 71(11):1003-5.
42.Goldhaber SB. Trace element risk assessment: essentially vs. toxicity. Regul Toxicol Pharmacol. 2003, 38:232–242
43.Colak H, Soylak M, Turkoglu O. Determination of trace metal content of various herbal and fruit teas produced and marketed in Turkey. J Trace Elem Electrolytes Health Dis. 2005, 22:192–195
44.Nriagu J. Zinc Toxicity in Humans. Elsevier B.V. University of Michigan, USA, 2007
45.FAO/WHO; Joint FAO/WHO food standards programme codex committee on contaminants in foods, fifth. session pp 64-89. 2011
46. Datta S, Sinha BK, Bhattacharjee S, Seal T. Nutritional composition, mineral content, antioxidant activity and quantitative estimation of water soluble vitamins and phenolics by RP-HPLC in some lesser used wild edible plants. Heliyon. 2019 Mar 28;5(3):e01431.
47.Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Cobalt. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. 1992
48.Schwarz FJ., Kirchgessner, M., and Stangl, GI. Cobalt Requirement of Beef Cattle - Feed Intake and Growth at Different Levels of Cobalt Supply. J. Anim. Physiol. Anim. Nutr. 2000, 83(3):121-128.

49.Prasad, M.N.V. (2004). Heavy Metal Stress in Plants, 2nd Edition, Springer, United Kingdom. pp. 484-487.
50.Oladeji SO and Saeed, MD. Assessment of cobalt levels in wastewater, soil, and vegetable samples grew along Kubanni stream channels in Zaria, Kaduna State, Nigeria. Afr. J. Environ. Sci. Technol. 2015, 9(10): 765-775.
51.Emsley J. Nature's Building Blocks, new edition, Oxford University Press, Oxford, 2011
52. Hoffman JB, Petriello MC, Hennig B. Impact of nutrition on pollutant toxicity: an update with new insights into epigenetic regulation. Rev Environ Health. 2017 Mar 1;32(1-2):65-72.
53.World Health Organization. Environmental Health Criterion 58—Selenium, World Health Organization, Geneva. 1987
54.Bedwal RS, Nair N, Sharma, MP, and Mathur, RS. Selenium—Its Biological Perspectives. Med. Hypotheses. 1993, 41(2): 150–159.
55.Sunde RA. Selenium. In: Ross AC, Caballero B, Cousins RJ, Tucker KL, Ziegler TR, eds. Modern Nutrition in Health and Disease. 11th ed. Philadelphia, PA: Lippincott Williams & Wilkins;225-37. 2012
56.Arinola OG, Olaniyi JA, and Akiibinu MO. Evaluation of antioxidant levels and trace element status in Nigerian Sickle cell disease patients with Plasmodium parasitaemia. Pakistan J Nutr. 2008, 7(6): 766 769.
57.World Health Organization. Trace Elements in Human Nutrition and Health. Geneva, Switzerland. 1996
58.Food and Nutrition Board. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Cop-per, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vana-dium, and Zinc. Washington, DC: National Academies Press. 2001
59.Bortels H. Molybdän als Katalysator bei der biologischen Stickstoffbindung. Archiv. Für Mikrobiol. 1930, 1, 333–342.
60. Novotny JA. Molybdenum Nutriture in Humans. J. Evid Based *Complement* Alternat Med. 2011, 16(3):164-168.
61.Mendel, R.R., and Bittner, F. Cell biology of molybdenum. Biochimica et Biophysica Acta (BBA) - Molecular Cell Research. 2006, 1763(7):621-635.
62. Vyskocia, A, and Viau, C. Assessment of Molybdenum toxicity in humans. J. Appl. Toxicol. 1999, 19(3):185-92.
63. Meeker JD, Rossano MG, Protas B, Diamond, MP, Puscheck E, Daly D, et al. Cadmium, Lead, and Other Metals in Relation to Semen Quality: Human Evidence for Molybdenum as a Male Reproductive Toxicant. Environ Health Perspect. 2008, 116(11): 1473–1479.
64. Meeker JD, Rossano MG and Protas B. Environmental exposure to metals and male reproductive hormones: circulating testosterone is inversely associated with blood molybdenum. Fertil Steril. 2010, 93:130-140.