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BIO-ASSESSMENT OF HEAVY METALS IN LEAFY VEGETABLES FROM SELECTED AGRICULTURAL FARMS IN LAGOS STATE, NIGERIA

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ABSTRACT

Vegetables grown on environmentally contaminated sites could take up and accumulate metals at concentration that are toxic to human health. This study analysed heavy metals in some leafy vegetables cultivated on some commercial farms within the Lagos metropolis. Three vegetables species namely *Telfairia occidentalis* (Ugwu), *Corchorus olitorius* (Ewedu) and *Celosia argentea* (Shoko) were sampled from various locations within three selected farmlands and tested for levels of Arsenic (As), Cadmium (Cd), Iron (Fe), Lead (Pb), Zinc (Zn), Nickel (Ni) and Copper (Cu) using Atomic Absorption Spectrometry. The results showed that levels of metals As, Cd, Fe, Zn, Pb, Ni and Cu ranges from 0.02±0.01 to 23.50±2.01 µg/g, Cd concentration levels ranged between 0.42±0.21 to 1.96±1.10 µg/g, Fe level ranged between 4.11±0.88 to 16.82±12.00 µg/g, Pb concentrations ranged between 2.30±0.01 to 5.60±1.47 µg/g, Zn contents ranged between 3.24±1.34 to 23.50 µg/g and Cu ranged between 1.60±0.46 to 4.93±0.39 µg/g respectively for all vegetable sampled. The analysis revealed that Zinc showed the highest concentration in *C. olitorius* and Iron in *T. occidentalis* at 23.50 µg/g and 16.82 µg/g respectively while the Arsenic showed the lowest level of 0.02 µg/g in *C. argentea* amongst all vegetables studied. The amount of heavy metals found in these vegetables were within safety baseline for human consumption. However, due to associated health risks vegetables contaminated with heavy metals should not be consumed.

Keywords: Contamination, Farmland, Health, Heavy metal, Vegetables

Introduction

Most food materials are majorly obtained from plants (vegetable, cereals, grains, fruits etc) and animals (Izah *et al.*, 2016). According to Prakash *et al.* (2012) people all over the world increase the intake of fresh vegetables instead of red meat to reduce the incidence of chronic disease and other age-related diseases. Green leafy vegetables are used as condiments of soups and sauce across

different cultures in Nigeria as well as other countries in West Africa (Ladipo and Doherty, 2011).

Vegetables act as essential diet for human nutrition and health, particularly as source of vitamins, protein, carbohydrate, calcium, iron and other short supply nutrients (Amin *et al.*, 2013). They also supply folic acid, minerals, niacin, thiamine,

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pyridoxine and dietary fiber, play biochemical role and anti-oxidative effects (Siegel *et al.*, 2014). Quite a large number of leafy vegetables indigenous to Africa have been reported and known to have health protecting properties and utility (Okeno *et al.*, 2003; Gido *et al.*, 2017).

Consumption of vegetables provide the body of the living organisms with trace elements and metals which are essentials for good health (Mohammed *et al.*, 2003). These trace elements are essential for healthy body if derived from an organic or plant source, in contrast; if derived from inorganic or metallic source they become toxic to the body. The process of plant growth depends on the cycle of nutrients which include trace elements from soil to plant (Mohammed *et al.*, 2003). The essential micro or trace nutrients in higher plants include Boron (Br), Chlorine (Cl), Copper (Cu), Iron (Fe), Molybdenum (Mb), Manganese (Mn), Nickel (Ni) and Zinc (Zn) and non-essential such as Mercury (Hg), Lead (Pb), Cadmium (Cd) and Arsenic (As) (Tchounwou *et al.*, 2012) and they play important processes in plant metabolism that include respiration, photosynthesis, synthesis of proteins, metallo proteins, function of metalloenzymes, redox processes, plant defense mechanisms and regulation of genes (Broadley *et al.*, 2012).

Vegetables, especially leafy vegetables cultivated in contaminated soils accumulate high amounts of heavy metals than those cultivated in uncontaminated soil due to the fact that they absorb these metals through their leaves (Mohammed *et al.*, 2003). Heavy metals are non-biodegradable having long biological half-lives and potential side effects when accumulated in different body organs (Sathawara *et al.*, 2004 and Radwan and Salama, 2006). They are ever present in the environment as a result of the extreme use of compounds in industrial applications (Vamerali *et al.*, 2010; Tchounwou *et al.*, 2012) with most being extremely toxic because of their solubility in water. Additionally, they negatively deplete some essential nutrients in the body leading to decrease

in intrauterine growth, immunological deficiencies, disabilities associated with malnutrition, impaired psycho-social behavior and a high prevalence of upper gastrointestinal cancer (Jarup, 2003; Duruibe *et al.*, 2007).

***Telfairia occidentalis* (Ugwu)**

Telfairia occidentalis commonly called fluted gourd, fluted pumpkin, Ugwu (Igbo) and Ikong – ubong (Efik/Ibibio) is a tropical vine grown in West Africa as a leafy vegetable and for its edible seeds (Osukoya *et al.*, 2016). It is a member of the Cucurbitaceae family and indigenous to southern Nigeria (Akoroda, 1990). It is used primarily for soups and herbal medicines (Akwaowo *et al.*, 2000). The leaves of this plant are also known to contain a high amount of antioxidants, hepatoprotective and antibacterial properties (Oboh *et al.*, 2006; Eseyin *et al.*, 2014). Flour produced from the seeds can be used for high protein bread (Giami, 2003).

***Celosia argentea* (Shoko)**

Celosia argentea L. is an herbaceous plant which belongs to the family Amaranthaceae and one of the leading leafy vegetables in south-western Nigeria (Hayakawa *et al.*, 1998). *C. argentea* or ‘Lagos spinach’ is one of the main boiled greens in West Africa where it is known as Sokoyokoto (Yoruba), Ferara leyyato (Hausa) (Hanelt, 2001). Ailments treated with *C. argentea* include: diarrhoea, wounds, abscesses, liver ailments, menstruation problems, colic, mellitus, eczema, snakebites, eye problems, gonorrhoea, infected sores, diabetes, muscle troubles, skin eruptions, cough, and dysentery (Kanu *et al.*, 2017).

***Corchorus olitorius* (Ewedu)**

Corchorus olitorius L. is a leafy vegetable belonging to the family of Sparmaniaceae (Isuosuo *et al.*, 2014) and also known as jute plant. The edible part of this plant are the leaves which are known to contain 17 active nutrients compounds including calcium, potassium, protein, fat,

carbohydrate, fibre, ash, iron, sodium, phosphorous, beta carotene, thiamine, riboflavin and ascorbic (Handoussa *et al.*, 2013). Consumption of the leaves is reported to be demulcent, lactagogue, deobstruent, purgative, and tonic (Owoyele *et al.*, 2015). The cold infusion is said to restore the appetite and strength (Nyadanu and Lowor, 2015). This plant is also used for its gastro protective properties and as anti-infertility agent (Handoussa *et al.*, 2013).

Cases of heavy metals toxicity through water and food consumption abound. The possibility of potential toxicity of heavy metals as a result of commonly consumed leafy vegetables necessitates this study to examine the level of some heavy metals (Pb, Cu, Fe, Zn, Ni, As and Cd) in edible portions of *Corchorus olitorius* (Ewedu), *Telfairia occidentalis* (Ugwu) and *Celosia argentea* (Shoko) grown on three commercial farms in different suburb of Lagos State, Nigeria.

Materials and Methods

Source of Plant Materials

The healthy edible portions of *T. occidentalis*, *C. olitorius* and *C. argentea* were randomly collected into different polythene bags using a sharp plastic knife. These were transported to the laboratory and cleansed with distilled water to remove suspended particles. They were authenticated and deposited at the Lagos University Herbarium. The study areas are commercial farms respectively located in Ikorodu (6°39'47" N, 3°30'25" E), Badagry (06° 12'30" N; 02° 21'60" E) and Agege (06°38'56" N; 03°19'44" E) in the Lagos metropolis, South Western Nigeria.

Heavy Metals Analysis

Sample for analysis were dried using oven dry method at 105°C for 24hours to remove the moisture content as described by official method of analysis (AOAC, 1990). The dried samples were powdered with a stainless-steel blender and passed through 2mm sieve and stored in polythene bags

until ready for use. About 2g of each sample was weighed and digested in a mixture of 10ml concentrated HCl, 5ml concentrated H₂SO₄ and 15ml of concentrated HNO₃ in a beaker under a fume hood. The mixture was heated constantly until a dense fume evolved. This was further heated strongly for about half an hour. The result solution was cooled and filtered through Whatman 42 filter paper before making up to 50ml volumetric flask with distilled water.

The determination of heavy metals that is, Copper, Cadmium, Lead, Zinc, Nickel, Arsenic and Iron was achieved by atomic absorption spectrophotometer (AAS) (Schmaizu 6800 AA). All determination was done in triplicates and a spike sample was used to verify the accuracy of the procedure. All reagents used were of analytical grades. All the plastic and glassware were cleaned by soaking in a 10% nitric acid solution and then rinsing with distilled water prior to use.

Results

The concentrations of heavy metals (Fe, Pb, Cd, Ni, Cu, As and Zn) in *T. occidentalis*, *C. olitorius* and *C. argentea* obtained from selected commercial farms in the Lagos metropolis was analyzed in our study and the results are presented in Tables 1 to 3. The tested heavy metals were detected in all vegetables investigated across the three farms but were found in different concentrations per dry weight of the tested samples.

Heavy metal analysis in *Telfairia occidentalis*

Results in Table 1 denotes the concentration of the sampled metals in *Telfairia occidentalis* with the highest concentration in Fe (16.82±12.00 µg/g) from the Badagry farm. The concentrations of metals like Pb, As, Cd and Ni were insignificant in all the farms.

Heavy metal analysis in *Corchorus olitorius*

In Table 2 the analysis of heavy metal in ewedu is presented. The result showed that Zn is

significantly present in ewedu as depicted from the various locations of the three farms sampled. The highest concentration of Zn is $23.50 \pm 2.01 \mu\text{g/g}$ from the Ikorodu farm while negligible concentration of As at $0.03 \pm 0.02 \mu\text{g/g}$ was detected as the lowest concentration of heavy metal in the sampled farms.

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Heavy metal analysis in *Celosia argentea*

Table 3 shows the result of the heavy metal analyzed in shoko with the highest mean concentration of $7.11 \pm 2.14 \mu\text{g/g}$ found in Pb from the Badagry farm. However, the values of all metals analyzed were insignificant in *C. argentea* as depicted from the table.

Table 1: Heavy metal concentration ($\mu\text{g/g}$) in *Telfairia occidentalis* (Ugwu) samples

Heavy metal ($\mu\text{g/g}$)	Ikorodu	Badagry	Agege	Permissible value (mg/kg) FAO/WHO (2011)
Iron (Fe)	10.34 ± 3.76	16.82 ± 12.00	6.67 ± 0.50	425.5
Copper (Cu)	4.885 ± 0.02	4.93 ± 0.39	4.86 ± 0.31	73.3
Cadmium (Cd)	0.42 ± 0.21	0.53 ± 0.21	0.46 ± 0.32	0.2
Zinc (Zn)	2.94 ± 0.04	5.82 ± 1.16	4.76 ± 0.58	99.4
Lead (Pb)	2.75 ± 0.78	2.30 ± 0.01	2.30 ± 0.01	0.3
Arsenic (As)	0.04 ± 0.04	0.03 ± 0.03	0.02 ± 0.01	0.2
Nickel (Ni)	0.17 ± 0.25	0.64 ± 0.67	0.21 ± 0.16	67.9

Values are expressed as means \pm SEM for three replicates

Table 2: Heavy metal concentration ($\mu\text{g/g}$) in *Corchorus olitorius* (Ewedu) samples

Heavy metal ($\mu\text{g/g}$)	Ikorodu	Badagry	Agege	Maximum permissible value (mg/kg) FAO/WHO (2011)
Iron (Fe)	5.18 ± 0.52	6.45 ± 0.75	7.65 ± 0.95	425.5
Copper (Cu)	4.29 ± 0.63	4.67 ± 0.00	4.66 ± 0.01	73.3
Cadmium (Cd)	1.26 ± 0.19	1.84 ± 0.66	1.22 ± 0.10	0.2
Zinc (Zn)	23.50 ± 2.01	18.78 ± 1.12	20.80 ± 3.46	99.4
Lead (Pb)	4.81 ± 0.01	4.85 ± 0.03	5.60 ± 1.47	0.3
Arsenic (As)	0.06 ± 0.04	0.03 ± 0.02	0.06 ± 0.02	0.2
Nickel (Ni)	0.62 ± 0.71	1.22 ± 0.62	0.46 ± 0.26	67.9

Values are expressed as means \pm SEM for three replicates

Table 3: Heavy metal concentration ($\mu\text{g/g}$) in *Celosia argentea* (Shoko) samples

Heavy metal ($\mu\text{g/g}$)	Ikorodu	Badagry	Agege	Maximum permissible value (mg/kg) FAO/WHO (2011)
Iron (Fe)	4.38 \pm 1.80	4.11 \pm 0.88	4.31 \pm 0.93	425.5
Copper (Cu)	1.70 \pm 0.36	1.67 \pm 0.37	1.60 \pm 0.46	73.3
Cadmium (Cd)	1.73 \pm 0.63	1.96 \pm 1.10	1.12 \pm 0.10	0.2
Zinc (Zn)	6.08 \pm 1.67	3.24 \pm 1.43	5.03 \pm 2.50	99.4
Lead (Pb)	4.49 \pm 0.37	7.11 \pm 2.14	4.69 \pm 0.36	0.3
Arsenic (As)	0.04 \pm 0.03	0.05 \pm 0.04	0.07 \pm 0.02	0.2
Nickel (Ni)	0.05 \pm 0.21	0.88 \pm 0.27	0.75 \pm 0.65	67.9

Values are expressed as means \pm SEM for three replicates

Discussion

This study reports the concentrations of heavy metals content of Lead (Pb), Arsenic (As), Copper (Cu), Zinc (Zn), Iron (Fe), Nickel (Ni) and Cadmium (Cd) in the leaves of *Corchorus olitorius* (Ewedu), *Telfairia occidentalis* (Ugwu) and *Celosia argentea* (Shoko) grown on three commercial vegetable farms in different suburb of Lagos State, Nigeria. The concentration of Zinc in *C. olitorius* (23.50 \pm 2.01 $\mu\text{g/g}$) was observed to be the highest among all heavy metals sampled. Zinc is known to be the least toxic and an essential element in human diet as it is required to maintain the functioning of the immune system (Garba *et al.*, 2018). Zinc deficiency in the diet may be highly detrimental to human health than too much Zinc in the diet. Vegetables that grow on heavy metal contaminated soil can accumulate high concentration of zinc and cause serious health risks to consumers. However, the range concentration of Zn in the present study is much lower than the recommended safe limit which indicates the safety of the vegetables (FAO/WHO, 2011). Significant quantity of Zinc had also been observed in *C. olitorius* by other researchers such as Idirs *et al.* (2009) who found 4.71 \pm 0.01

mg/100g and Isuosuo *et al.* (2019) found 0.090-0.942 $\mu\text{g}/100$ g. The primary source of Zn in the area could be the attrition of motor vehicle rubber tires exacerbated by poor road surface and waste combustion.

Within the selected vegetables, the highest concentration of Lead (Pb) was noticed in *Celosia argentea* (7.11 \pm 2.14 $\mu\text{g/g}$) followed by *Corchorus olitorius* (5.60 \pm 1.47 $\mu\text{g/g}$). Lead is a serious cumulative body poison which enters into the body system through air, water and food. According to Igwegbe *et al.* (2013) the higher levels of heavy metal contamination found in some fruits and vegetables could be closely related to the pollutant in irrigation water, soil and pesticides or alternatively could be due to pollution from traffic on the highway. This cannot be removed by washing fruits and vegetables (Itanna, 2002). In many plants, Pb accumulation can exceed several hundred times the threshold of maximum level permissible for human consumption (Mohammed *et al.*, 2003).

Our study also shows that the lead content in the selected vegetable samples are within the FAO/WHO safe limit. The concentration is also low compared to the value obtained by Osundiya

et al. (2014) who reported highest value of 24.07 µg/g in leafy vegetables while working on bioaccumulation of heavy metals in frequently consumed leafy vegetables along Seme border, Nigeria.

Copper is an important micronutrient which acts as a bio-catalyst required for body pigmentation in addition to iron, maintaining a healthy central nervous system, prevents anemia and interrelated with the functions of zinc and iron in the body (Uauy *et al.*, 1998). Most plants contain an amount of copper which is inadequate for normal development and is regularly guaranteed through artificial or organic fertilizer application. The highest value observed from the present study was in *Telfairia occidentalis*.

Iron an essential micronutrient is required for the delivery of oxygen to the rest of the body. It is an essential element for almost all living organisms as it participates in a wide variety of metabolic processes including oxygen transport, deoxyribonucleic acid (DNA) synthesis, and electron transport (Abbaspour *et al.*, 2014). The concentrations of Iron in the samples analysed varied with the highest mean concentration observed in *Telfairia occidentalis*. *T. occidentalis* is often recommended for anemic patients due to its high iron contents (Olaniyan and Adeleke 2005; Hamlin and Latunde-Dada, 2011). However, the values of iron found in the sampled *C. olitorius* and *C. argentea* was lower than what was reported for some leafy vegetables obtained in some agricultural farmlands in Ethiopia as well as the recommended maximum limit for vegetables (Itanna, 2002). Prabu (2009) on the study of the impact of heavy metal contamination in soil and cultivated vegetable crops revealed that high level of Fe above the permissible level may lead to leave chlorosis due to iron toxicity whereas in human, Fermer (2001) and Abbaspour *et al.* (2014) reported that it can cause vomiting, upper abdominal pain, pallor, cyanosis, diarrhea, dizziness, shock, haemochromatosis diabetes,

disease of liver, lungs and kidney hematoma and cardiomyopathy.

The variation in the concentrations of the heavy metals in the sampled vegetables at the different farmlands may be attributed to the heavy metal concentrations of the soil, air, fertilizer application and irrigation water of the site and also to the absorption of heavy metals from aerial correlating earlier suggestions of Osundiya *et al.* (2014).

The exposure of consumers to heavy metals and the related health risks are usually expressed in terms of the personal tolerance daily intake (PTDI) (FAO/WHO, 2011). The FAO/WHO have set limit for the heavy metal intake based on body weight for an average adult namely for a 100kg body weight, the average diet per person per day of vegetable and fruit are 98 and 78g respectively.

The contribution of the heavy metals intake for an average human being from the vegetable here are below the maximum safe limit as reported by FAO/WHO, (2011).

Conclusions

The results obtained in this study on bio-assessment of heavy metals in selected leafy vegetables was compared with earlier reports and WHO safe limits. Generally, the levels of heavy metals were observed to be within permissible levels thus the vegetables species are suitable for consumption for the communities around the area. However, the general public need to be educated on the adverse effects of accumulation of these metals in the human body.

References

- Abbaspour, N., Hurrell, R. and Kelishadi, R. (2014). Review on iron and its importance for human health. *Journal of Research in Medical Science*. 19(2): 164–174.
- Akoroda, M.O. (1990). Patterns of vegetative and sexual development of *Telfairia occidentalis*

- Hook. f. *Tropical Agriculture*. 67(3): 243-247.
- Akwaowo, E.U., Ndon, B.A. and Etuk, E.U. (2000). Minerals and antinutrients in fluted pumpkin (*Telfairia occidentalis* Hook f.). *Food Chemistry*. 70(2): 335-340
- Amin, N.U., Hussain, A., Alamzeb, S. and Begum, S. (2013) Accumulation of heavy metals in an edible part of vegetables irrigated with water and their daily intake to adults and children, District Mardan, Pakistan. *Food chemistry*. 136: 1515-1523.
- Akinyele, I.O. and Osinbanjo, O. (1982). Level of some trace elements in Hospital diet. *Food Chemistry*. 8: 247-251.
- Association of Analytical Communities (AOAC), (1990). Association of Analytical Chemist. Official Methods of analysis. P21
- Broadley, M., Brown, P., Cakarank, I., Rengel, Z. and Zhao, F. (2012). In: Marschner, P (Ed). *Functions of nutrients: micronutrients in mineral nutrition of higher plants*. 3rd Edition, London Academic Press. pp191-248.
- Duruibe, J.O., Ogwuegbu, M.O.C. and Egwurugwu, J.N. (2007). Heavy metal pollution and human biotoxic effects. *International Journal of Physical Sciences*. 2 (5): 112-118.
- Eseyin, O.A., Sattar, M.A. and Rathore, H.A. (2014). A Review of the pharmacological and biological activities of the aerial parts of *Telfairia occidentalis* Hook.f. (Cucurbitaceae). *Tropical Journal of Pharmaceutical Research*. 13 (10): 1761-1769
- Food and Agriculture Organisation (FAO)/World Health Organisation (WHO) (2011). Joint FAO/WHO food standards programme codex committee on contaminations in food. Fifth Session. The Hague, The Netherlands, 21-25 March, 2011.
- Fermer, D.J. (2001). Human health risks assessment of metals contamination through consumption of fish. *Medical Journal*. 2: 1-5.
- Garba, S. T., Mustapha, B.U. and Baba, A. (2018). Level of some heavy metals in selected fruits and vegetables. *International Journal of Scientific Research Engineering & Technology (IJSRET)*. 7(6),
- Gido, E.O., Ayuya, O.I., Owuor, G. and Bokelmann, W. (2017). Consumption intensity of leafy African indigenous vegetables: towards enhancing nutritional security in rural and urban dwellers in Kenya. *Agricultural and Food Economics*. 5(14). <https://doi.org/10.1186/s40100-017-0082-0>
- Giami, S. Y. (2003). Effects of germination on Bread making properties of wheat – fluted Pumpkin (*Telfairia occidentalis*) seeds for blends. *Plant Foods for Human Nutrition*. 58:1-9.
- Hamlin, F. and Latunde-Dada, G.O. (2011). Iron bioavailability from a tropical leafy vegetable in anaemic mice. *Nutrition and Metablism*. 8(9) doi: [10.1186/1743-7075-8-9](https://doi.org/10.1186/1743-7075-8-9)
- Hanelt, G. (2001). Mansfeld's encyclopedia of agricultural and horticultural crops. pp .7
- Handoussa H., Hanafi, R., Islam, E., El – Gendy, M., El Khatib, A., Michael, L., Mahran, L. and Ayoub, N. (2013). Anti – inflammatory and cytotoxic activities of dietary phenolics isolated ffrom *C. olitorious* and *Vitis vinifera*. *Journal of Functional Foods*. 5 (3): 1204-1216.
- Husain, A., Baroon, Z., Al-khalafawi, M., Al-Ati, T. and Sawaya, W. (1995). Toxic metals in

- imported fruits and vegetables marketed in Kuwait. *Environment International*. 21(6): 803–805.
- Idirs, S., Yisa, J. and Ndamitso, M.M. (2009). Nutritional composition of *Corchorus olitorius* leaves. *Animal Production Research Advances*. 5(2) DOI: [10.4314/apra.v5i2.49827](https://doi.org/10.4314/apra.v5i2.49827)
- Igwegbe, A.O., Agukwe, C.H. and Negbenebor, C.A. (2013). A survey of heavy metal (Lead, Cadmium and Copper) contents of selected fruit and vegetable crops from Borno State of Nigeria. *International Journal of Engineering and Science*. 2(1): 1-5.
- Isuosuo, C.C. and Akaneme, F.I. (2014). Genetic variability assessment of accessions of *Corchorus olitorius* L. using sodium dodecyl sulphate polyacrylamide gel electrophoresis. *Academic Journals*. 13:2004-2009
- Isuosuo, C.C., Akaneme, F.I. and Abu, N.E. (2019). Nutritional evaluation of the seeds of *Corchorus olitorius*: A neglected and underutilized species in Nigeria. *Pakistan Journal of Nutrition*. 18: 692-703.
- Itanna, F. (2002). Metals in leafy vegetables grown in Addis Ababa and toxicological implications. *Journal of Health Development*. 16 .3: 295-302.
- Izah, S. C., Kigigha, L. T. and Anene, E.K. (2016). Bacteriological quality assessment of melon domestica borkh and *cucumis sativas*. L. in Yenagoa metropolis, Bayelsa State, Nigeria. *Journal of Applied Sciences*. 1: 5- 7.
- Jarup, L. (2003). Hazard of heavy metals contamination. *Medical Bulletin*. 68: 167 – 182.
- Kanu, C.L., Owoeye, O., Imosemi, I.O. and Malomo, A.O. (2017). A review of the multifaceted usefulness of *Celosia argentea* Linn. *European Journal of Pharmaceutical and Medical Research*. 4(10): 72-79
- Ladipo, M. K. and Doherty, V. F. (2011). Heavy metal levels in vegetables from selected markets in Lagos, Nigeria. *African Journal of Food Science and Technology*. 2(1): 018-021
- Mohammed, A.E., Rasheed, M.N., and Mofty, A. (2003). Assessment of essential and toxic elements in some kinds of vegetables, *Ecotoxicological Environmental Safety*. 55: 251 – 260.
- Nyadanu, D. and Lowor, S. T. (2015). Promoting competitiveness of neglected and underutilized crop species: comparative analysis of nutritional composition of indigenous and exotic leafy and fruit vegetables in Ghana. *Genetic Resources and Crop Evolution*. 62(1): 131-140.
- Oboh, G., Nwanna, E.E. and Elusiyan, C.A. (2006). Antioxidant and Antimicrobial Properties of *Telfaira occidentalis* (Fluted pumpkin) Leaf Extracts. *Journal of Pharmacology and Toxicology*. 1: 167-175.
- Okeno, J.A., Chebet, D.K. and Mathenge, P.W. (2003). Status of indigenous vegetables in Kenya. *Acta Horticulturae*. 621: 95-100.
- Olaniyan, M.F. and Adeleke, A. A. (2005). Study of the effect of pumpkin (*Ugu-Telfaira occidentalis*) milk and raw egg mixture in the treatment of anaemic pregnant women in a rural area. *African Journal of Traditional, Complementary and Alternative Medicines*. 2:269–273
- Osundiya, M. O., Ayejuyo, O. O., Olowu, R.A., Bamgboye, O. A. and Ogunlola, A. O. (2014). Bioaccumulation of heavy metals in frequently consumed leafy vegetable grown along Nigeria-Benin Seme Border, West

Africa. *Advances in Applied Science Research*. 5(1):1-7.

Owoyele, B.V., Oyewole., Alimi, M.L., Sanni, S.L. and Oyeleke, S.A. (2015). Anti-inflammatory and antipyretic properties of *Corchorus olitorius* aqueous root extract in Wistar rats. *Journal of Basic and Clinical Physiology and Pharmacology*. 26(4) doi.org/10.1515/jbcpp-2013-0166

Prabu, P.C. (2009). Impact of heavy metal contamination of Akali River of Ethiopia on soil and metal toxicity on cultivated vegetable crops. *Electronic Journal of Environmental, Agricultural and Food Chemistry*. 8(9): 818-827.

Prakash, D., Upadhyayi, G., Gupta. C., Pushpangadan, P., and Singh, K.K. (2012). Antioxidants and free radicals screening activities of some promising wild edible fruits. *International Food Resources Journal*. 19: 1106 – 1116.

Radwan, M. A., and Salama. A. K. (2006). Market Basket survey for some heavy metals in Egyptian fruits and vegetables. *Food Chemistry*. 44: 1273 – 1278.

Sathawara, N.G., Prakash, D.J., and Agarwai, Y.K. (2004). Essential heavy metals in environmental samples from western India. *Bulletin. Environmental Contamination*. 73: 756 – 761.

Siegel, K.R., Ali, M.K., Srinivasiah, A., Nugent, R.A. and Narayan, K.M.V. (2014). Do we produce enough fruits and vegetables to meet global health need? *PLoS One*. 9:e104059

Tchounwou, P. B., Yedjou, C. G., Patlolla, A. K., and Sutton, D. J. (2012). Heavy metal toxicity and the environment. *Experientia Supplementum*. 101: 133–164. [doi:10.1007/978-3-7643-8340-4_6](https://doi.org/10.1007/978-3-7643-8340-4_6)

Uauy, R., Olivares, M. and González, M. (1995). Essentiality of copper in human. *American Journal of Clinical Nutrition*. 67(5 Suppl): 952S-959S DOI: [10.1111/j.1753-4887.1987.tb06081.x](https://doi.org/10.1111/j.1753-4887.1987.tb06081.x)

Vamerali, T., Bandiera, M, and Mosca, C. (2010). Field crops for phytoremediation of metal contaminated land. *Environmental Chemistry*. 8: 1-17.