academicJournals

Vol. 10(9) pp. 172-177, September 2016
DOI: 10.5897/AJFS2016.1421
Article Number: D35946859661
ISSN 1996-0794

http://www.academicjournals.org/AJFS

African Journal of Food Science

Full Length Research Paper

Comparison of metal content in seeds of *Moringa ovalifolia* and *Moringa oleifera*

Natalia K. Ananias[1a*], Martha Kandawa-Schulz[1b], Marius Hedimbi[1c], Habauka M. Kwaambwa[2], Hlanganani Tutu[3], Charlene Makita[3] and Luke Chimuka[3]

[1]School of Pharmacy, Department of Pharmacology and Therapeutics, Faculty of Science, Department of Chemistry and Biochemistry, School of Medicine, Department of Microbiology, University of Namibia, P/Bag 13301, Windhoek, Namibia.
[2]School of Health and Applied Sciences, Department of Natural and Applied Sciences, Namibia University of Science and Technology, P/Bag 13388, Windhoek, Namibia.
[3]Molecular Sciences Institute, School of Chemistry, University of the Witwatersrand, P/Bag 3, WITS 2050, Johannesburg, South Africa.

Received 30 January 2016, Accepted 28 April, 2016.

The study aimed at determining the minor and major elements present in seeds of *Moringa ovalifolia* and *Moringa oleifera.* The seeds were air-dried after collection, then ground to a fine powder and digested with acids in a microwave system prior to analysis by inductively coupled plasma optical emission spectroscopy (ICP-OES). The concentration of different elements in *M. ovalifolia* seeds such as Ca, K, Fe, Ni, Cu, Mn, Co and Cd varied (P<0.05) amongst the 3 sites were sampled. However, no significant difference (P>0.05) in the concentrations of elements such Mg, Li, Ba, Si, Al, Na and Zn was observed between sites. Potasium (K) was found to be present in highest amounts at all sites with average concentration of 7938 mg/kg while Li (10.78 mg/kg) had the lowest concentration. This study showed that the content of some metals in *M. ovalifolia* seeds varied depending on geographical sites. Both *M. ovalifolia* and *M. oleifera* seeds are a good source of important minerals and need to be explored further for use as supplements and ready source of dietary minerals in animal and human food.

Key words: Elemental analysis, Inductively Coupled Plasma Optical Emission Spectroscopy, macronutrients,

INTRODUCTION

In many developing countries, the supply of minerals is inadequate to meet the mineral requirements of farm animals and rapidly growing population (Anjorin et al., 2010). Minerals are essential in animal feed and human nutrition. Minerals cannot be synthesized by animals and humans but are provided from plants or mineral- rich

*Corresponding author. E-mail: nkananias@unam.na. Tel: +264 61 206 5059.

water (Mosha et al., 1995).

There are 13 known species in the Moringaceae family and *M. oleifera* is the most widely studied and cultivated as a multi-purpose tree (Ramachandran et al., 1980). The only endemic southern Africa Moringa species is *Moringa ovalifolia* which is distributed from central-southern Namibia to south-western Angola (Dyer, 1975). Moringa seeds have a number of benefits. For instance, they contain iron and amino acids in addition to anti-inflammatory and antiseptic properties (Padayachee and Bijnath, 2012).

Determination of minerals and trace elements is important in enhancing production efficiency in plants and foods (Rodriguez et al., 2011). Some of the trace elements, which include iron, manganese, zinc and copper, are essential micronutrients with a variety of biochemical functions in all living organisms (Hicsonmez et al., 2012). Different elements have many functions in plant growth and development. Metal ions, including iron, zinc and copper, are required for catalytic and structural properties of many proteins and are therefore essential for growth and development of all organisms. Essential elements also play a major role in nerve transmission, blood circulation, cellular integrity, energy production and muscle contraction (Belay and Kiros, 2014). However, excessive amounts of these metals, or of non-essential metals such as cadmium (Cd) and lead, are toxic and inhibit plant growth (Guo et al., 2008).

The macronutrients are distinguished between two sub groups, major ones and secondary ones. The nutrients like nitrogen (N), phosphorus (P) and potassium (K) are referred to as the major macro-elements, and calcium (Ca), magnesium (Mg), and sulfur (S) are the secondary ones. The micronutrients, which are needed only in trace amounts, are iron (Fe), manganese (Mn), boron (B), zinc (Zn), copper (Cu), molybdenum (Mo), chloride (Cl), sodium (Na), nickel (Ni), silicon (Si), cobalt (Co) and selenium (Se) (Ronen, 2007; Pakade et al., 2013). Micro-nutrients are important just like macro-elements. Plant performance is crucially dependent on adequate supply of all elements including those that are demanded in relatively small quantities (Ronen, 2007).

The aim of the study was to compare the mineral content present in *M. ovalifolia* and *M. oleifera* seeds. Elements found in the seeds were divided in two categories, namely major (Ca, K, Mg and Na) and minor (Ba, Cd, Co, Li, Mn, Si, Al, Zn, Cu, Ni and Fe) elements. To the best of the authors' knowledge, no such comparative study of the two species has been done before and the elemental composition of *M. ovalifolia* seeds is yet to be reported.

MATERIALS AND METHODS

Chemicals and reagents

Nitric acid (HNO_3) and hydrogen peroxide (H_2O_2) were purchased from Sigma Aldrich (Johannesburg, South Africa). Ultra-pure water from a Milli-Q Millipore purification system (MA, USA) was used in the experiment.

Instruments

Metal content were analyzed using inductively coupled plasma optical emission spectroscopy (ICP-OES) (Spectro Genesis, Spectro, Germany). Before metal analysis, samples were digested using the microwave instrument (Anton Par, Switzerland).

Sample collection

M. oleifera seeds were collected from one of the biggest and oldest Moringa farms in Limpopo Province, South Africa. *M. ovalifolia* seeds were collected in Namibia from the following areas: Moringa Farm (designated as area A, which is 40 km west of Okahandja, Otjozondjupa region), Halali (designated as area B, situated in Etosha National Park, Kunene region), and in Tsumeb (designated as area C, Oshikoto region). A map of Namibia showing the collection areas is provided in Figure 1. Samples were collected in paper bags.

Preparation of samples

Dry seeds were deshelled and the resulting kernels were ground into fine powder using a pestle and mortar. Samples were kept in a cool dry place until use.

Microwave digestion of seeds for metal analysis

The method by Pakade et al. (2013) was used. A mass of 0.1 g ground seed powder was placed in a microwave digestion vessel and concentrated nitric acid (8 mL) and hydrogen peroxide (2 mL) were added. Digestion was carried out for about 30 min in the microwave. After digestion, the samples were transferred to a 25 mL volumetric flask and made up to volume with deionised water. The solutions were directly analysed for metal content using ICP-OES and results were expressed as mg/kg of dry weight.

Data analysis

The experiments were carried out in triplicates and result presented as mean ± standard deviation (SD). Normality of the data was tested using Kolomongorov-Smirnov test and the normally distributed data was analyzed by ANOVA and means were compared with a post-hoc Scheffe multiple comparison test, using SPSS™ for windows® version 18. All analyses were done at confidence interval (CI) = 95%, $\alpha = 0.05$.

RESULTS AND DISCUSSION

Comparison of metal content in M. ovalifolia and M. oleifera seeds from different sites

Both minor elements: (Ba, Cd, Co, Li, Mn, Si, Al, Zn, Cu, Ni, Fe) and major elements (Ca, K, Mg and Na) were present in seeds of M. ovalifolia. The concentrations of

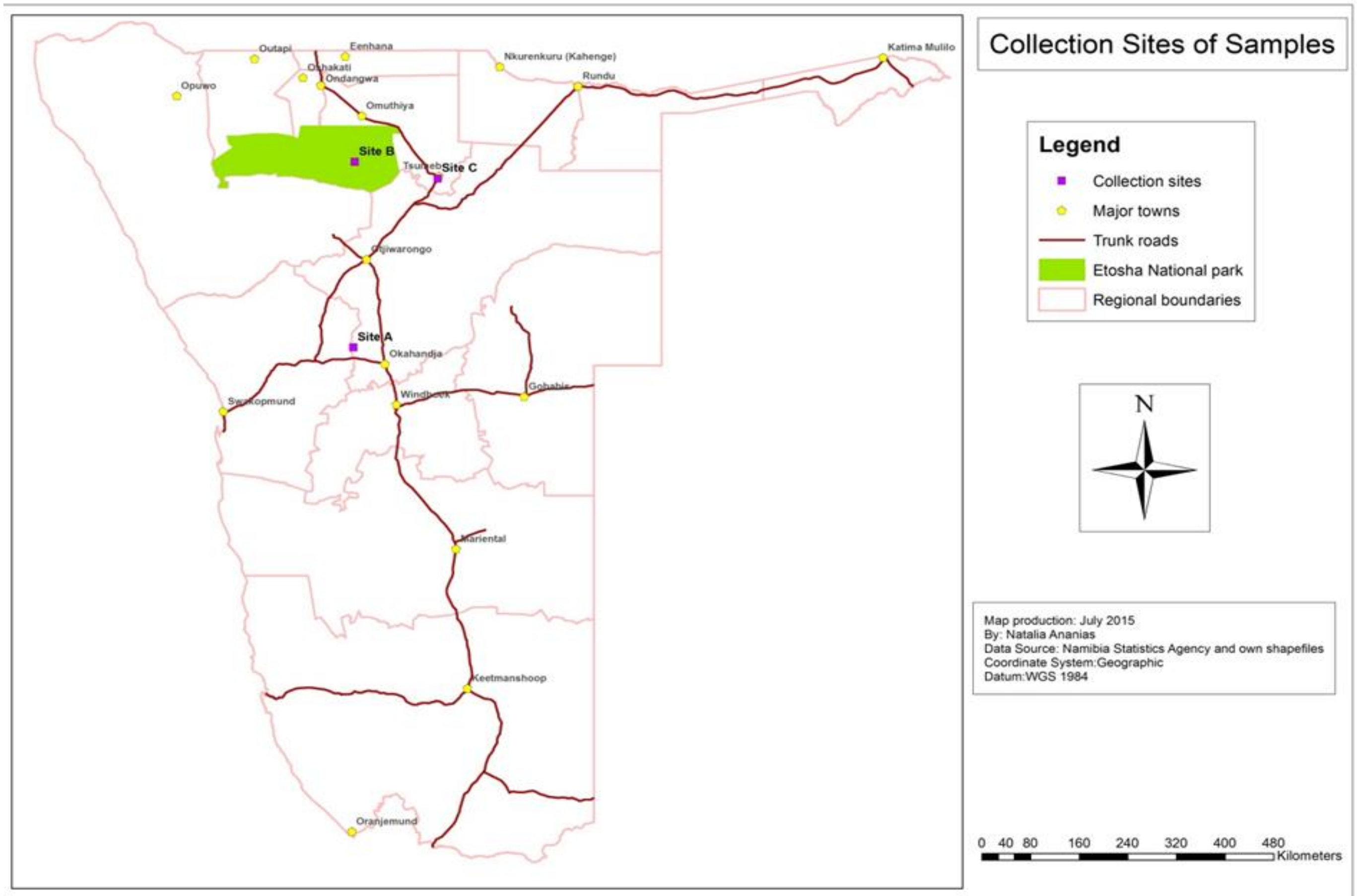

Figure 1. Map of Namibia showing different collection sites for *M. ovalifolia.*

minor elements in the two Moringa species are shown in Table 1, while that of major elements are shown in Figure 1. Similar types of elements were detected in *M. oleifera.* Among the micro nutrients, barium (Ba) had the lowest concentration (1.5-2.1 mg/kg) at all three sites of *M. ovalifolia*. This was followed by Co and Cd. Fe had the highest concentration among the micronutrients (62.7-84.7 mg/kg) and this is followed by the Zn (59.1-63.9 mg/kg) and Al (23.2-28.4 mg/kg). There was no significant difference ($P>0.05$) in site concentrations of Ba, Li, Si, Al, and Zn, whereas there was a significant difference ($P<0.05$) in Fe, Ni, Cd, Mn, Co and Cu concentrations at different sites. Cd concentration at site A (6.2 mg/kg) was significantly higher ($P<0.05$) to sites B (3.9 mg/kg) and C (3.9 mg/kg). There was a lower concentration of Co from site C (1.92 mg/kg) compared to sites A (3.4 mg/kg) and B (3.8 mg/kg). Site C had a higher concentration of Mn (26.5 mg/kg) compared to site A (17.7 mg/kg) and B (18.8 mg/kg). This illustrates that the concentration of some of these individual micro nutrients varied according to the site.

The concentration of K was highest in all sites compared to other elements (average of 6399.9 mg/kg) among the macro nutrients (Figure 2). This might be because potassium is generally found in the highest concentration in plants and is the third most abundant mineral in the human body. Except for N, the plants require more potassium than any other nutrient. Thus, its mobility in the plant allows it to influence almost all aspects of plant growth. Potassium increases crop yield and improves quality, it increases root growth and improves drought resistance (Armstrong et al., 1998). Ajayi (2008) reported that seeds were good sources of mineral elements. The study by Ajayi (2008) revealed that potassium as the most prevalent mineral element with concentration of 2470 and 1680 ppm in *Artocarpus heterophyllus* and *Treculia africana*, respectively. Mg is the second highest macronutrient in the seeds followed by Ca and Na.

The variation observed in some metal concentration of *M. ovalifolia* seeds may have been due to either different genetic makeup of the plants or more probably due to

Table 1. Concentration (mg/kg; dry weight) of minor elements in *M. ovalifolia* and *M. oleifera* seeds from different sites (Mean ± SD of 3 replicates are presented).

Elements	*M. ovalifolia* Site A (Moringa Farm)	*M. ovalifolia* Site B (Halali)	*M. ovalifolia* Site C (Tsumeb)	*M. oleifera* Limpopo
Ba	2.1±0.1	1.5±0.1	1.5±0.1	1.9±0.4
Cd	6.2±0.3	4.0±0.9	4.0±0.1	3.7±0.1
Co	3.4±0.2	3.8±0.1	1.9±0.4	2.8±0.3
Li	10.9±0.1	10.8±0.1	10.8±0.1	10.8±0.1
Mn	17.7±0.2	18.8±0.1	26.5±1.0	21.2±0.2
Si	12.6±0.1	13.9±0.4	13.3±0.6	16.6±0.7
Al	28.4±2.6	25.8±1.5	23.2±0.8	16.0±0.9
Zn	59.1±0.9	63.9±0.4	65.5±0.3	64.0±1.2
Cu	29.8±0.4	29.0±0.2	12.5±0.3	7.5±0.4
Ni	27.4±1.0	11.1±1.4	19.2±1.2	38.8±6.4
Fe	84.7±2.2	79.1±0.2	62.7±0.7	93.9±5.1

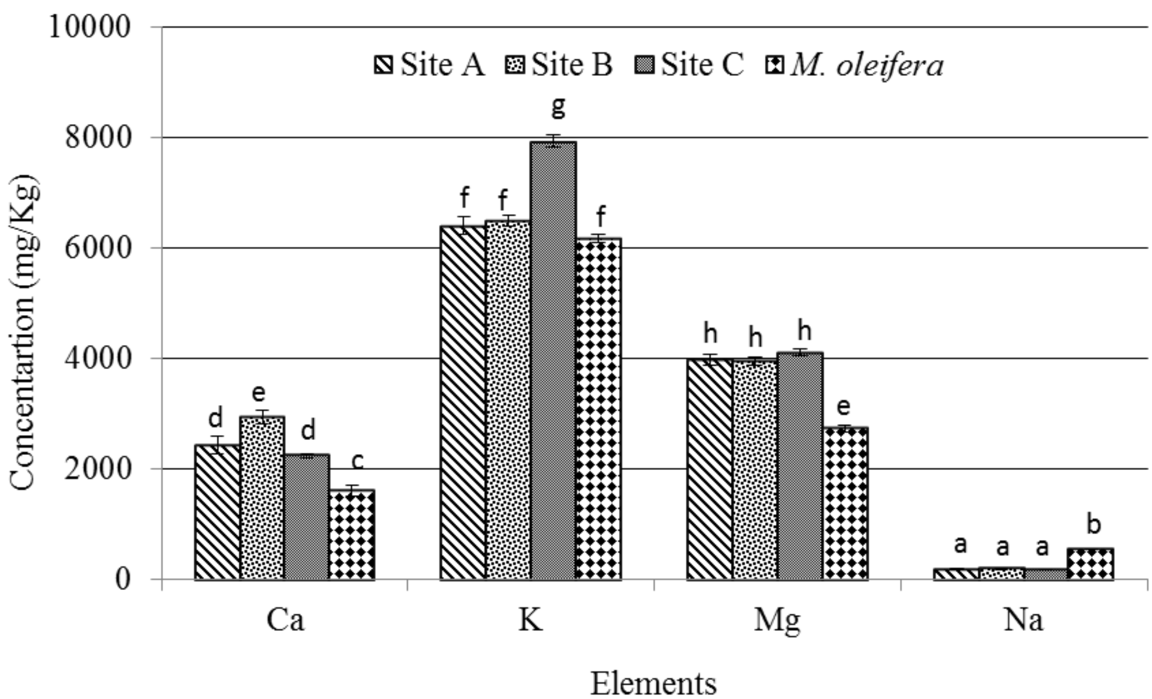

Figure 2. Comparison of concentration of major elements in seeds of *M. ovalifolia* from different sites in Namibia (Site A, B and C) and *M. oleifera* (from Limpopo, South Africa). Means (±SE) of three replicates are presented. Mean with the same letters were not significantly different from each other (p<0.05).

the environmental effects. It is reasonable to expect the concentration of seed elements of plants from Etosha to be different from others as these have been exposed to drought conditions since there is a low rainfall in that region unlike other sites. Moreover, there is a possibility that Moringa plants from Tsumeb may have accumulated some heavy metals, as that region has Cu mining.

Comparison of the metal content in the seeds of the two Moringa species

Among the micronutrients, there were no significant differences in the concentrations of Ba, Li, Zn, Si and Co in the seeds of the two species (Table 1). There were significant difference in the concentrations of Cd, Mn, Cu,

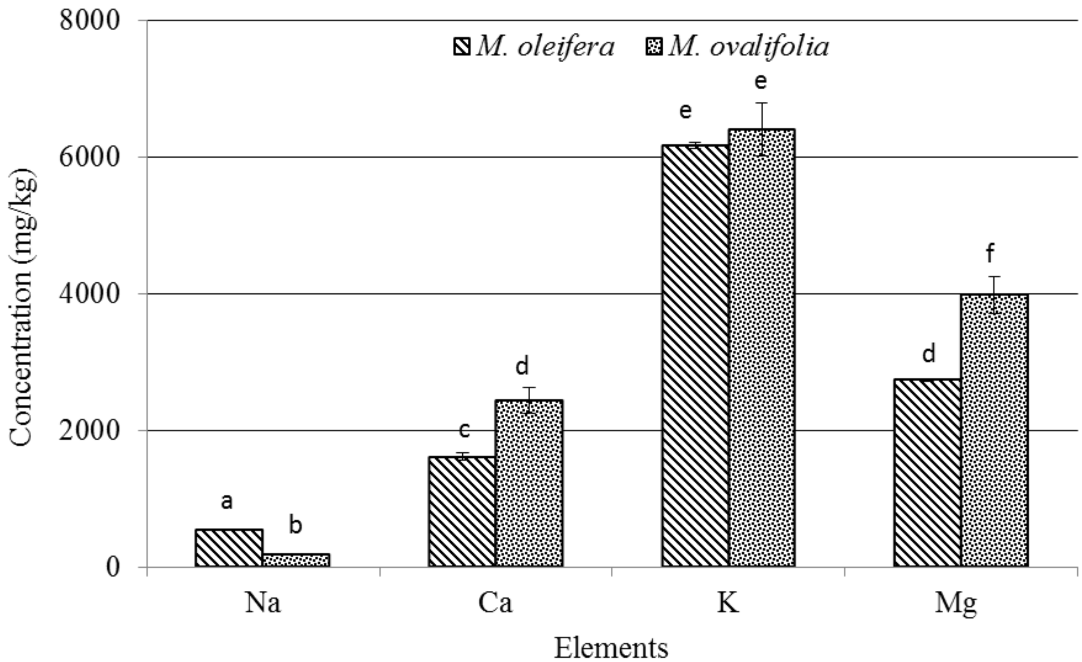

Figure 3. Comparison of macronutrients in the seeds of *M. oleifera* and *ovalifolia.* Means (±SE) of three replicates are presented. Mean with the same letters were not significantly different from each other (p<0.05).

Table 2. Concentrations of trace elements in plants (dry weight) to the deficient, normal and phytotoxic levels (Pugh et al., 2002).

Level	Concentration (mg/kg)			
	Cd	Cu	Pb	Zn
Deficient	NA	<1.5	-	<10
Normal	0.05-2	3-30	0.5-10	10-150
Phytotoxic	5-700	20-100	30-300	>100
This study	3.7-6.2	7.5-29.8	NA	59.1-65.5

NA = not analyzed.

ovalifolia. Among the macronutrients, there was no significant difference in the concentration of K of the two species (Figure 3) but there were significant differences in the concentration of Ca, Mg and Na. However, the general trends of the micro- and macro-nutrients elements in the seeds of the two Moringa species were the same. Elements that are highest in *M. ovalifolia* were also highest in *M. oleifeira* and vice versa. *M. ovalifolia* seeds had higher concentrations of the following elements: Ca (2428 mg/kg), K (6400 mg/kg), Mg (3975 mg/kg), Cu (29.8 mg/kg) and Al (28.4 mg/kg) than that of *M. olefeira*. *M. oleifera* seeds have higher concentrations of Si (16.5 mg/kg), Fe (93.9 mg/kg), Na (545.2 mg/kg) and Ni (38.8 mg/kg) compared to *M. ovalifolia*. A study by Anjorin et al. (2010) reported that Ca and Mg were relatively higher in *M. oleifera* leaves and seeds from Nigeria. However, this study also showed high content of Ca and Mg in *M. oleifera* (South Africa) and *M. ovalifolia* (Namibia) seeds. This indicates that Moringa seeds are good source of Ca and Mg, and hence they can be used in farm animals or humans as food. Some people cook and eat flesh Moringa pods, especially *M. oleifera*, that contain seeds as a source of food. This practice should thus be encouraged as these may prove to be a good source of much needed micro- and macro- nutrients.

Comparison of metal content with normal levels

The Cd, Cu, and Zn concentrations in the seeds were compared to the deficient, normal and phytotoxic levels (Table 2). The concentrations of these metals in *M. ovalifolia* and *M. oleifera* seeds is within the normal levels. Therefore, according to this analysis, the *Moringa seeds* in this study are fit for human consumption. Although levels of trace elements in the soil are much higher (Pakade et al., 2013), there is little accumulation in the biomass to reach phytotoxic levels. This is important for human consumption of Moringa seeds as food.

Conclusion

This study showed that some metal content of *M.*

ovalifolia seeds varies depending on geographical location (sites). Both *M. ovalifolia* and *M. oleifera* seeds are a good source of important minerals and needs to be explored further for use as a supplement and ready source of dietary minerals in animal and human food. There was a significant variation in micronutrients and macroelements in *M. oleifera* and *M. ovalifolia* seeds for some elements but also some did not show significant differences. This might be attributed to the variable uptake of minerals by the plants and variable agro-ecologies of the different regions. *M. oleifera* is the most well-known of the genus and its given recognition as a multipurpose tree. However, more studies needs to be done on *M. ovalifolia* for its potential as food and medicinal plant.

Conflict of Interests

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

The authors wish to acknowledge the joint research grant under the South Africa-Namibia Research Partnership Programme Bilateral Agreement.

REFERENCES

Ajayi IA (2008). Comparative study of the chemical composition and mineral element content of *Artocarpus heterophyllus* and *Treculia africana* seeds and seed oils. Bioresour. Technol. 99(11):5125-5129.

Anjorin TS, Ikokoh P, Okolo S (2010). Mineral composition of *Moringa oleifera* leaves, pods and seeds from two regions in Abuja, Nigeria. Int. J. Agric. Biol. 12(3):431-434.

Armstrong DL, Griffin KP, Danner M (1998). Potassium for agriculture. Better Crops. 82(3):1-40.

Belay K, Kiros H (2014). Spectroscopic determination of trace metals (Mn, Cu and Ni) content in *Moringa oleifera*. Int. J. Chem. Nat. Sci. 2(5):141-144.

Dyer RA (1975). The genera of Southern African flowering plants. South Africa Botanical Research Institute, Pretoria, South Africa.

Guo WJ, Meetam M, Goldsbrough PB (2008). Examining the specific contributions of individual *Arabidopsis matallothioneins* to Copper distribution and metal tolerance. Plant Physiol. 146 (4):1697-1706.

Hicsonmez U, Ozdemir C, Cam S, Ozdemir A, Erees FS (2012). Major-minor element analysis in some plant seeds consumed as feed in Turkey. Nat. Sci. 4(5):298-303.

Mosha TC, Pace RD, Adeyeye S, Mtebe K, Laswai H (1995). Proximate composition and mineral content of selected Tanzanian vegetables and the effect of traditional processing on the retention of ascorbic acid, riboflavin and thiamine. Plant Foods Hum. Nutr. 48(3):235-245.

Padayachee B, Bijnath H (2012). An overview of the medicinal importance of Moringaceae. J. Med. Plants Res. 6(48):5831-5839.

Pakade V, Cukrowska E, Chimuka L (2013). Metal and flavonol contents of *Moringa oleifera* grown in South Africa. South Afr. J. Sci. 109:1-7.

Pugh RE, Dick DG, Freden AL (2002). Heavy metal (Pb, Zn, Cd, Fe and Cu) contents of plant foliage near Anvil Range Lead/Zinc mine, Faro, Yukon Territory. Ecotoxicol. Environ. Safety 52:273-279.

Ramachandran C, Peter KV, Gopalakrishnan PK (1980). Drumstick (*Moringa oleifera*): A multipurpose Indian vegetable. Economic Bot. 34(3):276-283.

Rodriguez LH, Morales DA, Rodriguez ER, Romero CD (2011). Minerals and trace elements in a collection of wheat landraces from Canary Islands. J. Food Comp. Analysis. 24:1081-1090.

Ronen E (2007). Micro-Elements in Agriculture. Practical Hydroponics & Greenhouses July/August: pp. 39-48.