Levels of Essential and Non-Essential Elements in Commercially Available Moringa Herbal Teas Sold In Nigeria

Jasper, E. E*; Yakubu, M. B. and Baganjiya, Y. P.

Department of Applied Science, Kaduna Polytechnic, Kaduna State.
Email: *enebijasper@yahoo.com Tel:+2347034674625 .

ABSTRACT

The focus of this study was to assess the quality of commercially packaged moringa tea brands available in the retail markets in Nigerian cities on the basis of the essential and nonessential elemental content in their tissues. Four different brands of moringa tea comprising two locally processed teas and two imported teas were obtained and analysed for their elemental concentrations using X-ray Fluorescence Spectrometry. The observed mean concentrations of the essential mineral elements in all samples ranged between 50.78 to 61.13 mg/kg K, 29.81 to 42.03 mg/kg Ca 5.62-9.23 mg/kg S, 0.24 to 0.72 mg/kg Fe, 0.02-0.07 mg/kg Zn, 0.33-0.37 mg/kg Mn, and 0.01mg/kg Mo. Non-essential elements detected were Sr, Sc, Rb and Zr, all had concentrations below 1mg/kg. The heavy metals Pb and Cd were not detected. All concentrations of elements detected were within recommended daily allowance values. No toxic levels of heavy metals were determined in the brands analyzed.

Keywords: Moringa oleifera, x-ray fluorescence spectrometry, commercial.

INTRODUCTION

Plants have been used as medicine since prehistoric times. The therapeutic benefits of these plants have been attributed to the presence of a variety of phytochemicals (such as essential oils, vitamins, flavonoids, glycosides, etc.). Their elemental composition is also partially responsible for their medicinal and nutritional properties, as well as their toxic ones. These elements play an important role in plant metabolism and biosynthesis and act as cofactors for enzymes[1, 2]. The elemental composition of herbs is a reflection of the environment they grow in. The levels of essential elements in plants vary according to the geographical region, geochemical soil characteristics, and the ability of plants to selectively accumulate some of these elements. Generally, these elements are absorbed through the root systems and dispersed throughout the plant body [3]. Some metals are essential nutrients (zinc, iron, copper, and chromium), yet become toxic at high concentrations, while others (lead, mercury, arsenic and cadmium) have no known beneficial properties and are toxic[1, 4].

Herbal teas in general and the Moringa tea in particular are gaining increasing consumer attention due to a growing awareness of the health benefits derived from their consumption. Unfortunately, besides the beneficial components, herbal teas can also host undesirable ones, due to environmental or

processing contamination with heavy metals and their prolonged intake can cause health problems.[5, 6]

Moringa leaf has been advocated as an outstanding indigenous source of highly digestible proteins with an excellent amino acid profile. It contains the sulphur-containing amino acids methionine and cysteine. It is particularly rich in calcium and iron and vitamins A, B, C and E. The leaves are also rich in β -carotene and are an exceptionally good source of fiber.[7]

M. oleifera is used in practice in the treatment of various diseases and is available without a medical prescription, often in the form of an herbal infusion for everyday use.[8] In developing countries, *M. oleifera* is used as an alternative to imported food supplements to treat and combat malnutrition, especially among infants and nursing mothers, by virtue of its chemical constituents[9]. It has also been reported that the leaves contain trace elements that are essential to human health. For instance, magnesium, iron, selenium, and zinc play an important role in metabolism, and interest in these elements is increasing together with reports relating trace element status and oxidative diseases.[10] These tremendous therapeutic benefits of the moringa leaf has led to an increasing consumption of its teas and infusions, especially as they are readily available in supermarkets and stores.

In parallel with the increasing interest in the therapeutic benefits of herbal products, there has been an increasing concern over the safety and toxicity of natural herbs and formulations available in the market. There is a widespread misconception that natural herbs and plants are inherently safe; nevertheless, there has been a large volume of reports on incidences of toxicity and adverse effects linked to the use of herbal plants and their formulations in different parts of the world[11]. For instance, certain studies revealed the presence of toxic elements in dried moringa leaves[12] and a host of other herbal teas[13]. There is therefore the need to identify the mineral composition of this widely consumed herbal tea in a bid to ascertain the safety as well as toxicity of these brands available to and widely consumed by the Nigerian populace.

X-ray fluorescence (XRF) spectrometry was employed in this analysis. The technique has progressively become an effective method of obtaining high-resolution elemental records because of its non-destructive and nearly continuous measurements. The advanced operating conditions enhance the detection efficiency and improve the minimum detection limits for several elements analyzed.[14] It was chosen as a preferred method over AAS because of its advantages which include the limited preparation required for solid samples, non-destructive analysis, increased total speed, the decreased production of hazardous waste, the low running costs and portability.[15]

The main aim of this research was to identify and quantify the essential and non-essential elements as well as to determine heavy metal accumulation in the herbs tissues of the commercial moringa herb teas as a consequence of environmental pollution. For this reason all elements laying between sodium (Na) to uranium (U) were analyzed using X-ray fluorescence (XRF) spectrometry.

EXPERIMENTAL

Sample collection

Four brands of moringa teas, which are commonly consumed in Nigerian cities were collected from different retail markets and drugstores between February and April 2015.Two of these brands originated from Nigeria while the other two originated from Sri Lanka. Three packs of each brand with different production dates were obtained. Each sample was analyzed to determine the amount of elements present in the samples. The samples were coded in order to conceal the original source.

Sample Preparation

All samples were pulverized and sieved to assure surface homogeneity. The samples were protected from light until further analysis.

X ray fluorescence spectroscopy

Approximately, 3.0 g of loose powder of each sample of commercial dry moringa tea were used for XRF analysis. The samples were put inside a polyethylene cell with 32 mm outer diameter and 23 mm in height with 6 μm thick Mylar® film in its bottom. The Thermo Scientific Niton XL3t 950 model X-ray fluorescence spectrometer was used in the analysis. All elements lying between sodium (Na) to uranium (U) were analyzed.

RESULTS AND DISCUSSIONS

The results of the elemental analysis of the selected commercial moringa teas are presented in Table 1, revealing the presence of eleven elements.

Table 1: Mean concentrations (mg/kg) of elements determined in commercial moringa teas

		M1	M2	M3	M 4
Origin		**Nigeria**	**Nigeria**	**Sri Lanka**	**Sri Lanka**
Essential Elements	**K**	50.78±0.19	50.93±0.39	61.13±0.74	58.48±1.40
	Ca	38.73±0.28	42.03±0.32	29.81±0.43	33.25±1.00
	S	9.23±0.08	5.62±0.02	8.03±0.18	7.29±0.40
	Fe	0.72±0.01	0.71±0.08	0.27±0.07	0.24±0.03
	Mn	0.00±0.00	0.00±0.00	0.33±0.02	0.37±0.02
	Zn	0.05±0.00	0.02±0.00	0.07±0.01	0.05±0.00
	Mo	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00
Non-Essential Elements	**Sc**	0.30±0.01	0.30±0.01	0.13±0.03	0.21±0.01
	Rb	0.04±0.00	0.04±0.00	0.04±0.00	0.04±0.00
	Sr	0.08±0.01	0.12±0.00	0.03±0.00	0.04±0.00
	Zr	0.01±0.00	0.02±0.01	0.01±0.00	0.01±0.00

The essential macro elements detected were K, Ca and S.

The essential elements present in trace quantities were Fe, Zn, Mn, and Mo while the non-essential elements detected were Sr, Sc, Rb and Zr.

The results in Table 1 show a high mean concentration levels of macro elements, K, Ca and S in all samples, which ranged between 50.78-61.13mg/kg, 29.81- 42.03mg/kg and 5.6 – 9.23mg/kg respectively. The levels of all other elements determined, that is, Fe, Zn, Mn, Sc, Sr, Rb, Zr and Mo were less than 1mg/kg. As shown by other authors in related studies, K and Ca have been reported as the predominant macronutrients in leaves of *Moringa oleifera* leaves[8].The mineral elements found in *M. oleifera* play both a curative and preventive role in combating human disease.

Potassium. The presence of K in high amounts is of special interest in view of the importance of K in the diet of animals and humans. For instance K participates actively in the maintenance of cardiac rhythm[16]. It has also been reported that in contrast to Na, a high-potassium diet lowered blood pressure in individuals with raised blood pressure[17]. The concentration of K in all samples were fairly consistent. Results from this research showed the concentration of potassium in all samples were in the range of 50.78-61.13mg/kg. The uniform distribution of this element in the samples of different origin is the consequence of the role K^+ plays in the plant metabolism, as cell osmotic pressure regulator[18]. K levels of 30.86 to 225.00 mg/kg was reported in a study of the chemical composition of *Moringa* leaf [19], and the value found in this study falls within this range. It may then be inferred from the results that consumption of the tea of *M. oleifera* could make up for the daily requirement of K in human diet. The recommended daily allowance (RDA) for K is 4.7g.[20]

Calcium. Ca is a multifunctional nutrient essential to the body metabolism [21]. It is an important element in formation of bones and teeth; it is said to prevent osteoporosis.[22] It is a macro nutrient for humans, considerably sought for from other sources such as bones and shells of some crustaceans.[23] Calcium content varied between 29.81 to 42.03 mg/kg. 15.10 to 29.51 mg/kg Ca was reported in Moringa leaves cultivated in Thailand.[24] Beneficial effects of Ca exist in the human body up to intake threshold of about 800 mg per day.[25]

Sulphur. Sulphur, an essential non-metallic element presents itself in all the samples. Its presence could be attributed to presence of sulphur- containing amino acids, methionine and cysteine as reported by several authors.[26,27] The highest level of sulphur was determined in sample M1 (9.23mg/kg) while the lowest level was in sample M2 (5.62mg/kg). Aqueous Moringa leaf extracts have been reported in a study of contain 0.5g/100g sulphur. [28]

Iron. The most abundant micronutrient analyzed in all samples was Fe, an essential

heavy metal. The observed range for Fe was found to be between 0.24mg/kg and 0.72mg/kg. Fe is a necessary and useful element for organisms and a significant part of tissue and blood in animal and human bodies[29]. Deficiency of Fe may result in anaemia. In determining the nutritional potential of *M. oleifera*, Oduro and his colleagues[30] obtained Fe concentrations of 2.83 mg/kg in the leaf. In a similar analysis, Fe was reported in a range of 2.03 to 3.76 mg/kg. [24] These values are higher than those reported in this work. The iron content of food varies greatly, and factors such as the soil, climate conditions and processing can influence the iron content of similar foods. A recommended daily allowance limit of 8 mg is established.[20]

Zinc. Concentrations of Zn in all samples observed ranged from 0.02 to 0.07 mg/kg. Zinc is one of such element which is an extremely important part of insulin.[31] Zn is known to assist in the regulation of insulin levels in the blood.[32] The RDA value for Zn is 11mg.[20] The presence of zinc in these moringa tea leaves most probably contributes to the antidiabetic potential of moringa leaves. It is vital for many biological functions and plays a very important role in more than 300 enzymes in the human organism.[33] Higher levels of Zn have been reported in the Moringa leaf.[34] This could be due to the fact that they may have been cultivated in different regions from those studied here.

Manganese. Mn, another essential microelement and heavy metal was found present only in two variants, that is, samples M3 (0.33 mg/kg) and M4 (0.37mg/kg.). These two samples were sourced from the same country (Sri Lanka). Like other essential trace elements, manganese can function both as an enzyme activator and as a constituent of metalloenzymes.[35] It activates many enzymatic reactions associated with the metabolism of organic acids, carbohydrates, nitrogen and phosphorus. However, high doses of dietary manganese can be associated with long-term toxicity. Therefore, an estimated safe and sufficient daily dietary intake is 2-5 mg.[36]

Molybdenum.

Molybdenum is a nutritionally essential trace element that enters the body primarily from dietary sources. In humans, molybdenum is a cofactor for three enzyme classes—sulfite oxidase, aldehyde dehydrogenase, and xanthine oxidase.[37] The Mo levels in the samples were 0.01mg/kg in all the samples. The recommended dietary allowance for adult men and women is 45 µg/day and the average dietary daily intake of molybdenum is approximately 100 µg/day.[20]

Strontium. Sr is a non-essential trace element that can be found in substantial concentrations in nature, as a result of natural mineral degradation or consecutively on polluting anthropic activities [38]. Sr is a naturally occurring mineral in the same family as Ca and Mg. The levels of Sr in all samples analyzed

ranged between 0.03-0.12 mg/kg. These levels do not pose any health risks to humans.[39]

The levels of other non-essential microelements Sc, Rb, Zr established in the study were all below 1mg/kg and do not pose any health risks at all. It is important to note that toxic heavy metals such as Pb, Cd, As and Hg were not detected in these brands of Moringa tea samples analysed.

CONCLUSIONS

Twelve samples of 4 different brands of moringa herbal teas widely consumed among Nigerian population were analyzed for concentration of macro and microelements, with an aim of establishing the mineral status and hence the health safety of this very popular herbal tea. The research revealed that the teas are beneficial sources for K, Ca, S and Fe. It was observed that all the brands sampled contained the elements K, Ca, S, Fe, Zn, Mn, Mo, Sr, Sc, Rb and Zr with the exception of the two brands from Nigeria (M1 and M2) that did not contain detectable levels of Mn. The brands from Sri Lanka (M3 and M4) had similar concentrations of Mn, that is, 0.33 mg/kg and 0.37mg/kg respectively. The analyzed brands may be considered as non-toxic natural sources of essential macro and microelements. No toxic heavy metals were determined in this study. This paper represents a basis for further research on the safety of other brands of Moringa herbal teas present in the Nigerian Markets.

ACKNOWLEDGEMENTS

The Department of Applied Science and the Centre for Solid Minerals Research and Development of the Kaduna Polytechnic are acknowledged for providing their laboratories and equipment for this research. Special thanks to Dr. M.M Imam for guidance throughout the course of the research.

REFERENCES

1. Maiga A., Diallo D., Bye R., Paulsen B.S., J. Agric. Food Chem., 53(2005) 2316.

2. Tokalioğlu, S. Food Chemistry, 134, (2012) 2504

3. Hondrogiannis, E., Peterson, K., Zapf, C. M., Roy, W., Blackney, B., and Daily, K. Food Chemistry, 135, (2012) 2825

4. Gjorgieva, D., Kadifkova-Panovska, T., Bačeva, K., and Stafilov, T., American-Eurasian Journal of Toxicology and Science, 2, (2010). 57

5. Jabeen S., M. Tahir S., Khan, M. Qasim H., Pakistan. Journal of Medicinal Plants Research, 4,(2010) 559

6. Khan S.A., L. Khan, I. Hussain, K.B. Marwat, N. Akhtar., Pakistan Journal of Weed Science Research, 14, (2008) 101

7. Nambiar V., Bhadalkar K. and Daxini M., Indian Journal of Peadiatrics 70(5),(2003) 11

8. Valdez-Solana, M. A. , Mejía-García, V. Y., Téllez-Valencia A., García-Arenas G., Salas-Pacheco J., Alba-Romero J.J., and Sierra-Campos E., Journal of Chemistry. Article ID 860381, (2015).

9. Dhakar RC, Maurya SD, Pooniya BK, Bairwa N, Gupta M, Sanwarmal, Chron Young Sci 2(2011)119

10. Pelus E, Arnaud J, Ducros V, Faure H, Favier A, Roussel AM Inter J Food Sci Nutr 45 (1994)63.

11. Ernst, E, Trends in Pharmacological Sciences, 23(3), (2002) 136

12. Offor, I. Ehiri, R and Njoku, C. IOSR Journal of Environmental Science, Toxicology and Food Technology, 8(1) (2014) 57

13. Muntean N, Muntean E, Creta C and Duda M., ProEnvironment 6, (2013) 591

14. Liang L, Sun Y, Yao Z, Liu Y, Wu F. Catena 92 (2012) 75.

15. McComb J, Rogers C, Han F X, and Tchounwou P B. Water Air Soil Pollut. 225(12) (2014) 2169.

16. Martin Jr, D. W., Mayers, P. A., Rodwell, V. W., Granner, D. K. (1985). Harper's Review of Biochemistry, 20th ed., Lange Medical Publications, California, pp. 651-660

17. He F.J, and MacGregor G.A., Physiologia Plantarum 133 (4), (2008). 725

18. Kékedy-Nagy, L., Ionescu, A., Acta Universitatis Sapientiae, Agriculture and Environment, 1 (2009). 11

19. Yameogo CW, Bengaly MD, Savadogo A, Nikiema PA, Traore SA Pak. J. Nutr. 10(3 (2011) 264

20. Institute of Medicine (IOM). Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic,Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium,and Zinc. Washington, DC: National Academy Press (2001).

21. Sizer, F. and Whitney, E Nutrition: Concepts and Controversies, Wadsworth, Belmont, Calif, USA, 8th edition. (1999).

22. Susan Lanham-New A, J. Nutr. 138 (2008). 172S

23. Gupta M., Mazumder U.K., and Chakrabarti S., Fitoterapia 70 (1999) 244

24. Jongrungruangchok S, Bunrathep S, Songsak T. J. Health Res. 24(3) (2010). 123.

25. Boon N, Koppes L.L.J, Saris W.H.M, Van Mechelen W., Am. J. Epidemiol. 162 (2005). 27

26. Moyo B., Masika P.J, Hugo A, Muchenje V., Afr. J. Biotechnol. 10(60) (2011). 12925

27. Okereke, C. J. & Akaninwor, J. O., Ann Biol Res; 4 (2013). 34

28. Nweze M.O and Nwafor F Afr J of Biotech. 13(53) (2014). 4720

29. Lesniewicz A., Jaworska K., Zyrnicki W. Food Chemistry 99 (4), (2006) 670

30. Oduro I, Ellis WO, Owusu Sci. Res. Essay 3(2) D (2008) 057

31. Kinlaw W.B., Levine A.S., Morley J.E., Silvis S.E. and McClain C.J Am. J.Med. 75, (1983) 273

32. Hamid AZ, Nissar AS, Shariq RM, Bashir AL, Farooq AD, Khan AR, Fayaz AS, Arshad IW Postgrad. Med. J. 74 (1998). 665

33. Haban M, Habanova M, Otepka P, Lukac N, Massanyi P J Environ Sci Health B. 43(6) (2008) 533

34. Anjorin TS, Ikokoh P, and Okolo S., Int. J. Agric. Biol. 12 (2010). 431.

35. Pond, W. and Maner, J. Swine Production and Nutrition. The AV, Publishing Company Inc. West Port Connecticut. Pp 546-548. (1984).

36. Mehra A and Baker C.L., Food Chemistry, 100(4) (2007) 1456.

37. Kisker C., Schindelin H., Rees D.C.,Annual Review of Biochemistry 66. (1997) 233

38. Chegrouche, A. Mellah and M. Barkat, Desalination, 235, (1-3)(2008) 306

39. Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological profile for strontium Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. (2004)