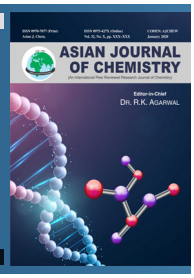
Asian Journal of Chemistry; Vol. 32, No. 9 (2020), 2279-2283

ASIAN JOURNAL OF CHEMISTRY

https://doi.org/10.14233/ajchem.2020.22788



Quantitative Evaluation of Macro and Micronutrients in *Averrhoa bilimbi*, *Mimusops elengi* and *Carissa carandas* Fruits of Bangladesh

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Received: 21 April 2020; *Accepted*: 8 June 2020; *Published online*: 20 August 2020; AJC-20026

In present study, a quantitative evaluation of macro and micronutrients in *Averrhoa bilimbi*, *Mimusops elengi* and *Carissa carandas* tropical fruits have been presented. Concentration of the nutrients namely calcium, chromium, manganese, iron, nickel, zinc and two toxic heavy metals cadmium and lead present in the fruits are used as traditional folk medicines in Bangladesh were determined by flame atomic absorption spectrometric method. The concentration of the elements for *Averrhoa bilimbi* was found to be followed by the order as: Ca (1.98 ppm) > Fe (0.515) > Zn (0.080) > Mn (0.038) > Cr (0.006) > Pb (0.004) > Ni (0.0016) > and Cd (0.0015 ppm), respectively. The order for that of *Mimusops elengi* was found to be as: Ca (3.175 ppm) > Fe (0.784) > Zn (0.049) > Mn (0.038) > Pb (0.008) > Ni (0.008) > Cd (0.003) > Cr (0.001 ppm) and the same issue for the *Carissa carandas* was found to be Ca (4.277 ppm) > Fe (0.676) > Zn (0.040) > Mn (0.040) > Pb (0.005) > Ni (0.004) > Cr (0.002) > Cd (0.0009 ppm), respectively. From the obtained results, the analyzed fruits might be an admirable natural source of nutrients Ca, Fe and Zn. Concentration of toxic elements Pb and Cd found to be of very few ppb levels and should not be considered as toxic in consumption by human beings.

Keywords: *Averrhoa bilimbi*, *Mimusops elengi*, *Carissa carandas*, Nutrients, Flame atomic absorption spectrometry.

INTRODUCTION

The extent of elements presence in plants shows a variance depending upon the composition of soil in which they grow and other environmental factors such as climate, grazing stress, phonological stages, seasonal changes as well as the plant's ability to uptake the minerals present in the soil and embody the minerals [1]. Even, content of the trace elements is different in the different parts of the same plant (root, bark, leaves, flower, fruit, seed, *etc*.). In addition, traditional medicine has a momentous role to the global health care system [2]. A portion of our world′s population trusts on traditional medicine to care their basic health needs [3]. The trace metal content in fruits as well as in seeds is important because of toxicological and their nutritional and medicinal viewpoint. *Averrhoa bilimbi*, *Mimusops elengi* and *Carissa carandas* fruits (Fig. 1) are sweet, sour or astringent tastes, which are a great source of carbohydrate, vitamins, minerals and fiber. Also, these fruits have nutritional properties and used as an ayurvedic medicine to control obesity, skin diseases, urinary disorders, diabetic ulcer, *etc*. [4]. Numerous researches have been done on these medicinal plants based on their interesting pharmacological activities. In this regard, *Averrrhoa bilimbi* is one of the significant therapeutic plants of many countries of which different extracts of the plant have been widely used as traditional medicines for the treatment of a variety of ailments, particularly as an antidiabetic, antihypertensive, and antimicrobial agent [5]. Different extracts of *Carissa carandas* have been mentioned as histamine releasing [6] and the extracts of *Mimusops elengi* showed antiviral [7] and spermicidal [8] activities. On the other hand, trace metals present in plants as micronutrients are very important as they have many important roles in the formation of chemical constituents responsible for medicinal and toxic property [4,9]. Parmar *et al*. [10] reported that medicinal plants

Fig. 1. Images of: (a) *Averrhoa bilimbi*, (b) *Mimusops elengi* and (c) *Carissa carandas* fruits of Bangladesh. These fruits were collected from the Pachimpara residential area of Rajshahi University Campus, Bangladesh

are beneficial in the homeopathic system due to the presence of trace elements like Ca, Cr, Fe, Zn, Cu, *etc*. However, there are no reports available about the mineral contents of the fruits of the plants analyzed here. Based on these view points, the essential metal as well as some toxic elements from *Averrhoa bilimbi*, *Mimusops elengi* and *Carissa carandas* fruits were evaluated using sensitive flame atomic absorption spectroscopic method, which is widely used for the quantitative analysis of micronutrients present in the selected samples in this study.

EXPERIMENTAL

All the chemical and reagent used in this study were of analytical grade. Analytical grade concentrated HNO_3 and $HClO_4$ acid were used for digestion of the sample. Double distilled water was used in all steps throughout the experiment. Before the use of plastic and glassware, these were soaked in 5% (v/v) HNO_3 overnight then rinsed with double distilled water and dried. Standard solutions for each metal calcium, chromium, manganese, iron, nickel, zinc, cadmium and lead were supplied by Merck (Germany).

Sample collection, digestion and sample preparation for elemental analysis: The ripe fruits of three plants such as *Averrhoa bilimbi*, *Mimusops elengi* and *Carissa carandas* were collected from the Pachimpara (Western region) residential area of Rajshahi University Campus, Bangladesh during the summer season. After collection, the fruits were washed with distilled water and air dry. Roughly, 250 g of the air dried fruit samples of three plants individually were transferred to a porcelain crucible. The samples were covered with a cap and burned to ashes in a muffle furnace at 200 ºC for the period of 6 h. After burning, the burnt samples were taken out from the muffle furnace and kept it until becoming room temperature. A mortar and pestle were used to grind the samples properly and then the grind samples were made a homogeneous powder and transferred into polyethylene storage container for further analysis.

Digestion of the plant materials was carried out by wet ashing method [11]. Typically, 0.2 g of homogenized grinded sample was placed into acid cleaned borosilicate digestion test tube and then 5.0 mL conc. nitric acid was added and left for overnight. The test tubes were placed in a muffle furnace for ashing at 100 ºC for about 4 h and then 5.0 mL of conc. HCl was added. Then the test tubes containing acid solution was put on hot plate digested to obtain a clean solution. The final residue was dissolved in additional 2 mL of HNO_3 made it up to 100 mL with double distilled water. Finally, digested solution was filtered using Whatman filter No. 41 paper. A blank sample was made exactly following the same procedure without adding plant materials. The filtrate was stored in refrigerator at 4 ºC until analysis.

Instrumentation and calibration: The concentration of all the eight elements *viz*. Ca, Cr, Mn, Fe, Ni, Zn, Cd and Pb was determined by flame atomic absorption spectrometer (AAS) (Shimadzu, AA-6800) at the Central Science Laboratory of Rajshahi University. In order to cross verify the results, the same samples were analyzed by AAS (Shimadzu, AA-7000, Japan) at Asia Arsenic Network, Jessore, Bangladesh. Triplicate measurements were taken to provide the value of standard/ relative standard deviation.

RESULTS AND DISCUSSION

The concentration measured by AAS of eight elements *viz*. Ca, Fe, Mn, Zn, Ni, Cr, Cd, and Pb in the fruits of *Averrhoa bilimbi*, *Mimusops elengi* and *Carissa carandas* plants have been observed. Among these eight analyzed elements, Ca is known to be the macromineral and Fe, Mn, Zn, Ni and Cr are renowned as essential micronutrients, whereas, Cd and Pb are considered to be toxic trace elements [12,13]. The observed concentrations of the micro-minerals are summarized in the Table-1. An inconsistency of concentration of the elements has been observed and that might be due to the mode of different bioaccumulation progression of the micro-minerals in the fruits of the plants. It was found to be followed by the order obtained from Central Science Laboratory, Rajshahi University (RU lab) as: Ca (1.980 ppm) > Fe (0.515) > Zn (0.080) > Mn (0.038) > Cr (0.006) > Pb (0.004) > Ni (0.0016) > and Cd (0.0015 ppm), respectively. The order of the concentration obtained from Asian Arsenic Network (AAN lab) as: Ca (2.00 ppm) > Fe (1.280) > Mn (0.11) > Zn (0.097) > Cr (0.0055) > Cd (0.0041) > Ni (0.002) and Pb (0.001 ppm), respectively. Deviation of the results between two analysis processes was calculated and was found to be around 1 or less than 1%. Therefore, the obtained results are considered to be good consistent.

TABLE-1
DESCRIPTION OF THE PLANTS ANALYZED IN THIS STUDY

S. No.	Botanical name	Family	Common name	Investigated part
1	*Averrhoa bilimbi*	Oxalidaceae	Bilimbi, cucumber	Total fruit
2	*Mimusops elengi*	Sapotaceae	Spanish cherry, medlar	Total fruit
3	*Carissa carandas*	Apocynaceae	Bangla currant, karanda	Total fruit

It has been generally observed that all the fruits are comparatively rich in Ca and Fe. A comparison study of the content of Ca and Fe in *A.bilimbi*, *M. elengi*, and *C. carandas* is shown in Fig. 2. In this study, concentration of the macro-nutrient Ca showed range from 4.350 to 1.980 ppm. The *Carissa carandas* contained the highest amount of Ca of around 4.350 ppm whereas *Mimusops elengi* contained around 3.170 ppm and *Averrhoa bilimbi* contained the least amount of around 1.980 ppm (Table-2). It is reported that calcium is the most abundant elements in many plants and is an essential macronutrient for the central regulator of growth and development [9-11]. Low level of calcium showed the defects such as poor root development, leaf necrosis and curling blossom end root, bitter pit, fruit cracking, poor fruit storage and water soaking, *etc*. [12,13]. It plays an inevitable character in the cell wall formation [11, 14]. On the other hand, calcium helps to overcome the human health problems such as heart attack, old age osteoporosis, colon cancer, high blood pressure, *etc*. [15]. However, the daily endurable upper intake level of calcium is 2.5 g [16]. Although, high intake of calcium may increase the risk of stone accumulation in the kidney and is said to be the reason of increasing the risk of cardiovascular disease as well [17-21].

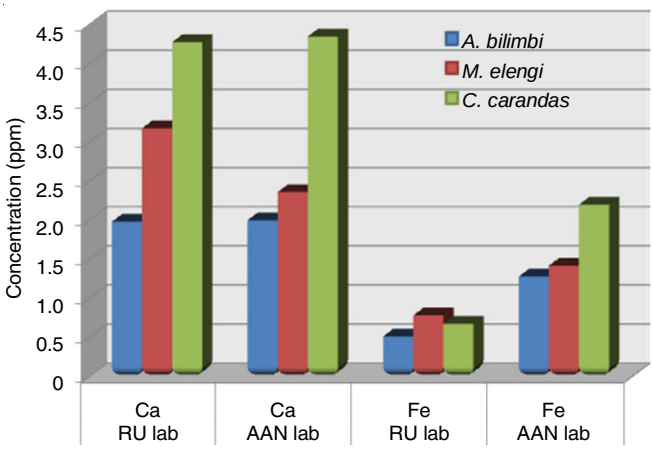

Fig. 2. Concentration of the macro-nutrient Ca and micro-nutrient Fe of the *A. bilimbi*, *M. elengi* and *C. carandas* fruits. Concentration of the elements was determined in the Centre Science Lab of Rajshahi University (RU lab) and in the lab of Asian Arsenic Network (AAN lab), Jessore, of Bangladesh. The concentration is expressed in ppm

Concentration of Fe showed the ranged from around 2.20 to 0.515 ppm. Amongst the three fruits, *Carissa carandas* contained the highest amount of around 2.20 ppm, whereas *Mimusops elengi* and *Averrhoa bilimbi* contained around 1.420 and 1.280 ppm, respectively (Table-1). It is known that Fe is an essential element for chlorophyll synthesis and maintaining the structure and functions of chloroplast. Iron-deficient plants are of poor root formation and shows symptoms of interveinal chlorosis in young leaves. Fe deficiency leads to the growth problem of plant and finally death [22,23]. On the other hand, the recommended dietary for human consumption is about 8~11 mg/day [24]. Higher consumption of Fe may cause the risk of colon cancer as well as the hemosiderosis and haemochromatosis may be caused due to the excessive accumulation in the liver, heart and other tissues [25,26].

A comparison of the content of Zn and Mn in *A. bilimbi*, *M. elengi* and *C. carandas* is shown in Fig. 3. It has been observed that *A. bilimbi* contains comparatively high level of Zn of which the concentration varied from 0.097 to 0.0407 ppm. In *C. carandas*, the concentration of Zn was found to around 0.04 to 0.05 ppm and the concentration around 0.055 ppm in *A. bilimbi* has been observed (Table-1). Zinc has a vital role in plant metabolism as it influences the activities of hydrogenase and carbonic anhydrase, stabilization of ribosomal fractions and synthesis of cytochrome [27]. It activates the plant enzymes involving in the maintenance of the integrity of cellular membranes, carbohydrate metabolism, pollen formation and synthesis of protein [28]. In human, the most important functions of Zn are detox, immune function, growth development, healing and DNA synthesis. However, high intake of Zn might be the reason for causing vomiting, diarrhea, bloody urine, liver failure,

TABLE-2
CONCENTRATION OF THE TRACE MINERALS OF *Averrhoa bilimbi*, *Mimusops elengi* AND *Carissa carandas* FRUITS COLLECTED FROM THE PACHIMPARA RESIDENTIAL AREA OF RAJSHAHI UNIVERSITY CAMPUS, BANGLADESH. CONCENTRATION WAS DETERMINED IN TWO DIFFERENT LABORATORIES. (i) CENTRAL SCIENCE LABORATORY, RAJSHAHI UNIVERSITY (RU LAB) (ii) ASIAN ARSENIC NETWORK (AAN LAB), JESSORE, BANGLADESH. THE CONCENTRATION HAS BEEN EXPRESSED IN ppm

Minerals/Toxic elements	RU lab			AAN lab		
	A. bilimbi	*M. elengi*	*C. carandas*	*A. bilimbi*	*M. elengi*	*C. carandas*
Ca	1.9808	3.1754	4.2772	2.000	2.360	4.350
Fe	0.5150	0.7840	0.6769	1.280	1.420	2.200
Zn	0.0807	0.0498	0.0407	0.097	0.055	0.0505
Mn	0.0385	0.0376	0.0408	0.1100	0.1600	0.1500
Ni	0.0016	0.0008	0.0042	0.002	0.0011	0.004
Cr	0.0065	0.0018	0.0028	0.0055	0.0022	0.003
Cd	0.0015	0.0039	0.0009	0.0041	0.0011	0.0027
Pb	0.0043	0.0086	0.0057	0.0011	0.0031	0.0050

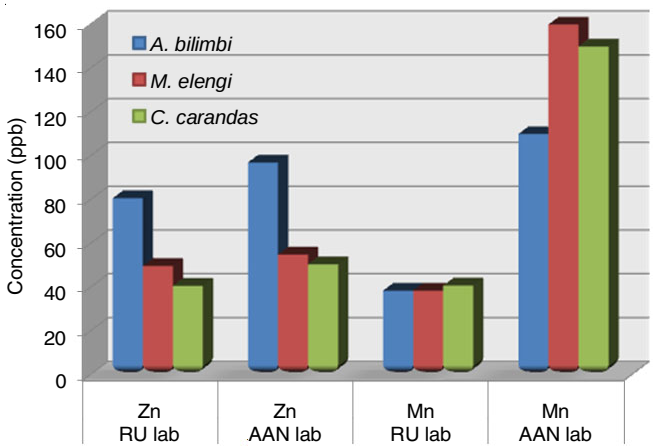

Fig. 3. Concentration of the micro-nutrients Zn and Mn of *A. bilimbi*, *M. elengi* and *C. carandas* fruits. Concentration of the elements was determined in the Centre Science Lab of Rajshahi University (RU lab) and in the lab of Asian Arsenic Network (AAN lab), Jessore, of Bangladesh. The concentration is expressed in ppb

kidney failure, and anemia [29]. The functions of micronutrient Mn are enzyme and hormone production as well as an antioxidant. The concentration was found to be around 0.11 to 0.16 ppm among all the three fruits.

The contents of Ni and Cr in all the *A. bilimbi*, *M. elengi* and *C. carandas* are found to be ppb level. The concentration showed the range from 1 to 6 ppb and is shown in Fig. 4. Nickel and chromium have also been considered as micronutrients. The important functions of Ni in the body are fat metabolism, hormonal activity, urea synthesis whereas the functions of Cr are metabolism and blood sugar control. The marginal concentration of Cr improves the impairment of glucose tolerance and reduces the risk of diabetes and possibly the heart diseases [30-33].

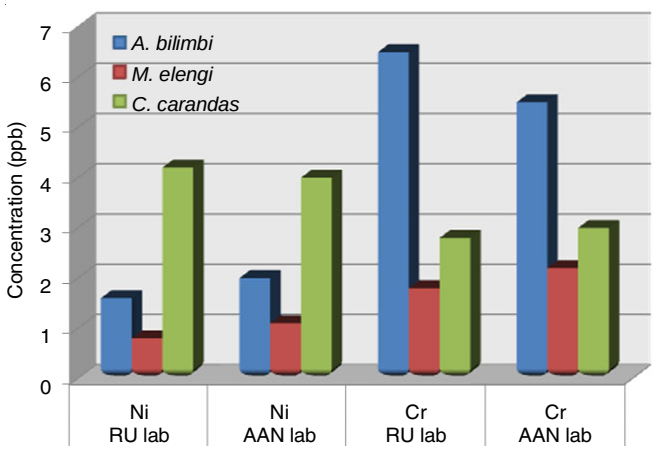

Fig. 4. Concentration of the micro-nutrients Ni and Cr of *A. bilimbi*, *M. elengi* and *C. carandas* fruits. Concentration was determined in the Centre Science Lab of Rajshahi University (RU lab) and in the lab of Asian Arsenic Network (AAN lab), Jessore, of Bangladesh. The concentration is expressed in ppb

A comparison of concentration of the toxic trace elements Cd and Pb of *A. bilimbi*, *M. elengi* and *C. carandas* fruits is shown in Fig. 5. An inconsistency was found between the two results of RU lab and that of AAN lab in this study. The concentration of Cd showed the range between 1 to 4 ppb and the concentration of Pb showed the range of 1 to 8 ppb (Table-1). Pb and Cd are very toxic elements due to having no biochemical and physiological significance. They found in different plants due to environmental contamination such as fertilizer, herbicide, irrigation system and lead containing petrol [34-36]. The permissible limit of Cd and Pb is 20 and 60 ppb, respectively [37]. Therefore, analyzing all the data here, it is seemingly considered as in toxic natural food of and a great source of the macro and micronutrients of Ca, Fe, Zn, Mn, Ni and Cr.

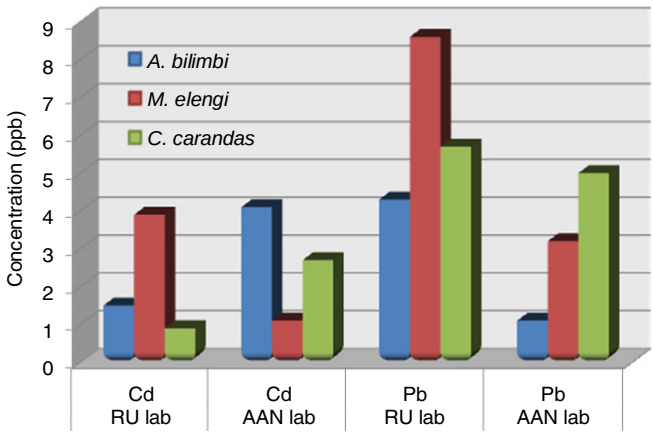

Fig. 5. Concentration of the toxic trace elements Cd and Pb of *A. bilimbi*, *M. elengi* and *C. carandas* fruits. Concentration was determined in the Centre Science Lab of Rajshahi University (RU lab) and in the lab of Asian Arsenic Network (AAN lab), Jessore, of Bangladesh. The concentration is expressed in ppb

Conclusion

A comparative study of quantitative assessment of micronutrients in three fruits of Bangladesh such as *Averrhoa bilimbi*, *Mimusops elengi* and *Carissa carandas* has been assessed. Three elements *i.e.* Ca, Fe and Zn out of eight elements were found to be of comparatively high level in all the three analyzed fruits than those of the other elements. Contents of other five elements *i.e.* Mn, Cr, Ni, Pb and Cd were found to be within the WHO recommended level. From the obtained results, the fruits *Averrhoa bilimbi*, *Mimusops elengi* and *Carissa carandas* are being recommended as a natural source of the macronutrients Ca and also micronutrients Fe and Zn as well. Contents of the toxic elements Pb and Cd found to be within the permissible limit should not be considered as toxic element when consumed.

ACKNOWLEDGEMENTS

This research is financially supported by the Faculty of Science, University of Rajshahi, Bangladesh (Project No.: A-880/5/52/B.M.K/Science -03//18-19).

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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