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Determination of Macro and Trace Element Contents of Some Indigenous Fruits of North Eastern Region of India

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In the present study, the potential health benefits of three widely used indigenous fruits like *Musa balbisiana*, *Garcinia pedunculata* and *Citrus grandis* of North Eastern region of India were assessed. Three different sites of Kamrup district of Assam, India were selected to collect the samples and the edible part of the fruits were tested for essential and toxic minerals *viz*., K, Na, Fe, Mn, Zn, Pb, Cr, Cd, Cu, Co, Ni and Se by atomic absorption spectrometer. *Garcinia pedunculata* was recognized as a good source of Fe. Moreover *Garcinia pedunculata* showed more metal content than other two fruits. There is also variation of mineral content of these fruits in three different sites of Kamrup district of Assam. Lead, Cd and Cr level in all the three fruits were below the WHO permissible limit. So these fruits are free from heavy metal contaminations. The present investigation indicates that these fruits may be considered as a good source of essential elements and can be used as a raw material for further herbal drug preparations as used in the traditional folk.

Keywords: Fruits, Minerals, Multidimensional analysis, Northeast India, Permissible limit.

INTRODUCTION

Minerals have important and vital role in health and disease[1]. Minerals are needed for normal cellular function, enzyme activation, bone formation, hemoglobin composition, gene expression and amino acid, lipid and carbohydrate metabolism[2]. It functions as coenzymes and also plays an important role in the formation of bioactive constituents in medicinal plants[3]. It is widely accepted that fruits are considered as healthy food supplements and are good sources of minerals and trace elements[4,5]. Fruit consumption has been reported to prevent degenerative and chronic diseases such as cancer and cardiovascular diseases[6]. The element status in plants and fruits are directly related to their interaction with all environmental, geological and biological systems[7].

Ingestion of heavy metals through food can cause accumulation in organisms, producing serious health hazards such as injury to the kidney, symptoms of chronic toxicity, renal failure and liver damage[8,9]. In many countries particularly in developing countries heavy metal intake by human populations through the food chain has creating a lot of problems. An excess or deficiency of trace metals can cause harmful effects to the human body. For example, high level of Pb has been reported to be responsible for anemia and affect central nervous system, causing mental retardness and convulsion in childhood[10] while a deficiency of Zn is responsible for retarded body growth[11]. Now a days trace metal contamination is of great concern due to its carcinogenic effects. Hence, determination of both major and trace levels of metal contents in food is important for both food safety and nutritional considerations[12]. *Musa balbisiana*, *Garcinia pedunculata* and *Citrus grandis* are exclusively grown in North Eastern region of India and has pharmaceutical and food value[13]. These fruits have potential antioxidant activity and rich in phytochemicals[14-16]. Antiperoxidative effect of *Citrus grandis* and *Musa balbisiana* was reported by same author[14,16]. These fruits have tremendous health benefits. Therefore present study was undertaken to determine the macro element and trace metal content of these fruits.

EXPERIMENTAL

Sample collection: Botanical description of the fruits to be analyzed is given in Table-1. Fruits samples were collected from the non cultivated area of three different sites *viz*., Hajo, Azara and Sonapur of Kamrup district of Assam. Kamrup district lies between 25.46 and 26.49 North latitude and between 90.48 and 91.50 East longitude and it is situated in the central part of Assam, a state of North Eastern region of India (Fig. 1).

Digestion and analysis of samples: The collected fruits were washed with distilled water. About 10 g ripe pulp of the

TABLE-1
THREE INDIGENOUS FRUITS OF NORTH EASTERN REGION OF INDIA SELECTED FOR THE STUDY

Botanical name	Family	Place of collection	Local name	Parts of plants used in medicinal use
Musa balbisiana	Musaceae	Hajo Azara Sonapur	Athia kol, Bhim kol, Guti kol	Whole plant
Garcinia pedunculata Roxb	Clusiaceae	Hajo Azara Sonapur	Bor thekera, Tabing esing, Tikul, Tikur, Ampri Arong	Fruit
Citrus grandis	Rutaceae	Hajo Azara Sonapur	Robab tenga	Leave, peel, fruit, root

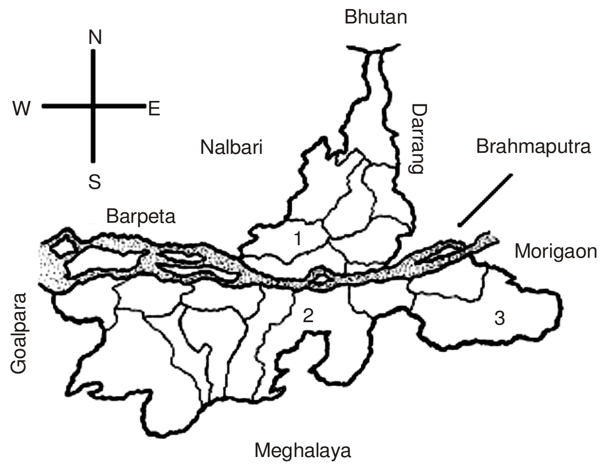

Fig. 1. Map of Kamrup district of Assam showing the selected areas for sample collection. Site-1 Hajo, Site- 2 Azara, Site-3 Sonapur

fruits was repeatedly digested in concentrated nitric acid until the residue became colorless. After digestion the volume was made up to 100 mL with distilled water and filtered through Whatman no. 42. All necessary precautions were adopted to avoid possible contamination of the samples. K, Na, Fe, Mn, Zn, Pb, Cr, Cd, Cu, Co, Ni and Se were estimated by atomic absorption spectrometer (AAS, Model: Perkin Elmer 3110, USA)[17].

Statistical analysis: Results were expressed as mean ± SE. The correlation analysis was performed for measured parameters to determine the relationship between the variables using SPSS software 12 version. The significance level reported ($p < 0.05$) is based on the Pearson's coefficients.

RESULTS AND DISCUSSION

The statistical analysis of the mineral contents of the three different fruits of different study areas exhibits an asymmetric distribution. In case of *Musa balbisiana*, the distribution pattern of macro and trace element content in three different places *viz*., Hajo, Azara and Sonapur is K > Zn > Fe > Na > Mn > Cu > Ni > Co > Cd, K > Na > Zn > Mn > Fe > Cu and K > Mn > Fe > Cu > Zn > Na > Ni > Cr, respectively. K was the dominant minerals. Lead, Cr and Se were not detected in all places except Cr (0.002 ± 0.001 mg/100 g pulp) in Sonapur area. Co and Cd were detected only in Hajo area (Table-2).

In case of *Garcinia pedunculata*, the distribution pattern of mineral contents is K > Fe > Na > Zn > Cu > Mn > Cr > Cd in Hajo, K > Fe > Zn > Na > Cu > Mn > Cd in Azara and K > Zn > Fe > Na > Cu > Mn > Cd in Sonapur area of Kamrup district of Assam (Table-3). Nickel, Co, Pb and Se were not detected in *Garcinia pedunculata* in all those selected areas. The distribution pattern of mineral contents of *Citrus grandis* fruit is K > Fe > Zn > Cu > Na > Pb > Cd > Cr > Co, K > Zn > Fe > Cu > Pb > Mn > Na > Cd > Co and K > Zn > Fe > Na > Cu > Mn > Cd in Hajo, Azara and Sonapur area respectively (Table-2). Nickel and Se were not detected in *Citrus grandis* of all places. Moreover the K, Na, Fe, Cu, Mn and Zn content were much higher in *Garcinia pedunculata* in comparison to that of other two fruits.

Data obtained in the present study areas are quite divergent and no regular pattern of metal content was observed. Iron concentration was found highest in *Garcinia pedunculata* (3-7 mg/100 g pulp). *Musa balbisiana* and *Citrus grandis* showed lesser concentration of Fe that is 0.1 ± 0.002 mg/100 g pulp and 0.086 ± 0.003 mg/100 g of pulp, respectively. Iron is an important component of haemoglobin and intake of iron in human body from fruits is very good to health. In other studies the concentration of iron was reported as 35.6 mg/kg for raw food stuff[18]. Iron deficiency anemia affects the one third of the world population. The present study showed that the *Garcinia pedunculata* may be a good source of iron.

On the contrary, in all the fruit samples, the uptake and accumulation of Mn were relatively lower *i.e.*, 0.01-0.213

TABLE-2
MINERAL CONTENT OF *Musa balbisiana, Garcinia pedunculata* AND *Citrus grandis*

Minerals (mg/100 g pulp)	*Musa Balbisiana*			*Garcinia pedunculata*			*Citrus grandis*		
	Hajo	Azara	Sonapur	Hajo	Azara	Sonapur	Hajo	Azara	Sonapur
K	35.42±0.4	34.26±0.12	33.75±0.021	67.68±0.3	73±0.71	127.72±0.4	32.6±0.31	36.63±0.1	28.6±0.22
Na	0.12±0.01	2.2±0.20	0.04±0.001	1±0.01	1.4±0.1	3.7±0.1	0.04±0.001	0.02±0.001	0.05±0.001
Fe	0.13±0.003	0.2±0.01	0.1±0.002	3.1±0.11	5.42±0.14	7±0.02	0.086±0.003	0.13±0.001	0.12±0.01
Cu	0.087±0.002	0.05±0.001	0.047±0.001	0.3±0.014	0.42±0.1	0.6±0.014	0.08±0.003	0.1±0.001	0.041±0.001
Mn	0.12±0.014	0.213±0.01	0.16±0.001	0.135±0.003	0.14±0.01	0.15±0.003	ND	0.01±0.001	0.02±0.001
Zn	0.23±0.001	0.3±0.04	0.04±0.001	0.78±0.001	3.57±0.14	13.2±0.3	0.081±0.002	0.32±0.01	0.16±0.003
Ni	0.06±0.003	ND	0.03±0.001	ND	ND	ND	ND	ND	ND
Co	0.02±0.001	ND	ND	ND	ND	ND	0.003±0.001	0.01±0.001	ND
Cd	0.014±0.002	ND	ND	0.002±0.0003	0.1±0.01	0.2±0.01	0.015±0.001	0.02±0.0004	0.01±0.001
Pb	ND	ND	ND	ND	ND	ND	0.04±0.003	0.1±0.01	ND
Cr	ND	ND	0.002±0.001	0.05±0.002	ND	ND	0.01±0.0004	ND	ND
Se	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND - Not detectable

TABLE-3
PEARSON CORRELATION COEFFICIENTS BETWEEN THE VARIABLES CONSIDERED ON THE DATA OF MINERAL CONTENT OF *Musa balbisiana*, *Garcinia pedunculata* AND *Citrus grandis*

		Musa balbisiana					*Garcinia pedunculata*						*Citrus grandis*				
		K	Na	Fe	Cu	Mn	K	Na	Fe	Cu	Mn	Zn	K	Na	Fe	Cu	Zn
Na	Cc	–0.187					0.998(*)						-0.977				
	p	0.880					0.044						0.136				
Fe	Cc	0.473	0.777				0.849	0.883					0.217	-0.418			
	p	0.686	0.433				0.355	0.311					0.861	0.725			
Cu	Cc	0.973	-0.409	0.256			0.910	0.937	0.992				0.965	-0.888	-0.046		
	p	0.149	0.732	0.835			0.272	0.228	0.083				0.168	0.304	0.971		
Mn	Cc	-0.567	0.915	0.458	-0.742		0.968	0.983	0.954	0.985							
	p	0.616	0.264	0.697	0.468		0.161	0.117	0.193	0.111							
Zn	Cc	0.539	0.727	0.997(*)	0.329	0.388	0.991	0.998(*)	0.913	0.958	0.993		0.657	-0.802	0.878	0.437	
	p	0.638	0.049	0.482	0.786	0.746	0.087	0.043	0.268	0.185	0.074		0.544	0.408	0.317	0.712	
Cd	Cc						0.932	0.954	0.983	0.999(*)	0.993	0.972	0.982	-0.920	0.028	0.997(*)	0.503
	p						0.193	0.237	0.118	0.035	0.076	0.150	0.121	0.257	0.982	0.047	0.665

*Correlation is significant at the 0.05 level (2-tailed); Cc = Correlation coefficient; p = p-Value.

mg/100 g of fresh pulp. High level of Mn causes psychiatric disorder including difficulty in walking, speech and compulsive behaviour such as running, fighting and singing. So these fruits are far away from health hazard as the US National Academy of Sciences recommended 2.5-5 mg per day manganese[19] and the WHO recommended 2-9 mg per day for an adult[20].

Zinc is an essential metal. The concentration of Zn was highest in *Garcinia pedunculata* ranging between 0.78 ± 0.001-13.2 ± 0.3 mg/100 g pulp and minimum was in *Musa balbisiana* of Sonapur (0.04 ± 0.001 mg/100 g pulp). The maximum tolerable daily intake of Zn is 0.3-1 mg/kg[21]. Copper plays a critical role in a variety of biochemical processes. The lowest concentrations of Cu (0.047 ± 0.001and 0.041 ± 0.001 mg/100 g pulp) were found in *Musa balbisiana* and *Citrus grandis,* respectively from Sonapur area and highest concentration was in *Garcinia pedunculata* (0.6 ± 0.014 mg/100 g pulp) from Sonapur area.

Lead above the permissible level in any food substances can cause severe health problems. The concentration of lead was found maximum in *Citrus grandis* (0.1 ± 0.001 mg/100 g pulp) fruit of Azara and minimum (0.04 ± 0.003 mg/100 g pulp) in Hajo which was much lower than the provisional tolerable intake as WHO has established a provisional tolerable weekly intake for lead of 0.025 mg/kg of body weight[22].

In the present study K level was found lower in *Musa balbisiana* compared to the literature[23-25]. Na content was in support of earlier reports of wills *et al*[23,24]. Chauhan *et al.*[25] in different banana varieties. The level of Zn and Mn in *Musa balbisiana* was in accordance with the previous reports of Wills *et al.*[23,24]. Potassium and sodium content of *Citrus grandis* were lower than previous literature reported by Okwu and Emenike, 2007 and Paul and Saha, 2004 in citrus fruits[26,27]. In case of Cu, Mn and Zn, similar results were found with Paul and Saha, 2004. Though there is no report available regarding the mineral content of *Garcinia pedunculata*, it can be compared with the works of Morabandza *et al*[28]. 2013 which determined the mineral content of *Garcinia kola Heckel* (*Clusiaceae*) Fruit. But there are wide variations in published data for the metal content.

The values of Pearson correlation coefficients between mineral concentrations of three different fruits are given in Table-3. There was a strong positive correlation of Na with Fe, Mn and Zn whereas K with Cu and Zn. Mn shares negative correlation with K and Cu. It was found from the Table that there is a significant positive correlation between Fe and Mn in case of *Musa balbisiana*. Regarding the mineral level of *Garcinia pedunculata*, Na has significant positive correlation with K and Zn and Cu with Cd (Table-3). Most of the mineral shows strong positive correlation. In case of *Citrus grandis*, there is a significant positive correlation of Cu with Cd (Table-3). Na shares negative correlation with K, Fe, Cu, Zn, Cd and Fe with Cu. There is a strong positive correlation of K with Cu, Zn and Cd and Zn with Fe and Cd.

Soil type, irrigation, fertilization and other cultural practices influence the water and nutrient supply to the plants, which can affect the composition and quality attributes (appearance, texture trade and aroma) of the harvested plant parts[29]. The fruits analyzed here can be considered as a good source of some mineral elements, some of them with various medicinal properties. Their optimum consumption is required for better health not only in India but also in all other countries of sub continental region where a large number of people are suffering from macro and micro element-deficiency syndrome.

Conclusion

The study revealed wide variability of metal content among the fruit species with respect to different areas. Fruits showed good source of metal and macro element. Biomonitoring of these fruits of North Eastern region of India indicated that the mineral contents of these fruits were within the safe limit. Such type of study is highly essential as the human health is directly affected by ingestion of fruits and vegetables.

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