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Toxic Metals and Essential Nutrients Concentration in Different Vegetables Collected from Market Sites of Chittagong Metropolitan City, Bangladesh

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Abstract

The current research has been conducted to investigate concentrationsof some toxic metals such as Mn,Cr,Pb,Cd, Cu,and Co along with essential nutrients K,Ca,Mg,Fe and Zn in twenty two different types of vegetables collected from wholesale market of Chittagong Metropolitan city, Bangladesh. Toxic metals and essential nutrients concentration in the vegetables were determined using Atomic Absorption Spectrometer (AAS) after acid digestion. Percentages of moisture, organic and inorganic matter of these vegetables were also determined. Metals concentration was measured by AAS after wet digestion system. The result of this study showed that the average concentration detected for toxic metals ranged from 0.11-2.49, 0.04-4.45, 0.05-1.59, 0.04-5.19, 0.01-0.09, and 0.001-0.35 mg/kg for Cu, Mn, Cr, Pb, Cd and Co respectively. Essential nutrientsranged from 572.64-8915.40, 4.99-242.56, 81.39-4797.63, 0.09-14.67, and 0.13-9.36 mg/kg for K,Ca,Mg,Fe and Zn respectively and percentage of moisture, organic and inorganic matter ranged from 68.35-95.43, 4.46-30.28 and 0.12-3.94 respectively.These values are within the tolerable limits except for Mn, Cr and Pb that have values which are higher than the FAO/WHO recommended values. The main objective of the present work is to focus on contamination of toxic metals in different vegetables in order to assure a significant improvement in food safety.

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"Atomic Absorption Spectrometer(AAS)",
"Chittagong"

Introduction

Vegetables are vital sources of minerals, vitamins, dietary fibers, antioxidants, protein and carbohydrate[1,2].Whereas, both essential and lethal elements (metals) are present in vegetables. Heavy metals in vegetables mainly occurred due to contaminated soil and irrigation[3].Further, vegetables can easily absorb the metals accumulated on plant surfaces exposed to the tainted ambient[3].the existence of heavy metals in fertilizers enhance

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the probability of metal pollution for vegetables[4]. Human activities like as farming, industrialization and urbanization amplify the level of heavy metal in the environment, as a result, elevate the metal concentration in the vegetables[5].

Heavy metals from point sources, for instance metalliferous mining, smelting and industrial activities, on the other hand non-point source, for example fertilizers,pesticides,sewage sludge, organic manure and compost contribute to uplift the level of concentration in vegetables[6].Emission from the industries and vehicles may be stored heavy metals on the vegetables surface during its production, transport and marketing. For instance, The level of heavy metals aggrandized into vegetables sold at Riyadh city in the Saudi Arabia due to atmospheric deposition[7]. Another reference, the amount of heavy metals rise up in the vegetables sold at open market in the Varanasi, India because of same cases[8,9].

Plants grown in contaminated environment can aggregate heavy metals at elevated concentration causing serious risk to human health when consumed. However, heavy metals are toxic because they tend to bio accumulate in plants and animals, bioconcentrate in the food chain and attack specific organs in the body[10,11]. Long time consumption of heavy metals through vegetables may causes disruption of numerous biochemical processes, Consequently occurred cardiovascular, nervous, kidney and bone diseases[12,13]. Despite trace quantities of certain heavy metals such as Cr,Co,Cu,Mn and Zn etcetera are essential micronutrients for human and plants growth but their high concentration may cause health problem[4,15]. Hence lot of works have been carried out to assess heavy metals bioaccumulation in different vegetables and plants all over the world[16,17].

The uptake of heavy metals in vegetables is trendy to be higher and accumulation of these toxic metals in human body generated warning in the present days. The daily vegetables consumption by an adult of Bangladesh is 130gm[18]. Varieties of vegetables are grown the whole year in tropical Bangladesh, but using little is known .about the heavy metal contents of vegetables[1]. Few articles[18, 19] are available reporting the heavy metals concentration in different vegetables grown in various parts of our country. But such researches are not conducted in the metropolitan city of Chittagong, Bangladesh. The present study was undertaken with the aim to investigate the concentration of some specific toxic metals (Mn, Cr, Pb, Cd, Cu and Co) and essential nutrients (K, Ca, Mg, Fe and Zn) in selected vegetables available in this region.

Materials and Method

Study Area and Sampling Locations

The present study was carried out in the Chittagong metropolitan area of Bangladesh. Samples of vegetables were randomly collected from central whole sale market of Chittagong metropolitan city

Fig. 1: Map of the Chittagong metropolitan city

named Reazuddin bazar (figure 1). All the vegetables were collected from three different locations (south, medium, and north) to provide replicate samples of each vegetable. All samples were stored in clean polyethylene bag according to their type and transported to the laboratory for further processing. The scientific, common and family name of each studied vegetables are listed (table 1).

Table 1: English name, Common name, scientific name and family name of different vegetables collected from Reazuddin bazar

English name	Common name	Scientific name	family
String bean	Borbati	*Vignasesquipedalis*	Leguminoseae
Snake gourd	Chichingga	*Trichosanthesanguina*	Cucurbitaceae
Okra	Dherosh	*Abelmoschusesculentus*	Malvaceae
Palwal	Patal	*Trichosanthesdioica*	Cucurbitaceae
Green papaya	Papay	*Carica papaya*	Caricaceae
Eddoe	Mukhikachu	*Colocasiaesculenta*	Araceae
Wax gourd	Chalkumda	*Benincasahispida*	Cucurbitaceae
Bitter gourd	Karala	*Momordicacharantia*	Cucurbitaceae
Teasle gourd	Kakrol	*Momordicacochinchinensis*	Cucurbitaceae
Cabbage	Bandhakopi	*Brassica oleracea* var *capitata*	Cruciferae
Radish	Mula	*Raphanussativus*	Cruciferae
Ribbed gourd	Jhinga	*Luffaacutagula*	Cucurbitaceae
Brinjal	Begun	*Solanummelongena*	Solanaceae
Carrot	Gajor	*Daucuscarota*	Umbelliferae
Chili	Marich	*Capsicum* species	Solanaceae
Turnip	Shalgom	*Brassica rapa*	Cruciferae
Sweet gourd	Mistikumra	*Cucurbita maxima*	Cucurbitaceae
Potato	Alu	*Solanumtuberosum*	Solanaceae
Coriander leaf	Dhanepata	*CoriandrumSativum*	Apiaceae
Cauliflower	Phulkopi	*Brassica oleracea* var *botrytis*	Cruciferae
Hyacinth bean	Sheem	*Lablab niger*	Leguminoseae
Tomato	Tomato	*Lycopersiconesculentum*	Solanaceae

Sample Pre-Treatment and Digestion

The collected vegetables samples were washed with distilled water to remove dust particles. The samples were then cut into nearly uniform size using clean knife. This was done to facilitate drying of the pieces at the same rate. After air drying the samples were placed in clean acid washed porcelain crucibles according to the label and oven dried at 105 ^{0}C for 24 hours until they were brittle and crispy. Now these dried samples of vegetables were grounded into fine particles using blender. The powdered samples were placed in labeled Petri dishes and dried to constant weight in desiccators until they acid digested. These samples were digested by using conc. H_2SO_4 and 30% H_2O_2, in a three neck round bottom flask.

Analytical Technique

The samples were analyzed by an atomic absorption spectrophotometer (Thermo Scientific iCE 3300 AA Series Atomic Absorption Spectrophotometer), using an air acetylene flame. The analysis was carried out using hollow cathode lamps under standard instrument conditions.

Results and Discussion

All the twenty two vegetables sample contain more than 84% moisture except eddoe(68.35%), maximum amount of organic matter was found in eddoe (30.28%) due to presence of lots of carbohydrate whereas inorganic matter varies from 0.12%-3.94% (Table 2).

Table 2: Moisture content, organic and inorganic part of vegetables collected from Reazuddin bazar

Name of vegetables	Moisture (%)	Organic matter (%)	Inorganic matter (%)
String bean	87.47	10.84	1.69
Snake gourd	94.19	4.46	1.35
Okra	90.12	9.03	0.85
Palwal	91.83	7.42	0.75
Green Papaya	92.70	6.32	0.98
Eddoe	68.35	30.28	1.37
Wax gourd	95.43	4.12	0.45
Bitter gourd	93.55	5.64	0.81
Teasle gourd	87.97	11.35	0.68
Cabbage	92.13	7.02	0.85
Radish	93.46	6.42	0.12
Ribbed gourd	93.20	6.28	0.52
Brinjal	92.18	6.26	1.56
Carrot	84.42	11.64	3.94
Chili	88.96	10.07	0.97
Turnip	91.23	8.32	0.45
Sweet gourd	92.17	6.62	1.21
Potato	77.30	21.56	1.14
Coriander leaf	87.12	11.33	1.55
Cauliflower	93.15	6.23	0.62
Hyacinth bean	84.69	14.85	0.46
Tomato	95.01	4.50	0.49

Essential nutrients and Toxic metals (Table 3, Table 4) concentrations (mg/kg) of twenty two vegetables are depicted below. The potassium concentration in the vegetables samples varied from 572.64 mg/kg in green papaya to 4097.43 mg/kg in coriander leaf (Table 3).The concentration (mg/kg) of K is higher than the others essential nutrients because potassium is one of the main components of NPK fertilizer which is frequently used by farmer in cultivation field consequently vegetables under examination abundant with potassium since K can easily be absorbed by vegetables. Evidence Show that dietary potassium plays a role in decreasing blood pressure, controlling nerve and muscle function. Low potassium and high sodium level in food increase the probability of blood pressure[21].

The concentration of calcium was found to be 4.99-242.56 mg/kg. All the vegetables except tomato contain reasonable amount calcium. Ca is essential for skeleton and central ion for vast range of biological process such as muscle contraction,glycolysis and gluconeogenesis ,ion transport, cell division and growth[22]. The Mg concentration (mg/kg) in most green vegetables is more than 150 mg/kg since Mg is the central element of chlorophyll structure. So that in leafy vegetables coriander leaf contain highest 4797.63 mg/kg of Mg. Lack of Magnesium can affect most of vital organ of human body[23].High content of iron were observed in cabbage (14.67 mg/kg) since it is fully leafy vegetable. Iron is an inevitable element since it is the central ion for hemoglobin which is involved in oxygen and carbon dioxide transportation[24]. A deficiency of iron influence the formation of hemoglobin consequently limits the oxygen delivery to cells, resulting in fatigue, poor working efficiency and immunity. On the reverse side, excess iron can result in toxicity and even death[25, 26].

Cu,Mn,Cr,Pb,Cd and Co concentration (Table 4) of twenty two vegetables collected from Reazuddin bazar, central vegetables market, Chittagong metropolitan city, Bangladesh. The average concentration of toxic metalsestimatedin twenty two vegetables ranged from0.18-2.49 mg/kg for

Cu, 0.04-3.92 mg/kg for Mn, 0.05-1.59 mg/kg for Cr, 0.04-2.97 mg/kg for Pb, 0.01-0.07 mg/kg for Cd, 0.02-0.35 mg/kg for Co. Heavy metals content in the examined vegetables found in the decreasing order as Mn>Cu>Pb>Cr>Co>Cd(Table 4). Though trace amount of Mn, Cu and Cr are accounted as important electrolyte for several biological processes in human body, but higher levels of these metals can affect the major organs on consumer health[13]. Manganese plays major role in oxygen evolution catalyzed by the proteins of the photosynthetic reaction center and pyruvate carboxylase in human being and also involved in bone concentration, protein, lipid and metabolism[22]. The Adequate Intake (AI) of Mn for adult men and women is 2.3mg/day and 1.8 mg/day respectively[26]. Copper plays an important role as biocatalyst in the body[13]. Generally soil contain inadequate amount of copper so that copper is provided to plants through artificial or organic fertilizers[27]. Further, the copper toxicity can induce lipid peroxidation, iron deficiency and destruction of cellwall[28].The highest value of copper is found 2.49 mg/kg in string and lowest value is found 0.11mg/kg in tomato(Table 4).Chromium can cause ulceration, liver and kidney damage[27, 28]. In addition, Chromium in trace amount controls the glucose level in blood[28]. Chromium concentration is highest in string bean (1.59 mg/kg) and lowest in radish (0.05 mg/kg).

When Pb is up taken by crops from soil, it's mainly stay at root area as it cannot effectively transport the endodermis of roots whereasleaves can absorb vast quantities of Pb from the atmosphere[30]. Pb is toxic metals which have carcinogenic effects and teratogenic abnormalities in human, even at very low concentration[31]. Pb has been reported as a severe aggregative body toxin which enters the body through food, air and water, cannot be eliminated through washing vegetables[32, 33]. In our tested vegetables all the vegetables contain huge (more than 0.50 mg/kg) amount of Pb which is really a great concern for consumer health issue. The high concentration of Pb in all the vegetables might be due to contaminants in irrigation water, soil or industrial and vehicular emission as lead occurs in the fuel as antiknocking agents[33].Artificial fertilizers are one of the major source of soil contamination by trace metals especially Cd, as it is naturally found as an impurity in phosphate rocks[34, 35].It was found that the Cd concentration(Table 4) of all the vegetables were within the safe limit recommended by FAO/WHO for human consumption.The Co found in most of the vegetables were with in the limit recommended by WHO/FAO[36]. Among all the tested vegetables Co was found highest in Brinjal (0.35 mg/kg) and lowest in potato (0.001 mg/kg).

Table 3: Essential nutrients concentration (mg/kg) in different vegetables collected from Reazuddin bazar

Name of Vegetables	K (mg/Kg)	Ca (mg/Kg)	Mg (mg/Kg)	Fe (mg/Kg)	Zn (mg/Kg)
String bean	2402.37±3.82	91.23±0.55	480.30±0.96	8.59±0.34	9.36±0.02
Snake gourd	977.75±2.93	30.03±0.57	246.74±0.49	5.87±0.05	4.41±0.01
Okra	1991.82±5.97	242.56±1.21	537.48±2.69	8.29±0.02	7.65±0.04
Palwal	1483.61±4.45	69.07±0.35	187.17±0.37	8.43±0.13	2.92±0.01
Green papaya	572.64±2.86	84.58±0.25	126.26±0.76	9.41±0.02	2.22±0.03
Eddoe	1164.01±10.48	11.77±0.26	155.46±0.78	6.51±0.05	2.29±0.01
Wax gourd	1018.24±5.09	75.25±0.38	171.48±0.51	8.04±0.05	1.47±0.01
Bitter gourd	1619.34±4.85	23.41±0.09	174.75±0.87	6.21±0.11	2.87±0.01
Teasle gourd	1211.73±2.42	54.62±0.87	193.27±0.19	7.55±0.04	5.88±0.02
Cabbage	1781.63±7.13	190.55±2.09	163.16±0.81	14.67±0.21	8.09±0.05
Radish	1624.59±1.62	148.05±0.15	149.21±0.89	12.97±0.03	5.61±0.02
Ribbed gourd	875.05±2.62	50.85±1.22	133.26±0.13	5.46±0.13	3.76±0.02
Brinjal	2766.42±2.77	176.77±3.71	420.67±2.52	4.42±0.10	3.92±0.06
Carrot	4107.58±2.32	28.82±1.09	205.64±1.23	0.55±0.43	0.20±0.01
Chili	8915.40±3.73	101.23±0.71	1174.08±2.34	8.04±0.11	6.84±0.01
Turnip	895.46±0.89	8.18±0.21	81.39±0.49	2.11±0.03	1.27±0.02

Sweet gourd	3125.86±5.63	10.76±0.21	208.95±1.46	0.09±0.01	3.42±0.03
Potato	1353.39±6.77	66.68±1.06	221.50±2.88	5.08±0.04	3.19±0.01
Coriander leaf	4097.43±3.87	228.99±0.68	4797.63±9.59	0.58±0.42	1.88±0.01
Cauliflower	2105.26±8.42	60.34±1.99	196.16±0.98	2.12±0.01	2.31±0.01
Hyacinth bean	1181.93±2.64	53.55±1.34	215.04±0.21	3.69±0.06	3.17±0.02
Tomato	1596.12±6.38	4.99±0.06	200.87±0.20	0.25±0.90	0.13±0.01

*All the values of concentration are expressed in Average±SD

Table 4: Toxic metals concentration in different vegetables collected from Reazuddin bazar

Name of Vegetables	Cu (mg/Kg)	Mn (mg/Kg)	Cr (mg/Kg)	Pb (mg/Kg)	Cd (mg/Kg)	Co (mg/Kg)
String bean	2.49±0.02	3.92 ±0.04	1.59±0.03	2.88±0.06	0.07±0.02	0.02±0.05
Snake gourd	0.88±0.07	1.29±0.02	0.94±0.01	2.08±0.11	0.03±0.02	0.09±0.01
Okra	1.69±0.08	4.45±0.02	0.27±0.00	1.73±0.03	0.07±0.06	0 .24±0.01
Palwal	0 .74±0.03	0.45±0.01	0.28±0.00	1.87±0.05	0.05±0.01	0.30±0.02
Green papaya	0.36±0.01	0.21±0.00	0.22±0.00	1.89±0.03	0.01±0.01	0.02±0.01
Eddoe	0.87±0.03	1.09±0.02	0.16±0.00	1.16±0.05	0.02±0.01	0.13±0.01
Wax gourd	0.28±0.01	0.85±0.01	0.30±0.00	1.22±0.02	0.02±0.01	0.002±0.01
Bitter gourd	1.07±0.04	1.59±0.02	0.18±0.00	2.45±0.13	0.02±0.02	0.10±0.05
Teasle gourd	0.21±0.01	3.55±0.02	0.54±0.01	2.97±0.04	0.06±0.03	0.24 ±0.01
Cabbage	0.81±0.08	2.04±0.02	1.33±0.02	5.19±0.12	0.09±0.07	0.10±0.06
Radish	0.39±0.02	0.40±0.01	0.05±0.00	1.89±0.06	0.03±0.01	0.09±0.03
Ribbed gourd	0.91±0.04	1.50±0.03	0.55±0.00	2.53±0.07	0.06±0.02	0.19±0.01
Brinjal	2.28±0.03	1.64±0.02	0.68±0.00	1.68±0.01	0.06±0.01	0.35±0.03
garlic	2.23±0.07	2.41±0.03	0.17±0.00	1.77±0.01	0.05±0.02	0.27±0.01
Carrot	0.18±0.02	0.04±0.00	1.07±0.01	0.12±0.01	0.04±0.01	0.33±0.01
Onion	1.14±0.05	2.29±0.01	0.19±0.00	0.86±0.01	0.03±0.01	0.06±0.03
Chili	2.16 ±0.11	2.14±0.04	0.79±0.03	1.71±0.09	0.05±0.03	0.13±0.08
Turnip	0.58±0.06	0.74±0.01	0.33±0.05	0.91±0.01	0.02±0.01	0.11±0.08
Sweet gourd	0.55±0.02	0.31±0.03	0.39±0.05	0.19±0.02	0.02±0.01	0.17±0.03
Potato	1.37±0.04	1.99±0.02	0.58±0.02	0.91±0.02	0.02±0.01	0.001±0.01
Coriander leaf	0.41±0.02	1.17±0.01	0.68±0.02	0.04±0.02	0.02±0.01	0.30±0.02
Cauliflower	0.26±0.01	0.75±0.01	0.19±0.04	0.46±0.03	0.02±0.00	0.09±0.02
Hyacinth bean	0.92±0.04	1.52±0.03	0.25±0.06	1.18±0.02	0.01±0.00	0.10±0.02
Tomato	0.11+0.01	0.05±0.00	0.55±0.01	0.11±0.01	0.02±0 .01	0.17±0.01

*All the values of concentration are expressed in Average±SD

Conclusion

Though all the vegetables are great source of essential nutrients such as K,Mg,Ca,Fe and Zn but the average concentration of heavy metals especially Mn, Cr and Pb exceeding the recommended limits whereas Cu, Cd and Co level maintained within the safe limits in all the vegetables. Consuming heavy metals contaminated vegetables for prolonged time might create different types of chronic diseases. Therefore regular monitoring of heavy metals in vegetables is crucial to avoid excessive uptake of these metals in the food chain and concern authority should take necessary steps to avoid heavy metals contamination in vegetables.

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