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Assessment of copper in diverse pulses, bananas, vegetables and arums of five upazila of Chittagong area in Bangladesh by spectro-photometric method

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Abstract

Copper is common element in the environment. People are exposed to copper by breathing air, drinking water, eating food, and by skin contact with soil, water and other copper-containing substances. Most copper compounds found in air, water, sediment, soil and rock are strongly attached to dust and dirt or imbedded in minerals. It rapidly enters into the bloodstream and is distributed throughout the body after eating or drinking the copper containing products. Certain substances in foods are eaten with copper can affect the amount of copper that enters into the bloodstream from the gastrointestinal tract. The present investigation shows that four verities of vital food i.e. pulses, bananas, vegetables and arums contain diverse amount of copper in Chittagong area of Bangladesh. This food is taken for survival the life. The amounts of copper in pulses were found to vary from 3.2250-29.6531µg/g of that region. The highest and lowest values were found in *Vigna muungo* (Anowara) and *Lathyrus sativus* (Mirsharai) respectively. The amounts of copper in bananas were varied from 0.595-7.861 µg/g and the highest and lowest values were found in banana of Musa paradisiaca but two different upazila i.e. Lama and Satkania respectively. The amounts of copper in vegetables were found to vary from 1.16-15.13 µg/g. In this case, the highest and lowest values were found in *Centella asiatica* (Pahartali) and *Alternanthera philoxeroides* (Fatickchari) severally. The amounts of copper in twenty samples of arums were observed to vary from 0.8298-49.7008 µg/g. The highest and lowest value was found in *Colocasia esculenta* (Patiya) and *Amorphophallus campanulatus* (Satkaniya) respectively. Finally, the analysis of four types of food were investigated that the highest value of copper is present in *Colocasia esculenta* (Patiya) and the lowest value of copper in *Musa paradisiaca* (Satkania) respectively.

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Introduction

Copper is a metallic element that occurs naturally as the free metal or associated with other elements in compounds that comprise various minerals. Most copper compounds occur in Cu (I) and Cu (II) valence states. It takes place physically in many minerals such as cuprites (Cu_2O), malachite ($CuCO_3•Cu(OH)_2$), azurite ($2CuCO_3•Cu(OH)_2$), chalcopyrite ($CuFeS_2$), chalcocite (Cu_2S), and bornite (Cu_5FeS_4).

Copper is a reddish metal that occurs in rock, soil, water and sediment. Copper also occurs naturally in all plants and animals. It is an essential element for all known living organisms including humans and other animals at low levels of intake. At much higher levels of copper that can frequently occurs a toxic effect in the human body (Public Health Service, 2004).

In agriculture, copper compounds are used as fungicides and to prepare copper fungicidal products, algaecides for reservoirs and streams and nutritional supplements in animal feed and fertilizers. Industrial applications of copper sulfate include use as an activator in froth flotation of sulfide ores, production of chromate copper arsenate wood preservatives, electroplating, azoic dye manufacture, mordant for textile dyes, petroleum refining and in the manufacture of other copper compounds such as copper hydroxide and copper carbonate. In this way, the copper come in plants and animals from that product.

Copper is an essential nutrient that is incorporated into a number of metallo-enzymes involved in hemoglobin formation, drug/xenobiotic metabolism, carbohydrate metabolism, catecholamine biosynthesis, the cross-linking of collagen, elastic, and hair keratin and the antioxidant defense mechanism. Copper-dependent enzymes such as superoxide dismutase, ferroxidases, monoamine oxidize and dopamine β-monooxygenase, function to

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reduce activated oxygen species or molecular oxygen. Symptoms associated with copper deficiency in humans include normocytic, hypo chromic anemia, leucopenia and osteoporosis. The daily needs or the world's daily average uptake of 2-3 mg/day copper is considered to be suitable for human adults by weighing of 70 kg (Mahan and Scott-Stump, 1996). Copper that eludes binding to intestinal metallothionen is transported to the liver. It is stored in the liver bound to liver metallothionen, from which it is ultimately released into bile and excreted in the feces. Although copper homeostasis plays an important role in the prevention of copper toxicity, exposure to excessive levels of copper can result in a number of adverse health effects including liver and kidney damage, anemia, immuno toxicity and developmental toxicity. Many of these effects are consistent with oxidative damage to membranes or macromolecules (Public Health Service, 2004).

The chronic-duration database for copper consists of two occupational exposure studies reporting respiratory (Askergren and Mellgren, 1975; Suciu *et al*., 1981) and gastrointestinal irritation and hepatic effects (Suciu *et al.*, 1981). The available human and animal acute-duration studies strongly suggest that the gastrointestinal tract is the most sensitive target of copper toxicity. Numerous studies and case reports have reported nausea, vomiting and/or abdominal pain in human immediately following ingestion of copper-contaminated water or other beverages (Chuttani *et al*., 1965; Spitalny *et al*., 1984; Knobeloch *et al*., 1994; Gotteland *et al.*, 2001; Olivares *et al*., 2001; Pizarro *et al*., 1999, 2001; Araya *et al*., 2001; 2003a; 2003b; 2003c). In human studies involving a single exposure to copper following an overnight fast, adverse gastrointestinal effects (nausea, vomiting, abdominal pain, and/or diarrhea) have been observed at doses of 0.011-0.03 mg Cu/kg (Gotteland *et al.*, 2001; Olivares *et al.*, 2001; Araya *et al*., 2001; 2003a ; 2003c).

Chittagong is the commercial capital city of Bangladesh. Many types of Industry were built in this area. Chittagong port is the largest port of Bangladesh. For that reason, it has become a burning question of the day to find out the amount of copper from diverse eating materials. The environment of Bangladesh is suitable for growing of diverse pulses, bananas, vegetables and arums. So, people can easily collect those vital foods from local market by cheap rate or they can grow easy way to this pulses, bananas, vegetables and arums as well. Diverse pulses, bananas, vegetables and arums contain different amount of copper. In this investigation, the spectro-photometric method is used to determine the amount of copper in some pulses, bananas, vegetables and arums of Chittagong region.

Materials and Methods

Ammonium citrate, Na_2 EDTA, Sodium diethyldiethio carbamate (copper reagent), Carbon tetrachloride (CCl_4), $CuSO_4.5H_2O$ and Ammonia solutions were used purchasing from Sigma Aldrich Chemicals (Steinheim, Germany) and Cresol red, Conc. Hydrochloric acid (HCl) and Conc. Nitric acid (HNO_3) from Merck (Germany). All the chemicals used were of analytical grade. Twenty samples of all items i.e. pulses, bananas, vegetables and arums were collected from five upazila (The upazila constitutes by some villages) of Chittagong area, Bangladesh. All samples were washed with water followed with DDI (double de-ionized distil water). Samples were cut into small pieces and dried at 105^{o}C for 18 hrs (Wiermans *et al*., 1986) through gravity convention oven (DX 600, Yamato Scientific America). After drying, the samples were burned into the maffle furnace (L 3/11, Nabertherm, Germany) and then the ashes were weighed out and stored in the stopper bottles. Taking the weight of the ash sample, the amount of Cu present in the sample was determined by using GBC UV-visible cintra spectro-photometer through conventional spectro-photometric method (Vogel's *et al*., 1978).

Results and Discussion

Copper is an essential element required for normal growth and development and for a variety of metabolic functions including iron metabolism, cross-linking of connective tissue and lipid metabolism of all living things. Averagely, 2-3 mg copper consumption per day is considered to be suitable for an adult (Mahan and Scott-Stump, 1996). The people of Bangladesh mainly depend on the different kinds of pulses, bananas, vegetables and arums for fulfill the demand of essential mineral elements like copper. The signs of copper deficiency in infants and children include anemia that is unresponsive to iron supplementation, neutropenia, bone abnormalities and hypo pigmentation of the hair (Danks, 1988; Cordano, 1998). Interestingly, copper deficiency is rarely observed in humans; in the existence of covert copper deficiency among segments of the population is unknown. On the other hand, at much higher level of copper, toxic effects can occur in the human body. The term 'Copper' in this profile not only refers to copper metal but also a number of compounds of copper that may be in the environment (Public

Table 1. Amount of Cu (µg/g) in diverse pulses in different upazilas of Chittagong area, Bangladesh

Biological name of the pulses	English name of the pulses	Bengali name of the pulses	Name of the Upazilas	Amount of Cu (µg/g) in pulses
Vigna muungo	Black gram	Mash kalai	Hathazari	6.0849
			Anowara	29.6531
			Rawzan	4.5689
			Mirsharai	5.5068
			Chandanaish	5.8992
Phaseolus vulgaris	Southern pea	Felon kalai	Hathazari	5.4816
			Anowara	6.1131
			Rawzan	5.2909
			Mirsharai	8.3307
			Chandanaish	7.3216
Phaseolus aureus	Green gram	Mung dal	Hathazari	13.4143
			Anowara	8.6386
			Rawzan	5.7780
			Mirsharai	8.4467
			Chandanaish	8.8658
Lathyrus sativus	Grass pea	Kheshari dal	Hathazari	15.6971
			Anowara	24.9360
			Rawzan	6.7716
			Mirsharai	3.2250
			Chandanaish	12.0331

Table 2. Amount of Cu (µg/g) in diverse bananas in different upazilas of Chittagong area, Bangladesh

Biological name of the bananas	English name of the bananas	Bengali name of the bananas	Name of the Upazilas	Amount of Cu (µg/g) in bananas
Musa sapientum	Lady finger banana	Bangla kala	Hathazari	1.10
			Anowara	1.12
			Satkania	1.22
			Lama	1.89
			Ramgarh	1.11
Musa acuminata	Champa banana	Champa kala	Hathazari	2.141
			Anowara	1.831
			Satkania	1.943
			Lama	1.804
			Ramgarh	1.167
Musa cavendishii	Cavendish banana	Sagor kala	Hathazari	1.162
			Anowara	4.302
			Satkania	5.685
			Lama	1.318
			Ramgarh	1.617
Musa paradisiaca	Green banana	Kanch kala	Hathazari	1.585
			Anowara	0.835
			Satkania	0.595
			Lama	7.861
			Ramgarh	1.736

Table 3. Amount of Cu (µg/g) in diverse vegetables in different upazilas of Chittagong area, Bangladesh

Biological name of the vegetables	English name of the vegetables	Bengali name of the vegetables	Name of the Upazilas	Amount of Cu (µg/g) in vegetables
Enhydra fluctuans	Water cress	Helencha Shak	Hathazari	2.96
			Patia	1.83
			Anowara	1.97
			Pahartali	3.00
			Fatickchari	2.06
Alternanthera philoxeroides	Alligator weed	Moloncha Shak	Hathazari	3.67
			Patia	2.92
			Anowara	1.69
			Pahartali	4.64
			Fatickchari	1.16
Ipomoea aquatica	Swamp cabbage	Kolmi Shak	Hathazari	2.97
			Patia	1.28
			Anowara	4.45
			Pahartali	4.40
			Fatickchari	3.19
Centella asiatica	Indian pennywort	Thankuni Pata	Hathazari	5.46
			Patia	4.49
			Anowara	14.42
			Pahartali	15.13
			Fatickchari	2.42

Table 4. Amount of Cu (µg/g) in diverse arums in diverse upazilas of Chittagong area, Bangladesh

Biological name of the arums	English name of the arums	Bengali name of the arums	Name of the Upazilas	Amount of Cu (µg/g) in arums
Colocasia esculenta	Eddoe	Pani Kachu	Patiya	49.7008
			Chandanish	2.10611
			Satkaniya	2.188
			Lohagara	1.72609
			Boalkhali	3.5049
Typhonium trilobatum	Taro	Mukhi Kachu	Patiya	13.2071
			Chandanish	2.456
			Satkaniya	4.037
			Lohagara	2.1395
			Boalkhali	0.8836
Alocasia indica	Giant taro	Man kachu	Patiya	1.0358
			Chandanish	1.3151
			Satkaniya	4.72
			Lohagara	1.2209
			Boalkhali	2.6815
Amorphophallus campanulatus	Elephant foot yam	Oal Kachu	Patiya	1.6081
			Chandanish	2.5544
			Satkaniya	0.8298
			Lohagara	2.8815
			Boalkhali	2.6815

Health Service, 2004).

Nearly all selected area of the Chittagong region in Bangladesh, the value of copper was found in diverse pulses (Table 1) with some exception, which is almost the same (around 5-8 µg/g) that is comparatively about ten times lower than that of same species in India (Zia-Ul-Haq *et al*., 2011). But the *Vigna muungo* pulses of Anowara upazila, Chittagong contains the highest amount of copper i.e. around 30 µg/g, whereas the value of copper in other selected regions of Chittagong were around five times lower than that of Anwara and the second highest amount of copper was found i.e. approximately 25 µg/g in the same upazila in *Lathyrus sativus* pulses.

Table 2 summarized the amount of copper was found in various species of banana in different region of Chittagong. The value of copper for the species of *Musa sapietum* and *Musa acuminata* in different upazila of Chittagong was observed to be nearly about the same values varying between 1.10 µg/g to 2.15 µg/g. For the species of *Musa cavendishii*, the value of copper found in Ramgarh, Lama and Hathazari were around 1.16 µg/g, 1.31 µg/g and 1.62 µg/g, respectively. But in Anowara and satkania upazila the value of copper contained was around 4.30 µg/g and 5.69 µg/g, respectively, which is comparatively higher than those of other upazila. The green banana (species of *Musa paradisiaca*) of Hathazari and Ramgarh contained comparatively the same amount of copper (about 1.60 µg/g and 1.70 µg/g respectively). But in *Lama upazila* this value (around 7.9 µg/g) was interestingly five times higher than those of other regions, whereas the green banana of Anowara and Satkania contained comparatively much lower amount of copper (around 0.83 µg/g and 0.60 µg/g respectively). It is observed from another investigation (Joshua *et al.*, 2010) in Nigeria, the value of copper of diverse species of Banana is comparatively much higher than those of Bangladesh. The lady finger (*Musa Sapientum*) banana of Nigeria contained more than 15 times higher amount of copper than those of Chittagong area of Bangladesh.

According to this investigation, the amount of

copper in the different species of vegetables e.g., *Enhydra fluctuans*, *Centella asiatica*, *Ipomoea aquatica* and *Alternanthera philoxeroides* in different upazila of Chittagong area were varied from around 1.5 µg/g to 5.0 µg/g (Table 3). But the vegetable of the species *Centella asiatica* in Pahartali (around 15.0 µg/g) and Anowara (around 14.0 µg/g) upazila contained more than three times higher than the other selected area and species comparatively. An investigation of copper contents in diverse vegetables of India (Monu *et al.*, 2008; Nirmal *et al.*, 2009; Sumayya *et al.*, 2010) and Pakistan (Sumayya *et al.*, 2010; Javid *et al*., 2010; Mahwash *et al.*, 2011) showed that the amount of copper present in diverse vegetables in Pakistan and India is comparatively higher than those regions of Bangladesh.

Arums of Bangladesh are also an important source of copper. The research showed (Table 4) that the amount of copper of different species of arums e.g. *Colocasia sculenta*, *Typhonium trilobatum*, *Alocasia indica* and *Amorphophallus campanulatus* in various upazila of Chittagong were found to be around 1.0-4.0 µg/g. But the species of *Colocasia esculenta* and *Typhonium trilobatum* in *Patiya upazila* contained much higher value of copper (e.g. around 50.0 µg/g and 13.0 µg/g respectively) than those of other regions. The result has also indicated that the amount of copper in diverse arums of different upazila of Chittagong area in Bangladesh is greater than that of Tanzania and Uganda (Ndabikunze *et al.*, 2011).

Overall, the amount of copper in arums (1-50 µg/g) is comparatively higher than that of Pulses (3-30 µg/g), Bananas (1-8 µg/g) and Vegetables (1-15 µg/g). Specially, *Colocasia esculenta*, one species of arum contained the highest value of copper and the amount was around 50.0 µg/g.

Conclusions

Bangladesh is a densely populated country. About 31.5% people live below the poverty line (Economy of Bangladesh-Wikipedia). As a result, they are not able to buy copper sufficient food. People who suffer from copper deficiency, can get relieve of their diseases by selecting the copper rich pulses, bananas, vegetables and arums which can easily grow in the field or easily available from the local market. This study provides a base line data for our efforts directed towards maintaining a healthy life style.

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