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HEAVY METAL CONCENTRATION IN COMMONLY SOLD STEM VEGETABLES IN DHAKA CITY MARKET AND PROBABLE HEALTH RISK

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Key words: Stem vegetables, Kawran Bazar market, Heavy Metal, Average daily intake, Hazard Quotient, Hazard index

Abstract

The present study was carried out to assess the concentration of chromium (Cr), cadmium (Cd), lead (Pb), nickel (Ni), copper (Cu), zinc (Zn), iron (Fe) and manganese (Mn) in four stem vegetables such as Potato (*Solanum tuberosum* L.), Ginger (*Zingiber officinale* Roscoe), Garlic (*Allium sativum*L.) and Onion (*Allium cepa* L.) by using Atomic Absorption Spectrophotometer (AAS). Average daily intake (ADI), hazard quotient (HQ) and hazard index (HI) were also estimated to assess the human health risks posed by heavy metals from the consumption of the studied vegetables. The studied stem vegetable samples were collected in four phases from Kawran Bazar fresh vegetable market of Dhaka city of Bangladesh. Mean concentrations of Cr, Cd, Pb, Ni, Cu, Zn, Fe and Mn in the studied stem vegetables ranged between 0.88 to 2.35, 0.08 to 0.15, 0 to 2.25, 0 to 3.30, 5.70 to 9.85, 18.83 to 40.67, 50.60 to 456.38 and 9.23 to 852.35 mg/kg of dry weight, respectively. Mean concentration of maximum permissible limit (MPL) exceed in onion for Cr, in potato and onion for Pb and in ginger for Fe, Ni and Mn. Average daily intake was found to be lower than the maximum permitted tolerable daily intake in most cases except for Mn (26.475 mg/person/day) for consumption Ginger. Hazard quotient of Mn for dietary intake of Ginger (3.152) and hazard indices of Ginger (4.626), Garlic (1.183) and Onion (1.069) exceeded unity, signifying potential health risks from the dietary intake of these vegetables. This study suggests regular monitoring of heavy metals in vegetables to avoid the potential health hazards on human.

Introduction

Trace heavy metals (Cu, Fe, Zn, Mn) are essential to maintain human metabolism but when exceed the range are toxic in nature and the contamination of food stuffs by heavy metals is of great concern for human health. This problem is receiving more and more attention all over the world and particularly in developing countries like Bangladesh. Heavy metals are being excessively released into the environment due to

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rapid urbanization and industrialization. Heavy metals are extremely persistent in the environment; they are non-biodegradable and non-thermo degradable and thus their accumulation readily reaches to toxic levels(1). Plants are able to mobilize and accumulate nonessential trace elements because of chemical similarity to other essential elements or ions(2). If excessive amounts of these trace elements are accumulated in a plant, a pathway is created for potentially hazardous trace elements to enter the food chain and impact on human health(1,2).

Vegetables forms the major part of our daily diet and it is an important source of vitamin and minerals required for human health. Vegetables are considered as the cheap source of energy in Bangladesh. They are very common source of essential nutrients such as carotene, protein, vitamins, calcium, iron, ascorbic acid and palpable concentration of minerals(2). The contamination of vegetables with heavy metals due to soil and atmospheric pollution poses a threat to its quality and safety. The uptake and bioaccumulation of heavy metals in vegetables are influenced by many factors such as climate, atmospheric deposition, the concentration of heavy metals in soil, the nature of soil and the degree of maturity of the plants at the time of harvesting(3). Air pollution may pose a threat to post-harvest vegetables during transportation and marketing causing elevated levels of metals in vegetables. In a developing country like Bangladesh, urbanization and industrialization may significantly contribute to elevate the heavy metal loads in atmosphere as well as in soil which consequently through bioaccumulation increases the heavy metal concentration in vegetables to a toxic level.

Heavy metals pose a serious threat because of their toxicity, bioaccumulation and bio magnification in food chain(4). Even low concentrations of heavy metals have damaging effects to man and animals because there is no good mechanism for their elimination from the body. The ingestion of excessive heavy metal contaminated vegetables may lead to various long-term lingering diseases. The chronic buildup of heavy metals in the liver and kidney of human results in disruption of many biochemical processes, which leads to nervous, kidney, cardiovascular and bone diseases. High concentrations of Cd and Pb in vegetables are related to high prevalence of gastrointestinal cancer(4).

Soil and water pollution by heavy metals is one of the reasons of metal accumulation in vegetables. Nowadays heavy metals are ubiquitous because of their excessive in industrial applications. Wastewater contains substantial amounts of toxic heavy metals, which create problems(4,5).Vegetable contamination and human exposure result from anthropogenic activities such as industrial production and use, mining and smelting operations, exhaust from vehicles, untreated sewage sludge, solid waste dumping on agricultural lands and rivers, agricultural activities like indiscriminant use of fertilizers, animal manures, pesticides and wastewater irrigation of agricultural land. An attempt has been taken to determine the heavy metal concentrations in stem vegetables available in Dhaka city markets and potential health risks on the residents via dietary intake of the studied stem vegetables considering the over population and pollution of the city.

Materials and Methods

Study area: The present study was carried out by collecting samples from Kawran Bazar vegetable market, Dhaka. Kawran Bazar is the biggest wholesale market near the Farmgate area of Dhaka city. The vegetables in this market mainly come from Savar, Munshiganj, Narsingdi, Mymensingh, Kishoregonj, Rajshahi, Jessore, Kushtia, Bogra, Chittagong etc. All kinds of vegetables, fish, rice and different commodities are supplied to the other fresh markets of Dhaka city from Kawran Bazar. Therefore, this study gave a representative result of vegetables found in other vegetable markets of Dhaka city.

Sample collection: Four different native stem vegetable samples were collected in 4 phases with at least 14 days interval for 2 months. In each sampling phase fresh raw samples of the stem vegetables were randomly purchased and brought to the laboratory. The details of the vegetable samples collected from the study area are shown in Table 1.

Table 1. Description of the collected and analyzed stem vegetable samples.

Common name	Botanical name	Local name	Moisture content (%)
Potato	*Solanum tuberosum* L.	Alu	79.0
Ginger	*Zingiber officinale* Roscoe	Ada	81.3
Garlic	*Allium sativum* L	Roshun	69.0
Onion	*Allium cepa* L	Peaj	86.0

Sample preparation and preservation: The collected vegetable samples were washed thoroughly with fresh tap water and rinsed three times with distilled water to remove surface pollutants and any items adhering to the surfaces. Samples were sliced into small pieces and open air dried on paper for about 2 hours to eliminate excess moisture. Fresh weight of each sample was taken, then dried in an oven at 60-70° C for 72-96 hours depending on the sample size and reweighed to determine the dry weight. The dried vegetable samples were ground by means of a clean pestle and mortar and passed through a 0.2 mm sieve to obtain homogenized sample. The powdered samples were then preserved in labeled clean dry polythene bags at ambient temperature before analysis.

Digestion of the sample: One gram of the oven dried sample was weighed into 100 ml beaker, followed by the addition of 10 ml conc. HNO_3 and 2 ml conc. $HClO_4$. The digestion was carried out on a hot plate at 150-200°C. After digestion, the samples were cooled, filtered, made up to 100 ml in a volumetric flask and then preserved in plastic bottle for analysis.

Analysis of the samples: Concentration of heavy metals i.e. Chromium, Cadmium, Lead, Nickel, Copper, Zinc, Iron and Manganese in the extracts were analyzed by using Varian AA 240 Atomic Absorption Spectrophotometer.

Average Daily Intake (ADI): The ADI of a heavy metal was calculated as a product of average vegetable daily consumption per person, percentage of dry weight of vegetables, and average heavy metal concentration per dry weight vegetable as shown in the following equation[6]:

$$ADI = Av_{consumption} \times \%\ DW_{vegetable} \times C_{heavy\ metal}$$

Where ADI is average daily intake of heavy metal per person per day (mg/person/day), $Av_{consumption}$ is average daily consumption of vegetable per person per day (g/day), % $DW_{vegetable}$ is percentage of dry weight of vegetable (%DW = [(100– % moisture)/100]), and $C_{heavy\ metal}$ is average heavy metal concentration of dry weight vegetable (mg/g). The average daily consumption of vegetables reported by Household Income and Expenditure Survey of Bangladesh is 166.1 g per person[7]. The value 166.1 g/person/day is used in calculating the ADI values and an average weight of person is considered to be 60 kg[8]. If the ADI is above the maximum permissible daily intake (MTDI) value it may cause various health hazards.

Hazard Quotient (HQ): Hazard quotient is a proportion of the probable exposure to an element/chemical and level at which no negative impacts are expected. When the quotient is <1, this means no potential health effects are expected from exposure, but when it is >1, it signifies that there are potential health risks due to exposure[9]. The HQ is calculated as a fraction of determined dose to the reference dose as shown in the following equation:

$$HQ = ADI/R_fD$$

Where ADI is the average vegetables intake per day (mg/kg/day) and R_fD is the oral reference dose of the metal (mg/kg/day). R_fD is an approximation of daily tolerable exposure to which a person is expected to have without any significant risk of harmful effects during a lifespan. R_fD for Pb, Zn, Cu, Cd, Cr, Ni, Fe and Mn is 0.004, 0.3, 0.04, 0.0005, 0.003, 0.02, 0.7 and 0.14 mg/kg/day, respectively[10].

Hazard Index : An exposure to more than one pollutant results in additive effects. Thus, hazard index (HI) is a vital index that assesses overall likely impacts that can be posed by exposure to more than one contaminant. When the HI is >1, this suggests that there are significant health effects from consuming pollutants contained in a foodstuff. The HI is calculated as an arithmetic sum of the hazard quotients for each pollutant as shown in the following equation[6]:

$$HI = \sum_{i=1}^{n} HQ$$

Statistical analysis: The results of the experiment were statistically evaluated by using ANOVA (Analysis of Variance) and Duncan's Multiple Range Test in IBM SPSS statistics version 20[11]. The letter was used for testing the significance of differences between mean values. The 0.05 level of probability was chosen for the statistical judgment.

Results and Discussion

Metal concentration in stem vegetables: Mean concentrations of the lead, nickel and iron in the studied stem vegetables varied significantly ($p<0.05$), but mean concentration of chromium, cadmium, copper, zinc and manganese revealed no significant variation ($p<0.05$) (Table 2). Mean concentrations of Cr, Cd, Pb, Ni, Cu, Zn, Fe and Mn in the studied stem vegetables ranged between 0.88 to 2.35, 0.08 to 0.15, 0 to 2.25, 0 to 3.30, 5.70 to 9.85, 18.83 to 40.67, 50.60 to 456.38 and 9.23 to 852.35 mg kg^{-1} of dry weight, respectively. Mean Cr concentration in Onion; Pb concentration in Potato and Onion; Ni, Fe and Mn concentration in Ginger were found to be higher than the Maximum Permissible Limit (MPL)[12-14].

Concentration of heavy metals in stem vegetables collected in in each phase was also compared with maximum permissible limit suggested by FAO/WHO[12-14]. Concentration of Cr was found to be higher in Ginger collected in 3rd and 4th phase and in Onion collected in 2nd and 3rd phase. Cadmium concentration was found to be higher than the MPL in Potato, Ginger and Garlic collected in 2nd phase. Potato collected in 3rd phase; Ginger collected in 2nd phase and Onion collected in 2nd, 3rd and 4th phase showed higher concentration of Pb then the MPL. Concentration of Ni was higher than the MPL in Ginger collected in 3rd and 4th phase of sampling. Copper concentration in Ginger collected in 3rd phase, Garlic collected in 4th phase and Onion collected in 2nd phase showed higher value than the MPL. Zinc concentration was found to be higher in Ginger collected in 1st and 3rd phase. Concentration of Fe exceeded the MPL in Ginger collected in 3rd and 4th phase and Mn concentration was higher than the MPL in Ginger collected in 3rd phase of sampling.

Highest mean concentrations of Cr, Pb and Cu were observed in Onion; Cd was observed in Garlic; Ni, Zn, Fe and Mn were observed in Ginger. Lowest mean concentrations of Cr, Pb, Zn and Fe were found Garlic; Cd in Potato and Onion; Ni in Onion; Cu and Mn in Potato. The comparison among the studied stem vegetables revealed that mean Cr and Pb concentrations decreased in the order of Onion > Potato > Ginger > Garlic, mean Cd concentration decreased in order of Garlic > Ginger > Potato and Onion, mean Ni concentration decreased in order of Ginger > Garlic > Potato > Onion, mean Cu concentrations decreased in order of Onion > Garlic > Ginger > Potato, mean Zn and Fe concentration decreased in order of Ginger > Onion > Potato > Garlic and mean Mn concentration decreased in the order of Ginger > Onion > Garlic > Potato.

Table 2. Concentration of heavy metals in studied stem vegetables (mg/kg dw).

	Concentration of Cr (mg/kg dw)					Concentration of Cd (mg/kg dw)				
Stem vegetables	1st phase	2nd phase	3rd phase	4th phase	Mean (mg/kg)	1st phase	2nd phase	3rd phase	4th phase	Mean (mg/kg)
Potato	0.50	0.00	2.30	1.20	1.00 a	0.00	**0.30**	0.00	0.00	0.08 a
Ginger	0.90	1.00	**3.20**	**2.60**	1.93 a	0.20	**0.30**	0.00	0.00	0.13 a
Garlic	0.30	0.50	1.60	1.10	0.88 a	0.20	**0.40**	0.00	0.00	0.15 a
Onion	0.50	**3.00**	**4.20**	1.70	**2.35 a**	0.20	0.10	0.00	0.00	0.08 a
MPL[12,13]	2.3 mg/kg					0.20 mg/kg				
	Concentration of Pb (mg/kg dw)					Concentration of Ni (mg/kg dw)				
Stem vegetables	1st phase	2nd phase	3rd phase	4th phase	Mean (mg/kg)	1st phase	2nd phase	3rd phase	4th phase	Mean (mg/kg)
Potato	0.00	0.00	**4.00**	0.00	**1.00 ab**	0.00	0.00	0.80	0.00	0.20 a
Ginger	0.00	**1.00**	0.00	0.00	0.25 a	2.20	0.00	**4.50**	**5.40**	**3.03 b**
Garlic	0.00	0.00	0.00	0.00	0.00 a	0.00	0.00	1.00	0.00	0.25 a
Onion	0.00	**4.00**	**4.00**	**1.00**	**2.25 b**	0.00	0.00	0.00	0.00	0.00 a
MPL[12]	0.30 mg/kg					0.20- 2.70 mg/kg				
	Concentration of Cu (mg/kg dw)					Concentration of Zn (mg/kg dw)				
Stem vegetables	1st phase	2nd phase	3rd phase	4th phase	Mean (mg/kg)	1st phase	2nd phase	3rd phase	4th phase	Mean (mg/kg)
Potato	6.30	2.20	7.40	6.90	5.70 a	22.44	13.78	23.34	31.49	22.76 a
Ginger	6.50	3.30	**11.60**	5.50	6.73 a	**57.67**	13.97	**72.26**	18.78	40.67 a
Garlic	6.30	0.80	6.60	**14.70**	7.10 a	25.43	25.98	8.98	14.94	18.83 a
Onion	8.80	**13.90**	9.10	7.60	9.85 a	17.76	30.81	35.27	24.19	27.01 a
MPL[12]	10 mg/kg					50 mg/kg				
	Concentration of Fe (mg/kg dw)					Concentration of Mn (mg/kg dw)				
Stem vegetables	1st phase	2nd phase	3rd phase	4th phase	Mean (mg/kg)	1st phase	2nd phase	3rd phase	4th phase	Mean (mg/kg)
Potato	100.00	25.00	48.80	68.10	60.48 a	6.3	12.1	10.5	8.0	9.23 a
Ginger	314.90	107.60	**723.40**	**679.60**	**456.38 b**	327.5	140.4	**2657.2**	284.3	**852.35 a**
Garlic	37.50	28.30	64.30	72.30	50.60 a	5.7	8.7	22.9	11.7	12.25 a
Onion	87.40	59.40	132.40	54.90	83.53 a	9.2	16.5	32.7	14.5	18.23 a
MPL[14]	**450 mg/kg**					**500 mg/kg**				

Mean values with same letter(s) in a column do not differ significantly from each other at 5% level by DMRT.

The result obtained from the present study revealed that the concentrations of heavy metals in the studied stem vegetables are from background levels for some metals to excess level when compared with the standard limits. In previous researches it was observed that Zn, Cd and Pb concentrations in Potato collected form industrial area in Kushtia of Bangladesh were higher than the maximum permissible limit[(15)]. Higher concentrations of Pb and Cd than the MPL were found in Onion collected from fresh markets in the Lower North of Thailand[(16)]. Lead concentration in Potato collected from Jharkhand of India was higher than the MPL[(17)] which is in compliance with the present study. But concentrations of heavy metals were lower than the maximum permissible limit in stem vegetables was observed in Bangladesh[(2)].

The excess level of heavy metals in vegetables may be incorporated via contaminated soil, irrigated waste water or others[(5)]. Soils may be contaminated by accumulation of heavy metals and metalloids through emissions from rapidly expanding industrial areas, mine tailings, disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, waste water irrigation, coal combustion residues, spillage of petro chemicals and atmospheric deposition[18]. Intensive uncontrolled operation of various industries has resulted in the release of trace metals in the local environment[(5)]. Vegetables grown in the nearby sites are contaminated by relevant metals, especially Zn, Cd and Pb. Tannery industries around Dhaka city acts as the major source of Cr[(5)]. Transportation and marketing of vegetables may elevate the levels of heavy metals in vegetables through surface deposition[(19)].

Average Daily Intake (ADI) of heavy metals: The average daily intakes of heavy metals were calculated according to the concentration of each metal in each stem vegetable. The mean ADI values and the Permitted Maximum Tolerable Daily Intake (PMTDI) of the studied metals via dietary intake of the studied stem vegetables are represented in Table 3. Mean ADI values of the heavy metals from the consumption of studied stem vegetables revealed no significant variation except for Pb, Ni and Fe (Table 3). Mean ADI values of all the heavy metals were below the PMTDI except for Mn by consumption of Ginger as endorsed by FAO/WHO[(8,10,12,18,-21)]. Mean ADI values of Cr, Cd, Pb, Ni, Cu, Zn, Fe and Mn ranged from 0.035 to 0.060, 0.002 to 0.008, 0.00 to 0.052, 0.00 to 0.094, 0.199 to 0.366, 5.351 to 8.602, 1.942 to 14.175 and 0.322 to 26.475 mg/person/day, respectively.

The order of contribution for Cr intake via dietary consumption of studied stem vegetables was Ginger > Onion > Garlic > Potato, for intake of Cd was Garlic > Ginger > Potato > Onion, for intake of Pb was Onion > Potato > Ginger > Garlic, for intake of Ni, Zn and Fe were Ginger > Garlic > Potato > Onion, for intake of Cu was Garlic > Onion > Ginger > Potato and for Mn intake was Ginger > Garlic > Onion > Potato.

Iron, copper, zinc and manganese are essential metals for humans, since they play an important role in the biological systems, but these essential heavy metals can produce toxic effects when there is excessively elevated[(2)]. A copper surplus can cause acute stomach and intestine aches and liver damage[17]. Toxicity of zinc due to excessive intake may lead to electrolyte imbalance, nausea, anemia and lethargy[4,17]. The gradual buildup of iron or iron overload in human body causes hereditary hemochromatosis. Untreated hemochromatosis increases the risk of arthritis, cancer, liver problems, diabetes and heart failure[2,4,17,21]. Chronic exposure effects result in neurological disorder like Parkinson's disease[21].

Table 3. Average daily intake of heavy metals (mg/person/day).

Name of stem vegetables	Average Daily Intake (mg/person/day)							
	Cr	Cd	Pb	Ni	Cu	Zn	Fe	Mn
Potato	0.035 a	0.003 a	0.035 ab	0.007 a	0.199 a	6.179 a	2.109 a	0.322 a
Ginger	0.060 a	0.004 a	0.008 a	0.094 b	0.209 a	8.602 a	14.175 b	**26.475 a**
Garlic	0.045 a	0.008 a	0.000 a	0.013 a	0.366 a	6.751 a	2.605 a	0.631 a
Onion	0.055 a	0.002 a	0.052 b	0.000 a	0.229 a	5.351 a	1.942 a	0.424 a
PMTDI	**0.20**[18]	**0.046**[8]	**0.21**[8]	**0.30**[10]	**2.00**[12]	**20.00**[12]	**17.00**[12]	**2.0-5.0**[20]

Mean values with same letter (s) in a column do not differ significantly from each other at 5% level by DMRT.

Whereas metals such as cadmium, chromium, mercury and lead are cumulative poisons, which cause environmental hazards and are reported to be exceptionally toxic[5,21]. Cadmium exposures are associated with kidney and bone damage. Cadmium has also been identified as a potential human carcinogen, causing lung cancer[10]. Chromium can cause kidney, liver, gastrointestinal, cardiac, hematologic or reproductive disorders, growth problems, nasal perforation, corneal injury as well as cancer[22]. Lead can adversely influence the intelligence development of children and induce hypertension, nephropathy, fanconi syndrome and cardiovascular disease[4,21,22]. Nickel is not a cumulative poison, but larger doses or chronic inhalation exposure may be toxic, even carcinogenic[22,23,24].

Hazard Quotient (HQ) and Hazard Index (HI): The HQ values presented in Table 4 shows that for each of the eight types of heavy metals, the calculated HQ values were below 1 except for Mn in Ginger. The HQ value for Mn in Ginger was 3.15 which represented that the consumption of Ginger can pose severe health effects to the residents of Dhaka city. The HQ values for Cr, Cd, Pb, Ni, Cu, Zn, Fe and Mn were ranged from 0.19 - 0.33, 0.06 - 0.26, 0.00 - 0.22, 0.00 - 0.08, 0.08 - 0.15, 0.30 - 0.48, 0.05 - 0.34 and 0.04 - 3.15, respectively.

Table 4. Hazard Quotient for individual heavy metals and Hazard Index for consumption of individual stem vegetables.

Name of stem vegetables	Hazard quotient (HQ)								Hazard index (HI)
	Cr	Cd	Pb	Ni	Cu	Zn	Fe	Mn	
Potato	0.194	0.087	0.145	0.006	0.083	0.343	0.050	0.038	0.947
Ginger	0.332	0.129	0.032	0.078	0.087	0.478	0.338	**3.152**	**4.626**
Garlic	0.250	0.257	0.000	0.011	0.152	0.375	0.062	0.075	**1.183**
Onion	0.304	0.058	0.218	0.000	0.095	0.297	0.046	0.050	**1.069**

The comparison among studied stem vegetables revealed that HQ values for the metals decreased in the following order: **Cr:** Ginger > Onion > Garlic > Potato; **Cd:** Garlic > Ginger > Potato > Onion; **Pb:** Onion > Potato > Ginger > Garlic; **Ni:** Ginger > Garlic > Potato > Onion; **Cu:** Garlic > Onion > Ginger > Potato; **Zn:** Ginger > Garlic > Potato > Onion, **Fe:** Ginger > Garlic > Potato > Onion and **Mn:** Ginger > Garlic > Onion > Potato.

The Hazard Index of heavy metals due to consumption of four stem vegetables is represented in Fig. 1. The results showed that all the studied stem vegetables except Potato pose potential health risks as their HI values exceeded the unity[9]. The highest and lowest value was found to be 4.63 and 0.95 for consumption of Ginger and Potato respectively and the HI value decreased in order of Ginger>Garlic>Onion>Potato.

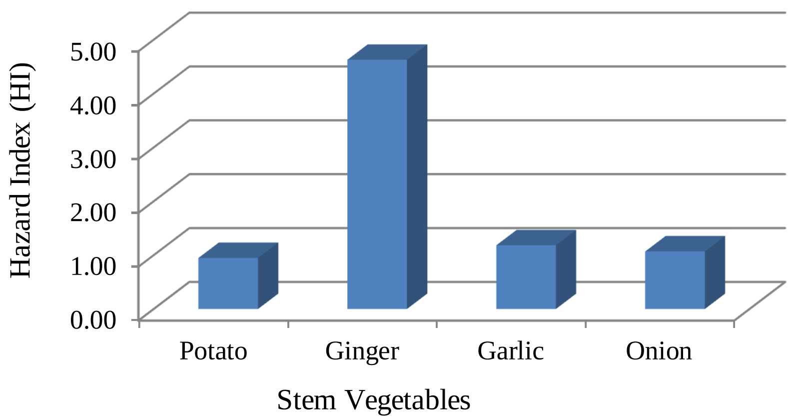

Fig. 1. Hazard Index for consumption of stem vegetables.

The Hazard Quotient (HQ) has been recognized as a useful parameter for evaluation of risk associated with consumption of metal contaminated food crops[25] and Hazard index (HI) is estimated as the sum of hazard quotients when more than one heavy metal is involved. Hazard index (HI) for consumption of most of the stem vegetables were found to be greater than 1 which indicated that there might be a potential health risk to those consuming these vegetables.

The study revealed the presence of heavy metals in four mostly consumed stem vegetables in Bangladesh as well as the average daily intake of heavy metals by consumption of the studied vegetables and their probable health risks on the resident of Dhaka city in terms of hazard quotient and hazard index. Mean concentration of the heavy metals was observed to exceed the maximum permissible limit except for Cd, Cu and Zinc in the studied stem vegetable samples. Except Mn from dietary intake of Ginger average daily intake of the studied metals were also below the permitted maximum tolerable daily intake. Among the studied stem vegetables except for potato all stem vegetables poses potential health risks to the residents.

Contamination of environment by heavy metals is of great concern due to its potential to contaminate food stuffs and their excessive buildup in human food chain. Environmentalists, administrators and public health workers should come forward to create public awareness to minimize environmental pollution and to avoid consumption of vegetables grown in polluted environment, hence reducing health risks. Regular monitoring of heavy metals in vegetables and extensive research also required to avoid extreme accrual in food chain. Very few studies have been carried out to estimate the health hazard caused by consumption of stem vegetables. Therefore, the finding of this study will significantly contribute to the field of food safety.

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