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Heavy metal concentration in wet market ginger and its assessment on public health risks

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Abstract

Heavy metals like Cr, Cu, Pb, and Zn can induce public health risks through consumption over time. Gingers of both native and foreign origin were randomly collected from two large wet markets, Karwanbazar and Shyambazar, Dhaka, Bangladesh and were analyzed to determine the concentrations of heavy metals using atomic absorption spectroscopy. The data were used to assess various health risk indices. From the results, it is observed that the Pb concentration of almost all the ginger samples was higher than the MPL and consumption of such samples can be considered hazardous. But the concentration of Cu and Zn in all of the ginger samples was found to be lower than the MPL. The ADI of Cr, Cu, Pb, and Zn in native ginger samples were all below the PMDTI. Moreover, HI of half of the imported ginger samples was above unity and therefore injurious to human health when consumed.

Keywords: Ginger; Wet market; Dhaka metropolis; Health risk; Metal concentration; Average daily intake

Introduction

Heavy metals are one of the key causes of food contamination and happen to be the current biggest health hazard issues (Zaidi *et al.* 2005). Excessive levels of heavy metals can reduce the security of plant-based meals and feeds as well as lower plant production (Zheljazkov *et al.* 2006). Globally, this issue is becoming more severe, especially in developing nations (Hezbullah *et al.* 2016).

During cultivation processes, vegetables readily absorb heavy metals and other toxic elements from the soil in high concentration (Intawongse *et al.* 2006). Bioaccumulation of such metals in large amounts in the edible parts of plants may take place even at their low soil concentrations (Zhou *et al.* 2016). The elements that must be consumed by humans to sustain and support typical physiological activities are known as essential trace elements. A progressive buildup of metals occurs when toxic heavy metals accumulate in body tissues more quickly than the body's detoxification systems can remove. Risk evaluations distinguish between two forms of trace element toxicity: one with large intakes that leads to toxicity (Tuzen and Soylak 2003), and the other with low ingestions that contribute to nutritional issues (Goldhaber, 2003).

Heavy metals are often non-biodegradable and have lengthy biological half-lives. These can accumulate in many human organs and might show harmful side effects (Radwan and Salama, 2006). Industrial emissions, transportation, storage, and marketing are all potential sources of heavy metal contamination to the agricultural fields. In addition, harvesting processes, irrigation with polluted water, adding fertilizer, and using metal-based pesticides enhance the contamination process further (Tuzen and Soylak, 2007; Duran *et al.* 2007). Such metals are seriously detrimental to the health of humans and can lead to cancer, diseases of the liver, heart, and a variety of other illnesses. Excessive metal exposure can cause a variety of injurious health consequences, including liver and kidney damage, mental retardation, loose stools,

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central nervous system (CNS) degeneration, hookworm illness, and degeneration of the basal ganglia in the liver and brain (Misra and Dinesh, 1991). An overabundance of heavy metals in the diet can lead to ailment of heart, nervous system, kidneys and bone as well (Sanchez-Castillo *et al.* 1998; Steenland and Boffetta, 2000). Lead-toxicity and its harmful consequence on human health are widely known. Consumption of this metal may pose a major risk to public health and could cause long-term human bodily symptoms such colic, constipation, and anemia

Ginger (*Zingiber officinale* Roscoe, Fam.: Zigiberaceae) is a most common spice ingredient in our daily food preparation. So, its cultivation process must be free of heavy metal contamination. Ordinarily, a farmed field receives heavy metals via irrigation water, chemical fertilizers, and pesticides which may easily be up taken into the ginger rhizome and can cause health threat. It is therefore necessary to carry out research on the concentration of heavy metals present in the commercially available gingers from the market. The objective of the present research was to determine the concentration of Cr, Pb, Cu, and Zn in the domestic and imported zinger samples. To evaluate the human health risks via calculating the average daily intake (ADI), hazard index (HI), and hazard quotient (HQ) was also targeted.

Materials and methods

Study area and sample collection

Experimental ginger (*Z. officinale*) samples for the present study were collected from two famous wet market of Dhaka Metropolis namely, Karwanbazar and Shyambazar (Table I). Fresh gingers of native (Narsingdi, Savar, Munshiganj, Kushtia, Rajshahi, Bogra, Kishoreganj, Jessore, Mymensingh, Chittagong, etc.) and foreign origin (India and China) are supplied in these two markets. Three different types of gingers were bought randomly from different stores of the above-mentioned markets. The chemical analysis for determining the heavy metal concentration of the samples were done in the Advanced Research Laboratory, Department of Soil, Water, and Environment; University of Dhaka.

Sample preparation and preservation

To eliminate excess moisture from the collected zinger samples, they were cut into thin slices and air dried openly on paper for ~ 2 h. Each sample was initially measured for fresh weight, then depending on sample sizes, it was oven-dried for 72-96 h at 60-70°C. Afterwards, the samples were weighed again to obtain the dry weight. The dried ginger samples were grounded in a mortar and pestle and then sieved via 0.2 mm sh screen. Before analysis, the grounded samples were carefully stored at an ambient temperature in properly labelled dry polythene bags with caution.

Table I. Abbreviations of the ginger samples studied

Sample names	Abbreviation
Shayambazar Native Ginger 1	SNG 1
Shayambazar Native Ginger 2	SNG 2
Karwanbazar Native Ginger 1	KNG 1
Karwanbazar Native Ginger 2	KNG 2
Karwanbazar Native Ginger 3	KNG 3
Shayambazar Indian Ginger 1	SIG 1
Shayambazar Indian Ginger 2	SIG 2
Shayambazar Indian Ginger 3	SIG 3
Shayambazar Chinese Ginger 4	SCG 4
Karwanbazar Indian Ginger 1	KIG 1
Karwanbazar Indian Ginger 2	KIG 2
Karwanbazar Indian Ginger 3	KIG 3
Karwanbazar Chinese Ginger 1	KCG 1
Karwanbazar Chinese Ginger 2	KCG 2
Karwanbazar Chinese Ginger 3	KCG 3

Digestion of the samples

A common acid-based digestion method was used for the sample (Blum *et al*. 1996; Alain *et al*. 2021; Samuel and Babatunde, 2021). In a 100 mL beaker, 1 g oven-dried sample was weighed and taken, along with 10 mL of concentrated HNO_3 and 2 mL of concentrated $HClO_4$ (E. Merck, Germany). Afterwards, the digestion was completed on a hot plate at a temperature between 150 and 200°C. After digestion the samples were taken away from the hot plate and allowed to cool down to normal room temperature. The samples were then filtered and poured into a volumetric flask with 100 mL of distilled water. The sample stock solution of 100 mL was preserved in a plastic bottle for further analysis.

Analysis of the samples

Atomic Absorption Spectrophotometer (Varian AA 240, Australia) was used to measure the concentrations of Cr, Cd, Pb, Ni, Cu, Zn, Fe, and Mn using a hollow cathode lamp (detection limits of 1.7963, 0.1986, 100, 3.5473, 20.0, 5.1260, 30.0, and 10.0 µg L^{-1}, respectively) at wavelengths of 357.9, 228.8, 283.3, 232, 324.7, 213.9, 248.3, and 279.5 nm, respectively. Intermittently, the standard solutions were used to check and maintain the sensitivity.

Average daily intake (ADI)

The ADI of heavy metals can be determined from the product of the average consumption daily of vegetable by each person, the average concentration of heavy metal per dry weight vegetable, and the percentage of vegetable dry weight (Kacholi and Sahu, 2018):

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

Where, ADI = the average intake on daily basis of heavy metals by each person each day (mg/person/day); $Av_{consumption}$ = the average consumption on a daily basis of vegetables by each person each day (g/day); $C_{heavymetal}$ = the average heavy metal concentration in dry weight vegetable (mg/g), and % $DW_{vegetable}$ is the percentage of dry weight of vegetable (% DW = [(100− % moisture)/100]). According to Household Income and Expenditure Survey of Bangladesh (HIES, 2011), each person consumes an average of 166.1 g of vegetables per day. The average weight of a human, 60 kg is taken into account when calculating the ADI values, which is 166.1 g/person/day (JECFA, 1993). The ADI may result in a number of health risks if it surpasses the maximum allowable daily intake threshold (MTDI).

Hazard quotient (HQ)

The hazard quotient exhibits a proportion of possible exposure to a chemical substance and the concentration at which no harmful impacts are expected. The quotient denotes potential health hazards owing to exposure when it is >1 and indicates no potential health impacts when it is <1 (Bermudez *et al.* 2011). The HQ can be determined as a ratio of the observed dose to the reference dose, such as:

$$HQ = \quad HQ = \frac{ADI}{R_f D}$$

In this equation, ADI is the average vegetable intake by each person each day (mg/person/day) while $R_f D$ denotes the oral reference dose of metal (mg/kg/day). $R_f D$ is a rough estimate of the amount of metal a person can be exposed to on a daily basis without posing a consequential risk of unfortunate health effects over the course of their lifetime. $R_f D$ for Cr, Cu, Pb and Zn is 0.003, 0.04, 0.004 and 0.3 and mg/kg/day, correspondingly (WHO/FAO, 2013).

Hazard index (HI)

When one is exposed to multiple pollutants, it results into additive harmful issues in one's health. Because of this, the hazard index (HI) is an essential parameter for assessing the comprehensive dangers associated with coming in contact with various pollutants. If the HI is greater than 1, it could suggest that ingesting tainted food has a detrimental effect on one's health. According to the following equation, the hazard index (HI) is measured as the arithmetic summation of the hazard quotients for each individual contaminant (Kacholi and Sahu, 2018):

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

Statistical analysis

Using Duncan's Multiple Range Test in IBM SPSS statistics version 20 and ANOVA (Analysis of Variance), the experiment findings were statistically analyzed as defined by Gomez and Gomez (1984). The former was utilized to evaluate if the variations in mean results were statistically notable. It was decided to use a probability threshold of 0.05 for statistical analysis.

Results and discussion

Heavy metal concentrations in ginger samples

The concentration of Cr, Cu, Pb, and Zn from five native ginger samples and ten foreign ginger samples obtained from the wet markets, Shyambazar and Karwanbazar, Dhaka have been presented in Table II and Table III, respectively.

Chromium (Cr)

Mean concentrations of Cr in the five native ginger varieties ranged from 0.00 - 2.82 mg/kg. The study depicted that mean levels of Cr in the native samples were generally below the Maximum Permissible Limit (MPL) of 2.30 mg/kg (FAO/WHO, 2011) except SNG 2 (Table II). Compared to the MPL, the Cr concentration in SNG 2 was 18.44% higher. Though the Cr concentration of KNG 2 is below the MPL, it did not significantly differ from that of SNG 2. The other three varieties, SNG 1, KNG 1 and KNG 3 showed no trace of Cr at all. Comparing the results, the mean Cr levels in the native ginger samples descended SNG 2 > KNG 2 > SNG 1, KNG 1, and KNG 3 (Table II).

Chromium concentrations in the collected ten foreign ginger samples are listed in Table III. The observations exhibited that there were noticeable variations in Cr concentrations in foreign ginger samples. The mean concentration of Cr varied from 0.00 - 14.10 mg/kg of DW. SCG 4 sample was found to have the maximum amount of Cr, almost 83.7% higher than the MPL. Both SCG 4 and KCG 1 showed higher Cr concentrations than the maximum permissible limit of 2.30 mg/kg

(FAO/WHO, 2011). While the Cr concentration of SIG 2 was lower than the MPL, it didn't show a significant difference from that of KCG 1. The rest of the varieties showed a Cr concentration of 0 mg/kg dw (Table III).

Elevated Cr concentration in vegetables may result due to irrigation of agricultural lands carried out with water polluted by tannery factories (Ullah, 1999; Nuruzzaman *et al.* 1995). Globally, about 51% of the total amount of Cr excreted into the soil is caused by the dumping of commercial commodities possessing chromium (Nriagu and Nieboer, 1988). Other significant sources of Cr discharge into soil are agricultural wastes and food scraps (5.3%), animal litter (3.9%), atmospheric debris and fallout (2.4%), and coal fly ash disposal from electrical utility industries and other factories (33.1%) (Nriagu and Nieboer, 1988). Numerous publications claimed that the areas around Dhaka had higher Cr concentrations (Ullah, 1999; Chamon *et al.* 2005; Elahi *et al.* 2010; Mondol *et al.* 2011). One plausible explanation for the increased concentration of Cr in vegetables is that they are cultivated on soils with a high Cr content.

Copper (Cu)

According to Table II, all the native ginger samples were safe for intake as the Cu concentrations were significantly below the MPL of 10 mg/kg dry weight, set by FAO/WHO (2001). The concentrations of Cu ranged from 3.48-4.37 mg/kg. The samples didn't have much significant variation in the mean Cu concentrations with SNG 1 possessing the maximum and SNG 2 possessing the least.

Copper concentrations in collected foreign ginger samples are presented in Table III which indicates that there were

Table II. Heavy Metal Concentrations in Native Ginger Samples

Types of native ginger	Metal concentrations (mg/kg dw)			
	Cr	Cu	Pb	Zn
SNG 1	0.00 a	4.37 d	4.00 c	20.25 c
SNG 2	2.82 c	3.48 a	1.00 a	7.98 a
KNG 1	0.00 a	3.90 c	3.00 bc	26.93 d
KNG 2	2.14 b	3.56 b	3.00 bc	34.18 e
KNG 3	0.00 a	3.60 b	2.00 ab	19.46 b
MPL (mg/kg)	2.30[1]	10.00[2]	0.30[2]	50.00[2]

[1](FAO/WHO, 2011) [2](FAO/WHO, 2001)
Means with the same letter (s) in a column do not differ significantly from each other at 5% level by DMRT.

Table III. Heavy Metal Concentrations in Foreign Ginger Samples

Foreign ginger type	Metal concentrations (mg/kg dw)			
	Cr	Cu	Pb	Zn
SIG 1	0.00 a	1.59 a	3.00 b	6.34 a
SIG 2	2.18 b	5.63 h	25.00 g	11.34 b
SIG 3	0.00 a	3.74 d	5.00 c	26.05 f
SCG 4	14.10 d	6.03 i	15.00 d	18.77 e
KIG 1	0.00 a	3.37 c	18.00 f	16.73 c
KIG 2	0.00 a	4.24 e	16.00 de	32.74 i
KIG 3	0.00 a	2.82 b	1.00 a	17.24 d
KCG 1	2.63 c	4.44 f	17.00 ef	28.84 g
KCG 2	0.00 a	6.24 i	18.00 f	39.43 j
KCG 3	0.00 a	5.02 g	0.00 a	28.90 h
MPL (mg/kg)	2.30[1]	10.00[2]	0.30[2]	50.00[2]

[1](FAO/WHO, 2011) [2](FAO/WHO, 2001)
Means with the same letter (s) in a column do not differ significantly from each other at 5% level by DMRT.

significant variations in the Cu concentrations found in ten foreign ginger samples. Cu concentration was lower than the MPL in all the collected foreign ginger samples without any exceptions. The maximum and minimum Cu concentrations were 6.24 and 1.59 mg/kg in KCG 2 and SIG 1, respectively. Heavy metals like Cu in the field could be ascribed to agricultural products that were added to the soil as fertilizer.

Lead (Pb)

The concentration of Pb in the different native ginger samples varies from 1.00 - 4.00 mg/kg which indicated that Pb concentration of all native ginger samples were above the MPL set at 0.30 mg/kg by FAO/WHO (2001). The maximum Pb concentration was observed (4.00 mg/kg) in SNG 1 and the minimum was observed (1.00 mg/kg) in SNG 2. The Pb concentration in SNG 1 was almost 92.5% higher than the MPL while in SNG 2, it was almost 70% higher. The juxta-position exhibited the average Pb content in the domestic ginger samples reducing in the sequence of SNG 1 > KNG 1 and KNG 2 > KNG 3 > SNG 2 (Table II).

Significant variations were shown in the concentration of Pb in ten studied foreign ginger samples presented in Table III. Pb concentrations were seen to be above the MPL in all foreign ginger samples except for KCG 3, which doesn't show any trace of Pb. Pb concentrations in foreign ginger samples varied starting from 0.00 - 25.00 mg/kg with the least being in KCG 3 and the highest in SIG 2. The Pb concentration in SIG 2 is shown 98.8% higher than the MPL. Ingestion of such high concentration of Pd is extremely injurious to health. Pb is a contaminant that is known to emanate from traffic activities, such as fuel combustion, lubricating oil, tire, and brake wear, road abrasion, and road runoff, which in one way or the other can impact roadside grown vegetables (Kacholi and Sahu, 2018).

Zinc (Zn)

Significant variations have been found in the mean concen-trations of Zn of the examined native ginger varieties (Table II). The study revealed that Zn concentration in native ginger samples was lower than the MPL of 50.00 mg/kg dry weight inscribed by FAO/WHO (2001). The concentration of Zn in native ginger samples ranged between 7.98 - 34.18 mg/kg, thus making them save to ingest. The highest and the lowest concentration of Zn was 34.18 mg/kg in KNG 2 and 7.98 mg/kg in SNG 2 respectively.

There can be seen significant variations in the Zn concentra-tion in the foreign ginger samples with the MPL as indicated by Table III. Zn concentrations were lower than the MPL in all the collected foreign ginger samples. The maximum and minimum Zn concentrations were 39.43 and 6.34 mg/kg in KCG 2 and SIG 1, respectively. Most of the samples collect-ed from Karwanbazar tended to have a higher concentration of Zn compared to the samples collected from Shayambazar (Table III). Even though Zn elements occur naturally in soil, human activity has increased the concentration of zinc. Most of the Zn gets added in the soil through industrial processes; including steel processing, mining as well as coal and waste combustion. Zinc concentrations in soil can also rise because of other types of pollution, such as high zinc concentrations in sewage sludge or industrial waste fluids, air deposition from adjacent industrial sources, and overuse or use of zinc-rich items. Because zinc accumulates in soil, plants constantly absorb more zinc than their bodies can consume (Greany, 2005). In some soils of Dhaka that have been already contaminated, a notably high concentration of Zn has been observed by Chamon *et al.* (2005) like Hazaribag bulk soil, Dhaka (3000 mg/kg) and Tejgaon soil, Dhaka (685 mg/kg). A higher Zn concentration in such polluted soils of Dhaka was also reported earlier by many authors (Ullah, 1999; Nuruzzaman *et al*. 1995; Mondol *et al.* 2011; and Elahi *et al.* 2010). Therefore, high content of Zn present in the soil might be one of the reasons for high Zn concentration in ginger collected from Karwanbazar, Dhaka.

Average daily intake of heavy metals present in stem vegetables

Average daily intake (ADI) of heavy metals

In order to gauge the danger to an organism's health, evaluat-ing the level of heavy metal exposure is essential (Othman, 2001). The number of heavy metals that humans are exposed to daily determines how harmful they are (Singh *et al.* 2010). In this study, the mean concentration of each heavy metal in consumable portions of the vegetables, the equivalent vegetable dry weight, and the average human body mass of 60 kg were taken into consideration. In addition, the average intake of eighty metals in a daily diet of 166.1g of edible vegetable (HIES, 2011) was also considered.

Table IV exhibits the average daily intake (ADI) of Cr, Cu, Pb and Zn as a result of consumption of five native ginger samples as well as their permitted maximum tolerable daily intake (PMTDI).

Chromium (Cr)

The ADI of Cr for all the local samples were seen to be below 0.20 mg/kg/day which is the suggested PMTDI by RDA (1989). ADI of Cr was seen to be within the span of 0.00 to 0.07 mg/kg/day. The SNG 1, KNG 1 and KNG 3 samples showed no signs of Cr concentration while the rest two

Table IV. Average daily intake of native ginger samples

Types of Ginger	Average Daily Intake (mg/kg/day)			
	Cr	Cu	Pb	Zn
SNG 1	0.00 a	0.11 b	0.10 d	0.51 b
SNG 2	0.07 b	0.08 a	0.02 a	0.19 a
KNG 1	0.00 a	0.11 b	0.08 c	0.74 d
KNG 2	0.06 b	0.10 ab	0.08 c	0.96 e
KNG 3	0.00 a	0.11 b	0.06 b	0.60 c
PMTDI (mg/person/day)	0.20[1]	2.00[3]	0.21[2]	20.00[3]

[1](RDA, 1989) [2](JECFA, 2003) 3 (FAO/WHO, 2011)
Means with the same letter (s) in a column do not differ significantly from each other at 5% level by DMRT.

samples of SNG 2 and KNG 2 showed very little Cr concentration which is still below the PMTDI limit. The Cr intake order was as follows: SNG 2 > KNG 2 > SNG 1, KNG 1 and KNG 3 (Table IV).

Table V exhibits significant variations in the ADI values of Cr from ingestion of ten foreign ginger samples as well as its PMTDI. ADI of Cr was seen to be within the span of 0.00 to 0.17 mg/kg/day which was below 0.20 mg/kg/day which is the suggested PMTDI by RDA (1989). Most of the foreign samples showed no evidence of Cr except for SCG 4 and KCG 1. SCG 4 seemed to have the highest concentration of Cr of 0.17 mg/kg/day which was still below the PMTDI limit.

Copper (Cu)

Table IV shows the overview of ADI for Cu in stem vegetables (native ginger). The values of ADI of Cu in studied native ginger samples showed no significant difference. The mean ADI values varied in the extent of 0.08 to 0.11 mg/kg/-day and reduced in the sequence of SNG 1, KNG 1 and KNG 3 > KNG 2 > SNG 2. Mean values of average intake on a daily basis of Cu by the consumption of the studied native ginger samples were less than 2.00 mg/kg/day which is the PMTDI inscribed by FAO/WHO, 2011.

The calculated rates of average daily intake of Cu through the dietary intake of ten foreign ginger samples are displayed in Table V. The ADI values showed no noticeable variations. The highest and the lowest value was estimated due to the consumption of SIG 2 and SIG 1, respectively. The mean values of ADI spanned between 0.03 to 0.14 mg/kg/day. It was discovered that the foreign ginger samples' average daily intake levels fell short of the FAO/WHO established PMTDI (2.00 mg/kg/day) (2011). Therefore, consumption of the foreign ginger samples deemed no danger from Cu contamination.

Lead (Pb)

Table IV represented significant variations in the ADI values of five native gingers as well as the PMTDI of Pb. The

Table V. Average Daily Intake of Foreign Ginger Samples

Types of ginger	Average daily intake (mg/kg/day)			
	Cr	Cu	Pb	Zn
SIG 1	0.00 a	0.03 a	0.06 c	0.13 a
SIG 2	0.06 b	0.14 d	0.63 h	0.29 c
SIG 3	0.00 a	0.12 c	0.13 d	0.66 h
SCG 4	0.17 d	0.07 b	0.18 e	0.22 b
KIG 1	0.00 a	0.07 b	0.38 g	0.36 e
KIG 2	0.00 a	0.10 c	0.39 g	0.80 i
KIG 3	0.00 a	0.05 ab	0.02 b	0.31 d
KCG 1	0.13 c	0.07 b	0.28 f	0.48 g
KCG 2	0.00 a	0.06 b	0.18 e	0.40 f
KCG 3	0.00 a	0.05 ab	0.00 a	0.29 c
PMTDI (mg/kg/day)	0.20[1]	2.00[3]	0.21[2]	20.00[3]

[1](RDA, 1989) [2](JECFA, 2003) 3 (FAO/WHO, 2011)
Means with the same letter (s) in a column do not differ significantly from each other at 5% level by DMRT.

average daily intake of Pb was below 0.21 mg/kg/day which is the PMTDI suggested by JECFA, 2003 for the consumption of native ginger. ADI of Pb was found within the range of 0.02 - 0.10 mg/kg/day.

The PMTDI and ADI of Pb from ten samples of foreign ginger are shown in Table V that represent significant variations in the ADI values. ADI of Pb was found within the range of 0.00 - 0.63 mg/kg/day. The ADI of Pb in SIG 2, KIG 1, KIG 2 and KCG 1 were found to be above 0.21 mg/kg/day which is the PMTDI suggested by JECFA, 2003. The sample SIG 2 had the highest concentration of Pb which is almost 66.67% higher than the PMTDI. Consumption of such a high concentration of Pb is extremely injurious to human health.

Zinc (Zn)

Table IV shows the overview of ADI for Zn in native ginger samples. The values of ADI of Zn in studied native ginger samples showed significant differences. The mean ADI values varied within the rnage of 0.19 - 0.96 mg/kg/day. Mean values of average intake on a daily basis of Zn by the ingestion of the studied native ginger samples were less than 20.00 mg/kg/day which is the PMTDI inscribed by FAO/WHO (2011).

The calculated values of ADI of Zn through consumption of ten foreign ginger varieties are illustrated in Table V. The ADI values showed significant variations. The highest and the lowest value was estimated due to the consumption of KIG 2 and SIG 1, respectively. The mean values of ADI span from 0.13 to 0.80 mg/kg/day. The average daily Zn consumption for the imported ginger samples was found to be below the 2011 FAO/WHO PMTDI (20.00 mg/kg/day). Zn is an essential element responsible for healthy development and growth of human beings. High Zn dietary intake can result in a variety of negative symptoms, including gastrointestinal corrosive effects, anxiety, sadness, and tiredness. However, there is no proof that Zn causes mutations in humans or causes cancer; instead, a Zn shortage may be a hazardous factor for the disease (Nriagu, 2007).

The ADI of heavy metals were established utilizing the concentration of each heavy metal in the samples of native and foreign ginger. The average ADI values as well as the PMTDI of the analyzed metals through dietary ingestion of the native and foreign ginger are shown in table IV and V respectively. The tested native ginger samples' ADI values for heavy metals varied widely, except for Cu. Conversely, after consumption, the heavy metals' ADI values in each of the examined samples of foreign ginger varied considerably.

Because of the consumption of foreign ginger, the values of ADI of the heavy metals, excluding Pb, were lower than the PMTDI. The largest supplement into the ADI of various heavy metals was observed by the ingestion of SIG 2 (Pb), KIG 1 (Pb), and KIG 2 (Pb and Zn). It discloses that there was a higher likelihood of heavy metal transmission through foreign ginger compared to native ginger samples.

Hazard quotient (HQ) and hazard index (HI)

To evaluate the hazardous health effect due to contamination of different vegetables with heavy metal collected from Shyambazar and Karwanbazar of Dhaka city, the hazard quotient (HQ) and the hazard index (HI) were determined. On the basis of the oral reference doses, the HQ values were measured. HI is an index of risk for the people residing in Dhaka city of ingesting these metals by consuming vegetables and it was estimated by the summation of HQ of all heavy metals for each individual native and foreign ginger sample.

The four heavy metals' HQ for ingestion of native ginger samples are depicted in Fig. 1. The observations showed that HQ values of each of the metals in each of the native ginger samples were not more than 1. So, consumers are free from health risks for ingestion of the native ginger. The comparison among the native ginger samples depicted that HQ values for the heavy metals ranged as follows: for Cr: 0.00-0.37; for Pb: 0.03-0.05; for Cu: 0.10-0.42; for Zn: 0.01-0.05.

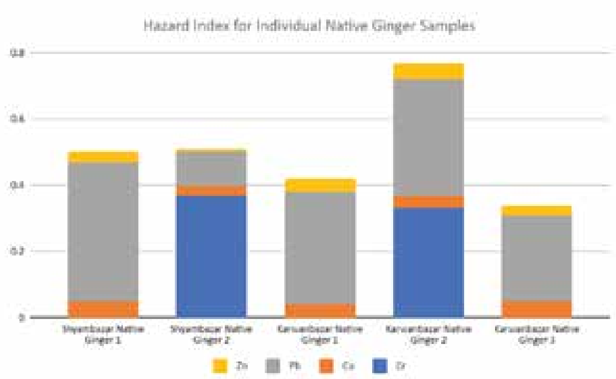

Fig. 1. Hazard quotient for each of the four heavy metals and hazard index for ingestion of each of the native samples

The HI values represented in Fig. 1 expressed health risks for consumption of all the native ginger samples. HI of native ginger sample which was below the unity and had no potential to cause health hazards due to consumption. The highest HI value was 0.78 for ingestion of KNG 2 and the lowest value was 0.34 for ingestion of KNG 3. The HI values reduced in the sequence of KNG 2 > SNG 2 > SNG 1 > KNG 1 > KNG 3.

The HQ values of trace metals present in foreign ginger varieties are depicted in Fig. 2. The observations showed that HQ values of Pb in SIG 2, KIG 1, KIG 2 and KCG 1 were more than 1. So, consumers are not free from risks for ingestion of these analyzed foreign gingers. The HQ values for heavy metals ranged as follows: for Cr: 0.00-0.92; for Cu: 0.01-0.06; for Pb: 0.00-2.65; and for Zn: 0.01-0.04 (Fig. 2).

The comparison of HQ values for the metals among foreign ginger samples exhibited, declined in a sequence of:

Cr: SCG 4 > KCG 1 > SIG 2 > SIG 1 > SIG 3 > KIG 1 > KIG 2 > KIG 3 > KCG 2 > KCG 3;

Pb: SIG 2 > KIG 2 > KIG1 > KCG 1 > KCG 2 > SCG 4 > SIG 3 > SIG 1> KIG 3 > KCG 3;

Cu: SIG 2 > SIG 3 > KIG 2 > KIG 1 > SCG 4 > KCG 1> KCG 2 > KCG 3 > KIG 3> SIG 1;

Zn: SIG 3 > KIG 2 > KCG 1 > SIG 2 > KIG 1 > KIG 3 > KCG 2 > KCG 3 > SIG 1 > SCG 4.

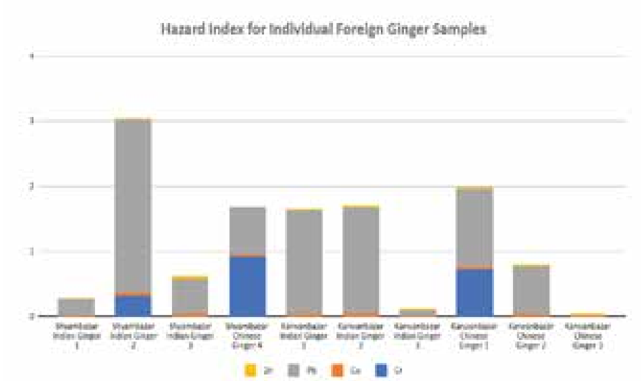

Fig. 2. Hazard quotient for each heavy metals and hazard index for consumption of each foreign ginger samples

The HI values represented in (Fig. 2) expressed health risks for consumption of all the foreign ginger samples. HI of half of the foreign ginger samples was above unity and had potential to cause health hazards due to consumption. The highest HI value was 3.03 for ingestion of SIG 2 and the lowest value was 0.04 for ingestion of KCG 3. The HI values decreased in order of SIG 2 > KCG 1 > KIG 2 > SCG 4 > KIG 1 > KCG 2 > SIG 3 > SIG 1 > KIG 3 > KCG 3.

The HI is quantified as the summation of the HQ when numerous heavy metals are present. It has been acknowledged as a helpful parameter for estimating the hazards linked with the intake of food crops contaminated by heavy metals (Zhuang *et al.* 2009).

Conclusion

Native and imported zinger samples (15) were collected from two different wet markets of Dhaka Metropolis, Bangladesh and were analyzed for their heavy metal concentration. Results show that most of the ginger samples had mean levels of heavy metal (Cr, Cu, Pb, and Zn) concentration that were above the maximum permissible limit. Pb intake values on a daily average were typically higher than the PMTDI. Other than Pb, the HQ values of the rest of the metals were <1 in the majority of the samples. However, the HI of almost all ginger samples were above 1 and it is quite concerning due to its carcinogenic effect on living beings' health. The majority of the trace metals mentioned have the potential to be hazardous, but the negative effects don't manifest until years or even decades of exposure. Therefore, it is recommended that heavy metal content in foods and vegetables should be monitored and evaluated routinely. In the present investigation, it has been exhibited that ginger may have a link to health risks, including cancer, kidney failure, immune system imbalance, and even death through biomagnification and bioaccumulation. A much more extensive study and research is required to evaluate the possibility of danger to human health and to avert a harmful risk-rise of these trace metals and contaminants in the food chain of humans. Sources of those contaminants could be water, plant, soil, and ginger entering into the markets and various industrial production sites. Limited and brief published facts are accessible on heavy metal levels in ginger from various market places in Bangladesh.

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References

Alain TK, Luc BT and Ali D (2021), Assessment of heavy metal concentration and evaluation of health risk of some vegetables cultivated in Loumbila Farmland, Burkina Faso, *J Environ Prot.* **12**: 1019-1032. DOI: 10.4236/jep.2021.1212060

Bermudez GMA, Jasan R, Pl´a R and Pignata ML (2011), Heavy metal and trace element concentrations in wheat grains: Assessment of potential non-carcinogenic health hazard through their consumption, *J Hazard Mater*. **193**: 264-271. DOI: 10.1016/j.-jhazmat.2011.07.058

Blum WEH, Spiegel H and Wenzel WW (1996), Bodenzutstandsinventur. Konception, Durchführung and Bewertung, Empfehlungen Zur Vereinheitlichung der Vorgangsweise in Österreich. Bundesministerium für Land und Forstwirtachaft, Wien. 1-19.

Chamon AS, Gerzabek MH, Mondol MN, Ullah SM, Rahman M and Blum WEH (2005), Influence of Soil Amendments on Heavy Metal Accumulation in Crops on Polluted Soils of Bangladesh, *Commun. Soil Sci. Plant Anal.* **36**(7-8): 907-924. DOI: 10.1081/css-200049472

Duran A, Tuzen M and Soylak M (2007), Trace element levels in some dried fruit samples from Turkey, *Int J Food Sci Nutr*. **59**: 581-589. DOI: 10.1080/13561820701507910

Elahi SF, Faiz B, Chamon AS and Mondol MN (2010), A project report on "Speciation of Heavy Metals in Soils, Plants and Water of Bangladesh". Ministry of Science and Information and Communication Tecnology, Government of the People's Republic of Bangladesh. Dhaka, Bangladesh. **36**.

FAO/WHO (2001), Food additives and contaminants, Joint Codex Alimentarius Commision, FAO/WHO Food Standards Programme, ALINORM **01/12A**: 1-289.

FAO/WHO (2011), Codex Alimentarius Commission, Joint FAO/WHO food standards programme codex committee on contaminants in foods, Food CF/5 INF/1, Fifth Session, The Hague, The Netherlands. 3-38.

Goldhaber SB (2003), Trace element risk assessment: essentially vs. toxicity, *Regul Toxicol Pharmacol*. **38**: 232-242. DOI: 10.1016/s0273-2300(02)00020-x

Gomez KA and Gomez AA (1984), Statistical procedures for agricultural research. 2nd Ed. John wiley and sons, NewYork. 680.

Greany KM (2005), An assessment of heavy metal contamination in the marine sediments of Las Perlas Archipelago, Gulf of Panama, M.S. thesis, School of Life Sciences Heriot-Watt University, Edinburgh, Scotland. **5**(1): 10-26.

Hezbullah M, Sultana S and Patwary Md (2016), Heavy metal contamination of food in a developing country like Bangladesh: An emerging threat to food safety, *Journal of Toxicology and Environmental Health Sciences*. **8:** 1-5. DOI: 10.5897/JTEHS2016.0352.

HIES (Household Income and Expenditure Survey) (2011), Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Dhaka, Bangladesh.

Intawongse M and Dean JR (2006), Uptake of heavy metals by vegetable plants grown on contaminated soil and their bioavailability in the human gastrointestinal tract. Food Additives & Contaminants **23**(1): 36-48. DOI: https://doi.org/10.1080/02652030500387554

JECFA (Joint FAO/WHO expert Coommittee on Food Additives) (1993), Evaluation of certain food additives and cotaminants: 41st report of JECFA, Technical report series no. 837, World Health Organization, Geneva.

JECFA (Joint FAO/WHO Expert Committee on Food Additives) (2003), Food additives and food contaminants, FAO procedural guidelines for the Joint FAO/WHO Expert Committee on Food Additives Rome, February 2003.

Kacholi DS and Sahu M (2018), Levels and Health Risk Assessment of Heavy Metals in Soil, Water, and Vegetables of Dar es Salaam, Tanzania, *J. Chem.* **10**: 1-9. DOI: 10.1155/2018/1402674

Misra SG and Dinesh D (1991), Soil Pollution, Ashing Publishing House, New Delhi.

Mondol MN, Chamon AS, Faiz B and Elahi SF (2011), Seasonal variation of heavy metal concentrations in water and plant samples around Tejgaon industrial area of Bangladesh, *J Bangladesh Acad. Sci.* **(35):** 19-41. DOI: 10.3329/jbas.v35i1.7968

Nriagu J (2007), Zinc Toxicity in Humans, Elsevier Publication, Michigan. 71-87. DOI: 10.1016/ B978-0-444-52272-6.00675-9

Nriagu JO and Nieboer E (1988), Chromium in the Natural and Human Environments. Advances in Environmental Science and Technology, John Wiley & Sons, New York. **20:** 1-571.

Nuruzzaman M, Gerzabek MH and Ullah SM (1995), Studies on Heavy Metal and Microbiological Pollution of Soils, Sediments and Water Systems in and Around Dhaka City; Bericht an die O¨ sterr. Akademie der Wissenschaften, Austrian Research Centers Seibersdorf (O¨ FZS): Vienna, Austria, 5-20.

Othman OC (2001), Heavy metals in green vegetables and soils from vegetable gardens in Dar es Salaam, Tanzania, Tanz. *J Sci.* **29**(1): 37-48. DOI: 10.4314/t-js.v27i1.18334

Radwan MA and Salama AK (2006), Market basket survey for some heavy metals in Egyptian fruits and vegetables, *Food Chem Toxicol.* **44**: 1273-1278. DOI: 10.1016/j.fct.2006.02.004

RDA (Recommended Dietary Allowances) (1989), National Research Council (US) Subcommittee on the Tenth Edition of the Recommended Dietary Allowances. 1-190.

Samuel PN and Babatunde BB (2021), Risk assessment of heavy metals in food crops at abandoned lead-zinc mining site at Tse-Faga, Logo, Lga, Benue State, Nigeria, *J Environ Prot* **12**(9): 624-638. DOI: 10.4236/-jep.2021.129038

Sanchez-Castillo CP, Dewey PJS, Aguirre A, Lara JS, Vaca R and de la Barra PL (1998), The mineral content of Mexican fruits and vegetables, *J Food Compos Anal.* **11**: 340-356. https://doi.org/10.1006/jfca.1998.0598

Singh A, Sharma RK, Agrawal M and Marshall FM (2010), Risk assessment of heavy metal toxicity through contaminated vegetables from wastewater irrigated area of Varanasi, India, *Trop. Ecol.* **51**: 375-524.

Steenland K and Boffetta P (2000), Lead and cancer in humans: where are we now? *Am J Ind Med.* **38**: 295-299. DOI: 10.1002/ 1097-0274 (200009) 38:3<295::aid-ajim8>3.0.co;2-l

Tuzen M and Soylak M (2007), Evaluation of trace element contents in canned foods marketed from Turkey, *Food Chem.* **102**: 1089-1095. DOI: 10.1016/j.foodchem. 2006.06.048

Ullah SM (1999), International conference on arsenic pollution of ground water in Bangladesh: causes, effects and remedies, Dhaka Community Hospital, Dhaka, Bangladesh. **133**.

WHO/FAO (2013), Guidelines for the safe use of wastewater and food stuff, Wastewater uses in agriculture, World Health Organization and Food and Agriculture Organization (FAO), Geneva, Switzerland. **2**(1): 988.

Zaidi MI, Asrar A, Mansoor A and Farooqui MA (2005), The heavy metal concentrations along roadside trees of Quetta and its effects on public health, *J Appl Sci.* **5**: 708-711. DOI: 10.3923/jas.2005.708.711

Zheljazkov VD, Craker LE and Xing B (2006), Effects of Cd, Pb, and Cu on growth and essential oil contents in dill, peppermint, and basil, *Environ Exp Bot.* **58**: 9-15. https://doi.org/10.1016/j.envexpbot.2005.06.008

Zhou H, Yang WT, Zhou X, Liu L, Gu JF, Wang WL, Zou JL, Tian T, Peng PQ and Liao BH (2016), Accumulation of Heavy Metals in Vegetable Species Planted in Contaminated Soils and Health Risk Assessment, *Int. J. Environ. Res. Public Health* **13**: 289. DOI: 10.3390/i-jerph13030289

Zhuang P, McBride MB, Xia H, Li N and Li Z (2009), Health risk from heavy metals via consumption of food crops in the vicinity of Dabaoshan mine, South China. *Sci. Total Environ.* **407**: 1551-1561. DOI: 10.1016/j.scito-tenv.2008.10.061