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Determination of Toxic Heavy Metal Contents of Some Selected Tropical Fruits Grown in Industrial Areas of Bangladesh

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Abstract

Fourteen tropical fruit items were collected from different industrial sites of the Dhaka and Chattogram region, Bangladesh to determine toxic heavy metal contents. This study aimed at the assessment of the distribution of heavy metals (As, Pb and Cr) as well as comparison of their level among different locations. The fruit items were analyzed for the quantification of the selected heavy metals using Atomic Absorption Spectrophotometer (AAS). The range of lead, chromium and arsenic in the fruit items were 1.12 ± 0.077 to 2.899 ± 0.013, 0 to 0.217 ± 0.005 and 0 to 0.078 ± 0.002 mg kg^{-1} respectively. It was revealed from the results that the level of toxic metals (As, Cr) in almost all fruit samples were within tolerable limit whereas the level of Pd in all of the fruit samples exceeded the acceptable limits of WHO standard value. It was also observed from the results obtained that the concentration of the metals found in the samples from Dhaka regions were considerably higher than that of Chattogram. These metal contributors mainly arising from anthropogenic sources including industrial wastes, automobile emissions, use of fertilizers, pesticides and herbicides in agriculture, paints, sewage and waste disposal. The extended level of these metals causing environmental pollution is hazardous since plants accumulate them. Subsequently, crops uptaking these heavy metals consumed by humans and animals which is detrimental to health. It is therefore very important that necessary actions need to be taken to monitor the level of these deleterious elements in food plants. In decision making, planning and risk assessing this present study will play significant role.

Keywords: Heavy metals, Fruits, Lead, Chromium, Arsenic

I. Introduction

Heavy metal contamination in different plants, fruits and vegetables is an issue of global concern considering its toxicity and pernicious effects on human health. Fruit and vegetables constitute plentiful sources of numerous minerals, vitamins, fibers and antioxidants[1]. However, plant sources absorb poisonous metals from polluted soils and environments. Regular consumption of fruits and vegetables that are contaminated with toxic heavy metals have the favorable ability to become a threat to human health; hence the heavy metal contamination analysis in food is most prominent aspect of quality assurance[2]. Generally, heavy metals are non-biodegradable and have prolong biological half-lives. Inadmissible amount of these metals penetrate in body organs, leading to serious adverse health effects[3]. Heavy metals including- Lead (Pb), Cadmium (Cd), Zinc (Zn), Mercury (Hg), Arsenic (As), Silver (Ag), Chromium (Cr), Copper (Cu) and Iron (Fe) largely found in soil and water sources as environmental toxins. These pollutants on deposition on the earth surface, accumulated into the fruits tissues[4]. Abundant tropical fruits of different varieties such as mangoes, papayas, bananas, pineapples, guavas, pomelos, watermelons, star-fruits, dates, and passion fruit are grown in diverse areas of Bangladesh. These tropical fruits are also pretty well known all over the world.

Food safety of urban areas in Bangladesh is becoming a serious issue in the consideration of effects of these toxic heavy metals for human body. More than half of the total population in urban areas centered in four metropolitan cities - Dhaka, Chattogram, Khulna, and Rajshahi. Moreover, being a fast-growing economy, Bangladesh is becoming more and more industrialized day by day. But there are no effective effluent treatment plants for most of the industries in Bangladesh. As a result, plants sources are being easily contaminated by toxic metals from these industrial sites. Now it becomes so necessary to access the contamination level of heavy metal in regular consuming foods which are locally grown in these industrial sites for the public health security. Besides, an inspection of different toxic heavy metals among various tropical fruits is also necessary to confirm whether trace heavy metals are in well agreement with the international standards. This is particularly vital for those farm products which are located at heavy industrial sites such as Dhaka and Chattogram. Unfortunately, a few reports are accessible on heavy metal content in common fruits found in Bangladesh. Widespread perception of the poisonous nature of heavy metals in food products needs to be manifested. Therefore, in this paper the concentration of some toxic heavy metals (Pb, Cr, and As) found in some selected fruits from two massive industrial areas in Bangladesh-Dhaka and Chattogram was investigated and compared.

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II. Materials and Methods

Site and period of the experiment

The level of toxic metals in some selected tropical fruits grown in industrial area of Dhaka and Chattogram region were determined in this study. The study was performed from November, 2017 to April, 2018, at the Department of Applied Chemistry & Chemical Technology of Chattogram veterinary and animal sciences university (CVASU), Khlushi, Chattogram and Department of Chemistry, University of Dhaka, Bangladesh.

Collection of Samples

This research is related to fourteen different tropical fruits samples; seven of which are from Dhaka and other half were collected from Chattogarm. Banana, Mango, Jackfruit, Pomelo, Star fruits, Guava and Hog plum samples directly collected from different locally grown trees in Dhaka and Chattogram city and analyzed. Each type of fruit item were collected from several places for both cities. Fruit samples were raw, matured, and contain no organoleptic deterioration.

Pretreatment of sample

In order to remove dirt, the collected fruit samples were washed with deionized water to and blotting paper was used to soak the adherent water. Then the water was removed quickly with a blotting paper. Finally, fruits were kept in a dry and cool place for further analysis.

Digestion of sample

The samples were homogenized, weighed and digested with a mixture of 5-mL HCl and 2-mL H_2SO_4. and 20-ml conc. HNO_3. The mixture was heated on an electric hot plate at 180-200 ^oC for 30 min continuously heated until the evolution of white fumes ceased and afterwards heated for about 30 min. The solution was cooled and then transferred to a 50-mL volumetric flask after being filtered through Whatman filter paper no. 4 and it was preserved in a universal bottle for further analysis.

Table 1. Description of the collected and analyzed fruits samples

Common name	Local name	Scientific name
Banana	Kola	*Musa paradisiacal*
Mango	Aam	*Mangifera indica*
Jackfruit	Kanthal	*Artocarpus heterophyllus*
Pomelo	Batabi Lebu	*Citrus maxima*
Star fruit	Kamranga	*Averrhoa carambola*
Guava	Peyara	*Psidium guajava*
Hog Plum	Amra	*Spondias mombin*

Analysis of heavy metals

Three samples of each type of fruits were prepared for AAS. The concentration of heavy metals in the final digested solution was determined by Atomic Absorption Spectrophotometer (Shimadzu model No. AA-7000) to determine the level of heavy metals such as As, Pd and Cr by flame atomic absorption spectrometric method.

Statistical Analysis of data

SPSS statistical package program was used to conduct statistical analysis. One-way analysis of variance (ANOVA) and Duncan multiple range tests was used for the assessment of metal concentrations variation among tissues & seasonally. A 5% level of significance was used during data analysis.

III. Results and Discussion

It is revealed from the study here that the concentrations of As, Cr and Pb in frequently consumed fruits available in Bangladesh including jackfruit (*A. heterophyllus*), mango (*M. indica*), guava (*Psidium guajava*), hog plum (*Spondias mombin*), star fruit (*Averrhoa carambola*), banana (*M. paradisiacal*) and pomelo (*Citrus maxima*). In present study, all data were collected in fresh weight basis and the results are demonstrated in the Table 2.

The concentration ranged from nil to 0.078 ± 0.002 mg kg^{-1} for As, from nil to 0.217 ± 0.005 mg kg^{-1} for Cr, and the range was in between 1.12 ± 0.077 to 2.899 ± 0.013 mg kg^{-1} for lead. Banana from Chattogram contains the highest concentration of As at 0.078 ± 0.002 mg kg^{-1}. However, no arsenic was detected in Guava from both region and in jackfruit from Chattogram region (shown in Fig.1). According to the level of As, the present study demonstrated that all fruits are safe for consumption as all value was lower than safe level (0.1 mg kg-1) (Codex, 2001)[5]. A study by Shaheen et al[6] also reported that jackfruit and banana contain 0.007 mg kg^{-1} and 0 mg kg^{-1} arsenic respectively and for mango the value exceeded the safety standard at 0.13 mg kg^{-1}. Concentration of As in the fruits collected from Dhaka and Chattogram regions comparing with WHO standard (0.1 mg kg^{-1}) are shown in the chart below (Fig. 1).

Table 2. Mean value of heavy metals concentrations in the selected tropical fruits

Fruits	Region	Arsenic		Chromium		Lead	
		Mean ± SD	P value	Mean±SD	P value	Mean ± SD	P value
Jackfruit	Dhaka	0.058 ± 0.002	0.000	0	N/A	1.83 ± 0.039	0.000
	Chattogram	0		0		1.175 ± 0.006	
Mango	Dhaka	0.05 ± 0.021	0.168	0.032 ± 0.006	0.001	1.829 ± 0.016	0.018
	Chattogram	0.07± 0.002		0		1.785 ± 0.012	
Guava	Dhaka	0	N/A	0.176 ± 0.003	0.000	2.14 ± 0.003	0.000
	Chattogram	0		0.074 ± 0.003		1.785 ± 0.048	
Hog plum	Dhaka	0.05 ± 0.033	0.002	0.156 ± 0.004	0.000	2.228 ± 0.003	0.311
	Chattogram	0.034 ± 0.033		0.197 ± 0.003		2.14 ± 0.132	
Star Fruit	Dhaka	0.035 ± 0.004	0.007	0.217 ± 0.004	0.000	2.582 ± 0.055	0.009
	Chattogram	0.051 ± 0.004		0.176 ± 0.003		2.45 ± 0.033	
Banana	Dhaka	0.06± 0.012	0.059	0.056 ± 0.003	0.000	2.848 ± 0.04	0.004
	Chattogram	0.078 ± 0.002		0.115 ± 0.004		2.899 ± 0.013	
Pomelo	Dhaka	0.07 ± 0.01	0.072	0.197 ± 0.003	0.003	1.12 ± 0.077	0.000
	Chattogram	0.056 ± 0.003		0.217 ± 0.005		1.785 ± 0.003	

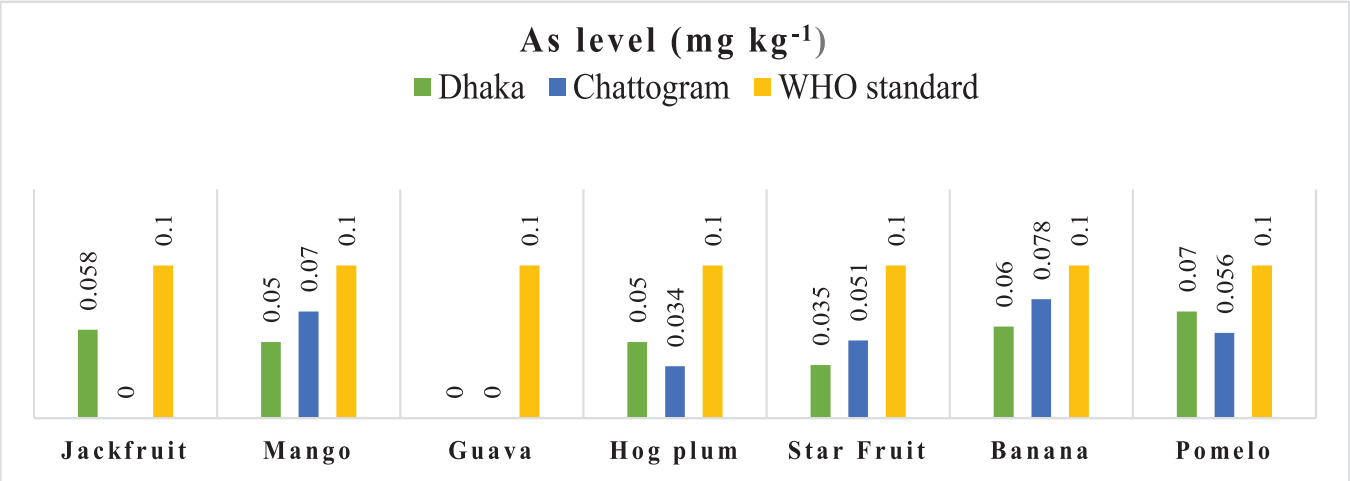

Fig. 1. Level of As in the fruits selected from Dhaka and Chattogram regions comparing with WHO standard (0.1 mg/kg)

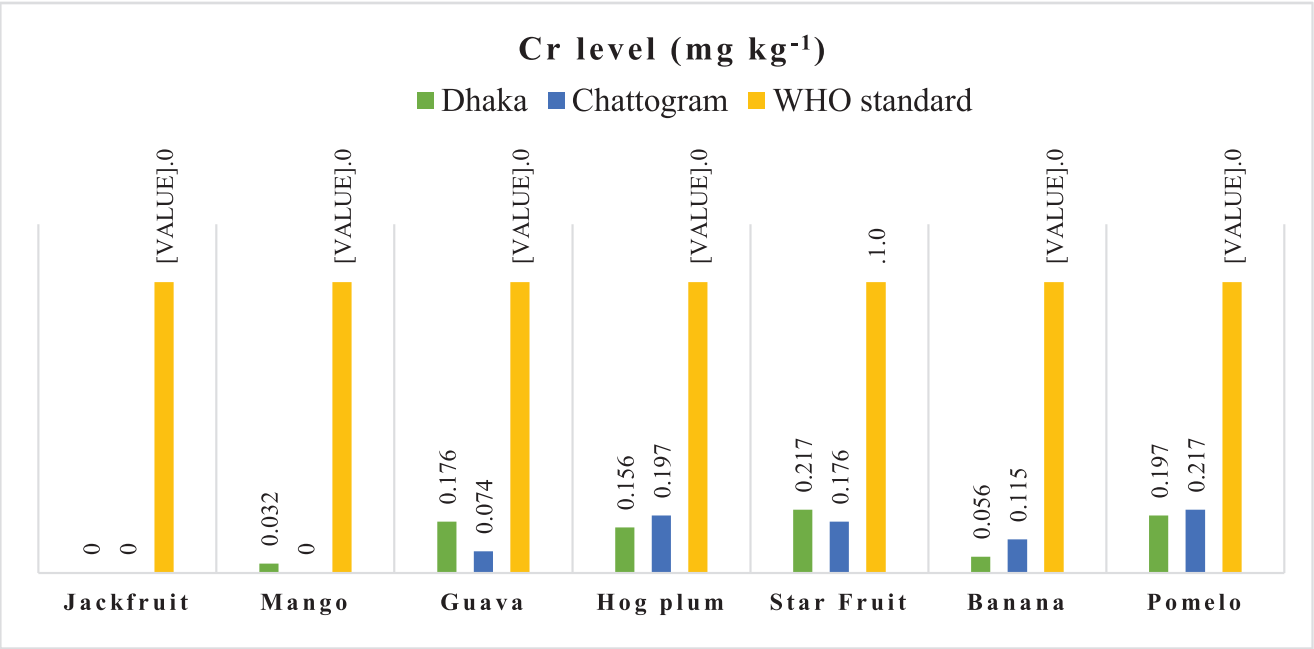

Fig. 2. Level of Cr in the fruits selected from Dhaka and Chattogram regions comparing with WHO standard (mg kg-1)

In terms of Chromium, star fruit and pomelo exhibited the highest value at 0.217 mg kg-1 in Dhaka and Chattogram respectively. Jackfruit from both region as well as mango from Chattogram region did not indicate any presence of chromium. Chromium content in all fruit items from both Dhaka and Chattogram region did not surpass the acceptable limit (1mg/kg) WHO/FAO (Codex, 2001) which is shown in the Fig. 2. Similar research was carried out by Sajib et al[7] in which they did not found Cr in mango. In previous literatures, roadside fruits in turkey were reported to contain Cr concentration of 0.32 mg kg-1 [8] and 0.00-7.14 mg kg-1 on dry weight basis in Iran[9].

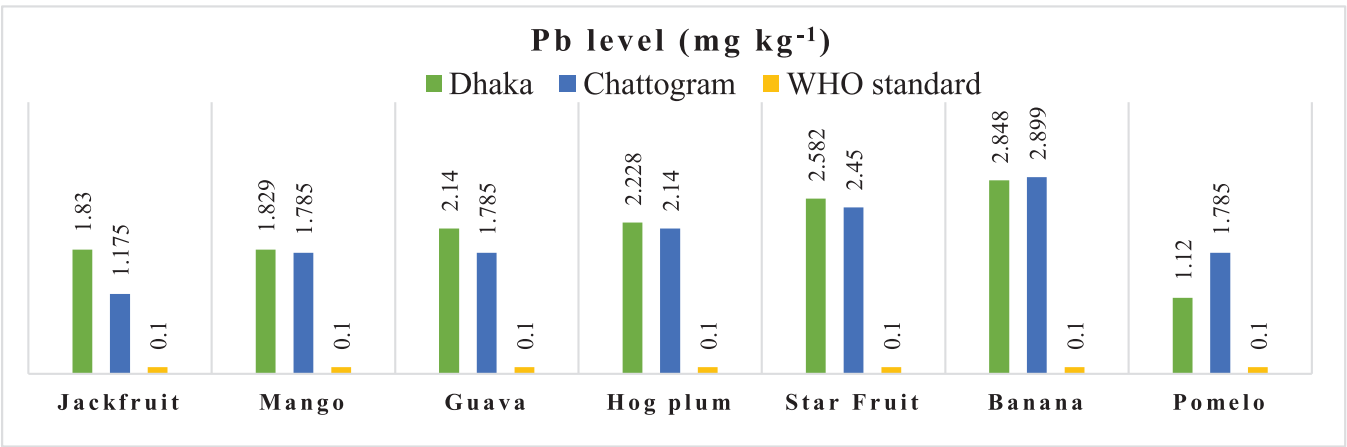

Fig. 3. Level of Pb in the fruits selected from Dhaka and Chattogram regions comparing with WHO standard (0.1 mg kg-1)

In case of lead, the maximum and minimum content of Pb was found in Banana (2.899 mg kg-1) from Chattogram region and Pomelo (1.12 mg kg-1) from Dhaka regime. It is obvious that all fruits contain high content of lead. WHO/FAO (Codex, 2001) recommended value of highest Pb concentration in fruits is 0.1 mg kg-1[5]. From the present findings, the lead concentration was almost 11 to 28 times higher than the tolerable limit (0.1 mg kg-1). The exceeded level of Pb in the fruits might be resulted from excessive industrial pollution and traffic in the areas while nurturing of plants. A previous study also found more than six times than the acceptable limit of lead in mango[6]. However, the study by Shaheen et al[6] also recorded the amount of lead at a level of 0.003, 0.017, 0.642 mg kg-1 in banana, jackfruit, mango respectively in their study. Some previous reports revealed the Pb content was 0.022 mg kg-1 in mango[7] and 0.02 mg kg-1 in banana[10]. Considering the levels of Pd in the fruits, the findings of this study were in well agreement with those of some previous authors[11, 12].

The results of the present study also revealed that the lead (Pb) contents found in almost all fruits samples from Dhaka region were considerably higher than that of Chattogram region except banana and pomelo. This could probably due to presence of higher Pb contributors in Dhaka and its adjacent area than that of Chattogram region.

Like fruits, concentration of heavy metals in other foods (such as vegetables, cereals, meat, egg, fish, milk etc.) are also significant in determining the health risk factors in human. Previous research conducted in Bangladesh revealed that high levels of heavy metals including Cr, Ni, As, Cd and Pb can be found in vegetables, cereals and fruits[13]. Although some micronutrients (e.g. Cu, Cr and Ni) are necessary for human and plant growth but at elevated level, these metals become toxic to human and animal health[14-17].

Some other toxic heavy metals such as Pb, As and Cd entering to the food chain can impose health risks to the human and animals[18, 19]. Even in trace level they can become toxic to human health. A study by Rahman et al[20] also recorded 1.12 mg kg^{-1} (range: 0.35–4. mg kg^{-1}) and 0.64 mg kg^{-1} (range: 0.18–1.91 mg kg^{-1}) concentration of Cr levels in leafy and non-leafy vegetables respectively. According to Rahman et al[19] the higher level of Pb in grains and vegetables probably resulted from smelting of Pd, vehicle emissions as well as industrial activity in the areas of study. This statement is agreed with the findings of the present study.

IV. Conclusion

The present study reveals the concentration of heavy metals(As, Cr, Pd) in highly consumed fruits grown in two different industrial cities of Bangladesh. Heavy metal concentration widely varied from region to region depending on the presence of potential metal contributors in the study area. As in general, exposure route is mainly through the intake of food contaminated with As which is associated with multiple disorders. The results of the study also claim that the level of metals were found in the Dhaka regions in maximum samples were considerably higher than that of Chattogram regions. This might be due to Dhaka and its adjacent areas are over industrialized compared to Chattogram regimes. As and Cr metals found in the fruits showed considerably to lie within the recommended value of WHO/FAO. However, in all of the fruit samples collected from both of the cities the Pd concentration was found to surpass the acceptable limit. This finding predicts a significant risk to the consumers and people would experience adverse health effects due to the exposure to toxic heavy metals from food in the study areas. Moreover, soils accumulating heavy metals results in an extended level of toxic metals in food crops, fruits and vegetables exceeding the permissible values. If measures are not taken properly than exposure to heavy metals from food can pose a serious threat to all people. So therefore, considering public health importance it is mandatory to closely monitor these toxic metals level in fruits, vegetables and other food crops consumed in highly polluted urban areas.

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