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Research Article

Assessment of lead (Pb) and cadmium (Cd) contamination in locally available vegetables in Mymensingh

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A B S T R A C T

The most hazardous elements are lead (Pb) and cadmium (Cd), which can cause a number of illnesses and interfere with a person's ability to operate normal physiology. This investigation was designed to determine the levels of Pb and Cd in locally available vegetables (Carrot, Brinjal and Green banana) in Mymensingh city. Atomic Absorption Spectrophotometer (AAS) was used to analyze the heavy metal concentration of samples that were randomly selected from Seshmor (SM) bazar and Kamal Ranjit (KR) market. In the samples collected from KR market, the content of Pb was 0.027, 0.29 and 0.00 mg/kg dry weight in Carrot, Brinjal and Green banana, respectively. Whereas in the samples from SM bazar, the content of Pb was 0.034, 0.273 and 0.00 mg/kg dry weight in Carrot, Brinjal and Green banana, respectively. In the samples purchased from KR market, the content of Cd was 0.19, 0.021and 0.00 mg/kg dry weight in Carrot, Brinjal and Green banana, respectively. In the contrary, in SM bazar the content of Cd was 0.07, 0.066 and 0.00 mg/kg dry weight of Carrot, Brinjal and Green banana, respectively. The concentration of Pb and Cd in Carrot, Brinjal and Green banana in both KR market and SM bazar were below the recommended permissible limit (RPL) guided by WHO. In conclusion, vegetables collected from the research area are safe to eat, but because of potential hazards and risks associated with metal ingestion, they should only be consumed in moderation.

Introduction

Vegetables are the primary source of vitamins, minerals, fiber, thiamin, folic acid, niacin and numerous bioactive components that are crucial to maintain sound health (Afrin *et al.*, 2021). But vegetables are contaminated by various forms of undesirable pollutants due to unplanned industrialization and the contamination of vegetables is becoming an alarming issue nowadays in Bangladesh (Ahmad and Goni, 2010). Among the all types of contaminations, heavy metal contamination of vegetables is one of the most serious environmental problems all over the world. Due to rapidly expanding urbanization and industry-related emissions have caused the extensive occurrence of heavy metals in vegetables and, the environment and vegetables are easily contaminated with those heavy metals (Islam *et al.*, 2018). For the people of Bangladesh, heavy metal and metalloid contamination from industrial and geological sources has grown to be a serious problem in recent years. The literature's findings unequivocally demonstrated that mining, industrialization, and urbanization are the primary factors linked to heavy metal and metalloid dangers in Bangladesh (Islam *et al.*, 2018). Consumption of these contaminated vegetables may cause several diseases and affects normal physiological functions of human. According to the International Agency for Research on Cancer, among the all-heavy metals Lead (PB) and Cadmium (Cd), are classified as category one toxic heavy metals and can lead to a variety of chronic diseases (Kim *et al.*, 2015). Ingesting Pb and Cd-contaminated vegetables increases the risk of cancer and cancer-related disorders by causing damage to DNA, altering the genetic code, and speeding up the cell death process (Sarker *et al.*, 2022).

According to the previous study a common heavy metal lead (Pb) causes neurological, skeletal, reproductive, hematological, renal, and cardiovascular system disruptions when it is absorbed, bioavailable, bio concentrated, and

biomagnified in the human body (Collin *et al.*, 2022). Exposure to lead for an extended period of time can impact an individual's nervous system's normal functioning (M Collin *et al.*, 2022). Furthermore, prolonged exposure has detrimental effects on the kidneys in addition to the brain (Abadin *et al.*, 2007). Compared to adults, children absorb more lead, which is extremely dangerous because it affects their development (Lidsky and Schneider, 2003). In addition, Lead can harm a cell's membrane and structure, but most significantly, it can obstruct DNA transcription (Yedjou *et al.*, 2010). Besides it, the main organs that are particularly sensitive to Cd poisoning are the kidneys and liver (Khan *et al.*, 2009). Kidney failure and damage to the testicles, lungs, and bones can also result from cadmium poisoning. Additionally, it has a carcinogenic effect that results in testicular, pancreatic, renal, and prostate tumors in humans (Sarker *et al.*, 2022).

Numerous literatures reported that heavy metals like Pb and Cd are entering in the human body through consumption of contaminated vegetables hence regular monitoring and assessment of vegetables is necessary. The presence of heavy metals in vegetables has recently been routinely assessed and monitored in many countries; however, there is a lack of published data on the concentrations of Pb and Cd in vegetables from the local market of Mymensingh, Bangladesh. The amount of heavy metals present in Bangladesh's widely consumed vegetables is not well known. This study, therefore, aim to ascertain the amount of Pb and Cd present in vegetables that are frequently consumed namely Carrot, Brinjal and Green banana in Kamal Ranjit (KR) market and Sesh More (SM) bazar of Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh.

Methodology

Location of the experiment

The research was conducted in the Interdisciplinary Institute for Food Security (IIFS), Food Safety and Quality Laboratory of Bangladesh Agricultural University, Mymensingh.

Sample collection

We were collected total ninety (90) vegetable samples (30 Carrot, 30 Brinjal and 30 Green Banana samples) from small sized market (KR market and SM bazar) in BAU, Mymensingh which play an important role in local life.

Sample preparation and processing

To get rid of dust, vegetable samples were thoroughly cleaned with tap water and then distilled water. Following a partial drying process in the air, the samples were sliced into tiny pieces using a stainless steel knife. The edible portion was cut into small pieces before air drying and then dried in an oven at 80°C until a constant weight was achieved. The non-edible portions were removed in accordance with standard household procedures. After being crushed in a mortar, the dried samples were run through a sieve with 100 meshes. Up until digestion, the resulting fine powder was kept in desiccators in the dark.

Digestion of samples

Three acids, namely nitric acid (HNO_3), sulfuric acid (H_2SO_4), and perchloric acid ($HClO_4$), were mixed and applied in a volume ratio of 5:1:1 to the powdered samples (each weighing 1 g). The temperature was maintained at 80°C for three hours, or until the samples' solution turned transparent. Following room temperature cooling, the samples were diluted to 50 milliliters using deionized water and filtered through Whatman cellulose filter papers. The samples were then prepared for examination.

Analysis of the samples

The concentrations of lead (Pb) and cadmium (Cd) in the examined samples were measured with an atomic absorption spectrophotometer (AAS) (model AA68, Shimadzu Corporation, Japan). Every sample was taken and examined three times, and the data was represented by the average of the three analyses.

Human health risk assessment

Daily intake of metal (DIM) was calculated by using the following equation (Rabiul *et al.*, 2017):

Daily intake of metal (DIM) = $(C_{metal} \times D_{foodintake})/B_{averageweight}$

Where, C_{metal} = Concentration of heavy metals in vegetables (mg/kg dry weight)

$D_{food\ intake}$ = Daily intake of vegetables (average consumption = 0.280 kg/person/day) (Guilbert J, 2003), $B_{average\ weight}$ = Average body weight 56 kg/person (Gupta *et al.*, 2015).

To evaluate the potential risk to human health through more than one heavy metal, the Health Risk Index (HRI) was calculated by using the following equation:

Health Risk Index (HRI) =DIM/RfD

The oral reference doses (RfD) of Pb and Cd are 0.004 (Wang *et al.*, 2005) and 0.001 (Antoine *et al.*, 2017) mg/kg/day respectively.

Results and Discussion

Lead (Pb) and Cadmium (Cd) concentration of Carrot, Brinjal and Green Banana in KR market

The Lead (Pb) and Cadmium (Cd) concentration of Carrot, Brinjal and Green Banana in KR market are shown in Table 1. The Pb concentration of Carrot, Brinjal and Green Banana were measured for three (3) times (total 30 samples) and in every time we measured 10 Carrot, 10 Brinjal and 10 Green Banana samples. The average Pb concentration of Carrot samples were 0.027 mg/kg dry weight (1st time), 0.030 mg/kg dry weight (2nd time) and 0.026 mg/kg dry weight (3rd time). The mean concentration of 30 Carrot samples was 0.027 mg/kg dry weight. The Pb concentration of Brinjal was 0.29 mg/kg dry weight (1st time), 0.28 mg/kg dry weight (2nd time) and 0.30 mg/kg dry weight (3rd time). The mean concentration of 30 Brinjal samples was 0.29 mg/kg dry weight. The Pb concentration of all samples of green banana was 0.00 mg/kg dry weight. The highest Pb concentration was found in Brinjal in compared to Carrot. Previous report showed that the concentration of Pb in the Brinjal was above the permissible levels of WHO (Yamaguchi *et al.*, 2019), which is not similar with our experiment, it may be due to the different in location of the experiment. According to the previous report the physical and chemical composition of Brinjal depends on the environmental factors like temperature, soil, water and genetic factors that may vary one place to another (Asafew and Chandravanshi, 2021). Though the average concentrations of Pb concentration in Carrot and Brinjal in this experiment were below the safe limit but the Pb content in Brinjal is very near to safe limit Therefore, due to potential hazards and risks associated with metal ingestion, it must be consumed in moderation.

The Cd concentration of Carrot, Brinjal and Green Banana were measured for three (3) times (total 30 samples) and in

every time we measured 10 Carrot, 10 Brinjal and 10 Green Banana samples. The average Cd concentration of Carrot samples was 0.19 mg/kg dry weight (1st time), 0.22 mg/kg dry weight (2nd time) and 0.17 mg/kg dry weight (3rd time). The mean concentration of 30 Carrot samples was 0.19 mg/kg dry weight. The Cd concentration of Brinjal samples were 0.023 mg/kg dry weight (1st time), 0.018 mg/kg dry weight (2nd time) and 0.022 mg/kg dry weight (3rd time). The mean concentration of 30 Brinjal samples was 0.021 mg/kg dry weight. The Cd concentration of all samples of green banana was 0.00 mg/kg dry weight. The highest Cd concentration was observed in Carrot (0.19 mg/kg dry weight) compared to Brinjal (0.021 mg/kg dry weight). According to the previous report the Cd concentration in Brinjal is below the safe limit which is similar with our current study (Asafew and Chandravanshi, 2021). Islam *et al.*, (2017) reported that Carrots grown on soil in floodplains have a Cd concentration that is far higher than what is considered safe which is much higher than that found in our study. It may be due to difference in soil composition in which Brinjal were grown.

Table 1. Lead (Pb) and Cadmium (Cd) concentration (mg/kg dry weight) with Standard Error Mean (SEM) of different vegetables in KR market with Maximum Permissible Level (MPL) (mg/kg dry weight).

Heavy metal	Vegetables	KR Market			Mean ± SEM	MPL
		1st time	2nd time	3rd time		
Pb	Carrot	0.027	0.030	0.026	0.027±0.001	0.30
	Brinjal	0.290	0.280	0.300	0.290±0.005	
	Green banana	0.000	0.000	0.000	0.000	
Cd	Carrot	0.190	0.220	0.170	0.190±0.014	0.20
	Brinjal	0.023	0.018	0.022	0.021±0.001	
	Green banana	0.000	0.000	0.000	0.000	

Lead (Pb) and Cadmium (Cd) concentration of Carrot, Brinjal and Green Banana in SM bazar

The Lead (Pb) and Cadmium (Cd) concentration of Carrot, Brinjal and Green Banana in SM bazar are shown in Table 2. The Pb concentration of Carrot, Brinjal and Green Banana were measured for three (3) times (total 30 samples) and in every time we measured 10 Carrot, 10 Brinjal and 10 Green Banana samples. The average Pb concentration of Carrot was 0.035 mg/kg dry weight (1st time), 0.034 mg/kg dry weight (2nd time) and 0.035 mg/kg dry weight (3rd time). The mean concentration of 30 Carrot samples was 0.034 mg/kg dry weight. The average Pb concentration of Brinjal was 0.29 mg/kg dry weight (1st time), 0.27 mg/kg dry weight (2nd time) and 0.26 mg/kg dry weight (3rd time). The mean concentration of 30 Brinjal samples was 0.273 mg/kg dry weight. The Pb concentration of all samples of Green banana was 0.00 (mg/kg dry weight). Compared to Brinjal, Carrots in SM bazaar had a higher Pb concentration but below the MPL level. The Pb concentration in Green banana was not detectable that is similar with the Green banana of KR market.

The Cd concentration of Carrot, Brinjal and Green Banana were measured for three (3) times (total 30 samples) and in every time we measured 10 Carrot, 10 Brinjal and 10 Green Banana samples. The mean Cd concentration in Carrot, Brinjal and Green banana collected from SM bazar are shown in Table 2. The average Cd concentration of Carrot were 0.1 mg/kg dry weight (1st time), 0.06 mg/kg dry weight (2nd time) and 0.07 mg/kg dry weight (3rd time). The mean concentration of 30 carrot samples was 0.07 mg/kg dry weight. The average Cd concentration of Brinjal were 0.069 mg/kg dry weight (1st time), 0.064 mg/kg dry weight (2nd time) and 0.067 mg/kg dry weight (3rd time). The mean concentration of 30 Brinjal samples was 0.07 mg/kg dry weight. The Cd concentration in all samples of Green banana was 0.00 mg/kg dry weight. The mean Cd concentration of Carrot and Brinjal in SM bazar were lower compared with that of KR market. It may be due to different sources of Carrot and Brinjal. The Cd concentration of Green banana in SM bazar were not detectable like the samples from KR market. Therefore, the vegetables that were evaluated in the present study are safe for consumption.

Table 2. Lead (Pb) and Cadmium (Cd) concentration (mg/kg dry weight) with Standard Error Mean (SEM) of different vegetables in SM bazar with Maximum Permissible Level (MPL) (mg/kg dry weight).

Heavy metal	Vegetables	SM Bazar			Mean ±SEM	MPL
		1st time	2nd time	3rd time		
Pb	Carrot	0.035	0.034	0.035	0.034±0.0003	0.30
	Brinjal	0.290	0.270	0.260	0.273±0.008	
	Green banana	0.000	0.000	0.000	0.000	
Cd	Carrot	0.100	0.060	0.070	0.070±0.012	0.20
	Brinjal	0.069	0.064	0.067	0.066±0.001	
	Green banana	0.000	0.000	0.000	0.000	

Daily Metal Ingestion (DMI) and Health Risk Index (HRI) in KR Market and SM Bazar

DMI and HRI in KR Market and SM bazar are shown in Table 3. The daily Pb ingestion from Carrot and Brinjal of KR market were 0.000135 and 0.00145 mg/kg respectively. The daily Cd ingestion from Carrot and Brinjal of KR market were 0.00095 and 0.000105 mg/kg respectively. The daily Pb ingestion from carrot and Brinjal of SM bazar were 0.00017 and 0.001365 mg/kg respectively. The daily Cd ingestion from carrot and Brinjal of SM bazar were 0.00035 and 0.00033 mg/kg respectively. According to the previous report (Ahmed *et al.*, 2021) if the HRI is more than 1, there is a greater possibility of non-carcinogenic health effects, and the probability increases with a rising value of HRI. In our study, the HRI of Pb and Cd were less than one (1) from Carrot and Brinjal from both KR market and SM bazar. Therefore, the vegetables that are studied in the current study are safe for consumption.

Table 3. Daily Metal Ingestion from vegetables and Health Risk Index of Pb and Cd in KR Market and SM Bazar.

Heavy metals	Vegetables	Daily metal Intake (DMI) (mg/kg)		Health Risk Index (HRI)	
		KR Market	SM Bazar	KR Market	SM Bazar
Pb	Carrot	0.000135	0.000170	5.4×10^{-7}	6.8×10^{-8}
	Brinjal	0.001450	0.001365	1.2×10^{-3}	5.5×10^{-6}
Cd	Carrot	0.000950	0.000350	9.5×10^{-7}	3.5×10^{-7}
	Brinjal	0.000105	0.000330	1.05×10^{-7}	3.3×10^{-7}

Conclusion

Carrot, Brinjal and Green banana are the most important vegetables of Bangladesh which are very rich in nutrition and have wide range of application in our food habit. But these vegetables are becoming contaminated with different heavy metals and become a major threat for the human being and ecosystems. One of the possible ways of risk is to consume products contaminated with heavy metals like cadmium (Cd) and lead (Pb). Our current findings revealed that the heavy metals (Pb and Cd) concentration of Carrot, Brinjal and Green banana in KR market and SM bazar are below the MPL recommended by WHO. In addition, Health Risk Index (HRI) of Pb and Cd of Carrot and Brinjal are below the recommended level in the vegetable samples collected from both KR market and SM bazar. These findings suggested that the vegetables (Carrot, Brinjal and green banana) intake from these areas are safe for human consumption. Given that this study only looked at selected vegetables, further research with more samples should be done on the possible health risks associated with other vegetables. The results of this study could be useful to the stakeholders as they plan how to reduce long-term health risks.

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References

Afrin S, Alam MK, Ahmed MW, Parven A, Jubayer MF, Megharaj M, Meftaul IM, Khan MSI (2021) Determination and probabilistic health risk assessment of heavy metals in widely consumed market basket fruits from Dhaka city. Bangladesh International Journal of Environmental Analytical Chemistry 1654. https://doi.org/10.1080/03067319.2021.2018578

Abadin H, Annette Ashizawa, Yee-Wan Stevens, Fernando Llados, Gary Diamond, Gloria Sage, Mario Citra, Antonio Quinones, Stephen J Bosch, Steven G Swarts (2007). Toxicological Profile for Lead. Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profiles, US. Toxicological profile for lead (cdc.gov)

Ahmad JU, Goni MA (2010) Heavy metal contamination in water, soil, and vegetables of the industrial areas in Dhaka, Bangladesh. Environmental monitoring and assessment 166(1):347–357. https://doi.org/10.1007/s10661-009-1006-6

Antoine JMR, Fung LAH, Grant CN (2017). Assessment of the potential health risks associated with the aluminium, arsenic, cadmium and lead content in selected fruits and vegetables grown in Jamaica. Toxicol Rep. 4:181-187. https://doi.org/10.1016/j.toxrep.2017.03.006

Asafew K and Chandravanshi BS (2021). Levels of major and trace metals in eggplant and soil. Bull. Chem. Soc. Ethiop. 2021, 35(2), 243-255. https://dx.doi.org/10.4314/bcse.v35i2.

Collin MS, Venkatraman SK, Vijayakumar N, Kanimozhi V, Arbaaz SM, Stacey RGS, Anusha J, Choudhary R, Lvov V, Tovar GI, Senatov F, Koppala S, Swamiappan S (2022). Bioaccumulation of lead (Pb) and its effects on human: A review, Journal of Hazardous Materials Advances, Volume 7, ISSN 2772-4166.

Guilbert J (2003). The World Health Report 2002 - reducing risks, promoting healthy life. Educ Health Change Learn Pract. 16:230-230. https://doi.org/10.1080/1357628031000116808

Gupta SK, Chabukdhara M, Singh J, Bux F (2015). Evaluation and potential health hazard of selected metals in water, sediments, and fish from the Gomti River. Hum Ecol Risk Assess. 21:227-240. https://doi.org/10.1080/10807039.2014.902694

Islam MM, Karim MR, Zheng X, Li X (2018). Heavy Metal and Metalloid Pollution of Soil, Water and Foods in Bangladesh: A Critical Review. Int. J. Environ. Res. Public Health, 15 (12), 2825. https://doi.org/10.3390/ijerph15122825

Islam RGM, Habib MR, Waid JL (2017). Heavy metal contamination of freshwater prawn (Macrobrachium rosenbergii) and prawn feed in Bangladesh: a market-based study to highlight probable health risks. Chemosphere. 170:282-289. https://doi.org/10.1016/j.chemosphere.2016.11.163

Islam MS, Ahmed MK, Proshad R (2017). Assessment of toxic metals in vegetables with the health implications in Bangladesh and Advances in Environmental Research, Vol. 6, No. 4, 241-254. https://doi.org/10.12989/aer.2017.6.4.241

Khan S, Farooq R, Shahbaz S, Khan MZ and Sadique M (2009). World Applied Sciences Journal 6 (12): 1602-1606, 2009ISSN 1818-4952. file:///C:/Users/Dell/Downloads/WASJ1.pdf

Kim HS, Kim YJ, amp Seo JR (2015). An overview of carcinogenic heavy metal: molecular toxicity mechanism and prevention. J. Cancer Prev. 20(4), 232–240. https://doi.org/10.15430/JCP.2015.20.4.232

Lidsky TI, Schneider JS (2003). Lead neurotoxicity in children: basic mechanisms and clinical correlates Brain, 126 (1), pp. 5-19. https://doi.org/10.1093/brain/awg014

Sarker A, Kim JE, Islam ARMT (2022). Heavy metals contamination and associated health risks in food webs- a review focuses on food safety and environmental sustainability in Bangladesh. Environ Sci Pollut Res 29, 3230–3245. https://doi.org/10.1007/s11356-021-17153-7

Wang X, Sato T, Xing B, Tao S (2005). Health risks of heavy metals to the general public in Tianjin, China via consumption of vegetables and fish. Sci Total Environ. 350:28-37. https://doi.org/10.1016/j.scitotenv.2004.09.044

Yamaguchi S, Matsumoto K, Koyama M, Tian S, Watanabe M, Takahashi A, Miyatake K, Nakmra K (2019). Antihypertensive effects of orally administered eggplant (Solanum melongena) rich in acetylcholine on spontaneously hypertensive rats. Food Chem. 276, 376–382. https://doi.org/10.1016/j.foodchem.2018.10.017

Yedjou CG, Tchounwou CK, Haile S, Edwards F, Tchounwou PB (2010). N-acetyl-cysteine protects against DNA damage associated with lead toxicity in HepG2 cells Ethn. Dis., 20 (1 Suppl 1)p. S1. S1–101-3. https://pubmed.ncbi.nlm.nih.gov/20521395