Research Article

Assessment of Heavy Metal Accumulation in *Capsicum annuum* Fruits Collected from Different Market and Farmer Fields of District Solan

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Abstract

Fruit samples of *Capsicum annuum* were collected from the farmers' field and vegetable markets of Himachal and Punjab and were tested for heavy metals such as Cr, Pb, Cd, Cu and Zn. Fruit samples of capsicum collected from three sources, Chandigarh sabji mandi, Solan sabji mandi and local vegetable vendors. Fruit samples of capsicum collected from six different farmer fields in district Solan. Highest concentrations of heavy metals in capsicum fruit samples were recorded in fruit samples collected from Chandigarh markets as compared to Solan markets or local vegetable vendors. The vegetables marketed in Chandigarh are mostly procured from Punjab, Haryana and adjoining plain area of Himachal Pradesh, where higher quantities of pesticide are used to control various pests and disease, which may have resulted in higher accumulation of heavy metals. The production of vegetable crops around industrial areas may also be contributing to accumulations of more heavy metals. The study concludes that the transportation and marketing systems of vegetables play a significant role in elevating the contaminant levels of heavy metals, which may lower the quality of vegetables with negative effect on the health of consumers.

Keywords: Heavy metal, accumulation, capsicum fruits, markets, farmer fields

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Introduction

Heavy metal contamination of vegetables cannot be underestimated as latter is the important components of human diet. Vegetables are rich sources of vitamins, minerals, fibres and also have beneficial antioxidative properties. However, the intake of heavy metal-contaminated vegetables may pose a risk to the human health. Heavy metal contamination of the food items is one of the most important aspects of food quality assurance [1, 2]. International and national regulations on food quality have lowered the maximum permissible levels of toxic metals in food items due to an increased awareness of the risk poses by these metals in contamination of food chain [3]. Rapid and unorganized urban and industrial developments have contributed to the elevated levels of heavy metals in the urban environment of developing countries such as China [4] and India [5]. Heavy metals are non-biodegradable and persistent environmental contaminants, which may be deposited on the surfaces and then absorbed into the tissues of vegetables. Plants take up heavy metals either from pollutants deposits on exposed plants tissue as a consequence of air pollution, or directly absorb them from the contaminated soils [6]. A number of studies have shown heavy metals as important contaminants in the vegetable crops [7, 8]. Heavy metal contamination of vegetables may also occur due to irrigation with contaminated water [9]. Emissions of heavy metals from the industries and vehicles may be deposited on the vegetable surfaces during their production, transport and marketing. Jassir *et al*. [10] have reported elevated levels of heavy metals in vegetables sold in the markets at Riyadh City in Saudi Arabia due to the atmospheric deposition. Recently, Sharma *et al*. [11, 12] have reported that atmospheric deposition can significantly elevate the levels of heavy metals contamination in vegetables commonly sold in the markets of Varanasi, India. Vegetable uptake of metals from soil is one of the major pathways by which metals enter into the food chain and accumulate to high concentrations. When plants' based food stuffs are consumed that may cause serious risk to the human health [13]. Zwarich and Mills [14] studied the effect of sewage sludge application on the copper, zinc, lead and cadmium content of lettuce, carrot and pea crops and the reported the small increase in the concentration of copper, whereas, zinc and cadmium with the sludge application.

Materials and Methods

Study area

To determine the status of heavy metals in *Capsicum annuum* Linn., the market and field survey was conducted in Sabji Mandi Solan, Chandigarh and Local Vegetable Vendors during 2015-2016**.**

Field Survey

Fruit sample of *Capsicum annuum* Linn. was collected from 6 different locations v.z., Baddi (Patta), Parwanoo (Datyar), Kandaghat (Dolang), Sultanpur (Katal-Kathar), Deothi (Chakli) and Oochghat (Nando) in Solan district in cropping season during 2015-2016.

Heavy metals analysis

The plant samples were digested in di-acid (HNO_3 + $HClO_4$) mixture as per standard procedure given by Singh *et al.* [15], and heavy metals viz; Cr, Cd, Zn, Pb, Cu and Ni were estimated by using Inductively Coupled Plasma Emission Spectrometer-6300 DUO (ICAP-6300 Duo).

Statistical analysis

Randomized block design was used for data analysis. Analysis of variance (ANOVA) was also worked out.

Results and Discussion

Heavy metal contaminations in capsicum fruits collected from vegetable market

Lead (Pb) contamination in capsicum fruits:

Present result revealed that mean concentration of Pb in capsicum fruits collected from three sources, Chandigarh Sabji Mandi, Solan Sabji Mandi and local vegetable vendors was ranged between 0.592 to 0.651 ppm (**Table 1**). The highest concentration of Pb (0.651 ppm) was found in Chandigarh sabji mandi, whereas minimum (0.592 ppm) was recorded in local vegetable vendors. The higher concentration of Pb (0.639 ppm) was reported during the off season compared to the main cropping season (0.592 ppm). The interaction studies revealed maximum concentration of Pb (0.680 ppm) in fruit samples collected from Chandigarh sabji mandi during the off season (Oct-Nov) which was statistically highest among three markets, whereas minimum Pb concentration (0.567 ppm) was recorded in local vegetable vendors during the main cropping season (June-July) which were significantly different from other markets. Sharma *et al.* [16] have also reported 17.54- 25.00 mg/kg concentration of Pb in vegetables grown in waste water irrigated areas of Varanasi, India, whereas in present studies Pb concentration in capsicum fruits collected from various markets were quite below the permissible limit (2.5ppm) as given by Awasthi [17].

Table 1 Distribution of heavy metals in capsicum fruits in different vegetable markets

Vegetable markets	**Distribution of Pb in capsicum fruits**			**Distribution of Cd in capsicum fruits**			**Distribution of Cu in capsicum fruits**			**Distribution of Zn in capsicum fruits**		
	Main cropping season (June-July)	**Off season (Oct-Nov)**	**Mean**	**Main cropping season (June-July)**	**Off season (Oct-Nov)**	**Mean**	**Main cropping season (June-July)**	**Off season (Oct-Nov)**	**Mean**	**Main cropping season (June-July)**	**Off season (Oct-Nov)**	**Mean**
Chandigarh	0.622	0.680	0.651	0.662	0.693	0.678	13.58	14.53	14.06	12.78	13.24	13.01
Solan	0.587	0.620	0.603	0.583	0.612	0.598	12.52	13.25	12.88	11.75	12.42	12.09
Local	0.567	0.617	0.592	0.563	0.603	0.583	12.31	12.96	12.64	11.61	12.30	11.95
Mean	0.592	0.639		0.603	0.636		12.80	13.58		12.05	12.66	
$CD_{0.05}$												
Season (S)			0.003			0.005			0.22			0.36
Market (M)			0.004			0.006			0.27			0.46
S×M			0.006			NS			NS			NS

Contamination of cadmium (Cd) in capsicum fruits

The mean highest concentration of Cd (0.678 ppm) in capsicum fruits was also observed in fruit samples collected from Chandigarh sabji mandi and minimum (0.583 ppm) in fruit samples collected from local vegetable vendors in Nauni, Solan (Table 1). The higher concentration of Cd (0.636 ppm) was recorded during the off season compared to the main cropping season (0.603 ppm). However, concentrations of Cd in capsicum fruits collected from various markets were below the permissible limit (1.5 ppm) for crops. Similar findings for Cd were observed by the previous researcher [17].

Contamination of Copper (Cu)

The analysis of Cu in fruit samples revealed that concentration of copper in fruit samples of capsicum collected from Chandigarh sabji mandi, Solan sabji mandi and local were in the range of 12.64 to 14.06 ppm (Table 1). The highest concentration of Cu (14.06 ppm) was found in Chandigarh sabji mandi, whereas minimum (12.64 ppm) was recorded in capsicum fruits collected from local vegetable vendors in Nauni which has also statistical similarity with capsicum fruits collected from Solan sabji mandi (12.88 ppm). The higher concentration of Cu (13.58 ppm) was found during the off season as compared to main cropping (12.80 ppm). However, concentration of Cu in capsicum fruit samples in different markets was found below the permissible limit (30 ppm) for crops as per the standard given by FAO/WHO [18]. In present results the accumulation of heavy metals from various sources was observed, while Sharma *et al*., [12] have also reported that atmospheric deposition can significantly elevate the levels of heavy metals contamination in vegetables commonly sold in the markets.

Contamination of zinc (Zn)

The pooled data of 2015 and 2016 indicated that mean concentrations of Zn in capsicum fruits collected from Chandigarh sabji Mandi, Solan sabji mandi and local vegetable vendors were in the range of 11.95 to 13.01 ppm (Table 1). The highest concentration of Zn (13.01 ppm) was found in Chandigarh sabji mandi, whereas, minimum (11.95 ppm) was observed in the fruit samples collected from the local vegetable vendors. The higher concentration of Zn (12.66 ppm) was recorded in the off season as compared to the main cropping season (12.05 ppm). However, the concentration of Zn in capsicum fruits from three sources Viz., Chandigarh sabji Mandi, Solan sabji mandi and local was below the permissible limit (20 ppm) as per the standard given by FAO/WHO [18].

Heavy metal contaminations in capsicum fruits collected from farmer's field

Lead (Pb) contamination in capsicum fruits

The concentrations of lead in fruit samples of capsicum collected from six different farmer fields in distict Solan ranged from 0.532 to 0.583 ppm (**Table 2**). The highest concentration of Pb (0.583 ppm) was found in Baddi, whereas minimum (0.532 ppm) was recorded in fruit samples collected from Oachghat site which was also at par with Pb concentration in fruit samples collected from Deothi (0.533 ppm), Sultanpur (0.535 ppm) & Kandaghat location (0.537 ppm). However, Pb concentrations in capsicum fruits were quite below than permissible limit (2.5 ppm). Sharma *et al.* [16] have also reported 17.54- 25.00 mg/kg of lead in vegetables grown in waste water irrigated areas of Varanasi, which were above the safe limit.

Table 2 Levels of heavy metals in fruit samples collected from farmer fields of Solan Distt.

Site	Pb	Cd	Cu	Zn
Kandaghat (Dolang)	0.537	0.555	12.51	11.40
Parwanoo (Datyar)	0.557	0.570	12.59	11.64
Baddi (Patta)	0.583	0.587	12.91	12.12
Deothi (Chakli)	0.533	0.552	12.47	11.32
Sultanpur (Katal- Kathar)	0.535	0.525	12.30	11.28
Oachghat (Nando)	0.532	0.515	12.27	11.18
Mean	0.546	0.551	12.50	11.49
$CD_{0.05}$	0.012	0.007	0.09	0.21
CV	3.736	4.888	1.86	3.01

Cadmium (Cd) contamination in capsicum fruits

Results showed that the concentrations of cadmium in fruit samples of capsicum collected from different farmers' fields of the district Solan were in the range of 0.515 to 0.587 ppm (Table 2). The highest concentration of Cd (0.587 ppm) was recorded from Baddi whereas, minimum 0.515 ppm was observed in fruit samples collected from Oachghat. The Cd concentrations in capsicum fruits were higher than reported by Khajuria [19] in brinjal and cauliflower (0.03 to 0.05 mg/kg) in Nalagarh industrial hub of Himachal Pradesh.

Copper (Cu) contamination in capsicum fruits

The concentration of Cu (12.91 ppm) in capsicum fruits collected from Baddi was highest as compared to other locations (Table 2), whereas minimum 12.27 ppm was observed in fruit samples collected from Oachghat, which was also at par with Sultanpur (12.30 ppm). No significant differences in Cu concentrations in capsicum fruits were observed between Kandaghat & Parwanoo and Kandaghat & Deothi. We observed Cu concentrations in capsicum fruits in the range of 12.27 to 12.91 ppm which are lower than earlier report of Sharma and Chettri [8] who reported 65.5 ppm of Cu in vegetable and soil of agricultural fields in Kathmandu valley.

Zinc (Zn) contamination in capsicum fruits

The mean concentrations of zinc in fruit samples of capsicum collected from six different farmers' fields of district Solan were ranged between 11.18 to 12.12 ppm (Table 2). Significantly highest concentration of Zn (12.12 ppm) was recorded in Baddi, whereas minimum (11.18 ppm) was found in Oachghat samples which were statistically similar with Zn concentration in fruit samples collected from Sultanpur (11.28 ppm) and Deothi 11.32 ppm. Ramteke *et al*. [20] have also reported 29 ± 10 ppm of Zn in brinjal (*Solanum melongena*) fruits collected from Urga area of Korba city, Chhattisgarh, India. The capsicum fruit samples collected from farmer's fields around Baddi industrial area contained highest concentrations of heavy metals compared to other locations. The soil pollution and contamination of irrigation water with industrial wastes may be the possible reasons for higher heavy metals accumulation in capsicum fruits in Baddi area. However, the heavy metals (Pb, Cd, Cu, & Zn) concentrations were below the permissible limit (2.5 for Pb, 1.5 -Cd, 30 - Cu and 20 ppm for Zn) as per standard given by Awashthi [17] and FAO/WHO [18] for different vegetable crops.

Conclusion

Highest concentrations of heavy metals (Pb, Cd, Cu and Zn) in capsicum fruits were observed in Chandigarh Sabji Mandi, followed by Solan Sabji Mandi and local vegetable venders in Nauni. The concentrations of heavy metal in fruits were higher during the off season as compared to the main cropping season. In farmer's fields, heavy metals (Pb, Cd, Cu and Zn) concentrations were found highest around Baddi industrial area and lowest in fruits collected from Oachghat and Sultanpur villages of Solan district.

References

[1] X.Wang, T. Sato, B. Xing, S. Tao. Health risk of heavy metals to the general public in Tianjan, China via consumption of vegetables and fish. Sci. Tot. Environ, 200, 350 (1–3): 28–37.
[2] S. Khan, Q.Cao, Y.M. Zheng, Y.Z. Huang, Y.G. Zhu. Health risk of heavy metals in contaminated soils and food crops irrigated with waste water inBeijing, China. Environ. Pollut., 2008, 152 (3): 686–692.
[3] M.A. Radwan, A.K. Salama. Market basket survey for some heavy metals in fruits and vegetables. Food Chem. Toxicol., 2006, 44: 1273–1278.
[4] C.S.C.Wong, X D. Li, G. Zhang, S.H. Qi, X. Z. Peng. Atmospheric depositions of heavy metals in the Pearl River Delta, China. Atmos. Environ., 2003, 37: 767–776
[5] R.M. Tripathi, R. Ragunath, T.M. Krishnamurty. Dietary intake of heavy metals in Bombay City, India. Sci. Total Environ., 1997, 208; 149–159.
[6] A.G. Kachenko, B. Singh. Heavy metals contamination in vegetables grown in urban and metal smelter contaminated sites in Australia. Water Air Soil Pollut., 2006, 169: 101–123.
[7] R.K. Sharma, M. Agrawal, F.M. Marshall. Heavy metals contamination in vegetables grown in wastewater irrigated areas of Varanasi, India. Bull. Environ. Contamin. Toxicol., 2006, 77: 311–318.
[8] B. Sharma, M. K. Chettri. Monitoring of heavy metals in vegetable and soil of agricultural fields of Katmandu valley. Ecoprint, 2005, 12: 1-9.

[9] S. Singh, M. Kumar. Heavy metal load of soil, water and vegetables in periurban Delhi. Environ. Monitor. Assess., 2006, 120: 71–79.
[10] M.S. Jassir, A. Shaker, M.A. Khaliq. Deposition of heavy metals on green leafy vegetables sold on roadsides of Riyadh city, Saudi Arabia. Bull. Environ. Contam. Toxicol., 2005, 75: 1020–1027.
[11] R.K. Sharma, M. Agrawal, F.M. Marshall. Atmospheric depositions of heavy metals (Cd, Pb, Zn, and Cu) in Varanasi city, India. Environ. Monit. Assess., 2008b, 142 (1–3), 269–278.
[12] R.K. Sharma, M. Agrawal, F.M. Marshall. Heavy metals (Cu, Cd, Zn and Pb) contamination of vegetables in Urban India: a case Study in Varanasi. Environ. Poll., 2008a, 154, 254–263.
[13] G. Zurera-Cosano, R. Moreno-Rojas, J. Salmeron-Egea, R. Lora. Heavy metal uptake from greenhouse border soils for edible vegetables. Journal of Food and Agricultural Science, 1984, 49(3): 307-314.
[14] M. A. Zwarich, J.G. Mills. Heavy metal accumulation by some vegetable crops grown on sewage-sludge-amended soils. Canadian Journal of Soil Science, 1981, 62: 243-247.
[15] D. Singh, P.K. Choonkar, B. S. Dwivedi. Manual on Soil, Plant and Water Analysis. New Delhi, 2005, pp.78-79.
[16] R.K Sharma, M. Agrawal, F. M. Marshall. Heavy metals contamination in vegetables grown in wastewater irrigated areas of Varanasi, India. Bulletin of Environment Contamination and Toxicology, 2006, 77: 311–318.
[17] S. K. Awasthi (3rd ed). Prevention of food adulteration Act No. 3 of 1954. Central and State Rules as Amended for 1999. Ashoka Law House, New Delhi. 2000.6p.
[18] FAO/WHO. Food standard Programme Codex Alimentarius Commission 13 session report. Joint FAO/WHO food standards programme, Houstan United State of America. 2001, 110p.
[19] N. Khajuria. Impact of industrialization on water quality and soil health in Baddi- Barotiwala – Nalagarh industrial hubs of Himachal Pradesh. Ph. D. Thesis submitted to Dr. Y. S. Parmar university of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh (H.P), 2010, p146.
[20] S. Ramteke, B. L. Sahu, N. S. Dahariya, K. S. Patel, B. Blazhev, L. Matini. Heavy metal contamination of vegetables. Journal of Environmental Protection, 2016, 7:996-1004.

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