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RESEARCH ARTICLE

HEAVY METALS IN VEGETABLES FROM SELECTED MARKET SITES IN CHITRAKOOT, SATNA, MP, INDIA

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ABSTRACT

This study investigated the level of four different heavy metals Copper, Zinc, Lead and Cadmium in ten vegetables viz; Potato, Brinjal, Pumpkin, Tomato, Carrot, Radish, Coriander, Menthe, Spinach and Pigweed collected from two local market sites in Chitrakoot. The evaluation of heavy metals present in the vegetables was carried out using Atomic Absorption Spectrophotometer (AAS). The mean concentrations for each heavy metal in the samples were calculated and compared with the standards set by the FAO and WHO. The results reveal that the levels of Copper, Zinc and Cadmium for vegetables ranged from 0.063-9.32, 0.04-0.83 and 0.001- 0.99 mg/kg dry weight respectively. Lead was not detected in vegetables from most of the samples and where detected, it was at very low or almost negligible concentrations of 0.001- 0.003 mg/kg. The study concludes that heavy metal levels in vegetables consumed in the area were found to be within permissible limit and are safe for consumption.

INTRODUCTION

Heavy metals have a relative density greater than 4g/cm3 and occur naturally in rocks but concentrations are frequently elevated as a result of contamination (Grant and Grant, 1987). Arsenic (As), Lead (Pb), Cadmium (Cd), Zinc (Zn), Mercury (Hg), Silver (Ag), Chromium (Cr), Copper (Cu), Iron (Fe) and the Platinum group elements are most important heavy metals with regards to potential hazards. Heavy metals are non-biodegradable and consequently can be accumulated in human vital organs and leading to unwanted side effect. Prolonged consumption of unsafe concentrations of heavy metals through foodstuffs may lead to the chronic accumulation of heavy metals in the kidney and liver of humans causing disruption of numerous biochemical processes, leading to cardiovascular, nervous, kidney and bone diseases (Jarup, 2003). Heavy metal contamination of the foodstuff is one of the most important aspects of food quality assurance. National and international regulations on food quality have lowered the maximum permissible levels of toxic metals in food item (Radwan *et al*., 2006). Vegetables are an important part of the human diets forming an important source of carbohydrates, proteins, vitamins, minerals, fibers as well as trace elements and have beneficial antioxidative effects. These substances help to build bone, teeth and protect the body from diseases and regulate body processes on which vitality and good health depends (D'Mello, 2003). Heavy metals rank high amongst the chief contaminants of leafy vegetables (Mapanda *et al*., 2005). Intake of heavy metal contaminated vegetables cause serious health risk to consumers (Sobukola *et al*., 2010). Excessive content of Pb and Cd in food is associated with etiology of a number of diseases especially with cardiovascular, kidney, nervous as well as bone diseases (WHO, 1992; WHO, 1995). Lead affect bones and teeth, nervous system, liver, weakness in the wrist and figure, pancreases, and gum and inhibit the synthesis of hemoglobin. Cadmium causes severe diseases such as tubular growth, excessive salivation, gastrointestinal irritation, cancer, kidney damage, diarrhea and vomiting. They have also been implicated in causing carcinogenesis, mutagenesis and teratogenesis. Copper toxicity induces iron deficiency, lipid per oxidation and destruction of membranes (Steenland and Boffeta 2000). Zinc is the least toxic and an essential element in human diet as it require to maintain the functioning of the immune system but high concentration of zinc in vegetables may cause vomiting, renal damage, cramps.

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Monitoring and assessment of heavy metals concentrations in the vegetables from the market sites have been carried out in some developed and developing countries, but limited published data are available on heavy metals concentrations in the vegetables from the market sites of India (Divrikli *et al*., 2006; Sharma *et al*. 2008a, Tripathi *et al*., 1997). Since the dietary intake of food may constitute a major source of long-term low-level body accumulation of heavy metals, the detrimental impact becomes apparent only after several years of exposure. Based on persistent nature and cumulative behavior as well as the probability of potential toxicity effects of heavy metals as a result of consumption of leafy vegetables, there is need to monitor heavy metals concentrations periodically to ensure that the levels of these trace elements meet the agreed international requirements. The present study therefore aims to obtain information of the concentration levels of heavy metals (copper, zinc, lead and cadmium) in selected vegetables grown locally and sold in open markets in Chitrakoot, Satna, Madhya Pradesh, India.

MATERIALS AND METHODS

Collection and Processing of Samples

The present study was carried out in two market sites; Maghgawan market and Chitrakoot market, Chitrakoot, Satna, Madhya Pradesh, India, during 2012. Fresh samples of ten types of vegetables were randomly purchased. A total of 20 vegetable samples were collected. After collection, the samples were brought to the laboratory and uneatable portions of the vegetables were removed and the edible portion were properly separated and washed with distilled water to remove dust particles and then chopped into small pieces using a knife. The samples were then dried in an oven at 80 °C and then ground into a fine powder (80 mesh) using a commercial stainless steel blender and stored in air tight plastic containers. The resulting fine powder was kept at room temperature before analysis.

Acid Digestion (Nitric acid, Perchloric acid Decomposition)

Heavy metals in vegetable samples were extracted by acid digestion. 2g of each sample was weighed into a digestion flask and treated with 10 ml of an acid mixture made up of concentrated nitric acid (HNO_3) and perchloric acid ($HClO_4$). A blank sample was prepared by applying 10 ml of above acid mixer into an empty digestion flask. The mixture was then digested on an electric hot plate at 80-90^{0}C to concentrate till the solutions became transparent (Sharma *et al*., 2009). After cooling, the solutions were filtered with Whatman No.4 filter paper and diluted to 50 ml using de-ionized water. The solution was then preserved in a universal bottle for further analysis.

Heavy Metals Analysis (Atomic Absorption Spectroscopy)

The resulting solutions were analyzed for concentrations of Cu, Zn, Pb, and Cd using an atomic absorption spectrophotometer (model AAS 7000, Shimadzu). The measurements were made using a hollow cathode lamp of Cu, Zn, Pb, and Cd at wavelengths of 324.8, 213.9, 213.3 and 288.8 nm respectively. The slit width was adjusted for all the heavy metals at 0.7 nm. A certified standard reference material was used to ensure accuracy and the analytical values were within the range of certified value. All reagents used were of analytical grade.

RESULTS

In present investigation, the vegetables samples used are tabulated in Table 1 in order of their common name, scientific name, natural order and parts used. In the present study, heavy metals vie- Cu, Zn, Pb and Cd were assessed in vegetables samples by means of atomic absorption spectroscpy. The results of concentration levels of heavy metals are tabulated in Table 2A and 2B. Table 2A shows the mean concentrations of heavy metals detected in commonly consumed vegetables selected from the Maghgawan market and Table 2B shows the concentration of heavy metals investigated in the vegetables sampled from Chitrakoot market. The values are given as mean ± SD and the results are means of three replicates. The heavy metal levels determined were based on plants dry weight. In this study, the concentrations of copper in all the vegetables from Maghgawan market varied between 0.32 – 9.32 mg/kg and from Chitrakoot market varied between 0.06-1.99 mg/kg. Zinc concentrations in vegetables from the Maghgawan markets ranged from 0.09 – 0.83 mg/kg and from the Chitrakoot markets ranged from 0.04 – 0.68 mg/kg. Lead was not detected in vegetables from most of the samples and where detected, it was at very low or almost negligible concentrations of 0.001- 0.003 mg/kg.

Table 1. Botanical Identification of Vegetables under Investigation

S.No.	Common name	English name	Scientific name	Natural order	Parts
1	Aaloo	Potato	*Solanum tuberosum* L.	Solanaceae	tubers
2	Bengan	Brinjal	*Solanum melongena* L.	Solanaceae	Unripe fruits
3	Kaddu	Pumpkin	*Cucurbita maxima*	Cucurbitaceae	fruits
4	Tamater	Tomato	*Lycopersium esculentum*	Solanaceae	fruit
5	Gajar	Carrot	*Daucus carota*	Apiaceae	Fleshy roots
6	Mooli	Radish	*Raphanus sativus*	Cruciferae	Leaf, root
7	Daniya	Coriander	*Coriandrum sativum*	Umbelliferae	leaf
8	Menthi	Menthi	*Trgonella foenum graceum*	Fabaceae	leaf
9	Palak	Spinach	*Spinacia oleraceaea*	Chenopodiaceae	leaf
10	Bathua	Pigweed	*Chenopodium album murale*	Chenopodiaceae	leaf

Table 2A. Concentration of heavy metals in vegetables collected from Maghgawan Market

S.No.	Heavy metal content (mg/kg)				
	Vegetables	Cu	Zn	Pb	Cd
1	Potato	3.30	0.16	ND	0.022
2	Brinjal	2.23	0.54	ND	0.041
3	Pumpkin	4.28.	0.83	ND	0.008
4	Tomato	2.06	0.48	ND	0.027
5	Carrot	1.93	0.53	0.002	0.099
6	Radish	3.43	0.11	ND	0.031
7	Coriander	0.32	0.47	ND	0.055
8	Menthi	0.41	0.35	0.001	0.009
9	Spinach	7.12	0.76	0.003	0.001
10	Pigweed	9.32	0.09	0.001	0.003
WHO/FAO Safe limit		40.0	60.0	5.0	0.2

Table 2B. Concentration of heavy metals in vegetables collected from Chitrakoot Market

S.No.	Heavy metal content (mg/kg)				
	Vegetables	Cu	Zn	Pb	Cd
1	Potato	0.327	0.07	ND	0.089
2	Brinjal	0.376	0.43	ND	0.001
3	Pumpkin	0.913	0.68	ND	ND
4	Tomato	0.063	0.38	ND	ND
5	Carrot	0.933	0.33	ND	ND
6	Radish	0.843	0.18	ND	ND
7	Coriander	0.732	0.49	ND	ND
8	Menthi	0.841	0.31	ND	0.023
9	Spinach	0.412	0.67	ND	0.001
10	Pigweed	1.990	0.04	ND	0.007
WHO/FAO Safe limit		40.0	60.0	5.0	0.2

ND=Not detected. Levels were below detection limit.
n=3. Results expressed as mean ±SD.
Cu = Copper; Pb = Lead; Zn =Zinc; Cd = Cadmium.

Cadmium was detected at low concentrations of 0.001-0.099 mg/kg in vegetables purchased from both local markets. All these value are within safe limit with respect to (FAO/WHO Codex Alimentarius Commission 2001)

DISCUSSION

Environmental pollution due to heavy metals is not a new phenomenon, as they are ubiquitous in the environment (soil and vegetation). Some trace heavy metals are significant in nutrition, either for their essential nature or their toxicity. In fact many of them are required as micronutrients for plants, animals, microorganism as well as human beings. Sources of contamination affecting predominately vegetables samples are due to various inputs, such as fertilizers, pesticides, sewage sludge, and industrial waste. A correct evaluation of the risk associated with heavy/toxic metals accumulation in vegetables as well as in the soil is strictly needed.

The present study has generated data on concentration of heavy metals (Copper, Zink, Lead and Cadmium) in vegetables. Copper is an essential micronutrient which functions as a biocatalyst required for body pigmentation in addition to iron, maintain a healthy central nervous system, prevents anemia and interrelated with the functions of Zinc and Iron in the body (Jarup, 2003). However, most plants contain the amount of copper which is inadequate for normal growth which is usually ensured through artificial or organic fertilizers. In this study, the concentrations of copper in all the vegetables from Maghgawan market varied between 0.32 – 9.32 mg/kg and from Chitrakoot market varied between 0.06-1.99 mg/kg. This is higher than the findings of previous researches (Ozcan, 2004) in which Copper concentrations of 0.02mg/kg and 0.0081mg/kg, respectively reported for Indian Basil. Zinc concentrations in vegetables from the Maghgawan markets ranged from 0.09 – 0.83 mg/kg and from the Chitrakoot markets ranged from 0.04 – 0.68 mg/kg. Levels of Zn were highest in Pumpkin with mean concentration of 0.83 and 0.68 mg/kg and lowest in Pigweed with mean concentrations of 0.09 and 0.04 mg/kg respectively. Muhammad *et al.* (2006) reported (0.777mg/kg) Zn for cabbage and Itanna, (2002) also analyzed three green leafy vegetables and reported a higher concentration of Zinc in spinach.

Lead is a serious cumulative body poison which enters into the body system through air, water and food and cannot be removed by washing fruits and vegetables (Divrikli *et al*., 2003). In this study, Lead was not detected in vegetables from most of the samples and where detected, it was at very low or almost negligible concentrations of 0.001- 0.003 mg/kg. This is consistent with the report of previous researchers (Ladipo and Doherty, 2011) which stated that lead was not detected in vegetable samples analyzed at the time of their study. Lead was detected in four samples of vegetables purchased from local market of Maghgawan only. It was detected at very low concentrations of 0.001mg/kg in pigweed and menthe and 0.002mg/kg in carrot and 0.003mg/kg in spinach. It was however not detected in all the vegetables collected from the Chitrakoot market. Cadmium is a non-essential element in foods and natural waters and it accumulates principally in the kidneys and liver (Divrikli *et al*., 2003). Various sources of environmental contamination have been implicated for its presence in foods. Differing values have been previously reported in leafy vegetables which include 0.090 mg/kg for fluted pumpkin by Sobukola *et al.* (2010) and 0.049 mg/kg by Muhammad *et al*., 2008) for lettuce. In this study, Cadmium was detected at low concentrations of 0.001-0.099 mg/kg in vegetables purchased from both local markets. Samples from Maghgawan market showed higher concentrations of 0.099 mg/kg for Cd and Chitrakoot market showed higher concentration of 0.089 mg/kg (Cd). The current findings indicate that the heavy metals in the vegetables were below the safe limits of 40, 60, 5, and 0.2 mg/kg for copper (Cu), zinc (Zn), lead (Pb) and cadmium (Cd) respectively set by the WHO/FAO.

However, the levels of heavy metals were quite difference in vegetables purchased from two different market sites but these variations may be ascribed to the physical and chemical nature of the soil of the farm site, absorption capacities of heavy metals by vegetables, atmospheric deposition of heavy metals, which may be influenced by innumerable environmental factors such as temperature, moisture and wind velocity, and the nature of the vegetables, i.e. leaf, root, fruit, exposed surface area. When samples were compared between Maghgawan market and the Chitrakoot Market, the result indicated that there was no significant difference between the levels of the heavy metals of vegetables from both the market. This may be due to the fact that those vegetable samples were grown on soil having almost the same level of metals. Generally, the levels of heavy metals were observed to be lower than those of previous published works and regulatory standards. This study thus showed that vegetables consumed in Chitrakoot area are safe for consumption.

Heavy metals have a toxic impact, but detrimental impacts become apparent only when long term consumption of contaminated vegetables and food stuffs occurs. These metals show toxic potential which injures to human health like metal poisoning incidences of Cd poisoning in Japan and Cu poisoning in Holland had made attention of scientists and common people towards the harmful effects of metals (Monali, 2012). It is therefore suggested that periodic monitoring of heavy metals contamination in vegetables and other food items should be performed in order to prevent excessive build-up of these metals in the human food chain.

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