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Heavy Metal Contamination of Vegetables and Fruits from Bangalore City

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ABSTRACT

Samples of fruits (grape, pomegranate, orange, banana, lemon, pear, apple, sapota, mango and guava), and vegetables (brinjal, cucumber, tomato, capsicum, cauliflower, bean, radish, carrot, bottle gourd, chilly, root beet, onions, potatoes, lady's finger, cabbage, garlic) were procured from the Bangalore city markets during the period from May through November 2007 with the objective of determining their heavy metals composition viz., lead, zinc, cadmium, copper, cobalt, chromium, iron, manganese and nickel. The samples were digested and analysed for heavy metals using flame atomic absorption spectrophotometer. The results showed that urban consumers are at greater risk of getting exposed to heavy metals through fresh vegetables and fruits because of higher levels of heavy metals beyond the legally permissible limits as defined by FAO/WHO. The results indicated the order of abundance of heavy metals in fresh vegetables samples as Fe > Mn > Pb > Co > Cu > Zn > Ni > Cr > Cd, and in fruits as Fe > Cr > Mn > Pb > Ni > Co > Zn > Cu > Cd.

INTRODUCTION

Fruits and vegetables offer the most rapid and cost effective source of vitamins, fibres and minerals to the majority of people in developing nations. Some of heavy metals like Fe, Cu and Zn are essential for plants and animals (Wintz et al. 2002).

Presence of trace elements in fruits and vegetables has been ascribed to their absorption from soil and sources such as fertilizer, agricultural chemicals and contaminating drifts (Banu et al. 1985). Other sources of heavy metal contamination of foodstuff include adaptation of mechanized farming, sprays, seed preservatives (Jones 1987), and components from global pollution. Evaluation of heavy metal content of food has been carried out by various Laboratories dealing with food and drug administration for many years (Misra & Dinesh 1991). Micronutrient metals such as Cu, Mn, Mo, Ni, Co and Zn do occur naturally in fruits and vegetables as essential trace elements needed for good health (Reeves & Baker 2000), but they could be toxic when concentrations exceed the limits of safe exposure (Reilly 1991, Skurikhin 1993, Monni et al .2002, Blaylock & Huang 2000). Urban food security in India is a matter of growing concern. It is estimated that by 2025, 60% of India's population will be living in urban areas (Barman et al. 2000). The monitoring programmes for residues and contaminants contribute to improving food safety, warn of actual and potential food scares, and facilitate evaluation of possible health hazards by providing continuous information on levels of environmental pollution in the country (Dogheim et al. 2004). Food chain contamination by heavy metals has become a burning issue in recent years because of their potential accumulation in biosystems through contaminated water, soil and air. As such, in recent years, research on heavy metal accumulation in crops has assumed greater importance (Fiona et al. 2003). The objective of this

paper is to describe the level of heavy metals contamination in vegetables and fruits of Bangalore market and assess how metal contamination might have impacted food safety standards of urban consumers.

MATERIALS AND METHODS

Sample collection: Fresh fruit and vegetable samples were collected from the two main Bangalore city markets, Krishna Rajendra and Yeshwantpur markets. Sampling was done at random from different retailers and vendors within these market areas. A total of 11 fruit varieties including orange, banana, pomegranate, lemon, pear, sapota, apple, mango, guava, grape and mandarins, and 18 vegetables, brinjal, cucumber, tomato, capsicum, cauliflower, bean, radish, carrot, bottle goud, chilly, beet root, onion, potato, lady's finger, cabbage and garlic were collected in pairs from each of these markets between June and October 2007. The sampling period covered the entire rainy season of the year with intent of coinciding with maximum harvest coming from different sources of agriculture in the region. The fruit and vegetable samples were then analysed for Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, and Zn. The results are represented as µg/g dry wt.

Sample preparation: The collected fruit and vegetables samples were thoroughly washed and rinsed with distilled water. The samples were then sliced to small pieces and oven dried at 105°C for 24 hours. The dried samples were grounded into fine powder and stored in plastic polythene bags ready for digestion.

Sample digestion: The fruit and vegetable samples were digested using a high performance microwave assisted digestion with HNO_3 and H_2O_2 using a 6 Monobloc Microwave Ethos D Labstation. The digested solution was then left for automatic ventilation for 10 min. After cooling, the sample was filtered through Whatman filter paper No. 40. The filtered sample was made up to 100mL with metal-free distilled water and stored in a special container ready for analysis.

Sample analysis for heavy metals: A Shimadzu Atomic Absorption Spectrophotometer 6300 model with air-acetylene flame of an average fuel flow rate between 0.8 and 4.0 L/min, and the support gas flow rate between 13.5 and 17.5 L/min was used. The single element hollow cathode lamps used in AAS were of Hamamatsu Photonics Co. Ltd., L2433 series. The standard references for the given elements were procured from Inorganic Ventures Inc. and Sisco Research Laboratories Mumbai Ltd. Calibration curves for various elements obtained from these standards were of first order reaction.

RESULTS AND DISCUSSION

Heavy metals are toxic contaminants since they are persistent, and accumulate in water, sediment and in tissues of living organisms through the mechanisms of bioconcentration and biomagnification through the food chains (Chaphekar 1991, Lokeshwari & Chandrappa 2006). The results of the present study showed that the urban consumers are at greater risk of consuming fresh vegetables and fruits contaminated with heavy metals, beyond the permissible limits as defined by the FAO/WHO as evidenced by the results shown in Tables 1-5.

The cadmium levels in fruits ranged between 6.05 and 11.67 µg/g with an average level of 7.05 µg/g, and in the vegetables between 0.0 and 3.3 µg/g with an average value of 0.17 µg/g. This is seven times more than the prescribed limits of the PFA Act (1954) of 1.5 µg/g dry wt in fruits and three times in one sample of the vegetables. Similarly, the chromium levels ranged between 19 µg/g and 166 µg/g with an average of 75.62 µg/g in fruits, and from 0.00 µg/g to 66.66 µg/g with an average of

10.10 µg/g in the vegetables. For cobalt, the average was 40.93 µg/g with a maximum of 138 µg/g and minimum of 6.14 µg/g in fruit, and 17.95 µg/g and 113.90 µg/g in the vegetables respectively.

Copper, like other metals generally enter the environment through industrial effluents. The mean value was 17.24 µg/g in vegetables, and 10.87µg/g in fruits. In 1993, the joint FAO/WHO Expert Committee for Additives and Contaminants (JECFA) reduced the value it had provisionally specified for adults in 1972, for tolerable lead (Pb) consumption per week (PTWI - provisional tolerable weekly intake), from 0.05 mg/kg body weight to 0.025 mg or 25 µg. However, in fresh fruit samples, Pb levels were at an average of 53.87 µg/g with the maximum of 185.64 µg/g and minimum of 8.49 µg/g. In the fresh vegetable samples, Pb levels were at an average of 29.42 µg/g with maximum of 88.88 µg/g and minimum of 3.70 µg/g.

The prescribed Zn level as per the PFA Act 1954 is 50 µg/g dry wt. For the collected samples of fruits, Zn levels ranged from 17.84 µg/g to 45.16 µg/g with an average of 30 µg/g showing that the concentrations are within the permissible level. In the vegetables, Zn ranged between 2.28 µg/g and 52.61 µg/g with an average of 15.99 µg/g, indicating higher degree of contamination. Nickel (Ni) in fruits ranged between 9.1 µg/g and 72.5 µg/g with an average of 53.87 µg/g, and in vegetables between 1.62 µg/g and 66.40 µg/g with an average of 12.14 µg/g. In fruits iron (Fe) and manganese (Mn) were found to be abundant in the samples. The maximum iron (Fe) level was at 282.18 µg/g, and the minimum at 64.26 µg/g. The average value was at 167.39 µg/g. Manganese (Mn) levels in fruits ranged from 10.8 µg/g to 344 µg/g with an average value of 61.0 µg/g. In vegetables, Fe was more abundant with 279.52 µg/g and 101.02 µg/g being maximum and minimum values. Manganese (Mn) in vegetables ranged between 4.48 µg/g and 1109.59 µg/g.

The fruit and vegetable samples in the present study exhibited variable trace metals concentrations depending on nature of soil and level of contamination. The crops are often grown in polluted and degraded environmental conditions in agricultural zones and are subject to further pollution from vehicles and industries during packaging, supplying and marketing. The findings revealed higher concentrations of all the studied heavy metals in vegetables and fruits. The present investigation shows concentrations of the metals in the fresh vegetables as Fe > Mn > Pb > Co > Cu > Zn > Ni > Cr > Cd, and in fruits as Fe > Cr > Mn > Pb > Ni > Co > Zn > Cu > Cd. Presence of trace metals in fruits and vegetables has been ascribed to their absorption from soils and sources such as fertilizer, agricultural chemicals and contaminated drift (Banu et al. 1985). Other sources of heavy metal contamination of most foodstuffs include adoption of mechanized farming, sprays, seed preservatives and components from global pollution (Jones 1987). Food chain contamination by heavy metals has become a burning issue in past years because of their potential accumulation in biosystems through contaminated water, soil and air (Dogheim et al. 2004).

CONCLUSION

It is concluded that the 11 fruits and 18 vegetables, investigated in the present study, accumulated heavy metals in much higher concentrations. The problem arises when the irrigation water comes from sewage and industrial fed lakes, rivers or contaminated ground water. In the case of the fruit and vegetable samples, collected from the Bangalore markets, a combination of factors including the use of polluted water, bad practices in post harvesting, handling of fruit products with disregard to the food safety guidelines, and the physical market environments in these locations surrounded by heavy urban pollution deposition might have exacerbated contamination levels.

Table 1: Average concentration of heavy metals in fruits collected from K.R market in µg/g dry weight.

Fruit Sample	Cd	Cr	Co	Cu	Fe	Mn	Ni	Pb	Zn
Oranges	1.80	32.82	ND	15.10	220.47	59.63	ND	ND	35.43
Bananas	4.64	37.87	6.06	0.88	84.53	12.99	ND	195.19	32.01
Pomegranates	0.51	68.16	88.88	27.55	152.50	35.27	34.47	26.92	44.69
Lemon	4.64	88.36	31.31	5.33	162.96	42.93	31.60	ND	22.14
Pears	3.85	47.61	7.39	ND	344.01	272.13	38.49	9.52	23.08
Sapota fruits	4.06	104.7	32.54	4.7401	221.36	24.66	14.06	38.09	31.96
Apple	6.42	ND	39.93	ND	286.55	43.17	97.72	19.04	28.05
Mangoes	2.14	85.71	ND	14.22	189.31	39.31	14.06	9.52	32.67
Guavas	3.85	ND	51.76	ND	213.62	35.46	46.64	9.52	38.53
Grapes	3.63	28.57	54.72	ND	206.99	39.31	44.42	57.142	17.40

ND = Not done

Table 2: Average concentration of heavy metals in fruits collected from Yeshwantpur market in µg/g dry weight.

Fruit Sample	Cd	Cr	Co	Cu	Fe	Mn	Ni	Pb	Zn
Oranges	15.39	61.25	15.241	12.78	114.04	17.51	33.20	70.44	22.01
Bananas	13.36	88.32	185.90	14.19	190.99	417.39	8.90	7.46	45.64
Pomegranates	5.59	140.00	15.241	4.51	80.54	34.56	26.87	176.10	31.44
Lemon	9.09	227.50	8.70	6.76	43.99	11.059	37.94	58.70	22.19
Pears	7.58	88.32	ND	13.07	170.39	63.76	ND	26.13	24.08
Sapota fruits	9.44	50.10	ND	12.32	134.87	11.59	4.32	29.86	23.90
Apple	8.39	8.750	25.40	3.00	121.15	8.75	47.43	23.48	35.88
Mangoes	16.9	37.36	6.23	6.34	75.16	11.59	ND	67.20	18.29
Guavas	7.58	27.17	ND	20.91	220.36	10.86	24.17	ND	28.97
Grapes	12.24	166.25	ND	ND	114.04	29.03	37.15	99.79	41.43

Table 3: Recommended maximum levels of heavy metals in vegetables.

Element	Recommended Max. level, mg/kg (µg/g dry weight)	Reference
Cd	0.2	FAO/WHO, 2001
Co	50	Pendias & Pendias, 1992
Cr	2.30	Wieght, 1991
Cu	73.30	Wieght, 1991
Fe	425.50	Wieght, 1991
Mn	500	Pendias & Pendias, 1992
Zn	99.4	Wieght, 1991
Pb	0.3	FAO/WHO, 2001
Ni	67	Wieght, 1991

Table 4: Recommended maximum levels of heavy metals in food (fruits).

Element	Recommended Max. level, mg/kg	Reference
Cd	0.2	Anon, 1987
Cu	10	Anon, 1987
Zn	150	Anon, 1987
Pb	1.5	Anon, 1987

Table 5: Average concentrations of heavy metals in vegetables collected from K.R. market in µg/g dry weight.

Vegetables	Cd	Co	Cr	Cu	Fe	Mn	Zn	Pb	Ni
Bottle gourd	ND	ND	54.54	32.13	279.51	1109.59	52.61	74.07	1.62
Cabbage	ND	ND	ND	19.77	244.81	107.43	21.73	29.62	34
Lady's fingers	ND	ND	ND	22.59	198.55	38.04	33.98	44.44	66.4
Potatoes	ND	ND	ND	15.53	243.85	39.16	17.64	51.85	55.06
Cauliflower	ND	15.58	ND	1.41	214.93	26.85	19.28	88.88	33.2
Onion	ND	ND	ND	26.12	256.38	32.45	16.50	22.22	28.34
Capsicum	ND	ND	ND	4.23	197.59	15.10	5.55	ND	ND
Brinjal	ND	48.68	ND	19.77	101.20	33.57	12.74	ND	ND
Carrots	3.2	ND	ND	8.82	117.59	19.02	3.59	ND	ND
Cucumber	ND	ND	ND	15.53	182.16	21.26	9.47	37.03	ND
Beet root	ND	ND	ND	10.59	197.59	19.02	2.28	3.70	ND
Beans	ND	ND	ND	14.82	167.71	19.58	ND	ND	ND
Garlic	ND	113.9	30.30	19.06	146.50	17.90	11.43	59.25	ND
Tomatoes	ND	83.72	30.30	25.42	107.95	26.85	10.13	ND	ND
White cabbage	ND	ND	ND	14.47	185.06	4.47	7.19	29.62	ND
Radish	ND	ND	66.66	21.53	158.07	164.50	13.56	44.44	ND
White gourd	ND	61.34	ND	24.01	131.08	15.66	15.85	29.62	ND
Chillies	ND	ND	ND	14.47	173.49	15.66	34.31	14.81	ND

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