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Market Basket Survey for Lead, Cadmium, Copper, Chromium, Nickel, and Zinc in Fruits and Vegetables

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Heavy metals are given special attention throughout the globe due to their toxic, mutagenic and teratogenic effects even at very low concentrations (Das 1990). Several cases of human disease, disorders, malfunction and malformation of organs due to metal toxicity have been reported (Avena 1979). Along with the human beings and animals, the plants are also affected by toxic levels of heavy metals. Toxicological significance of heavy metals have been recognized several decades ago in developed countries and extensive studies have been reported from Denmark (Hansen and Andersen 1982), Great Britain (MAFF 1972, 1973) and Japan (Tsuda et al. 1995) etc. However, developing countries lag behind in this area of research and scanty effort has come forth.

In the United States, the Food and Drug Administration regulates and monitors the levels of heavy metals in different food items, while several countries stick the maximum weekly intake of heavy metals as decided by the WHO (1972, 1973). These intakes are 450, 4500 mg/60 kg body weight for Cd and Pb respectively. Provisional Tolerable Daily Intakes (PTDIs) for Zn, Cr and Cu are 15000, 50-200 and 1000-1500 μg/day respectively (NRC 1989). Fruits and vegetables are an important component of human diet after cereals. Considering the significance of heavy metals and consumption of fruits and vegetables, this investigation was carried out to monitor the levels of heavy metals in these commodities.

MATERIALS AND METHODS

All the chemicals and reagents were of analytical-reagent grade and were purchased from Merck (Darmstadt, Germany) or BDH Laboratory Supplies (Poole, England).

Samples of fruits and vegetables were purchased from local markets of Karachi. On the basis of the manner of consumption, samples were peeled off or washed with distilled deionized water (DDW). Edible portions were homogenized, oven-dried at 105°C (Wiersma et al. 1986) and sub-sampled for heavy metal analysis. 5g of a sub-sample was mineralized (wet ashing) according to the recognized method (AOAC 1990).

A Perkin Elmer Model 3100 atomic absorption spectrophotometer equipped with hollow-cathode lamp (electrodeless discharge source lamp) depending upon the element to be determined was used for heavy metal analysis. Standard instrumental conditions are shown in Table 1.

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Integration time: 0.1 sec, Replicates: 3, Calibration type: Non-linear and Flame Atomic Absorption Technique were the instrumental parameters.

Table 1. Standard Conditions for Perkin Elmer Model 3100 Atomic Absorption Spectrophotometer.

Element	Wavelength (nm)	Slit width (nm)	Lamp current (mA)	Flame gases	Slit height
Cd	228.8	0.7	8	A-Ac[1]	High
Cr	357.9	0.7	12	A-Ac	High
Cu	324.7	0.7	10	A-Ac	High
Ni	232.0	0.2	30	A-Ac	High
Pb	283.3	0.7	15	A-Ac	High
Zn	213.9	0.7	10	A-Ac	High

A-Ac[1]=Air-Acetylene

RESULTS AND DISCUSSION

Toxic heavy metals easily enter into food commodities from various sources of polluted ecosystem. The aim of this study was to monitor the heavy metals in fruits and vegetables. The results obtained so far are shown in Table 2 for twenty-one different fruits and vegetables.

Within the five selected fruits Pb levels were: chiku>papaya>mango>muskmelon>apple. This trend of Pb levels in fruit could be attributed to methods of cultivation. Chiku and papaya, being fruits of humid tropics, are being abundantly planted in the surroundings of Karachi. The air in Karachi is high in Pb aerosol resulting from emission from automobile/industrial exhaust. This aerosol finally falls on foliage or soil and is absorbed by plants. Yousufzai (2001) reported the concentration of Pb in the range of 250 to 1155 ppm on foliage of trees in different sites in Karachi. Apple plantations are mainly concentrated in areas where automobile/industrial exhaust is negligible; the study of Ndiokwere (1984) also reported almost similar trend of Pb distribution depending upon the distance from roadside. Among vegetables, the cucurbits showed elevated Pb levels however roots, tubers and bulbs contained less quantity. Other vegetables showed lack of uniformity. The maximum quantity of 1.80 ppm was found in luffa while garlic had the lowest concentration 0.04 ppm. Pb levels in plants depend upon several factors amongst them are the nearness of plantation to roadside, back ground levels (soil concentration), application of Farm Yard Manure/Sewage sludge, part of plant analyzed and species of plants. Significant variations are encountered within cultivars.

After Pb, Cd is the most toxic heavy metal, which causes health disorders even at extremely low doses. In fruits so far analyzed the trend of Cd concentration is similar to that of Pb i.e. maximum 0.34 ppm in chiku while minimum 0.14 ppm in apple. In vegetables variation is hard to explain. The high concentration of Cd 0.36 ppm was found in lady's finger and cucumber; however, the levels in most of the vegetables were above the acceptable levels of 0.05 ppm (Gendi 2000). This is attributable to overall excess of Cd concentration in our soils as reported earlier (Ahmed et al. 1994).

Although Zn is an essential element for plants and animals, yet slight increase in its levels may interfere with physiological processes. Sufficient Zn is essential to neutralize the toxic effects of Cd. The soil physio-chemical characteristics of Pakistan limit the absorption of this element, so Zn deficiency is a common finding phenomenon. In this study, maximum Zn level was found in garlic 5.13 ppm and papaya showed minimum levels 1.74 ppm.

Table 2. Heavy metal content in fruits and vegetables.

S.#	Commodity	No. of Samples	Toxic Heavy Metals Av.[1] Qty.[2] found (ppm)		Essential heavy metals Av. Qty. found (ppm)			
			Pb	Cd	Cr	Ni	Cu	Zn
01	Apple	05	0.76	0.14	0.50	3.06	0.50	2.05
02	Muskmelon	14	0.12	0.26	1.07	5.47	5.04	2.73
03	Chiku	04	1.65	0.34	0.98	4.75	0.56	5.11
04	Papaya	05	1.63	0.33	0.73	5.68	0.75	1.74
05	Mango	04	1.51	0.27	1.04	8.77	1.18	2.40
06	Luffa	02	1.80	0.33	0.92	5.67	2.16	2.50
07	Bittergourd	02	1.52	0.31	0.69	5.08	1.86	1.98
08	Potato	07	0.16	0.08	0.15	0.83	0.10	ND[3]
09	Onion	04	0.06	0.07	0.36	ND	0.09	0.83
10	Ginger	04	0.05	0.05	0.33	0.39	0.19	ND
11	Garlic	04	0.04	0.09	0.15	0.58	0.12	5.13
12	Pumpkin	04	1.19	0.24	0.72	0.49	1.03	3.51
13	Indian squash	05	1.06	0.33	0.86	5.82	4.45	3.22
14	Cucumber	04	1.72	0.36	0.86	5.82	4.45	3.22
15	Brinjal	02	1.30	0.31	1.05	5.46	3.14	3.52
16	Lady's finger	02	1.66	0.36	0.74	3.87	2.08	4.63
17	Tomato	05	1.56	0.33	0.83	4.15	2.31	2.45
18	Chilies	03	1.62	0.32	0.99	9.05	1.67	2.69
19	Mint	04	0.07	0.10	0.52	1.06	0.29	ND
20	Salad	04	ND	0.11	0.33	ND	2.08	ND

Av.[1] = Average, Qty[2] = Quantity and ND[3] = Not Detected

Chromium is essential for carbohydrate metabolism in human beings and animals. Its toxicity results in hepatitis, gastritis, ulcers and lung cancer (Avena 1979). Muskmelon showed the highest concentration of Cr 1.07 ppm followed by brinjal 1.05 ppm and mango 1.04 ppm while lowest levels were found in potato and garlic 0.15 ppm.

Nickel has been introduced recently as an essential element. Its toxicity has not been established so far except for the formation of nickel carbonyl during cigarette smoking which is thought to be a main carcinogen in lung cancer. However, maximum quantity of Ni was found in chillies 9.05 ppm while broccoli and onion contained traces of Ni.

Like Zn, Cu is also an essential element but it is highly toxic for animals even when its concentration crosses the safe limits. Toxic level of Cu results in anaemia, intestinal disorders, circulatory disturbances and liver and kidney failures. Generally plants contain the concentration of Cu, which is inadequate for normal growth of plants. Application of micronutrient fertilizers and copper sulfate as a fungicide may sometimes increase it to the alarming levels. In this study maximum Cu level was found in muskmelon 5.04 ppm while minimum levels were found in onion 0.09 ppm.

In the present study, there was a strong positive correlation (r=0.911) between the Cd and Zn content of studied fruits and vegetables. Zn was reported to decrease the uptake of Cd in nutrient solution (Jarvis et al. 1976) but in case of field trials opposite relation has been found by Koshino (1973). MacLean (1976) found no influence of Zn on the uptake of Cd. A significant positive correlation was found between Zn and Cd in wheat grains (Andersson and Petterson 1981). The relationship of Cd and Zn in this investigation was similar to the results of studies conducted by Andersson and Petterson (1981).

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