Selected Trace-Metal Levels in Local Vegetables Procured from Punjab, Pakistan

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Summary: Heavy trace metal content of thirty three vegetable samples procured from local markets/farms of Rawalpindi/Islamabad is estimated by wet digestion atomic absorption method. The metals include Fe, As, Pb,Hg, Cd, Cr and Ni. The families of vegetables investigated include: Cucurbitaceae, Solanaceae, Cruciferae, Liliaceae, Chenopodiaceae, Leguminosae, Umbelliferae, Araceae, Malvaceae, Zingiberaceae, Asclepiadaceae, Compositae and Labiatae. The data are reported at 99% (± 2S) confidence level for triplicate measurements with an overall reproducibility within ± 1% compared with standard samples. Comparison of averages through t-test indicates that each vegetable group is distinctly different from other in terms of heavy trace metal content. Maxima Fe concentration was shown by parsley at 29.515 μg/g, dry weight. The vegetables, in general, are free from excessive Hg, the maximum amount of the metal being present in cauliflower (edible part-flower) at 1.045 μg/g,, dry weight. Nickel was found to be 1.985 μg/g (dry weight) in carrot (edible part-root) in the vegetable family Umbelliferae. Arsenic was not found above detection limit except in ghia tori (edible part-fruit) of Cucurbitaceae family which had As at 0.445 μg/g, dry weight. With a couple of exceptions, the overall trace metal levels in the vegetables investigated were found to be within the safe limits laid down for human consumption.

Introduction

Despite the fact that trace metals have miniscule presence in food, the very human existence is due to their role in body metabolism. It has been established that whatever is taken as food might cause metabolic disturbance if it does not contain the allowed upper and lower limits of trace metals. Thus, both deficiency and excess of essential micronutrients (e.g. iron zinc, chromium) may produce undesirable effects [1]. Effects of toxic metals (cadmium, chromium, lead, nickel, etc.) on human health and their interactions with essential trace elements may produce serious consequences [2]. From this viewpoint, metals such as iron, arsenic, lead, mercury, cadmium, chromium and nickel are considered suitable for studying the impact of various foods on human health. The human body contains 80-70 ppm of iron, most of which exists in complex forms bound to protein, either as porphyrin or haeme compounds. Arsenic occurs naturally in food at low concentration levels which are rather essential [3]. Arsenic can occur as a toxic contaminant of food due to pesticide spray. Likewise, lead is toxic and is assimilated through dietary intake upto 25 μg/day and through inhalation upto 15 μg/day. Mercury is considered to be non-essential for living organisms and has been considered as poison. Although little data are available, it appears that plants reflect the mercury content of their environment fairly well.

The human body burden of cadmium increases with age and relationship between cadmium concentration in blood and hypertension has been suggested [4]. Chromium is present in human tissues in variable concentrations and its deficiency is characterized by disturbance in glucose, lipid and protein metabolism. Lastly, it has been reported that in patients with acute myocardial infarction, the mean concentrations of serum nickel were significantly increased through the period of 1-36 hours after the onset of symptoms [5].

Vegetables are staple part of human meal, taken as food in raw and cooked forms. The environmental variations have direct or indirect impact on vegetables and they may be regarded as an index of trace metal concentration in the environment, i.e., soil, water and atmosphere.

In view of the importance of the role trace metals play in defining the nutritional status of human body, the present study was initiated to investigate into the present situation of metal pollution in the local environment as a function of trace metal content of vegetables. The above cited metals were estimated by atomic absorption method in thirteen vegetable families abundantly consumed by the local population.

Results and Discussion

Tables 1-4 present the concentrations of the trace metals in different groups of vegetables belonging to different edible parts of plants. The data appearing in the tables are presented at 99% (± 2S) confidence level for triplicate measurements in each case.

Table-1 shows that the vegetables (edible part-fruit) are rich in iron content, with a percent incidence of 100%; its minimum concentration was found in tomato (2.605 μg/g) and maximum in green chilli (8.860 μg/g). Arsenic was found in only one sample ghia tori, at 0.445 μg/g, with a percent incidence below 8%. Lead was found to have an incidence of occurrence of 38%; the maximum concentration being in tomato (0.255 μg/g) whereas the minimum in tinda (0.035 μg/g). The percent of Hg occurrence was 69% and maximum Hg was found in cucumber (0.935 μg/g); its minimum concentration being in ladyfinger (0.030 μg/g). The Cd incidence of occurrence was 92% (lower than iron only) with the maximum concentration in tomato (0.075 μg/g) and the minimum in ghia tori (0.015 μg/g). Chromium was present in 46% samples. Its highest concentration was found in sem (0.140 μg/g) and lowest in ghia tori (0.030 μg/g). The incidence of occurrence of nickel was nearly 69%; the maximum level was found in sem (1.150 μg/g) whereas the minimum in green chilli (0.010 μg/g).

Table-2 shows the trace metal content of vegetables whose edible part is stem. Iron and cadmium had a 100 percent incidence of occurrence. The stem appeared to be richer in iron content when compared with the fruit vegetables. Maximum concentration was shown by garlic (12.275 μg/g) and minimum by potato (3.415 μg/g). Arsenic and lead showed a 6% incidence of occurrence. Mercury showed up in 66% samples with the maximum level in onion (0.600 μg/g) and

Table-1: Concentration (μg/g, dry weight) of Heavy Trace Metals in vegetables. (Edible Part-Fruit) from Families: Cucurbitaceae, Solanaceae, Leguminosae and Malvaceae

Sample Name	Level	Fe	As	Pb	Hg	Cd	Cr	Ni
Tinda/Citrullus vulgaris	X	3.885	-	0.035	-	0.050	-	-
var. fistulosus	±S	0.020		0.002	-	0.001	-	-
Karaila/Momordica charantia	X	7.335	-	0.115	0.320	0.025	-	0.460
	±S	0.013	-	0.003	0.002	0.002	-	0.020
Cucumber/Cucumus sativus	X	3.745	-	-	0.935	0.030	-	0.135
	±S	0.011	-	-	0.010	0.002	-	0.008
Ghia Tori/Luffa aegyptica	X	5.035	0.445	0.130	-	0.015	0.030	0.950
	±S	0.009	0.011	0.010	-	0.002	0.002	0.100
Pumpkin/Cucurbita pepo	X	6.060	-	-	0.200	0.060	-	0.090
	±S	0.007	-	-	0.013	0.004	-	0.005
Black Tori/Luffa acutangula	X	7.250	-	-	0.100	0.065	0.125	0.260
	±S	0.008	-	-	0.009	0.004	0.005	0.007
Tomato/Lycopersicum	X	2.605	-	0.255	0.225	0.075	0.110	-
esculentum	±S	0.004	-	0.003	0.004	0.003	0.004	-
Green Pepper/	X	4.795	-	-	0.345	0.045	-	0.130
Capsicum frutescens	±S	0.021	-	-	0.003	0.002	-	0.008
Green Chilli/Capsicum annum	X	8.860	-	-	-	0.070	0.035	0.010
	±S	0.009	-	-	-	0.004	0.003	0.003
Brinjal/Solanum melongena	X	4.550	-	-	0.495	0.070	-	0.080
	±S	0.017	-	-	0.003	0.004	-	0.005
Ladyfinger/Hibiscus esculentus	X	3.160	-	-	0.030	0.070	-	-
	±S	0.019	-	-	0.007	0.030	-	-
Sem/Canavalia ensiformis	X	5.140	-	0.065	0.490	-	0.140	1.150
	±S	0.009	-	0.005	0.007	-	0.009	0.004
Broad Beans/Phaseolus vulgaris	X	6.905	-	-	-	0.045	0.055	0.650
	±S	0.007	-	-	-	0.006	0.009	0.006

- below detection limit

Table-2: Concentration (µg/g, dry weight) of Heavy Trace Metals in Vegetables (Edible Part-Stem) from Families: Solanaceae, Araceae, Zingiberaceae, Liliaceae, *Asclepiadaceae*, Cruciferae and Leguminosae.

Sample Name	Level	Fe	As	Pb	Hg	Cd	Cr	Ni
Potato/Solanum tuberosum	X	3.415	-	-	-	0.060	-	-
	±S	0.010	-	-	-	0.004	-	-
Gem/Colocacia antiquorum	X	3.780	-	-	0.350	0.015	-	-
	±S	0.020	-	-	0.002	0.005	-	-
Ginger/Zingiber officinale	X	5.720	-	-	-	0.020	0.005	0.265
	±S	0.011	-	-	-	0.005	0.001	0.007
Onion/Allium cepa	X	6.690	-	-	0.600	0.030	0.105	-
	±S	0.011	-	-	0.012	0.004	0.010	-
Choongain/Caralluma edulis	X	6.435	-	-	0.350	0.005	-	0.330
	±S	0.009	-	-	0.007	0.001	-	0.008
Garlic/Allium sativum	X	12.275	-	-	0.575	0.040	-	0.065
	±S	0.008	-	-	0.011	0.005	-	0.004
**Cauliflower/Brassica oleraccae var. botrytis	X	4.235	-	0.400	1.045	0.005	-	0.845
	±S	0.020	-	0.020	0.003	0.001	-	0.003
***Pea/Pisum sativum	X	14.280	-	-	0.160	0.085	-	0.880
	±S	0.008	-	-	0.007	0.009	-	0.005

- below detection limit
** edible part-flower
***edible part-seed

Table-3: Concentration (µg/g, dry weight) of Heavy Trace Metals in Vegetables (Edible Part-Root) from Families: Chenopodiaceae, Cruciferae and Umbelliferae

Sample Name	Level	Fe	As	Pb	Hg	Cd	Cr	Ni
Beet/Beta vulgaris	X	4.550	-	0.035	0.145	0.020	0.110	-
	±S	0.020	-	0.007	0.007	0.009	0.008	-
Radish/Raphanus sativus	X	4.030	-	0.005	0.015	0.035	0.030	-
	±S	0.020	-	0.001	0.004	0.003	0.004	-
Red Radish/Raphanus sativus	X	5.085	-	-	0.030	-	0.005	0.410
	±S	0.009	-	-	0.003	-	0.002	0.006
Turnip/Brassica rapa	X	3.345	-	-	-	0.115	0.005	-
	±S	0.017	-	-	-	0.005	0.001	-
Carrot/Daucus carota	X	4.395	-	0.485	0.720	-	-	1.985
	±S	0.007	-	0.005	0.011	-	-	0.006
*Parsley/Petroselinum sativum	X	29.515	-	0.650	-	0.010	0.005	1.430
	±S	0.006	-	0.010	-	0.002	0.001	0.003

- below detection limit
* leaf is also edible.

Table-4: Concentration (µg/g, dry weight) of Heavy Trace Metals in Vegetables (Edible Part-Leaf) from Families: Liliaceae, Chenopodiaceae, Labiatae, Compositae, Umbelliferae and Cruciferae.

Sample Name	Level	Fe	As	Pb	Hg	Cd	Cr	Ni
*Leek/Allium porrum	X	4.720	-	1.435	0.110	0.040	0.050	0.325
	±S	0.009	-	0.004	0.010	0.005	0.005	0.009
Spinach/Spinacea oleracea	X	11.290	-	1.755	-	0.060	0.030	-
	±S	0.030	-	0.008	-	0.010	0.008	-
Mint/Mentha virdis	X	8.730	-	0.330	0.210	-	0.060	0.925
	±S	0.009	-	0.007	0.005	-	0.003	0.010
Lettuce/Lactuca sativa	X	6.860	-	0.155	0.950	0.010	-	0.775
	±S	0.008	-	0.005	0.005	0.002	-	0.003
Coriander/Coriandrum sativum	X	8.515	-	0.655	0.820	-	-	1.445
	±S	0.006	-	0.007	0.012	-	-	0.007
Cabbage/Brassica oleracea var. capitata	X	5.485	-	-	0.290	0.090	0.005	-
	±S	0.009	-	-	0.003	0.004	0.002	-

- below detection limit
* stem is also edible

the minimum in gem and choongain (0.350 μg/g). The maximum concentration of Cd was found in potato (0.060 μg/g) and the minimum in choongain (0.005 μg/g). Chromium showed percent incidence level at 33%. Its maximum level was found in onion (0.105 μg/g) and minimum in ginger (0.005 μg/g). Nickel was found in 50% of samples; maximum level appeared in choongain (0.330 μg/g) and minimum in garlic (0.065 μg/g). The same table also shows the trace metal levels of cauliflower (edible part-flower) and pea (edible part-seed). Both vegetables did not show detectable levels of arsenic and chromium; however, lead was also below detection limit in case of pea. The iron content of pea was higher (14.280 μg/g) than that of cauliflower (4.235 μg/g). The nickel level appeared to be comparable for both the vegetables. Mercury content was relatively higher for cauliflower (1.045 μg/g).

Table 3 shows the concentrations of trace metals of vegetables whose edible part is root. Percent incidence level of iron was again (like other vegetables) 100%. The maximum concentration was noted for parsley (29.515 μg/g) being the highest of all the vegetable samples by analyzed. Minimum concentration was shown by turnip (3.345 μg/g). As was the case with stem vegetables, arsenic appeared below detection limit. The percent occurrence level of Pb was at 66% with maximum concentration in parsley (0.650 μg/g) and minimum in radish (0.005 μg/g). Mercury also showed occurrence level of 66% . Its highest concentration was shown in carrot (0.720 μg/g) and lowest in radish (0.015 mg/g). For cadmium, the percent incidence level was the same as that of mercury. Maximum level was found in turnip (0.115 μg/g) and minimum in parsley (0.010 μg/g). The incidence of occurrence of chromium appeared at 83%, maximum concentration being in beet (0.110 μg/g) and minimum in red radish, turnip and parsley (0.005 μg/g). Nickel showed percent incidence level of 50%. Its maximum concentration was found in carrot (1.985 μg/g) and minimum in red radish (0.410 μg/g).

Table-4 gives the concentration levels of trace metals in vegetables whose edible part is leaf. As for all other cases, iron was again present in 100% samples. Maximum concentration was found in spinach (11.290 μg/g) whereas minimum in leek (4.720 μg/g). Arsenic was below detection limit. Lead and mercury showed percent incidence level of 83%. Highest lead concentration was present in spinach (1.755 μg/g) and the lowest in lettuce ((0.155 μg/g). The maximum concentration of mercury was found in lettuce (0.950 μg/g) and minimum in leek (0.110 μg/g). The percent incidence level of Cd, Cr and Ni was 66%. Maximum concentrations of these metals were found in cabbage (0.090 μg/g), mint (0.060 mg/g) and coriander (1.445 μg/g), respectively. Minimum concentrations were present in lettuce (0.010 μg/g), cabbage (0.005 μg/g) and leek (0.325 μg/g), respectively.

Of all the vegetables analyzed, root vegetables showed the highest level of iron. Arsenic was shown by only one fruit vegetable. The overall lead content remained below 2 μg/g. Mercury level hardly exceeded 1 μg/g however, overall cadmium level remained quite low. Chromium content did not appear alarming but nickel level exceeded 1 μg/g in few cases. Almost all vegetables investigated for trace metal levels were found acceptable for human consumption [6].

Experimental

All vegetable samples were procured from local markets and farms of Rawalpindi/Islamabad and suburbs in late March and early April. On a comparative basis, sampling was preferably done from rich in organic content of the soil. The samples were immediately processed for analysis, with as much shortest time in between as was practically possible to achieve.

About 50g of each vegetable sample was dried overnight at 80 ±1 °C after washing with distilled water. The vegetables which are eaten after peeling, were peeled and then washed with distilled water [7,8]. The dried sample was ground in a mortar until fine powder was obtained.. An aliquote of exactly weighed 1.0 g of the powder was transferred to a china dish (150 ml), with an addition of 15.0 ml of 30% nitric acid [9] and heated the dish at 50 ±1 °C for about an hour. To the digested sample distilled water was added to make the volume up to 50.0 ml. This solution was aspirated directly onto a Shimadzu atomic absorption spectrophotometer, model AA-670, for the estimation of trace metal content. Thirty three samples of vegetables (divided into four groups on the basis of the part consumed; namely, root, stem, leaf and fruit) from thirteen families were analyzed in all. The analysis was carried out on the next day after procuring the samples and determining the water content.

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