Selected Trace Metal Levels in Common Vegetables Grown in NWFP, Pakistan

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Summary: Seventeen vegetables procured from local markets of Peshawar and its suburbs were analyzed using wet digestion atomic absorption method for Fe, As, Pb, Hg, Cd, Cr, and Ni. The families investigated were: Cucurbitaceae, Solanaceae, Cruciferae, Liliaceae, Araceae, Leguminosae, Malvaceae, Umbelliferae and Zingiberaceae. The heavy metal data are reported at 99% (± 2S) confidence level for triplicate measurements on subsamples of a given sample with an overall reproducibility of 2% compared with standard material samples. Comparison of averages through t-test indicates that each vegetable group is distinctly different from the other in terms of metal content. Maximum iron was present in garlic, at 4.585 μg/g, dry weight (edible part-stem) of the Liliaceae family. Arsenic was found to be below detection limit in all the vegetable groups. Lead levels were quite low; maximum concentration (0.0200 μg/g, dry weight) was found in karaila (edible part-fruit). Mercury levels were relatively higher, with maximum concentration (2.590 μg/g, dry weight) in gem (edible part-stem). The levels of nickel were moderately higher, being maximum (2.375 μg/g dry weight) in karaila. The overall content of trace metals appeared to be within limits laid down internationally for safe human consumption, with only a few exceptions.

Introduction

It is well known that trace metals play important role in various metabolic processes in human body. There is evidence that a disturbance in the concentration of trace metals can produce various psychiatric symptomatology [1]. The essential and the toxic metals may both be present in a variety of environmental substances, such as water, soil, air, food etc. Their actual concentration in the body depends on a number of factors, of which their actual local concentration, the food habits, the geographical and industrial environment and profession of the population segments are important [2].

Vegetables are staple part of food and are taken in cooked and raw forms. The determination of metal content in vegetables is important from the viewpoint of crop yield technology, food nutrition and health impacts [3]. The determination of the base-line levels of metals, such as Fe, As, Pb, Hg, Cd, Cr and Ni in agricultural and horticultural crops is necessary to evaluate their toxicological significance and to set action levels [4]. Since the metal contents of vegetables reflect the levels of metals in the environment fairly well, the present study was initiated to make an assessment of the levels of trace metals in vegetables drawn from the local environment. In our previous communication [5], we reported the levels of above-mentioned metals in vegetables procured from Punjab, Pakistan. In the present study, the levels of the same trace metals are being reported for seventeen vegetables belonging to nine different families procured from local markets of Peshawar, NWFP, Pakistan and analyzed by atomic absorption spectrophotometric technique.

Results and Discussion

Table 1 gives the concentrations of the trace metals in different groups of vegetables for different edible parts of the plants. The data are presented at 99% (±2S) confidence level for triplicate measurements in each case.

For vegetables whose edible part is fruit, iron showed a hundred percent incidence level, with maximum concentration (3.965 μg/g) in tomato and minimum (1.200 μg/g) in cucumber. This group appears to be quite rich in iron, especially pumpkin, brinjal and broad beans, all containing > 3 μg/g Fe. These vegetables may thus compensate for the deficient intake of the metal through other diets [6].

Table-1: Concentration (μg/g, dry weight) of heavy trace metals in various parts of vegetables from different families

Sample/Part/Family	Level	Fe	As	Pb	Hg	Cd	Cr	Ni
Fruit, Cucurbitaceae, Solanaceae, Leguminosae and Malvaceae								
Karaila/*Momordica*	X ± 2S	1.580	BDL	0.200	2.165	0.035	BDL	2.375
charantia		0.016		0.020	0.016	0.008		0.012
Cucumber/*Cucumus*	X ± 2S	1.200	-	BDL	0.585	BDL	0.010	0.910
sativus		0.020			0.006		0.004	0.010
Pumpkin/*Cucurbita*	X ± 2S	3.125	-	-	2.285	0.055	0.040	1.835
pepo		0.018			0.008	0.010	0.010	0.008
Black Tori/*Luffa*	X ± 2S	1.970	-	-	BDL	BDL	BDL	1.165
acutangula		0.016						0.014
Tomato/*Lycopersicum*	X ± 2S	3.965	-	-	0.755	-	-	1.365
esculentum		0.010			0.012			0.010
Brinjal/*Solanum melongena*	X ± 2S	3.795	-	0.060	BDL	-	-	1.500
		0.018		0.006				0.020
Broad Beans/	X ± 2S	3.670	-	BDL	1.845	-	0.035	0.880
Phaseolus vulgaris		0.040			0.010		0.014	0.014
Ladyfinger/*Hibiscus*	X ± 2S	2.245	-	-	1.405	0.020	BDL	2.115
esculentus		0.018			0.020	0.018		0.018
Stem, Solanaceae, Liliaceae, Araceae and Zingiberaceae								
Potato/*Solanum tuberosum*	X ± 2S	1.800	BDL	BDL	0.215	0.045	0.030	1.655
		0.014			0.014	0.010	0.008	0.008
Onion/*Allium cepa*	X ± 2S	1.405	-	-	BDL	BDL	BDL	1.075
		0.008						0.020
Garlic/*Allium sativum*	X ± 2S	4.585	-	-	2.030	0.005	-	1.020
		0.008			0.014	0.002		0.016
Gem/*Colocacia*	X ± 2S	2.400	-	-	2.590	0.045	0.020	1.990
antiquorum		0.020			0.018	0.010	0.006	0.016
Ginger/*Zingiber*	X ± 2S	1.885	-	-	BDL	0.010	0.005	1.405
officinale		0.016				0.004	0.008	0.016
Root, Cruciferae and Umbelliferae								
Turnip/*Brassica rapa*	X ± 2S	2.210	BDL	BDL	0.460	0.060	0.045	0.895
		0.020			0.014	0.014	0.020	0.008
Radish/*Raphanus sativus*	X ± 2S	3.295	-	0.170	0.905	0.015	0.010	1.780
		0.018		0.016	0.006	0.006	0.006	0.006
Carrot/*Daucus carota*	X ± 2S	2.300	-	BDL	BDL	0.035	BDL	1.685
		0.018				0.006		0.006
*Cabbage/*Brassica*	X ± 2S	1.405	-	-	0.410	0.025	-	1.815
oleraceae var capitata		0.020			0.016	0.010		0.010

BDL = Below Detection Limit
* = Edible part-Leaf

Nickel was another metal with a percent incidence of 100%, with maximum concentration (2.375 μg/g) in karaila and minimum (0.880 μg/g) in broad beans. Although in man nickel is bound to three different fractions of serum [7,8] and is generally connected with the maintenance of the structure and function of cellular membranes, there is great controversy regarding its essentiality for human body. The reported dietary intake of nickel ranges between 60 and 260 μg/day [9], thus, even a 100 g serving of karaila per person would not be harmful in terms of nickel content. Arsenic remained below detection limit, *i.e.*, at 0% incidence level.

Arsenic, in the form of arsenate, is a known teratogen in mammals [10]. Arsenate and arsenite are the main forms of inorganic arsenic in the general environment where food and drinking water often are the most important sources. It is also considered as carcinogenic to humans [11] and in view of this, the absence of the element in the vegetables studied is a good omen. It has also been suggested that arsenic is an essential trace element [7] and may be involved in the conversion of methionine to its metabolites taurine, labile methyl and the polyamines. The reported arsenic content of diets from various parts of the world indicates that the average daily intake of arsenic is in the range of 12-40 μg [12]. Lead showed 25% incidence of occurrence with maximum concentration (0.200 μg/g) in karaila and minimum (0.60 μg/g) in brinjal. Lead serves no useful purpose in the human body

[13]; however, in large amounts it becomes toxic. The normal lead content in the blood of persons who have not been particularly exposed lies around 200. μg/L or less however, amounts twice as high are quite often found. Concentrations above 800 μg/L in blood must be considered dangerous [11]. In view of this, the estimated concentrations of the metal in vegetables under investigation do not pose a health hazard for the consumers. Mercury was found in 75% of the samples; maximum concentration (2.285 μg/g) was found in pumpkin and minimum (0.585 μg/g) in cucumber. Oral ingestion of metallic mercury appears to be relatively harmless, in contrast to breathing mercury vapour which is responsible for most industrial intoxications. A content of 20 μg/L is considered to be a security limit. Normal levels lie around 5 μg/L or less. Seen in this perspective, the vegetables are quite safe for human consumption.

The percent incidence levels of Cd and Cr were the same, *i.e.*, 38%. Maximum concentration of Cd (0.055 μg/g) was found in pumpkin and that of Cr (0.040 μg/g) in the same vegetable. Minimum concentrations of Cd and Cr were present in ladyfinger (0.020 μg/g) and cucumber (0.010 μg/g), respectively. Once in the body, cadmium selectively accumulates in the liver and kidney [14]. It was also found that patients with hypertension had higher blood and kidney levels of cadmium as well as higher Cd/Zn ratios in the kidney than normal controls. Chromium has been reported to interfere with the enzymatic sulfur uptake of cells affecting the lungs, liver and kidneys [15]. Thus, both cadmium and chromium do not apparently pose a health threat in view of their concentration levels in the vegetables investigated.

The vegetables with stem as the edible part were found to be moderately rich in iron content. The incidence level of the metal was 100%. Maximum concentration (4.585 μg/g) was found in garlic whereas minimum (1.405 μg/g) in onion. The percent incidence levels of As and Pb in this case were zero, *i.e.*, below detection limit. Mercury appeared in 60% of the samples investigated. Its maximum concentration (2.590 μg/g) was found in gem and minimum (0.215 μg/g) in potato. The incidence level of Cd was 80% with maximum concentration (0.045 μg/g) in potato and gem and minimum (0.005 μg/g) in garlic. Chromium was present at 60% incidence with maximum concentration (0.030 μg/g) in potato and minimum (0.005 μg/g) in ginger. Nickel was present in all the vegetables, with maximum concentration (1.990 μg/g) in gem and minimum (1.020 μg/g) in garlic.

The heavy metal content of vegetables with root as the edible part gave a 100% incidence level for iron, as was found for the previous two groups of vegetables. Maximum concentration (3.295 μg/g) of the metal was found in radish and minimum (2.210 μg/g) in turnip. Arsenic once again remained below detection limit, *i.e.*, at zero percent incidence level. Lead appeared in only one vegetable sample, at 33% incidence level, in radish at 0.170 μg/g. Mercury, however, showed 67% incidence level, its maximum concentration (0.905 μg/g) was found in radish and minimum (0.460 μg/g) in turnip. Cadmium and nickel (after iron in this group) showed 100% incidence level. Maximum concentration (0.060 μg/g) of Cd was shown by turnip and minimum (0.015 μg/g) by radish; the latter showed the maximum concentration (1.780 μg/g) of Ni and the former showed the minimum (0.895 μg/g). Chromium was present in 67% of the samples studied. Its maximum concentration (0.045 μg/g) was found in turnip and minimum (0.010 μg/g) in radish. Table-1 also gives metal levels of cabbage (edible part-leaf, family-Cruciferae). Here, higher levels for nickel (1.815 μg/g) and iron (1.450 μg/g) were observed whereas mercury and cadmium showed low levels (0.410 and 0.025 μg/g, respectively). Also, lowest levels were shown by As, Pb and Cr, all these were found at levels lower than the detection limit.

In conclusion, all of the vegetable groups studied, the stem vegetables showed the highest iron level. The incidence levels of iron and nickel remained 100% for all groups. Slightly higher levels of mercury were found in fruit vegetables. The levels of cadmium and chromium, however, appeared quite low. Considering the current levels of lead pollution of environment, its levels in all vegetable groups are still within safe limits. The essentiality of iron [6] and nickel [7-9,16-17] makes it necessary that their concentrations should be high. Together with other food parts, vegetables may provide the required amounts of trace metals to the body. It is clear from the present study that the levels of the toxic metals are within limits laid down for safe human consumption [18]. The tolerable upper safe limits for the ingestion of the metals investigated in this work have been laid down by joint FAO/WHO environmental monitoring program [19] as: Fe, 1.0 μg/g; As, 0.001 μg/g, Pb, 0.100 μg/g; Hg, 0.750 μg/g; Cd, 0.05 μg/g; Cr, 0.05 μg/g and Ni, 1.0 μg/g, all on dry basis. Seen in this perspective, the present results are in good agreement with those from some of the earlier studies on vegetables/edible commodities conducted by various researchers [20,21].

Experimental

The vegetable samples were procured from local markets of Peshawar and its suburbs. After collection the samples were immediately processed for analysis.

The details on handling of samples have already been reported in our previous communication [5]. Briefly, 50g of each vegetable sample was dried overnight at 80 ±1°C after washing with distilled water. The vegetables (consumed after peeling) were peeled and then washed with distilled water [22,23]. After determining the water content of samples, these were ground in mortar until fine powder was obtained, of which an exactly weighed 1.0 g portion was transferred to a china dish (150 mL capacity). With an addition of 15.0 mL of 30% nitric acid, the content of the dish was heated at 150 ± 1°C for about an hour [24]. In cases where a clear digest was not obtained at this stage, 5 mL $HClO_4$ was added to the contents of the dish after cooling to about 40°C, and reheated to 80°C until white fumes ceased to evolve. Finally, distilled water was added to the digested sample to make the volume upto 50.0 mL. This solution was directly aspirated onto a Shimadzu Atomic Absorption Spectrophotometer, model AA-670, for the estimation of trace metal content. Mercury estimation was conducted following the standard flameless procedure [25]. Seventeen samples of vegetables (divided into three groups on the basis of parts consumed, namely, fruit, stem and root) were analyzed.

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