Pak. J. Agri. Sci.
24 (2) 140, 1987

CONCENTRATION OF SELECTED TOXIC TRACE METALS IN SOME VEGETABLES AND FRUITS OF LOCAL ORIGIN

M. Jaffar and Mohammad Saleem*

Department of Chemistry, Quaid-i-Azam University, Islamabad.
*Nutrition Division, National Institute of Health, Islamabad.

Using standard analytical procedures in conjunction with the atomic absorption technique, four toxic trace metal residues were estimated in 157 vegetable and fruit samples. These included green peas, radish, potato, onion, carrot, cabbage, beans, spinach, tomato, orange, mango, banana and apple, collected from Punjab, NWFP and Azad Kashmir areas. Lead, cadmium, nickel and mercury concentrations were determined alongwith percent recoveries. The study revealed that spinach from Jhelum (Punjab) contained maximum lead and cadmium contents, 3.470 mg/kg and 0.076 mg/kg, respectively. The maximum concentration of nickel, 0.468 mg/kg, was found in bean received from Rawalpindi (Punjab), while mercury had the maximum concentration of 0.021 mg/kg in potato, from Faisalabad (Punjab). The estimated concentration levels are reported at ± 1.5% for replicated measurements in each case.

INTRODUCTION

The determination of trace constituent levels of elements in food is becoming increasingly important from the view point of nutritional and food safety considerations. This is especially true for toxic trace metals such as lead, cadmium, nickel and mercury. A review of analytical techniques used for this purpose was presented by Stika and Morrison (1981). However, specific procedures for elemental assay of foods of varied nature were presented by other sources as well (Horwtiz, 1980. Pearson, 1970). The role of trace metals in nutritional and/or toxic respones was previously studied by many workers (Venugobal and Luckey, 1975; Johnston, 1976). The deficiency and over-supply aspects of essential and nonessential metaltraces were studied by Baccini (1976) and Wood (1974).

Increasing industrialization has polluted the environment with several toxic trace elements (WHO 1980). Higher concentration of several hazardous trace metals such as the ones mentioned adove have been found in various foodstuffs (Thomas and Rogan, 1973) causing deep concern to relevant public health authorities all over the world. Little is yet known of the maximum safe limits due to long term exposure of man to these elements through food, air and water. The matter becomes more complicated in view of the fact that the health impact of individual trace elements cannot be considered in isolation from other aspects of man's dietary intakes.

Consequently, the analysis of foods for trace metals is rather inevitable. In keeping with this requirement, various vegetables and fruits most commonly consumed by Pakistani population were subjected to the estimation of lead, cadmium, nickel and mercury. The reported data will help in assessing the quality criteria for safe consumption of these foodstuffs.

MATERIALS AND METHODS

The vegetable and fruit samples were collected through local sales agencies catering distribution in Punjab, NWFP and Azad Kashmir. The main commodities collected are listed in Table 1. As soon as the samples were received they were cleaned from foreign matter and impurities and then homogenized in an electric blender. After preparation, the samples were coded and deep frozen at -10°C till the time of analysis.

The analytical methodology adopted for determining trace metals essentially consisted of the destruction of organic matrix by HNO_3 based oxidation and subsequent estimation of lead, cadmium and nickel levels by the atomic absorption method, according to the procednre of WHO (1973). The mercury was estimated by the AOAC method (Horwitz, 1980). A Hitachi atomic absorption spectrophotometer, model 170-10, was used in the present study employing air-acetylene flame under optimum operating conditions. FAO reference standards were used for intercalibration of our own standards. Deionized water was used throughout this work. All measurements were made at 0.4nm band-pass at the specific wave-length for a given trace metal. The quantification was done by the standard curve technique. For consistency check, spiked recovery experiments were performed on a variety of samples throughout the study in addition to reagent blank tests.

Table-1. Average Concentrations of the Trace Metals in Various Vegetables and Fruits

S.No.	Commodity	Code	Number of Sample	Level	Concentration (mg/kg), dry weigh[t] Pb	Cd	Ni	Hg
1.	Green Pea	V-001/013	13	$\bar{X}$	0.575	0.013	0.111	0.019
				$\pm S$	0.083	0.008	0.098	0.010
2.	Radish	V-001/013	13	$\bar{X}$	1.516	0.019	0.113	0.007
				$\pm S$	0.511	0.009	0.084	0.003
3.	Potato	V-001/013	13	$\bar{X}$	2.903	0.030	0.317	0.021
				$\pm S$	0.633	0.012	0.083	0.005
4.	Onion	V-001/012	12	$\bar{X}$	2.363	0.014	0.283	0.019*
				$\pm S$	0.479	0.009	0.049	0.008
5.	Carrot	V-001/014	14	$\bar{X}$	1.017	0.029	0.300	0.008
				$\pm S$	0.433	0.018	0.201	0.003
6.	Cabbage	V-001/011	11	$\bar{X}$	3.180	0.028	0.239	0.015
				$\pm S$	0.987	0.020	0.134	0.008
7.	Bean	V-001/013	13	$\bar{X}$	2.679	0.034	0.468	0.017
				$\pm S$	1.031	0.020	0.103	0.010
8.	Spinach	V-001/012	12	$\bar{X}$	3.470	0.076	0.400	0.005
				$\pm S$	1.031	0.090	0.213	0.002
9.	Tomato	V-001/010	10	$\bar{X}$	1.020	0.021	0.369	0.090*
				$\pm S$	0.230	0.010	0.133	0.020
10.	Orange	F-001/014	14	$\bar{X}$	0.529	0.031	0.364	0.021**
				$\pm S$	0.138	0.020	0.123	0.011
11.	Mango	F-001/012	12	$\bar{X}$	1.001	0.012	0.132	0.011
				$\pm S$	0.421	0.009	0.061	0.009
12.	Banana	F-001/010	10	$\bar{X}$	0.723	0.011	0.141	0.004
				$\pm S$	0.213	0.008	0.080	0.002
13.	Apple	F-001/010	10	$\bar{X}$	1.390	1.119	0.431	0.008
				$\pm S$	0.200	0.092	0.200	0.004

* Two samples below detection limit; ** three samples below detection lim[it]

RESULTS AND DISCUSSION

Table 1 summarizes average concentrations (mg/kg) of lead cadmium, nickel and mercury in various vegetables and fruits at $\pm$ S level. The study revealed that these metals had almost a 100% frequency of occurrence in local vegetables and fruits, except for a few samples wherein only mercury was found to be present below detection limit. Recovery data given in Table 2 showed the applicability of the analytical methodology adopted for the estimation of trace metals.

Table - 2. *Recovery Data on Metallic Residues Found in Various Vegetables and Fruits**

Commodity	Lead	Cadmium %Recovery	Nickel	Mercury
Green Peas	85.7	96.7	87.4	90.1
Radish	83.9	94.9	89.3	91.2
Potato	87.2	95.3	91.2	94.6
Onion	89.4	94.5	94.2	95.1
Carrot	91.2	87.6	03.7	93.3
Cabbage	83.7	89.6	91.2	90.0
Beans	90.7	87.6	89.7	89.6
Spinach	91.2	92.7	87.0	89.5
Tomato	89.9	91.3	87.7	90.0
Orange	90.1	91.2	93.4	91.2
Mango	84.9	89.3	91.2	93.2
Banana	87.9	87.3	89.9	91.7
Apple	89.6	86.6	90.0	94.6

*under optimal operating conditions

The magnitudes of metal residues indicated that the levels of lead, cadmium, nickel and mercury were not commodity specific. For instance, apple and radish were comparable in terms of their lead content, same being true about orange and potato. Similarly, in the case of nickel content, apple and spinach were not found to be different, as was the case with mercury content of carrot and apple. The observed similarities between the two classes of food tested statietically through their comparison of average metal contents by the 't' test. In all the four cases it turned out that fruits were not distinctly different from vegetables as regards their trace metal content. This further proved that the trace metal contents of the food commodities under investigation were independent of their geographical origin. Potato samples, V-004 and V-009, from Azad Kashmir and Faisalabad respectively had almost the same lead content. Green pea samples, V-008 and V-011, too had almost identical mercury content; these, however, belonged to such diverse locations as Hazara (NWFP), Wah (Punjab) and Mir Pur (Azad Kashmir) respectively.

As for the range of concentrations, lead was found to be within 0.529-3.470 mg/kg in orange (Khanpur, NWFP) and spinach (Jhelum, Punjab), cadmium within 0.011-1.119 mg/kg, in banana (Peshawar, NWFP) and apple (Murree, Punjab), nickel within 0.111-0.468 mg/kg in green pea (Jhelum, Punjab) and bean (Rawat, Punjab) and mercury within 0.004-0.021 in banana (Haripur, NWFP) and orange and potato (Faisalabad, Punjab). Of all the metals, thus lead showed maximum concentration differential, arising probably due to a unnatural distribution of the metal in excess to its normal level in soil. The spinach sample V-012, received from a farm in close vicinity to the traffic cluttered G.T. road, showed maximum lead content and thus bore testimony to the axiom. The same situation was met with in case of cabbage sample V-006 received from the same source. This sample also had unusually high lead content, 3.190 mg/kg. The study thus indicated that trace metal levels were derived from contributions both from natural and man-made sources, and in the cases where these contributions were not too significant, the distribution of a given trace metal concentration was bound to be uniform. The case in point was that of mercury that showed almost a uniform concentration level of about 0.020 mg/kg for widely differing vegetables and fruits such as green peas, potatoes, onion and orange, all belonging to different geographical areas.

The maximum limit of lead prescribed in the food laws (Govt. of Pakistan, 1965, 1969), for all kinds of food in general is 20.0 mg/kg. Maximum tolerance limit quoted by the PCSIR Laboratories (1980) for lead is 8.0 mg/kg. The findings for lead residue in foods as per present study remained within the stipulated tolerance limits.

The joint FAO/WHO Commission (1976) has recommended maximum levels for some of the metal contaminants in foods. Maximum acceptable daily load and provisional tolerable weekly intake for man are also given in certain cases. There are few metals where no maximum levels have yet been recommended by the commission. However, overall view of the levels of these metallic contaminants in various commodities of food under study indicated that in all probability, their concentrations were well within the recommended standards.

In conclusion, the levels of metallic residues of lead, cadmium, nickel, mercury and arsenic, as established in the present study, reveal the status of Pakistani foods in respect of metallic contaminants to be 'non-critical'. The metallic contaminants whether within or beyond recommended levels are abundantly prevalent in Pakistani agricultural products in varying levels subject to the geographical areas. The difference in levels of trace metals needs temporal monitoring so as to ascertain the quality of these food stuffs and the origin of trace metal distribution.

ACKNOWLEDGEMENT

We are thankful to FAO for the equipment and related technical assistance, under project: NOR/078/PAK, used in this work.

REFERENCES

Baccini, P.Z. 1976. Hydrol. 38:121-158.

Bryan, G.W. 1976. Heavy Metal Contamination. *In* Johnston, R. (Ed.), Academic Press, London, pp. 185-302.

FAO/WHO. 1976. Joint FAO/WHO Food Standards, 2nd Series, CAC/FAL-3.

Govt. of Pakistan. 1965. West Pakistan Pure Food Rules, Govt. Printing Press, Lahore.

Govt. of Pakistan. 1979. Pakistan Standards Institute, Pub. 221 : 192.

Horwitz, W. (Ed.), 1980. Official Methods of Analysis of the Association of Official Analytical Chemists, 13th Edn., Washington. pp. 1-1018.

PCSIR. 1980. Technical Report. PCSIR Lab. under Project Rs/078/NOR.

Pearson, D. 1970. The Chemical Analysis of Foods, J & A Churchill, London, pp. 1-604.

Stika. K.M. and G.H. Morrison. 1981. Federation Proceedings 40:2115.

Thomas, P. and G. Rougan. 1973. Lead and cadmium contents of some canned fruits and vegetables. J. Sci. Food Agri. 24:447.

Venugopal, B. and T.D. Luckey. 1975. Heavy Metal Toxicity Stuttgart, Shieme pp. 4-73.

WHO. 1973. Trace Metals in Human Nutrition. WHO Expert Committee Report, WHO. No. 532, Geneva.

WHO. 1980. Recommended Health-based Limits in Occupational Exposure to Heavy Metals, WHO Technical Report No. 647.

Wood, J.M. 1974. Science, 183:1049-1052.