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ASSESSMENT OF THE LEVEL OF TRACE METALS IN COMMONLY EDIBLE VEGETABLES LOCALLY AVAILABLE IN THE MARKETS OF KARACHI CITY

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Abstract

A study was carried out to determine the concentrations of trace metals in common vegetables, which are locally available in the markets of Karachi for consumers. Samples of 18 varieties of vegetables, belonging to malvaceae, solanaceae, cucurbitaceae, crucifeareae, liliaceae, labiate, chenopodeaceae and zingaberaceae families were procured from local markets of different areas of Karachi and analyzed for Fe, Cu, Mn, Zn, and Cr by Atomic Absorption Spectrophotometry. The data is reputed at 99% (± 2S) confidence level after triplicate measure. Maximum concentration of Fe was found to be 32.3 µg/g in spinach, Zn 8.6 µg/g in ladyfinger, Mn 5.6 µg/g in mint, Cu 3.3 µg/g in mustard and chromium 1.2 µg/g in coriander. The overall content of trace metals appeared to be within the limit laid down for safe human consumption.

Introduction

Trace elements alongwith other pollutants are discharged in the environment through industrial activity, automobile exhaust, heavy-duty electric power generators, refuse burning and of use pesticides in agriculture etc. Man, animals and plants take up these metals from the environment through air, water and food.

Trace element plays an important role in chemical, biological, biochemical, metabolic, catabolic and enzymatic reactions in the living cells of plants, animals and human beings. Trace element have great significance due to their tendency to accumulate in the vital human organs over prolong period of time. Injury to vegetation caused by trace metal has been well recognized because of many botanical and chemical investigations during past 100 years. More than 60 elements in various parts of human body have been detected (Schwarz 1977). Among these at least 25 elements are essential to human health out of which 14 are termed as trace elements. The role of trace elements in body metabolism is of prime importance. Their deficiency causes diseases, whereas their presence in excess may result in toxicity to human life.

Food is the major intake source of toxic trace elements by human beings. Vegetables are used as staple part of food both in cooked and raw form. The people of Pakistan, particularly those of middle and low-income groups consume a significant quantity of vegetables. The required amount of vegetables in our daily diet must be 300 to 350 gm per person (Anon., 1998), whereas Butt & Haq (1993) have estimated, that only 80-90 gm of vegetable per person is being used in daily diet by our population.

Vegetables are considered as “Protective supplementary food”. They contain large quantities of minerals, vitamins, carbohydrates, essential amino acid and dietary fibers, which are required for normal functioning of human metabolic processes. They are also important to neutralize the acid produced during digestion, besides being useful "roughage" according to food experts. It is therefore necessary to assess the level of trace elements concentration in different varieties of vegetables.

Several studies have been carried out to estimate the trace metal content in vegetables. The determination of metal content in vegetables is important from the view point of crop yield technology, food nutrition and health impacts. In event of their excess presence, these metals enters into the body and may disturb the normal functions of central nervous system, liver, lungs, heart, kidney and brain, produce hypertension, abdominal pain, skin eruptions, intestinal ulcer and different types of cancer (Huheey *et al*., 2000).

The main aim of this study was to investigate the level of trace metals in different varieties of vegetables, which are available in local markets and consumed as a part of food. In this study, level Fe, Cu, Mn, Zn and Cr are being reported for 18 varieties of vegetables, belonging to 9 different families abundantly consumed by local population.

Material and Methods

Samples of 18 varieties of fresh vegetable (which include fruit, leaf, stem and root vegetables) were collected randomly from local markets of Karachi. The edible parts of the vegetables i.e., roots, stem, leaves and fruits of the collected vegetables were analysed for Fe, Cu, Mn, Zn and Cr. Three samples of each variety of vegetable were collected and hence all the samples were analyzed in triplicate.

All vegetable samples were separately washed with distilled/deionized water and air-dried. The dried samples cut into the pieces with Teflon knife, and the pieces of vegetables further dried at $80 \pm 1^{o}C$. Known amount of the dried samples were wet ashed with 5 to 10 ml (1:1) $HNO_3 – HClO_4$ mixture and heated to near dryness in a platinum dish, few drops of hydrofluoric acid were added and heating was continued to dryness. The residue was then treated with 10 ml concentrated HCl and after boiling for 30 minutes, 20 ml distilled water was added and solution was further heated for further 15 minutes, after that the solution was filtered and made up to 50 ml (Abou-El-Wafa *et al*., 1995).

All reagents were ultra-pure or analytical reagent (A.R) grade. Distilled and de-ionized water was used for dilution and preparation of reagents and standards. The purity of the distilled water used for the preparation of all reagents and calibration standards was equivalent to ASTM specification type II reagent water (Eaton, 1995). Reference standards were prepared from BDH spectrosol Aastandard. Analysis of Fe, Cu, Mn, Zn and Cr was carried out by Atomic Absorption Spectrophotometer (Perkin Elmer-3030B), equipped with a graphite furnace, a micro-processor and a built-in printer. Determination of trace elements were carried out by flameless (FAAS), Atomic Absorption Spectrophotometry, employing the standard addition technique. Analysis for each sample was carried out in triplicate to get representative results.

Results and Discussion

The average concentration of Fe, Cu, Mn, Zn and Cr analyzed in 18 varieties of vegetables are given in Table 1. The data have been presented at 99 % (± 2S) confidence level for triplicate measurements in each of the case. Table 2 shows the daily dietary allowance for the selected analyzed trace elements recommended by National Research Council, USA (Lawrence *et al*., 1993).

Table 1. Concentration of trace elements recorded in 18 varieties of vegetables procured from local markets of Karachi.

Vegetables	Family	Fe µg/g	Cu µg/g	Mn µg/g	Zn µg/g	Cr µg/g
Fruit vegetables						
Lady finger	Malvaceae	12.2 ± 0.04	1.8 ± 0.01	1.5 ± 0.00	8.6 ± 0.04	0.7 ± 0.01
Pumpkin	Cucarbitaceae	11.5 ± 0.05	1.7 ± 0.01	1.2 ± 0.00	4.1 ± 0.02	0.8 ± 0.02
Tomato	Solanaceae	30.2 ± 0.11	1.3 ± 0.01	0.9 ± 0.01	4.4 ± 0.03	0.5 ± 0.04
Brinjil	Solanaceae	16.8 ± 0.05	3.1 ± 0.02	2.5 ± 0.02	7.1 ± 0.05	0.7 ± 0.02
Tori	Cucarbitaceae	15.3 ± 0.12	1.3 ± 0.00	1.2 ± 0.00	7.4 ± 0.04	0.4 ± 0.00
Stem vegetables						
Potato	Solanaceae	16.6 ± 0.11	1.2 ± 0.00	1.8 ± 0.01	2.6 ± 0.01	0.3 ± 0.00
Ginger	Zingiberaceae	13.3 ± 0.01	1.7 ± 0.01	1.6 ± 0.01	3.4 ± 0.02	0.5 ± 0.01
Garlic	Liliaceae	18.7 ± 0.04	1.6 ± 0.01	1.2 ± 0.00	5.8 ± 0.02	0.5 ± 0.01
Onion	Liliaceae	13.4 ± 0.03	0.8 ± 0.00	1.9 ± 0.01	3.4 ± 0.01	1.1 ± 0.00
Root vegetables						
Beet	Chenopodiaceae	12.7 ± 002	1.9 ± 0.01	1.4 ± 0.00	3.6 ± 0.02	0.7 ± 0.02
Radish	Crucifeareae	15.5 ± 0.03	1.0 ± 0.00	1.8 ± 0.01	3.4 ± 0.02	0.5 ± 0.01
Carrot	Umbilifereae	11.4 ± 0.02	1.2 ± 0.00	1.6 ± 0.00	5.2 ± 0.04	0.8 ± 0.01
Turnip	Crucifeareae	8.8 ± 0. 01	1.1 ± 0.01	1.1 ± 0.01	4.1 ± 0.02	0.4 ± 0.00
Leave vegetables						
Mustard	Crucifeareae	16.3 ± 0.03	3.3 ± 0.01	2.6 ± 0.01	5.4 ± 0.03	0.1 ± 0.00
Cabbage	Crucifeareae	13.7 ± 0. 03	1.1 ± 0.00	1.7 ± 0.00	3.8 ± 0.02	0.4 ± 0.00
Spinach	Chenopodiaceae	32.3 ± 0. 05	2.9 ± 0.01	1.8 ± 0.01	6.1 ± 0.03	0.7 ± 0.02
Coriander	Umbellifeareae	14.2 ± 0.01	1.8 ± 0.00	3.9 ± 0.04	3.7 ± 0.04	1.2 ± 0.01
Mint	Labiateae	12.7 ± 0.01	2.3 ± 0.02	5.6 ± 0.04	4.5 ± 0.04	0.9 ± 0.02

Table 2. Recommended dietary allowance and estimated safe daily dietary intake of trace elements for human beings (Lawrence *et al*., 1993).

Trace elements analyzed	Maximum Conc. of trace elements observed in the 18 varieties of vegetables (µg/g)				Recommended dietary allowance (RDA)		Estimated safe adequate daily dietary intake
	Fruit vegetable	Root vegetable	Stem vegetable	Leafy vegetable	Male	Female	
Fe	30.2	15.5	18.7	32.3	10–12 mg	15 mg	---
Zn	8.6	5.2	5.8	6.1	12–15 mg	15 mg	---
Cu	3.1	1.9	1.7	3.3	---	---	0.9mg
Mn	2.5	1.8	1.9	5.6	---	---	11mg
Cr	0.8	0.8	1.1	1.2	---	---	25-35µg

In vegetables viz., lady ginger, pumpkin, tomato, brinjal and tori, maximum concentration of Fe 30.2 µg/g was observed in tomato, Cu and Mn 3.1 and 2.5 µg/g respectively in brinjal, Zn 8.6 µg/g in lady finger and Cr 0.8 µg/g in pumpkin, whereas minimum concentration of 11.5 and 4.1 µg/g Fe and Zn was noted respectively in pumpkin, Cu 1.3 µg/g in tomato and tori, Mn 0.9 µg/g in tomato and Cr 0.4 µg/g in tori. This group of vegetable appears to be rich in iron content, especially in brinjal, tori and lady finger, all containing >10 µg/g Fe. These vegetables may thus compensate for the deficient intake of metal through other diet**.**

In potato, ginger, garlic and onion, maximum concentration of Fe 18.7 µg/g and Zn 5.8 µg/g was recorded in garlic, Cu 1.7 µg/g in ginger, Mn and Cr 1.9 and 1.1 µg/g respectively in onion, whereas minimum concentration of Fe 13.3 µg/g in ginger, Cu 0.8 µg/g in onion, Mn 1.2 µg/g in garlic, Zn 3.4 µg/g in ginger and onion, and Cr 0.3 µg/g in potato.

In beet, radish, carrot and turnip, maximum concentration 15.5 µg/g of Fe was observed in radish, Cu 1.9 µg/g in beet, Mn 1.8 µg/g in radish, Zn and Cu 5.2 and Cr 0.8 µg/g in carrot respectively whereas minimum concentration of Fe, Mn and Cr was recorded 8.8, 1.1 and 0.4 µg/g respectively in turnip, Cu and Zn 1.0 and 3.4 µg/g respectively in radish.

In leafy vegetables viz., mustard, cabbage, spinach, coriander and mint maximum concentration of 32.3 and 6.1 µg/g Fe and Zn was observed respectively in spinach, Cu 3.3 µg/g in mustard, Mn 5.6 µg/g in mint and Cr 1.2 in coriander, whereas minimum concentration 12.7 µg/g of Fe was recorded in mint, Cu and Mn 1.1 and 1.7 µg/g respectively in cabbage, Zn 3.7 µg/g in coriander and Cr 0.1 µg/g in mustard. This leafy group of vegetables shows the higher concentration of trace elements, as the leaves are most exposed part of plant to the environmental pollution because of their large surface areas.

The trace metal like Fe, Cu, and Mn are considered as essential elements for normal life processes, whereas the function of Zn in the human body is well known. Cr is a toxic trace metal and its function in the animal and human body is well documented (Gullfraz *et al*., 2001). The results show that the vegetables studied appears to be rich in iron as these contain Fe above 11.4 µg/g and vegetables may thus compensate for the deficient intake of metal through other diet**.**

Iron is an important element in human body metabolism which acts as a catalyst and is present in greater amount than any other trace element. According to an estimate 57.6% of the body iron in human is contained in Hemoglobin and 8.9% in myoglobin, whereas approximately 33% in non-heme iron complexes, including ferritin and haemosiderin. The cytochrome enzyme contain about 0.5% of iron (Jacob & Worwood 1974).

Copper is an essential element widely distributed and always present in food, animal livers, which are the major contributor to dietary exposure to copper, various shellfish and some dry materials. It is necessary for normal biological activities of amino-oxides and tyrosinase enzymes. Tyrosinase is required for the catalytic conversion of tyrosine to melanin, the vital pigment located beneath the skin, which protects the skin from dangerous radiation**.** Concentration of Cu in these vegetables was recorded in the range of 0.8 – 3.1 µg/g. A daily dietary intake of 2 to 3 mg of copper is recommended for human adults (Dara, 1993). Ingestion of 15-75 mg of copper causes gastrointestinal disorders. Excessive intake of copper may cause heamolysis, hepatotoxic and nephrotoxic effects. Continuous ingestion of copper from food induces chronic copper poisoning in man.

Concentration of manganese in the vegetables studied was found to be in the range of 0.9–5.6 µg/g. A daily dietary intake of 2.5 to 5 mg of manganese by human contributes to the well being of the cells (Dara, 1993). Manganese deficiency causes diseases and excess of it causes poisoning of central nervous system absorption, ingestion, inhalation or skin contact may cause manganic pneumonia (Underwood, 1977).

Zinc is present in the body as a co-factor for enzymes such as arginase and diaminase. It takes parts in the synthesis of DNA, proteins and insulin. It is essential for the normal functioning of the cell including protein synthesis, carbohydrate metabolism, cell growth and cell division. Concentration of Zn in these vegetables was found to be 2.6–8.6 µg/g. A normal body contains 1.4 to 2.3 gm of zinc and it is present in all body cells. Recommended daily dietary intake of zinc is about 15 mg (Dara, 1993). Excessive intake of Zinc can have long term effects whereas the deficiency syndrome manifests itself by retardation of growth, anorexia, lesions of skin and appendages, impaired development and function of reproductive organs. In view of this the estimated concentrations of metals in vegetables under investigation do not cause health hazards for consumers.

Chromium is selectively accumulated in liver and kidney**.** It has been reported to interfere with enzymatic sulfur uptake of cells affecting the lungs, liver and kidney (Lawrence *et al*., 1993). Concentration of chromium was found in the range of 0.1–0.9 μg/g. Chromium does not apparently pose a health threat in view of its concentration levels in the vegetables investigated. Looking through this perspective the vegetables are quite safe for human consumption.

Trace elements are present in human body in very low amount, usually less than 1 micro-organism per gram of the tissues (Lawrence *et al*., 1993), some elements are essential trace elements and some are not essential but have well defined evidence in human metabolism. Fe and Zn are the essential trace elements for human metabolism and have recommended dietary allowance (RDA), whereas Cu, Mn and Cr, which have evidence for the essentiality in human metabolism but RDA has not yet been established; only the estimated safe dietary daily intake limits have been established (Lawrence *et al*., 1993). The comparison of recommended dietary allowance and safe daily dietary intake of trace elements with our analyzed values of trace elements are given in Table 2.

It would suggest that leafy vegetables show the highest concentration of trace elements. The incidence level of trace metals showed 100% in all groups. The estimated level of chromium appeared quite low. Considering the current level of Cu and Mn pollution in the environment, the level of these elements in all vegetables is within safe limit. Slightly higher level of Zn is found in some fruit vegetables. The essentiality of Fe and Zn make it necessary that their concentration should be high. As the vegetables are important source of essential trace elements may provide the required amount of trace metals to our body. Results of the study show that the levels of trace metals are within limits laid down for safe human consumption.

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