Study of the Trace Metal Concentration in Some Local Vegetables Available in Shillong City, Meghlaya, India

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***Abatract*- Vegetables provide the human body with the essential bioavailable trace elements, and a constant supply of these various elements is necessary and highly recommended for daily life. Minor elements such as Fe as well as trace elements such as Cd, Co, Cr, Cu, Mn, Ni, and Zn were determined using an atomic absorption spectrophotometer in 8 different species of vegetables from the local markets in and around the city of Shillong, Meghalaya, India. The different vegetables were *Diplazium esculentum* (Fern), *Curcuma longa* (Tumeric), *Beta Vulgaris* (Beet), *Zingiber officinale* (Ginger), *Oenanthe javanica*, *Houttuynia cordata*, *Mentha asiatica* (asian mint), *Coriandrum sativum* (Coriandar), *Spinacia oleracea* (Spinach) and *Lactuca sativa* (Lettuce). The results reveal that the different element concentrations of each vegetable depend upon the selective uptake of the elements by the plant. The element concentrations of these vegetables were within safety baseline levels for human consumption.**

Keywords- Essential; Intake; Metals; Toxic; Vegetables

I. INTRODUCTION

Vegetables constitute an important part of the human diet since they contain carbohydrates, proteins, as well as vitamins, minerals and trace elements. In recent years their consumption is increasing gradually, particularly among the urban community. This is due to increased awareness on the food value of vegetables, as a result of exposure to other cultures and acquiring proper education. However, they contain both essential and toxic elements over a wide range of concentrations. Metal accumulation in vegetables may pose a direct threat to human health (Mohsen and Mohsen, 2008).

Metals have an impact on human health in many ways. Some elements, such as Cu, Mn and Zn, are essential micronutrients with a human requirement of no more than a few milligrams per day. However, micronutrients may become harmful when their ingestion rates are too high. Furthermore, some elements (e.g. Ni and Sn) are likely to be essential micronutrients, although their positive role in human nutrition remains to be confirmed and, other elements have no proven essential functions in humans and are likely to have adverse physiological effects (e.g. Al). In contrast, trace elements such as Cd and Pb are well known as toxic if their intake through ingestion or inhalation is excessive. In addition, a metal can be toxic or be a micronutrient depending on its chemical form or speciation (e.g. Cr-VI and Cr-III). Also, deficiencies, excesses, or imbalances in the supply of inorganic elements from dietary sources can have an important deleterious influence on human health (Abraham, 2002; WHO, 1996).

The amount of metal ingested by man is directly related to alimentary habits and their content in foodstuff. It is now well recognized that several trace elements are essential constituents of enzymes and play a vital role in human metabolism (O'Dell and Sunde, 1997). All the nutrient elements are primarily supplied through diet. However, this may change depending on age, sex, health status, geographical and climatic conditions. Therefore, it is essential to determine elemental contents of food items and to estimate their daily dietary intake (Jansen, Kandall, and Jansen, 1990).

Vegetables can take up high amount of metals from contaminated soils, as well as from contaminated water and polluted air. Besides the natural levels present in soils, water and air, a matter of concern is the addition of chemical products as fertilizers, fungicides, insecticides and herbicides to crops. These products may contain several metals and their additions can increase the metal amounts in soil and water. Furthermore, the physical and chemical forms in which they are dispersed can increase the metal availability for plants and so increase the metal concentrations in vegetables (Fern´ıcola, 1983).

The knowledge of metal concentrations in foodstuff can provide important information on the impact of the use of chemical products in crops and on levels of environmental pollution in farms. Furthermore, such a survey may indicate local foodstuffs that are important to supply essential metals for population groups. Information on these topics is scarce, especially when dealing with developing countries. Thus, a first study on trace element concentrations (Cr, Mn, Fe, Co, Ni, Cu, Zn and Cd) in some frequent consumed locally grown vegetables by inhabitants of Shillong city was performed, aiming to verify metal levels and variations.

To assess the level of chronic exposure to metals occurring in several kinds of foods, a number of countries have initiated monitoring studies. So far, only limited individual attempts have been made in Shillong city, Meghalaya, India and are confined to specific contaminants and areas of local interest. This paper aims to assess the distribution of the eight selected trace metals in some locally available vegetable species that are frequently consumed by the local population of Shillong City.

Meghalaya, "*the Abode of Clouds*" is a state located in the North Eastern Region of India. The capital of the state is Shillong with an ever expanding population of about 2.5 to 3.0 million people. The diet of the indigenous inhabitants is a mixture of both vegetarian and non-vegeterian food items which include rice, potato, beef, pork, fish and vegetables suiting the climate of the region. Except for pork and some vegetables, the rest of the food items are imported from other states in India. Many vegetables (leafy and non-leafy) on the other hand are available locally. In this study, a few local vegetables have been selected to: 1) study the concentration of the eight trace elements (Cr, Mn, Fe, Co, Ni, Cu, Zn and Cd) so as to enable the researcher to understand the trace metal contribution of these vegetables to the diet of an individual: 2) identify the different vegetables that can be use as a potential source of essential trace metal and: 3) identify the vegetables that can be injurious to a consumer because of high content of metal (like Cd, Cr, etc.) that have toxic properties.

In the present paper the contents of metals Cr, Mn, Fe, Co, Ni, Cu, Zn and Cd, in selected vegetable samples available in Shillong have been determined by using acid digestion followed by AAS technique. This article intends to provide information about the content of the essential and toxic trace elements in the selected vegetables.

II. EXPERIMENTAL

A. Materials and Methods

Hydrogen Peroxide, Nitric and Perchloric acids (E.Merck) were of ultrapure grade. All aqueous solutions and dilutions were prepared with ultrapure water. All glassware was cleaned by soaking in dilute nitric acid and was rinsed with ultrapure water. Eight (8) vegetables i.e. *Diplazium esculentum* (Fern), *Curcuma longa* (Tumeric), *Beta Vulgaris* (Beet), *Zingiber officinale* (Ginger), *Oenanthe javanica*, *Houttuynia cordata*, *Mentha asiatica* (asian mint), *Coriandrum sativum* (Coriandar), *Spinacia oleracea* (Spinach) and *Lactuca sativa* (Lettuce) were chosen for the study. The vegetables were chosen base on the fact that they are available locally and are consumed by the local populace. All the vegetables were procured from local markets in and around Shillong City.

Some of the selected vegetables are eaten when fried with oil, onion, tumeric and ginger (eg: *Diplazium esculentum* (Fern), *Beta Vulgaris* (Beet) and *Oenanthe javanica*), some are taken raw after thorough washing with water (eg: *Houttuynia cordata*, *Mentha asiatica* and *Lactuca sativa*) and some are consumed as a chutney blended with onions, chillies, garlic and salt (eg: *Coriandrum sativum, Mentha asiatica* and *Houttuynia cordata*). *Spinacia oleracea* is usually prepared and eaten as a soup mixture along with meat and other vegetables.

For total metal extraction, 1g each of the oven dried vegetables were accurately weigh and transferred into a porcelain dish and then ashed in a muffle furnace at 450^0C till white ash. The whole ash is then taken and to this, concentrated nitric acid (10.0 mL) was added, the beaker was covered with a watch glass and material was boiled gently on a hot plate provided with a tunable thermostat until digestion was complete. The complete digestion took about 3hrs. 5.0 mL portion of 70% perchloric acid was then added and gentle heating was continued for another 1hr. Small aliquots of ultrapure water were added to prevent dryness due to evaporation and about 3 to 5 drops of hydrogen peroxide were added to discharge any colouration in the digest. After the digest was cooled, it was filtered using a Whatman No. 542 filter paper and transferred to a 50 mL volumetric flask that has been rinsed with ultrapure water. Three replicate digestions were made for each sample. The average of blank signals was subtracted from analytical signals of digested samples. All necessary precautions were adopted to avoid any possible contamination of the sample (Marbaniang et al., 2011)

A Perkin Elmer model 3110 Atomic Absorption Spectrophotometer available at Sophisticated Analytical Instrumentation facility, North Eastern Hill University, Shillong, Meghalaya, India was used for determination of Cr, Mn, Fe, Co, Ni, Cu, Zn and Cd in the different vegetables.

III. RESULTS AND DISCUSSION

The concentrations of toxic (Cr, Ni and Cd) and essential (Mn, Fe, Co, Cu and Zn) elements in the eight selected edible plants that are determined in this study are summarized in Table I. All the metals are present at μg g^{-1} level per dry weight. The order of concentration levels in the vegetables was Fe > Zn > Mn > Cu > Ni > Co > Cr > Cd.

(SPACE)

Iron (Fe): The result shows that these vegetables contained Fe concentration ranging from 73.2 to 251.3 μg g^{-1} with a mean value of 196.19 ± 62.66 μg g^{-1}. The lowest concentration (73.2 μg g^{-1}) was observed in spinach and the highest concentration (251.3 μg g^{-1}) was observed in tumeric.

Iron is an essential element in production of Red Blood Cells (RBCs). Low intake of Fe may cause anemia, tiredness and pallid physique, while high intake may result into hepatic megaly, cardiac infraction and nephric malfunction. The acceptable limit for human consumption of Iron is 8 to 11 mg/day for infants as well as adults (ATSDR, 1994b). In the present investigation, the value of Fe was found much lower than the acceptable limit. However among all the metals under investigation, Fe shows the maximum concentration which can be due to the iron rich soil in which the plants are grown.

Copper (Cu): The result shows that these vegetables contained Cu concentration ranging from 7.56 to 64.27 μg g^{-1} with a mean value of 27.07 ± 16.37 μg g^{-1}. The lowest concentration (7.56 μg g^{-1}) was observed in lettuce and the highest concentration (64.27 μg g^{-1}) was observed in ginger. The recommended daily intake of Cu for human consumption is 900 μg g^{-1} (Nair et al. 1997; NRC, 1989). When Cu exceeds its safe level concentration, it causes hypertension, sporadic fever, uremias, coma, etc.. Present investigation reveals that Cu range in all the vegetables is less than the safe limits prescribed for human health and hygiene. **Zinc (Zn)**: The result shows that these vegetables contained Zn concentration ranging from 40.84 to 146.04 µg g^{-1} with a mean value of 103.58 ± 36.10 µg g^{-1}. The lowest concentration (40.84 µg g^{-1}) was observed in ginger and the highest concentration (146.04 µg g^{-1}) was observed in *Houttuynia cordata*.

Among all metals, zinc is the least toxic and an essential element in the human diet as it is required to maintain the proper functions of the immune system. It is also important for normal brain activity and is fundamental in the growth and development of the foetus. Zinc deficiency in the diet may be more detrimental to human health than too much zinc in the diet. Although the average daily intake of zinc is 7-16.3 mg zn/day, the recommended dietary allowance for it is 15 mg Zn/day for men and 12 mg Zn/day for women (ATSDR 1994a). On the contrary, the high concentration of zinc may cause vomiting, renal damage, cramps, etc.. From the study it can be seen that the selected vegetables contribute a very small percentage to the dietary requirement for zinc. The acceptable daily intake limit for human consumption of Zn is 40mg (NRC, 1989).

Cobalt (Co): The result shows that these vegetables contained Co concentration ranging from 0.13 to 3.01 µg g^{-1} with a mean value of 1.27 ± 0.78 µg g^{-1}. The lowest concentration (0.13 µg g^{-1}) was observed in lettuce and the highest concentration (3.01 µg g^{-1}) was observed in ginger.

Deficiency of cobalt in diet results into pernicious anemia, severe fatigue, shortness of breath and hypothyroidism, while overdose may lead to angina, asthma, cardiomyopathy, polycy themia and dermatitis. The safety limit for human consumption of Co is 0.05 to 1 mg/day in humans (ATSDR 1994a). The recorded concentrations of cobalt in all the vegetables fall within the safety limit.

Manganese (Mn): The result shows that these vegetables contained Mn concentration ranging from 14.17 to 127.97 µg g^{-1} with a mean value of 61.22 ± 36.16 µg g^{-1}.

The lowest concentration (14.17 µg g^{-1}) was observed in lettuce and the highest concentration (127.97 µg g^{-1}) was observed in beet leaves.

Deficiency of manganese causes Myocardial infarction. 62% of diabetic patients are at risk with higher manganese content. The recommended daily requirement of manganese is 1.6 to 2.3 mg/day in humans (ATSDR 1994a). The inclusion of these vegetables in the diet can increase the manganese availability in the diet.

Cadmium (Cd): The result shows that these vegetables contained Cd concentration ranging from Below detection limit (BDL) of the instrument to 0.85 µg g^{-1} with a mean value of 0.38 ± 0.25 µg g^{-1}. The lowest concentration (BDL) was observed in ginger, lettuce and coriander and the highest concentration (0.85 µg g^{-1}) was observed in beet stem.

TABLE I MEAN CONCENTRATION (UG G^{-1} DRY WEIGHT) OF TRACE METALS IN THE SELECTED VEGETABLES

Types of Vegetables	Fe	Cu	Zn	Cd	Ni	Co	Mn	Cr
Diplazium esculentum (Fern)	95.1	22.37	72.89	0.39	1.32	1.12	32.7	0.33
Curcuma longa (Tumeric)	251.3	11.09	73.37	0.74	2.51	1.04	65.83	2.81
Beta Vulgaris (Beet) leaves	169.4	35.73	88.41	0.29	2.49	1.15	127.97	0.67
Beta Vulgaris (Beet) stem	101.4	20.63	48.35	0.85	1.27	0.53	36.39	0.85
Zingiber officinale (Ginger)	193.3	64.27	40.84	BDL	6.36	3.01	49.2	1.34
Oenanthe javanica	146.4	9.23	78.24	0.09	4.92	0.35	37.52	0.43
Houttuynia cordata	191.7	15.65	146.04	0.44	9.6	1.33	105.88	1.03
Mentha asiatica (Asian mint)	221.2	26.55	125.73	0.36	2.13	1.42	29.15	0.36
Coriandrum sativum (Coriandar)	230.7	20.79	134.49	BDL	8.96	0.96	18.39	0.64
Spinacia oleracea (Spinach)	73.2	9.8	46.05	0.28	1.47	0.43	33.79	0.43
Lactuca sativa (Lettuce)	92	7.56	77.8	BDL	1.69	0.13	14.17	0.34

BDL: Below Detection Limit

Cadmium can cause severe gastrointestinal irritation, vomiting, diarrhea, and excessive salivation, and doses of 25 mg of Cd/kg body weight can cause death. Low-level chronic exposure to Cd can cause adverse health effects including gastrointestinal, hematological, musculoskeletal, renal, neurological, and reproductive effects. The main target organ for Cd following chronic oral exposure is the kidney (ATSDR 1999a). Intake of Cd can double if one smokes cigarettes because each cigarette contains about 2 µg Cd. It was surprising to observe that almost in all the vegetable, cadmium is detected. The acceptable daily intake of Cd should be less than 100 µg (WHO, 1996).

Nickel (Ni): The result shows that these vegetables contained Ni concentration ranging from 1.27 to 9.60 µg g^{-1} with a mean value of 4.75 ± 3.11 µg g^{-1}. The lowest concentration (1.27 µg g^{-1}) was observed in beet stem and the highest concentration (9.60 µg g^{-1}) was observed in *Houttuynia cordata*.

Deficiency of nickel has been linked with hyperglycemia, depression, sinus congestion, fatigue, reproductive failures and growth problems in humans, while excess intake leads to hypoglycemia, asthma, nausea, headache, and epidemiological symptoms like cancer of nasal cavity and lungs. The prescribed safety limit of nickel is 3 to 7 mg/day in humans (ATSDR 1999a). Thus, the concentrations detected in the different vegetables fall within the prescribed safety limit and can be consumed without any risk.

Chromium (Cr): The result shows that these vegetables contained Cr concentration ranging from 0.33 to 2.81μg g^{-1} with a mean value of 1.03 ± 0.73 μg g^{-1}. The lowest concentration (0.33 μg g^{-1}) was observed in *Diplazium esculentum* and the highest concentration (2.81 μg g^{-1}) was observed in tumeric. Chromium is known to be essential for animals but not for plants. A dose of 0.24 μg g^{-1} is required per day. 50 μg g^{-1} of chromium in the diet has been found to induce growth depression together with liver and kidney damage. The concentration of chromium in the different vegetables can be said to be safe for the consumption and in fact turmeric and ginger are very good sources of chromium for the diet of humans.

The amount of metal accumulation in the aerial parts of a plant is higher than in the parts below the ground (Beet leaves > Beet root). This finding is comparable with the findings of Mohsen and Mohsen, 2008.

Hart et al., 2005, reported similar findings i.e. 40 to 651 μg g^{-1} Fe concentration range, 4.4 to 23 μg g^{-1} Cu concentration range and 29 to 240 μg g^{-1} Zn concentration range in vegetables grown in industrial polluted areas of Nigeria.

Mohsen and Mohsen, 2008 also reported concentrations for metals in Shahre Rey-Iran similar to that observed in the present study. They attribute the reason for the high accumulation of metals in vegetables to the discharge of domestic and waste water directly to the irrigation water which was used without the prior treatment.

Sobukala et al., reported concentration range for Cd (0.007 to 0.71 μg g^{-1}), Cu (0.009 to 0.07 μg g^{-1}), Zn (0.02 to 0.21 μg g^{-1}), Co (0.015 to 0.051 μg g^{-1}) and Ni (0.01 to 0.26 μg g^{-1}) in different vegetables in Logos, Nigeria which are much lower compared to our present findings.

The significantly high concentration of the Fe, Cu and Zn can be indicative of heavy metal pollution in the growing fields either through the irrigated water used, soil contamination via, fertilizers addition or through atmospheric deposition.

Some of the vegetables under investigation are available in the market throughout the year (eg: lettuce, turmeric, ginger and coriander) whereas the rest of the vegetables are available only in some months. i.e. available seasonally.

In this study we observed that the concentration of the toxic metals like Cd, Cr and Ni, were detected in all the different vegetable samples, which was quite alarming though the concentration were still lower than the acceptable daily intake prescribe for these toxic metals but chronic exposure poses a threat. The concentrations of the different trace metal vary significantly within a same plant and between the vegetables. This is due to the fact that plants can selectively accumulate a particular metal more than the other. This was also reported by Mohamed et al, 2003 when they conducted a study on the minor and trace element concentration in different vegetables in Saudi Arabia and reported that the difference of element concentrations in the vegetable families was the result of different of element selectivity and accumulation from the soil solution by the vegetables.

The consumption of the vegetables like *Diplazium esculentum* (Fern), *Beta Vulgaris* (Beet), *Oenanthe javanica*, *Houttuynia cordata*, *Mentha asiatica* (asian mint), *Coriandrum sativum* (Coriandar), *Spinacia oleracea* (Spinach) and *Lactuca sativa* (Lettuce) by the population of the city is not frequent and the amount consumed is also very less. Therefore, the slightly high concentration observed does not pose a threat to the health of the individual but can serve as a source of trace metals. Tumeric and ginger are the two food items that are consumed on a daily basis and with their high trace metal content they can also as a supplement of the essential metals that is required for metabolism.

However, since they also contain a significant concentration of the toxic metals like Cd, Cr and Ni. their consumption rate has to be properly regulated so as to minimize the exposure or accumulation of these toxic metals in the human body which can produce hazardous consequences.

It is very difficult to restrict the amount of trace metal from accumulating in vegetables because there are not only one but many sources contributing to their bio availability. However, we can limit the concentration of metal from reaching the individual by identifying the different types of vegetables containing elevated levels of toxic metals and thereby judiciously regulating the amount to be consumed in the daily diet.

IV. CONCLUSION

In the present work, trace metallic concentration study in 8 (eight) different vegetables was estimated and it was observed that all the vegetables show significant trace metallic content. The concentration of metal in almost all the vegetables follows the order Fe > Zn > Mn > Cu > Ni > Co > Cr > Cd. Except for lettuce, coriander and ginger the other vegetables were found to contain the toxic metal Cd. Though Cr and Ni are also toxic to human, their concentrations were found to be less than the acceptable daily intake limit. It can be concluded that all the vegetables are very good sources of the essential trace metal, but, since most of them contain the non-essential metals too, their consumption rate has to be properly regulated.

This is the first study conducted for assessing the trace metal concentration in these vegetables which are available locally and consumed by the population of the Shillong city, Meghalaya, India.

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