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Assessment of Certain Essential Elements in Some Common Edibles from Dadara and Agyathuri Villages of Kamrup District of Assam

***Anjali Haloi[1], Clarice R. Thabah[2], D.K. Limbu[1], Paul S. Dkhar[2] and Rahul Chakraborty[2]**

[1]Department of Anthropology, North Eastern Hill University, Shillong 793 022, Meghalaya, India
[2]Sophisticated Analytical Instrument Facility, North Eastern Hill University, Shillong 793 022, Meghalaya, India

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ABSTRACT Accumulation of certain essential elements as well as few non-essential heavy metals in some cereals and legumes, and several vegetables that are locally grown by the Sunni Muslims in two villages of Kamrup district of Assam, situated in the north-eastern region of India, have been assessed using atomic absorption spectroscopy. The samples recorded varied concentration of essential elements, but low iron in most of the samples *viz.* in coriander leaf, sweet gourd leaf, amaranthus leaf etc. Interestingly, selenium was recorded in all the samples examined except in pigeon pea. On the other hand, non-essential heavy metal such as cadmium was recorded in very low concentration in most of the samples. The aim of this study was to assess the concentration of different essential elements namely calcium, cobalt, copper, iron, magnesium, manganese, sodium, selenium and zinc, as well as few non-essential metals such as cadmium, nickel and lead in some locally grown edibles from this region. The significance of presence or absence of these essential and non-essential elements in the daily diet of the population has also been discussed.

INTRODUCTION

With the chemical analysis of elements in biological samples and the demonstration that certain elements were essential for growth of macro-organisms, the discovery of the importance of trace elements in nutrition began as early as nineteenth century (Sandstead and Clevay 2000). As for example, the essentiality of zinc in growth of *Aspergillus niger* (Raulin 1869). The clinical investigation by Stockman (1893, 1895a, 1995b), in a woman with 'chlorosis' and the iron deprivation experiment by Cloeta (1897) in dogs, were the first to show the dietary deficiency and/or less of trace elements for the body causes a specific disease such as anemia.

Trace elements are widely distributed in nature in variable proportions, which in higher concentration may become toxic (Bukhari et al. 1987). The elements such as zinc, copper, selenium, iron etc. serve a variety of functions that include catalytic structural and regulatory activities involved in all metabolic pathways (Sen 2008). On the other hand, eliminating hunger and malnutrition has become one of the most fundamental challenges facing humanity today. To address the issue of hunger and malnutrition, adequacy in terms of micronutrient is often compromised. But, it is important to keep in mind that, malnutrition and its associated diseases can be caused by eating too little, or too much, causing obesity, or eating an imbalanced diet that lacks necessary nutrients, such as adequate energy, protein and micronutrients to meet basic requirements for body maintenance, growth and development equally. Malnutrition is one of the major problems worldwide, especially in developing countries, which is intricately related to imbalanced diet and widely studied by several workers (Rouse 2003; Christian et al. 2006; Range et al. 2006).

The north-eastern region of India has certain characteristic features of its own, flora and fauna, soil and water quality (Chakraborty et al. 2002). Being in the foothill of Himalayas, the region has a unique pattern in the soil, resulting in deposition of some elements in higher concentration and deficiency of others (Seiler and Sigel 1988; Dkhar 1996; Nongkynrih et al. 1996). It is quite certain that the peculiarities in the elemental

**Address For Correspondence:*
Anjali Haloi
Sophisticated Analytical Instrument Facility,
North Eastern Hill University, Umshing,
Shillong 793 022, Meghalaya (India)
E-mail: haloi_81@yahoo.com

status of the soil influences the vegetation and animal health and nutritional status. A study on this effect suggested the deficiency of some trace elements and toxicity of others in some wild animals from this region (Dey et al. 1999).

As far as heavy metal concentration is concerned, among the various environmental objects that needs special attention are the human edibles, which are directly related to human health and disease. Several researchers have published their works and views on environmental pollution by heavy metals (Lottermoser 1998; Govil et al. 1999; Ansari et al. 1999; Lang et al. 1999; Adrienne and Resmissen 1998). Consequently, studies on pollutants in different environmental objects, particularly human edibles and its possible impact on health have not yet been addressed properly (Chakraborty et al. 2003). But the environment in north-east India is getting more and more polluted because of rapid industrialization, improper waste management and other anthropogenic activities. This requires for an urgent need of proper documentation of different types of pollutants in the human edibles to understand their level of impact on health.

The importance of the elements selected for this study has been amply highlighted in the existing literature (Ryan et al. 2001; Bureau et al. 1998; Johnson 2001; Reaney et al. 2002; Crossgroove et al. 2003; Tallman and Taylor 2003). As for example, cobalt is a constituent of vitamin B_{12}, that acts as coenzyme (Angerer and Heinrich 1988; Watanabe and Nakano 1999), manganese is important for superoxide dismutase (Finlay and Davis 1999), selenium provides protection from reactive oxygen species-induced, cell damage of glutathione peroxidase and selenoprotein-P (Chen and Berry 2003) and so on.

Thus, an attempt has been made to quantify certain essential elements and to sort out the presence of non essential heavy metals in the edibles of this region.

MATERIALS AND METHODS

Materials

For the present study, two varieties of rice *(Oriza sativa) viz.* Ranjit variety and Basmati variety; three varieties of legume *viz.* masur dal *(Lens culinaris)*, green gram or moong dal *(Phaseolus mungo)* and arhar dal or pigeon-pea or red gram *(Cayaners cajan)*; nine varieties of leafy vegetables *viz*. cabbage *(Brassica capitala)*, arum leaves with stem *(Colocasia esculanta)*, mustard leaves bigger size *(Brassica esculanta)*, whole mustard plant smaller size *(Brassica juncia)*, cauliflower *(Brassica oleraceae)*, spinach leaf *(Spinacea oleracea)*, coriander leaf *(Coriendrum sativum)*, sweet gourd tender leaves *(Cucurbita maxima)* and amaranthus leaves (*Amaranthus viridis*); six varieties of fruity vegetables, *viz.* garden peas *(Pisum sativum)*, green chilli *(Capsicum annum)*, French bean *(Phaseolus vulgaris)*, green mustard seeds *(Brassica juncea)*, tomato *(Lycopersicunm esculentum)* and dry mustard seeds *(Brassica juncea)*; and three varieties of rooty vegetables *viz.* potato *(Solanum tuberasum)*, knol khol *(Brassica cantirapa)* and carrot *(Daucus corota)*.

The samples were collected from different vegetable gardens at random of the two villages of Dadara and Agyathuri of Kamrup district of Assam, during the month of December 2008. Eight samples of each species were collected. Interactions with the cultivators and village elders suggested that the local population of the two villages depends mostly on these cultivators for their daily nutritional needs.

Nine essential elements *viz.*, calcium, cobalt, copper, iron, magnesium, manganese, sodium, selenium and zinc and three types of non - essential heavy metals cadmium, nickel and lead were taken up for the present study.

Analytical Methods

After collection and separation, the cereals legumes, and vegetables were washed with de-ionized doubled distilled water to remove all possible external contaminants. The samples were cut into small pieces, and were then oven dried to remove moisture. They were then crushed in to small powdery form with the help of a mortar and pastel. 1 g each of the samples were taken and were treated with a few drops of hydrogen peroxide, kept overnight and then to dryness. 1 ml of perchloric acid was then added to it, heated to dryness and repeated 2 to 3 times. 4 to 5 ml of hydrochloric acid was added to each of the samples and the solution was diluted with de-ionized double distilled water to 50 ml (Dey et al. 1999). The solution was then subjected to atomic absorption Spectrophotometry (Perkin Elmer 3110). The sample preparation procedure was followed as described by Dey et al. (1999). Eight replicates of each of the samples were used to confirm quantitative estimation of the elements and the mean values were taken into consideration. The standard deviation (SD) of each set results were evaluated.

RESULTS

Table 1 represents the concentration of essential elements in different varieties of cereals, pulses and vegetables. The Basmati variety of rice recorded highest concentration of cobalt (29.28ìg/Kg dry weight), but common vegetables like cauliflower, spinach, coriander, peas, green chilli, French bean etc. did not record any detectable amount of cobalt in them. High calcium was recorded in coriander leaf and spinach leaf (377.15ìg and 313.39ìg/Kg dry weight respectively) where in other samples, the concentration varied between 15ìg to 265ìg/Kg dry weight. Copper was recorded in various concentrations which ranged between 10 to 12ìg/Kg dry weight. Similarly, iron was recorded in various concentrations in all the samples .Coriander leaf, sweet gourd tender leaf and spinach leaf recorded high concentration of iron in them (132.2ìg, 136.87ìg and 79.39ìg/Kg dry

Table 1: Concentration of few essential elements in different varieties of cereals, legumes and vegetables collected from the villages, Dadora and Agyathuri of Assam. All values are in ìg/Kg dry weight, ND= Not detected. Values in parenthesis are standard deviations (SD).

Cereals and legumes: *Variety*	*Ca*	*Co*	*Cu*	*Fe*	*Mg*	*Mn*	*Na*	*Se*	*Zn*
Rice var. Ranjit	12.53 (±1.08)	0.97 (±0.33)	2.84 (±0.40)	13.3 (±0.75)	165.15 (±10.04)	7.51 (±0.69)	6.59 (±0.22)	14.86 (±1.68)	12.8 (±0.97)
Rice var. Basmati	21.36 (±1.10)	29.28 (±0.91)	2.05 (±0.67)	4.9 (±0.37)	228.81 (±1.09)	3.12 (±0.68)	15.14 (±0.67)	37.46 (±1.20)	22.51 (±0.98)
Masur dal	197.55 (±11.25)	4.64 (±2.26)	10 (±0.15)	53.49 (±5.24)	383.25 (±37.51)	9.91 (±0.21)	86.14 (±9.58)	ND	58.05 (±13.37)
Moong dal	178.45 (±33.56)	2.44 (±1.80)	11.98 (±3.63)	42.9 (±2.65)	259.53 (±45.410)	16.6 (±3.63)	71.55 (±15.55)	12.81 (±6.03)	58.32 (±8.68)
Arhar dal	165.58 (±33.56)	2.55 (±1.68)	11.11 (±3.30)	22.14 (±10.81)	321.58 (±27.55)	11.11 (±3.30)	105.39 (±11.45)	8.05 (±3.51)	50.63 (±8.74)
Vegetables:									
Leafy Vegetables:									
Cabbage	156.51 (±15.14)	2.08 (±0.65)	6.09 (±1.07)	41.24 (±6.19)	265.5 (±8.62)	7.8 (±1.98)	26.58 (±3.88)	50.61 (±5.04)	46.45 (±7.15)
Arum	122.41 (±1.72)	6.74 (±1.57)	6.67 (±1.36)	24.58 (±4.03)	207.31 (±4.31)	57.15 (±7.95)	15.32 (±1.60)	14.09 (±8.60)	32.27 (±10.86)
Mustard leaf (big)	263.96 (±10.11)	1.76 (±0.40)	2.03 (±0.57)	79.93 (±3.89)	308.88 (±2.91)	52.19 (±2.09)	72.6 (±1.73)	12.29 (±2.02)	72.23 (±1.24)
Cauliflower	29.84 (±0.85)	ND	4.46 (±0.73)	12.24 (±1.15)	254.38 (±1.83)	5.59 (±0.60)	36.47 (±1.73)	41.89 (±1.32)	33.79 (±1.06)
Spinach leaf	313.39 (±0.87	ND	1.56 (±0.41)	79.39 (±10.00)	315.19 (±13.41)	64.02 (±15.00)	145.9 (±17.11)	44.74 (±2.59)	54.15 (±0.19)
Coriander leaf	377.15 (±20.90)	ND	1.96 (±0.54)	132.2 (±17.00)	285.03 (±12.00)	17.13 (±1.08)	77.17 (±1150)	87.09 (±12.30)	34.41 (±7.60)
Sweet gourd leaves	424.47 (±17.50)	0.9 (±0.24)	3.68 (±0.82)	136.87 (±18.90)	345.82 (±16.40)	49.86 (±13.50)	11.45 (±0.70)	33.46 (±2.05)	66.74 (±10.50)
Amaranthus leaf	168.97 (±12.55)	ND	3.17 (±0.54)	95.96 (±1.19)	311.7 (±13.90)	28.47 (±0.52)	57.47 (±2.38)	32.63 (±8.65)	27.66 (±7.49)
Fruity Vegetables:									
Garden peas	18.13 (±1.01)	ND	4.94 (±0.82)	11.02 (±1.09)	245.08 (±12.84)	4.36 (±0.70)	11.29 (±1.73)	26.57 (±2.03)	11.29 (±1.73)
Green chilli	30.02 (±0.87)	ND	5.49 (±0.97)	50.61 (±2.55)	295.92 (±32.00)	5.34 (±0.66)	13.2 (±1.53)	59.83 (±15.11)	3.37 (±2.25)
French bean	50.48 (±16.00)	ND	2.12 (±0.06)	24.06 (±7.11)	295.22 (±22.43)	5.78 (±0.90)	11.53 (±0.92)	29.19 (±2.56)	23.8 (±1.55)
Mustard seed (Green)	38.9 (±1.19)	ND	2.92 (±0.60)	25.68 (±1.80)	294.48 (±1.94)	8.52 (±1.13)	16.32 (±1.70)	14.37 (±2.14)	65.11 (±2.74)
Tomato	42.14 (±1.25)	0.22 (±0.01)	5.66 (±0.84)	15.86 (±0.92)	229.35 (±12.56)	5.53 (±1.11)	19.93 (±2.37)	59.19 (±6.47)	10.52 (±0.74)
Dry mustard seeds	20.16 (±1.01)	ND	1.1 (±0.01)	7.32 (±1.13)	294.19 (±2.89)	7.41 (±0.66)	12.16 (±1.36)	15.38 (±1.15)	21.45 (±0.71)

weight respectively). Highest manganese was recorded in spinach leaf (64.02ìg/Kg dry weight), where among others the concentration of the element ranged between 4ìg to 58ìg/Kg dry weight.

High selenium was recorded in cabbage, spinach leaf, tomato and green chilly (50.61ìg, 44074ìg, 59.19ìg and 59.83ìg/Kg dry weight respectively). Among the rest, the concentration of the element ranged between 8ìg to 42ìg/Kg dry weight. Relatively high zinc concentration was recorded in sweet gourd tender leaf, mustard seeds and spinach leaf (66.74ìg, 65.11ìg and 54.15ìg/Kg dry weight respectively). High concentration of zinc in them (50ìg to 59ìg/Kg dry weight). In case of manganese and sodium, the elements were also found in various concentrations in all the samples.

Table 2 represents the concentration of cadmium, nickel and lead in the same cereals, legume and vegetable samples studied here. Arum leaves and stems showed 2.44ìg/Kg dry weight of cadmium which was maximum among the samples examined. On the other hand, most of the samples presented various concentration of nickel in them and maximum concentration of the metal was recorded in French-bean (13.36ìg/Kg dry weight). Ranjit variety of rice, moong dal, cauliflower and green-chilly did not record any detectable amount in them. masur dal, on the other hand recorded considerable amount of the metal (5.05ìg/Kg dry weight).

In case of lead, high concentration of the metal was recorded in potato, mustard leaf and arhar-dal or pigeon-pea (18.55ìg, 14.70ìg and 16.70ìg/Kg dry weight). Significantly, common edibles like cauliflower, sweet gourd tender leaf and stems, garden peas, French bean, knol khol etc., did not record any detectable amount of lead on them.

DISCUSSION

The staple food for the Sunni Muslim population of the two villages, *viz.*, Dadara and Agyathuri, of the Kamrup district of Assam, are rice, legume and vegetables which are locally grown. The present study, though does not contain an exhaustive number or varieties of edibles from that area, may give a fair idea about the possible essential elemental intake and at the same time possible exposure to toxic metals like

Table 2: Concentration of few non-essential heavy metals in some cereals, pulses and vegetables collected from the villages of Dadara and Agyathury of Assam. All values are in ìg/Kg dry weight, ND= Not detected. Values in parentheses are standard deviations (SD).

Cereals and legumes:			
Variety	*Cd*	*Ni*	*Pb*
Rice var. Ranjit	ND	ND	1.54 (±0.40)
Rice var.Basmati	ND	6.02 (±0.49)	ND
Masur dal	ND	5.05 (±0.45)	7.10 (±3.57)
Moong dal	1.50 (±1.00)	ND	8.46 (±4.34)
Arhar dal	ND	5.54 (±2.54)	16.17 (±9.35)
Vegetables:			
Leafy Vegetables:			
Cabbage	0.55 (±0.25)	3.92 (±1.12)	ND
Arum	2.44 (±0.81)	5.15 (±0.66)	ND
Mustard leaf (big)	ND	5.74 (±0.60)	14.70 (±0.97)
Whole mustard plant	0.60 (±0.26)	5.35 (±0.41)	ND
Cauliflower	ND	ND	ND
Spinach leaf	ND	7.04 (±1.19)	5.42 (±0.58)
Coriander leaf	ND	9.06 (±0.66)	1.60 (±0.39)
Sweet gourd leaves	ND	4.01 (±0.62)	ND
Amaranthus leaf	ND	ND	7.78 (±1.18)
Fruity Vegetables:			
Garden peas	ND	5.18 (±0.97)	ND
Green chilli	ND	ND	6.28 (±0.64)
French bean	ND	13.36 (±1.36)	ND
Mustard seeds(green)	ND	3.89 (±0.52)	ND
Tomato	1.82 (±0.32)	4.48 (±0.70)	17.27 (±0.77)
Mustard seeds (dry)	ND	ND	ND
Rooty Vegetables:			
Potato	ND	0.34 (±0.24)	18.55 (±1.47)
Knol khol	ND	12.58 (±0.93)	ND
Carrot	ND	0.33 (±0.03)	5.21 (±0.16)

cadmium, nickel and lead, for the general population. The observations suggest that the two varieties of rice, though contain all the essential elements examined in various concentrations, their quantity is not very high, especially in case of calcium, iron, manganese and zinc. But in case of legumes ,the concentration of the aforementioned elements were found to be relatively high. Therefore, the present study paints a picture that cereal food must be combined with legumes in order to ensure adequate intake of these essential elements required for the body. The study further suggests that a careful selection of different varieties of edibles is imperative to optimize the intake of essential elements.

The present study further indicates the possible cobalt deficiency for the general population. Regular consumption of vegetables containing cobalt such as cabbage, arum, mustard leaves, tomato etc. must be ensured to avoid any potential cobalt deficiency. It was worthwhile to mention here that, maximum cobalt was recorded in Basmati variety of rice. But interaction with the people from the two villages indicated that, most of them restrain from regular intake of this particular variety of rice because of the high cost involved. Few edibles recorded high concentration of manganese in them. Therefore, consumption of these selected items should be mandatory to maintain an adequate manganese balance in the body which should include vegetables like mustard leaf, spinach, arum leaves etc. The essentiality of manganese lies in the fact that its deficiency may lead to central nervous system (CNS) disorders (Torente et al. 2002), and low manganese level may reduce manganese dependent superoxide dismutase activity which can increase cancer susceptibility (Finlay and Davis 1999). Though the adequate dietary allowances of manganese recommended for an adult in Indian context has not yet been established to be 2.5 mg to 5 mg per day (NAS 1980).

It is interesting to note here that Basmati variety of rice recorded considerable concentration of cobalt, but low iron (i.e., only 4.90ìg/Kg dry weight). Several vegetables commonly consumed by the general population of the two villages are arum leaves, cauliflower, garden peas, tomato, knol khol etc., again with low iron. But vegetables like coriander leaf, sweet gourd tender leaves, amaranthus leaves etc. showed high iron concentration in them. Therefore, these vegetables become important in view of the fact that, their regular consumption might elevate iron level in body, which is essential for oxygen transport and cellular energy metabolism. The importance of ensuring adequate bio-available dietary iron arises from the severe consequences associated with iron deficiency and anemia, including reduced immune function and resistance to infection, development delays, irreversible work performances and adverse frequency outcomes (Cooper et al. 2006; Naghii and Fouladi 2006).

As far as selenium is concerned, the present study is relevant. It is important to note here that except masurdal, a common legume, all the samples examined recorded various concentrations of the element. Selenium acts as a cofactor for glutathione peroxidase (Maddipati and Marnett 1987) and 5'-de-iodenase type-1 or thyroxine de-iodenase (Mandel et al. 1992). The role of this element in protection from reactive oxygen species induced cell damage has been amply highlighted in (Chen and Berry 2003). Most of the legumes recorded high concentration of zinc, which makes them a vital component for total nourishment (Sondergaard et al. 2006; Bose et al. 2006; Patel and Harding 2004; McClung and Serimgeour 2005).

In case of toxic heavy metals, the result suggests their accumulation in cereals, legumes and vegetables studied, should be viewed seriously. Even though the concentrations were well within the tolerable limit for a human being, yet long exposure to these metals might bring about bioaccumulation and thus harmful effects on the population. Lead occurs naturally in soil in relatively low concentrations, but through the addition of industrial lead, like lead particles and chips from paints, automobile emission from leaded fuel and similar other sources, the range can go up to 500ppm to over 3000ppm, and it was observed that soil near heavily traveled roadways is typically 30 to 2000 ppm higher in lead content than soil in a neutral area (Chakraborty et al. 2004). It is a matter of concern that a good number of edibles examined here were found to contain lead in them. The genuine concern lies with the children, where the elevated lead in their blood may not show any symptoms, or may show a progression of non- specific symptoms such as neurocognitive development impairment (Zimmermann et al. 2006).

Similarly, nickel though in low concentration, was observed in several samples examined here.

Environmental contamination of nickel is again related to consumption of fossil fuel such as petroleum and coal and fly ash released from coal burning (Sundermann 1988; Chakraborty et al. 2004).

Though the concentration of non-essential heavy metals, such as lead, nickel and cadmium are not going to pose immediate danger to the general population, the study suggests their accumulation in cereals, legumes and vegetables should be viewed with concern. Though the concentrations were well within the tolerable limit for a human, yet long exposure to these metals could bring about bioaccumulation and thus harmful effects on the population.

CONCLUSION

This study presents a preliminary observation on concentrations of few essential elements in some common edibles consumed by the Muslim people of the two villages of Assam *viz.,* Dadara and Agyathuri. The study showed presence of some essential elements in fair quantities, as well as deficiency of some others, such as iron. Consumption of balanced and combination of different varieties of edibles can ensure adequate elemental intake by the population of the two villages. At the same time if a particular element known as essential is found to be deficient, care should be taken by the appropriate authorities or health officials to supplement them adequately.

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