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Potassium, Calcium and Sodium Distribution in Different Part of Common Vegetable Plants Grown under Field Condition

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ABSTRACT

A field experiment was conducted to investigate the distribution of Potassium, Sodium, Calcium in different parts of commonly used vegetables. Complete Randomize Design (CRD) was followed for the experiment. Seeds of nine vegetable plants were collected and cultivated. After 45 days, vegetables were harvested and nutrient concentration in different parts of nine vegetables (leaf, petiole and stem) was measured. The distribution order of potassium, sodium, calcium concentration among leaves, petioles and stems was found as petiole>stem>leaf, petiole>leaf>stem, petiole>leaf>stem, respectively. But individually, high concentration of K, Ca, Na was found in *Corchorus capsularis*, *Amaranthus lividus* (Green) and *Spinacia oleracia*, respectively and low concentration was found in *Lagenaria siceraria* for all nutrients. The K, Ca, Na concentration among the plants and within different parts of the each vegetable was significant ($p<0.05$). The present research work revealed that *Corchorus capsularis, Amaranthus lividus* (Green), *Spinacia oleracia* was highly nutritious for measured nutrients but *Lagenaria siceraria* contained low concentration of all measured nutrient. But for all the vegetables, petioles are highly nutritious compared to other parts of vegetables.

Key words: Vegetable, leaf, petiole, stem, distribution, potassium, sodium, calcium

INTRODUCTION

The problem of malnutrition with ever-increasing 'nutrition gap' is quite obvious in Asian, African and many developing countries, since, the traditional source of nutrition has not kept pace with population growth. It is desired, therefore, to explore and exploit the possible source of nutrition production to help the country to overcome the malnutrition. Malnutrition posses a continuing constrain to Bangladesh's development. Vegetable is one of the highest nutrition producers per unit area and time which can be very effective weapon to fight malnutrition. Nutrition plays a critical role in wellness, by not only providing essential nutrients but also promoting good health and preventing diseases (Willett, 1994). Human gets nutrition directly through artificial medicine or indirectly through foods. Among the different sources of food consumption of vegetable foods is a dominant source. Vegetable being the rich sources of carbohydrates, mineral, fats and proteins which form the major portion of the human diet. People of Bangladesh get nutrition by using some common vegetable as *Amaranthus tricola*, *Ipomea reptans, Corchorus capsularis*, *Basella alba, Spinach olerecea* etc. Plant uptake this mineral from soil and distribute, storage throughout the tissue. Calcium is a regulator of plant growth and development (Hepler, 2005) and is indispensable in a number of plant metabolic functions/pathways (Plieth, 2005), stem and root elongation of plant (White and Brodley, 2003). The

effects on human health of a diet low in Ca include reduced bone density and increased risks of bone fracture and osteoporosis (Institute of Medicine (IOM), 1997). Transpiration and water movement through plants can influence Ca^{2+}storage, as most plant Ca is stored in leaves and root to shoot transfer of Ca^{2+}has been elaborated at length elsewhere (Karley and White, 2009).

Complicated changes bring through plant aging in morphology and physiology which affect uptake, translocation and distribution of different ions in the plant parts. Accumulation of Ca, Mg and Na continued throughout the whole period of growth in petioles (Iwahashi *et al*., 1982). Therefore, a detailed study was conducted on the accumulation pattern of ions in individual leaves, petioles and stems in order to determine the relationship between the developments each plant organ and its ion distribution. Accumulation of Ca, Mg, K and Na in each individual leaf, petiole and stem of the cucumber plant (*Cucumis sativus* L. cv. Kasairaku) was investigated in relation to the growth of these organs under water culture condition (Iwahashi *et al*., 1982). Accumulation patterns of these major cations showed a close relationship with the growth characteristics of the organs (Iwahashi *et al*., 1982). Little study about the adequate nutrient concentrations in the different organs of vegetables has been reported in Bangladesh. Such studies are important because this information can be employed to optimize the fertilizer use in vegetable crops and nutrition value of vegetable crops for human consumption as well as solving some common problem as Hypokalemia, Hypocalcaemia, Hyponatremia. The present research was conducted to explore the distribution of the Ca, K, Na in different individual parts of leafy vegetable plants in field condition.

MATERIALS AND METHODS

A field experiment was conducted to evaluate the K, Na, Ca distribution in different parts of different commonly growing vegetables in Chittagong. The experiment was conducted by using Complete Randomize Design (CRD) method.

Land preparation: At first the land was selected in BCSIR laboratories field for vegetable cultivation. Weeds were cleared and land was prepared through crashing of large chunk of soil into smaller one as a place where equal sun light distribution takes place. The fields were divided into nine plots for cultivation of nine vegetables plant. Some soil was stored for laboratory analysis (Table 1).

Seed collection and cultivation: Total nine vegetable plants seed were collected for cultivation in the field from local marker. The seed of nine plants name is given in Table 2. Seeds were distributed equally throughout the each plot separately. Thinning was done after 10 days of seed sown.

Table 1: Physical and chemical properties of the soil used for vegetable cultivation

Parameters	Results
pH	5.7
EC	0.75 mS m^{-1}
Available K	77.24 mg kg^{-1}
Available Mg	0.061%
Available S	46.69 mg kg^{-1}
Available Fe	0.02%
Available Ca	0.034%
CEC	19.30 meq/100 g soil
Available P	2.12 mg kg^{-1}
OM	1.94%
Available N	0.045%

Table 2: List of cultivated vegetables and their family

Name of vegetables	Family name	Habit
Basella alba L.	Basellaceae	Perennial
Cucurbita moschata Duchesne ex Poir.	Cucurbitaceae	Annual
Amaranthus lividus L. (Green)	Amaranthaceae	Annual
Amaranthus gangeticus L.	Amaranthaceae	Annual
Lagenaria siceraria (Molina) Standl.	Cucurbitaceae	Annual herb
Spinacia oleracea L.	Amaranthaceae	Annual (rarely biennial)
Ipomoea aquatica Forssk.	Convolvulaceae	Perennial herb
Corchorus capsularis L.	Malvaceae	Annual herbs
Amaranthus lividus L. (Red)	Amaranthaceae	Annual

Harvesting and sample collection: After 45 days from seed sown vegetables plant were harvested and immediately wash with tap water. All the plants were taken into separate polythene bag and leveled it.

Sample preparation: After the collection of vegetable sample it brought in Soil Science Laboratory of Bangladesh Council of Scientific and Industrial Research, Chittagong. At first the vegetable samples was washed by tap water. Then second time it was washed by distilled water. After the washing of samples it was spread on a white paper and kept sometime for air dry. Then all the vegetables samples were cut down by scissors and differentiate into different parts as leaf, petioles and stem. The different parts of the vegetables were collected in different beaker and leveled by signature pen. Then the samples were kept in oven for oven dry at temperature 80°C. After 24 h the samples brought out and the dried plant samples were then ground and preserved for further analysis.

Sample digestion and analysis: One gram oven dry vegetable samples were taken into a 100 mL beaker. Then the samples were digested by the procedure outlined by Huq and Alam (2005). For determining the total content of K, Ca, Na the sample was extracted with aqua regia ($HCl:HNO_3$ = 3:1) and the extract was analyzed by using Flame emission spectrophotometer (JENWAY PFP7). The QC and QA were strictly maintained during the analysis.

Statistical analysis: The results were expressed as the averages of three replications. The data was subjected to ANOVA. The Tukey's test ($p<0.05$) was used to evaluate the differences between means. The graphs were drown by Microsoft excel 2007.

RESULTS AND DISCUSSION

Potassium distribution (K) in cultivated vegetables: Potassium concentration in different parts of cultivated different vegetables differed widely (Fig. 1). Concentration of potassium in stem was found range from 1.64±0.04% (in *L. siceraria*) to 9.96±0.04% in *A. gangeticus*; in petioles range from 12.70±0.05 to 1.88±0.02% in *C. capsularis, L. siceraria,* respectively; in leaf range from 0.14±0.02% to 4.39±0.01% in *L. siceraria* and *C. capsularis*, respectively. The distribution of K concentration among the vegetables parts was found as decreasing order petioles>stem>leaf. So, petioles contain high concentration of K compare to other parts of vegetables. The present work agreed with the work of Besford and Maw (1974). Besford and Maw (1974) reported that plant petioles contain high concentration of potassium. But among the vegetables *A. gangeticus* and *C. capsularis* retained high concentration of K that might be due to root absorption capacity, geometry in absorbing root surface, plant demand and water flux rate (Baligar and Barber, 1978) of those vegetables from soil solution but opposite condition was true for *L. siceraria* and *I. aquatica*. But soil K concentration (0.0077%) was much less than plant K accumulation.

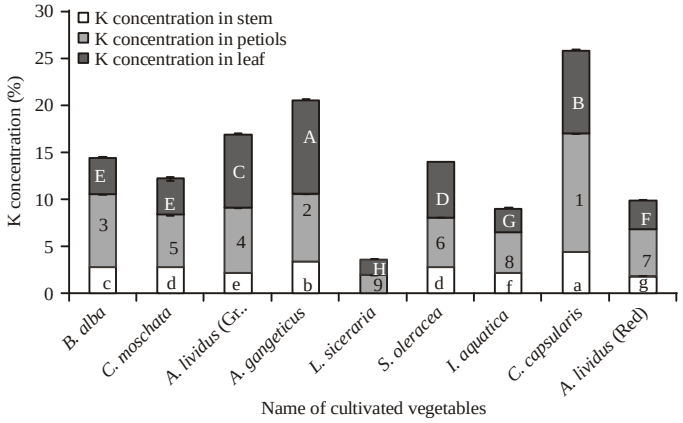

Fig. 1: Distribution of K (potassium) in different parts of different vegetables. Different letters but same color on bars indicate significant difference ($p<0.05$). Means followed by the same letter and same color are not significantly different ($p<0.05$). Error bars represent the standard deviations (SDs), Comparison among the vegetables

Statistical analysis revealed that K concentration was significant ($p<0.05$) not only within vegetables parts but also among the vegetables.

Distribution of Calcium (Ca) in cultivated vegetables: Calcium (Ca) concentration in stem was found range from 0.345±0.05% in *C. moschata* to 2.69±0.03% in *A. gangeticus,* in leaf range from 0.09±0.01% in *L. siceraria* to 5.1±0.05% in *A. lividus* (Green); in petioles range from 0.91±0.03% in *B. alba* to 5.34±0.06% in *A. lividus* (Red). Petioles contained high concentration of Calcium compare to other plants parts. Calcium (Ca) concentration was found as increasing order stem<leaf<petioles among the cultivated vegetables. Karley and White (2009) reported that most plant Ca is stored in leaves but the present result differed with them. Only 33.33% of cultivated vegetables plant's most Ca stored in leaves where most plant Ca stored in petioles about 55.56% of total vegetables. Iwahashi *et al.* (1982) reported that accumulation of Ca, Mg and Na continued throughout the whole period of growth in petioles that might be the possible reason of high concentration of Ca in petioles. In case of individual vegetables, *A. lividus* (Red and Green) contained high concentration of calcium followed by *A. gangeticus* and least concentration of Ca was observed in *L. siceraria* (Fig. 2) compare to soil calcium concentration (0.034%) that might be due to root absorption capacity, geometry in absorbing root surface, plant demand and water flux rate (Baligar and Barber, 1978). Statistically, Ca concentration differed significantly not only within plant parts but also among the plants (Fig. 2).

Distribution of sodium (Na) in cultivated vegetables: Sodium (Na) concentration among the petioles of cultivated vegetables was highest in *S. oleracea* followed by *I. aquatica* and least in *C. moschata*. But in case of Na concentration in leaf, Na percentage was found highest in *S. oleracea* followed by *C. capsularis* and least in *L. siceraria*. In stem, distribution of Na concentration was found mostly as like as petioles. Sodium concentration in soil was same for all plants as 0.006% but plants accumulation was higher in comparison to soil concentration. Sodium concentration for each individual plant's parts were measured and the result showed that 77.78% cultivated vegetables contained high concentration of Na in their petioles that might be due to the accumulation of Na throughout the whole period in growth of petioles (Iwahashi *et al*., 1982) and 22.22% vegetables plants contained high concentration of Na in their leaf (Fig. 3).

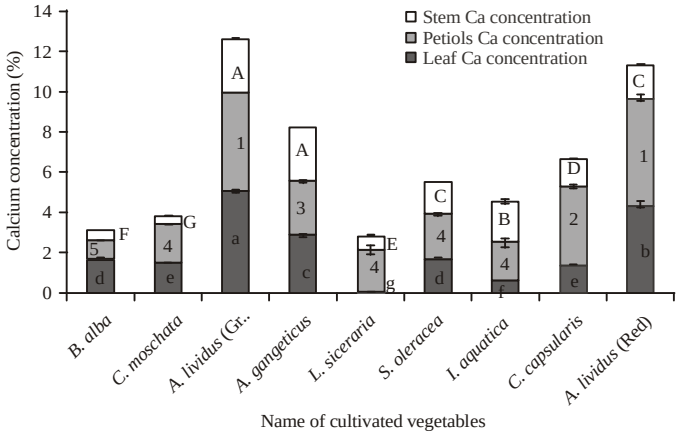

Fig. 2: Distribution of Ca (Calcium) in different parts of cultivated vegetables plants. Different letters but same color on bars indicate significant difference ($p<0.05$). Means followed by the same letter and same color are not significantly different ($p<0.05$). Error bars represent the standard deviations (SDs), comparison among the vegetables parts

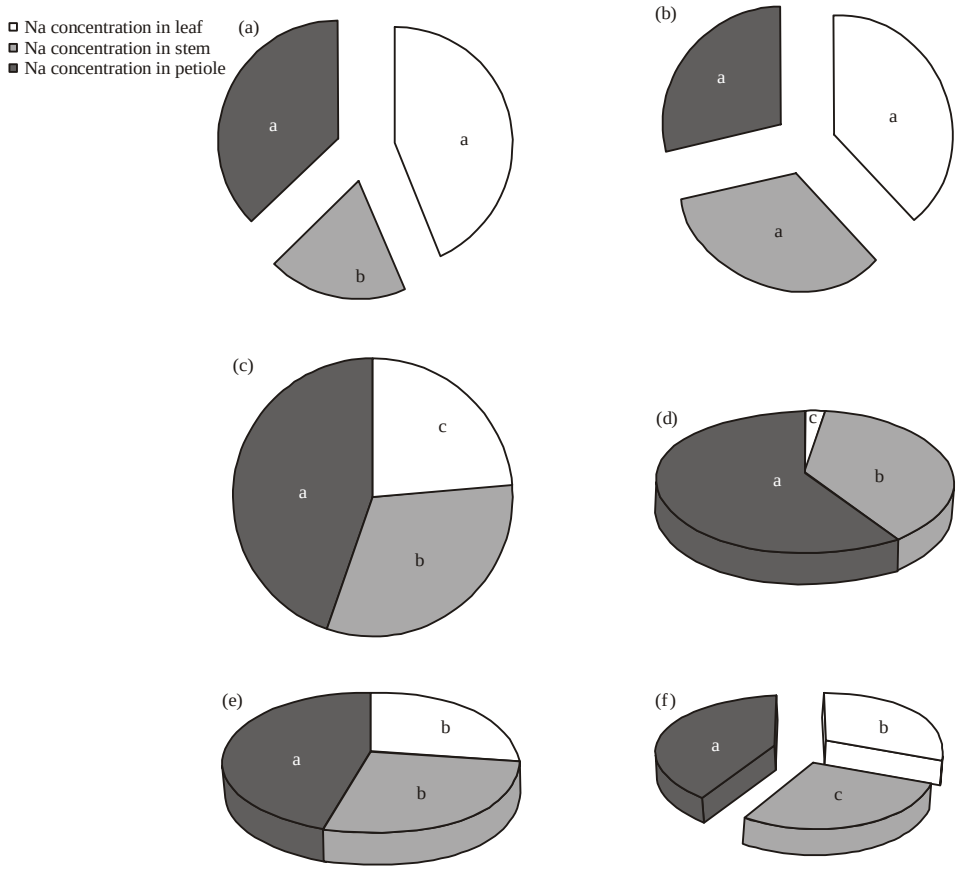

Fig. 3(a-i): Continue

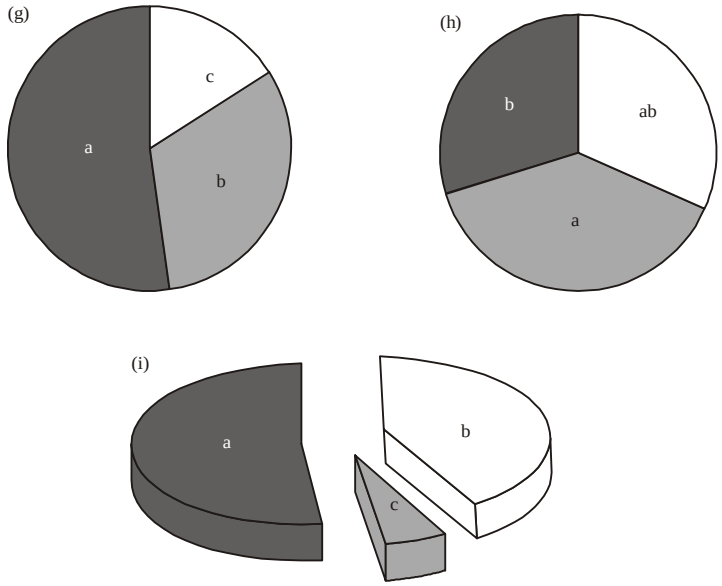

Fig. 3(a-i): Distribution of sodium percentage in different parts (leaf, petioles, stem) of each cultivated vegetables (3.1-3.9) separately. Different letters on pie chart indicate significant difference ($p<0.05$). Means followed by the same letter are not significantly different ($p<0.05$), (a) *B. alba*, (b) *C. moschata*, (c) *A. gangeticus*, (d) *L. siceraria*, (e) *I. aquatica*, (f) *S. oleracea*, (g) *A. lividus* (Red), (h) *A. lividus* (Green) and (i) *C. capsularis*

CONCLUSION

Na, K, Ca distribution within three parts of analyzed vegetables followed the same pattern for Na and K. Na, K concentration was found highest in petioles of 77.88% vegetables followed by stem 22.22%. But calcium concentration in 55.56% vegetables contained high concentration in their petioles but 33.33% vegetables contained high concentration in their leaf and 11.11% vegetables kept high in stem. This research revealed that petioles of commonly used vegetables are highly nutritious compare to other vegetables parts growing. South Asian people mostly uses stem of the vegetable plants instead of leaves and petioles but by using the leaves and petioles as their daily diet children of this area can overcome the malnutrition problem. Apart from this, it might be an efficient strategy by using the whole parts of the vegetable as daily diet for people's of South Asia as well as Africa can take preventive steps not only for some common problem like as hypokalemia, hypocalcaemia, hyponatremia but also arthritis, high blood pressure, heart disease, stroke, cancer and even infertility, blood clot, nerves system disorder to regulate sound health without using medicine.

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