Original Article

Effect of maturity on macromineral content of selected leafy vegetables

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Macro mineral contents were estimated in commonly consumed green leafy vegetables in India, namely: *Koyyathotakura* and *Peddathotakura* (varieties of *Amaranthus species*); *Erragogu* and *Tellagogu* (variety of *Hibiscus* species); *Gangabayalakura (Portulaca olereceo)* and *Palak* (*Spineces olerecea*) at three different stages of maturity. Varietal differences were also observed. The results of the study showed that as the plant matured from stage I (15 days) to stage II (30 days) calcium and magnesium content increased. In contrast, phosphorus content decreased as the plant matured. Varietal differences were also observed at different stages of maturity. The results also indicated that the consumption of green leafy vegetables at stage I (15 days) and stage II (30 days) potentially provide the greatest amount of minerals.

Key Words: : Koyyathotakura and Peddathotakura (Amaranthus species); Erragogu and Tellagogu (Hibiscus species); Gangabayalakura (Portulaca olerecea) , Palak (Spineces olerecea), Calcium, Magnesium; Phosphorus, Indian leafy greens.

Introduction

Leafy vegetables are the least expensive sources of a number of protective nutrients. They are readily available throughout the year, and are grown in sufficient quantities throughout India. Consumption of locally available green leafy vegetables is an important means to overcome defi-ciencies. Sheela[1] estimated mineral content in 10 uncommon green leafy vegetables. Karvanek and Bohmova[2] estimated the mineral content in 44 strains of spinach leaves from about 10 countries of Europe and USA and Smith[3] analysed mineral content in 21 leafy vegetables. Singh and Sexana[4] estimated cation content in six leafy vegetables at 5 stages (15, 30, 45, 60 and 75 days) of maturity. Different stages of maturity did not affect the sodium and potassium contents of the leaves. In the case of the stem, the maximum concentrations were observed at 30 days, after which they gradually declined. Giri *et al.*[5] reported that phosphorus (P), calcium (Ca), magnesium (Mg), sodium (Na), iron (Fe), copper (Cu) and manganese (Mn) increased and potassium (K) decreased with the age of the *Chekurmeni* plant.

A number of green leafy vegetables are consumed at different stages of maturity, but limited information is available on their mineral content at different stages of maturity. The present study was proposed to estimate the mineral content in commonly consumed green leafy vegetables in India at three different stages of maturity.

Materials and methods

Selection of Samples

Six commonly consumed green leafy vegetables in India, such as *koyyathotakura (Amaranthus blitum*), *peddathotakura (Amaranthus gongeticus), gangabayalakura (Portulaca olerecea), erragogu (Hibiscus subdariffe), tellagogu (Hibiscus cannabinus*) and *palak (Spineces olerecea)* were selected to determine mineral content at different stages of maturity. Of these six, two varieties from *Amaranthus Sp*. and two varieties of *Hibiscus Sp.* were selected to ascertain the varietal differences.

Growing of leafy vegetables

The vegetables were grown in black soil in three replications during the winter season. An area of 67.87 m^2 was divided into three rows for three replications. Each row was divided into six plots (Fig. 1). The density of the plants in the area was 10 plants per 15 X 1.3 m^2 section. The three different stages of maturity used in the study were 15 days, 30 days and 45 days of age. At the end of each stage, the edible portions of plant samples were taken and washed with distilled water. The washed samples were dried in a hot air oven (Memmert, 854 schwabech) at 60^O C and made into fine powder (60 mm mesh size) and stored in an air-tight container for mineral estimation.

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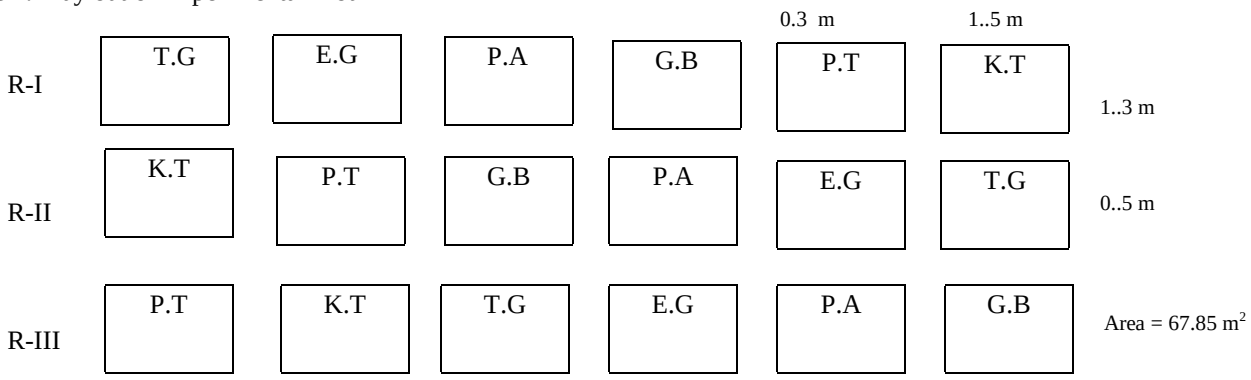
Accepted 28 June 2002

Figure 1. Lay out of Experimental Plot



KT = *koyyathtakura*; PT = *peddathotakura*; GB = *gangabayalakura;*
PA = *palak*; EG = *erragogu*; TG = *tellagogu*

Chemical analysis of samples

All the samples were analysed in duplicate for macro minerals (Ca, P and Mg) by standard methods using atomic absorption spectrophotometry.[6] Plant samples were broken down by 'wet digestion' which involves using concentrations of nitric acid, sulphuric acid and perchloric acid in the ratios at 10: 0.5: 2 by volume. The intensity of the colour was read at different wave lengths using atomic absorption spectrophotometry.

Statistical analysis

The data obtained from all the parameters studied were subjected to factorial randomized block design to enable the observation of significant differences amongst the three stages of each leafy vegetable and amongst all the leafy vegetables in each stage.[7]

Results and Discussion

Calcium content

In *peddathotakura* and *palak*, calcium content increased as the plant matured. Giri *et al.*[5] also found a continuous increase in calcium content from 3 months to one year of age in *chekurmenis* leaves (a similar leafy vegetable). It may be due to the immobile nature of the calcium and failure to retranslocate from older parts of the plant to the growing parts of the plant. The calcium accumulated in more mature parts of the plant than in the younger parts of the plant[8,9]. In *koyyathotakura* and *gangabayalakura*, calcium content was increased up to stage II and decreased at stage III (Table 1 and Fig. 2.). Singh and Saxena[4] reported similar results. During flowering stage the absorbed minerals are diverted to flower development. This may be the reason why the calcium content was decreased in *koyyathotakura* and *ganga-bayalakura* at stage III. Calcium content was found to be significantly increased from stage I to stage II in *ganga-bayalakura* and *tellagogu.* In all other leafy vegetables significant differences were not observed between the stages. *Peddathotakura* contained the greatest amount of calcium, followed by *koyyathotakura, gangabayalakura, tellagogu, palak* and *erragogu,* irrespective of stage of maturity.

Table 1. Mean calcium content in different leafy vegetables on dry weight basis (mg %) at different stages of maturity (average of six values).

Name of the Leafy vegetable	Stage of Maturation		
	Stage I (15 days)	Stage II (30 days)	Stage III (45 days)
koyyathotakura	101	136	121
peddathotakura	128	144	156
gangabryalakura	50	118	80
palak	55	68	87
erragogu	85	50	85
tellagogu	52	30	113

Critical difference: 42.55 at 5% level.

Varietal difference in calcium content

Significant differences were not observed between the Ca content of two varieties of *Amarnathus Sp. (koyyathotakura* and *peddathotakura*), and two varieties of *Hibiscus Sp. (erragogu* and *tellagogu).* The changing pattern in Ca content in all the three stages was almost similar in both the varieties of *Amarnathus Sp.* Up to stage II, the Ca content increased in both varieties, but as the plant matured to stage III in *peddathotakura* the increase was continued, but in *koyyathotakura* it decreased. This may have been due to the relatively longer growing period and later flowering of *peddathotakura* compared to *koyyathotakura.*[10] In *Hibiscus Sp.*, the changing pattern of Ca content was similar in both the varieties i.e. Ca content decreased as the plant matured from stage I to stage II and increased as age increased from stage II to stage III.

Phosphorus content

In all the leafy vegetables studied, P content was more at the initial stage and decreased continuously from the initial stage to final stage, except in *gangabayalakura* (Table 2 and Fig. 2). This result was in contrast with the results of Giri *et al* [5]. The higher amount of P in the initial stage of growth may be because the highest relative concentrations of P tend to occur in those particular regions. In young leaves the predominant effect is the synthesis of new protoplasm, which results in growth towards maturity. In older leaves, photosynthesis is the dominant function and little growth results.[11] Hence, in the present study the P content was higher in the initial stage where growth rate is high. Phosphorus content was significantly different among all leafy vegetables in all stages except between *koyyathotakura* and *gangabayalakura* in stage I and stage III, between *erragogu* and *tellagogu* in stage II and stage III and between *palak* and *erragogu* in stage I.

Table 2. Mean phosphorus content in different leafy vegetables on dry weight basis (mg %) at different stages of maturity (average of six values).

Name of the Leafy vegetable	Stage of Maturation		
	Stage I (15 days)	Stage II (30 days)	Stage III (45 days)
koyyathotakura	63	60	56
peddathotakura	45	30	27
gangabryalakura	63	70	56
palak	31	30	22
erragogu	27	16	14
tellagogu	19	18	16

Critical difference: 5.33 at 5% level.

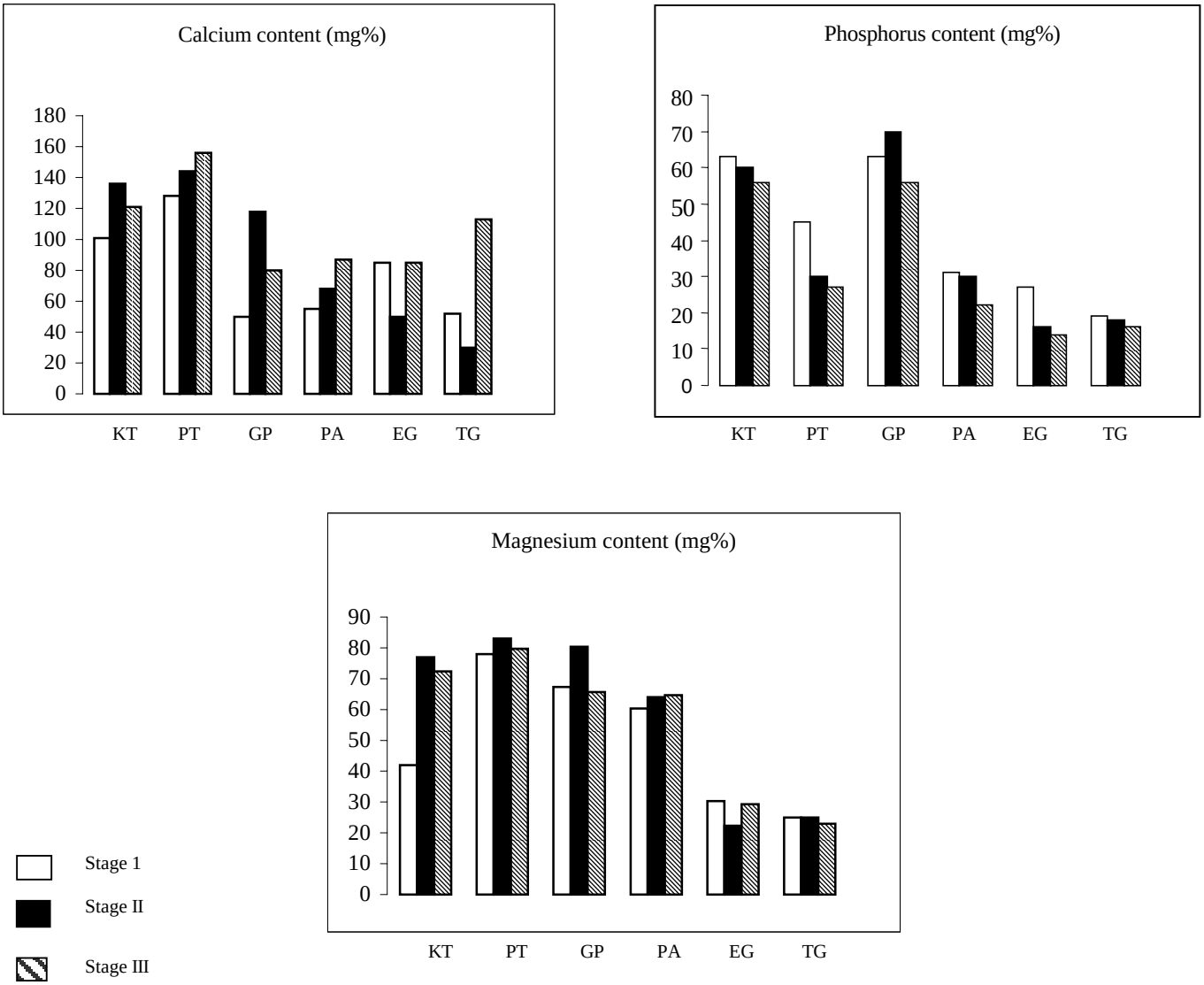


Figure 2. Macro mineral content in different leafy vegetables at different stages of maturity
KT= *koyyathotakura*; PT = *peddathotakura;* GP = *gangabryalakura*; PA = *palak;* EG = *erragogu;* TG = *tellagogu*

Varietal differences in phosphorus content

There was a significant difference in P content in the two varieties of *Amarnathus Sp.* The changing pattern of this mineral was similar in both varieties. Phosphorus was greater in *gangabayalakura,* followed by *koyyathotakura, pedathotakura, palak, erragogu* and *tellagogu* irrespective of stage of maturation. The phosphorus content decreased continuously as age increased.

Magnesium content

Chlorophylls are the only major stable compounds of plants which contain an atom of Mg as a fixed (non-dissociable) constituent. However, the Mg of chlorophyll represents only 10 percent of the total Mg in the leaf. Magnesium content was increased in *koyyathotakura, peddathotakura, gangabayalakura* and *palak* as the plant matured from stage I to stage II (Table 3 and Fig. 2). This increase was not continuous till stage III. This result was in agreement with results of Singh and Saxena.[4] They also found an increase in Ca plus Mg content from 15 days to 30 days and a decrease in Ca plus Mg content from 30 days to 45 days in most of the leafy vegetables studied. Giri *et al.* also found a continuous increase in Mg content from 3 months to one year.[5]

The increase may have been due to the Mg ion being in an unfixed or dissociable form that accumulates with age. In *erragogu,* Mg content decreased as the plant matured from stage I to stage II and decreased from stage II to stage III; the amount at stage III was lesser than that present at stage I. In *tellagogu* no change was observed at stage I and stage II, but as age increased further the Mg content decreased.

Magnesium content was similar at all stages of maturity in all the leafy vegetables. Magnesium content was greater in *peddathotakura* followed by *gangabayalakura, koyyathotakura, palak, erragogu* and *telagogu,* irrespective of stage of maturation.

Table 3: Mean magnesium content in different leafy vegetables on dry weight basis (mg%) at different stages of maturity (average of six values).

Name of the Leafy vegetable	Stage of Maturation		
	Stage I (15 days)	Stage II (30 days)	Stage III (45 days)
koyyathotakura	42.00	77.00	72.33
peddathotakura	78.00	83.00	79.67
gangabryalakura	67.33	80.33	65.67
palak	60.33	64.00	64.67
erragogu	30.33	22.33	29.33
Tellagogu	25.00	25.00	23.00

Critical difference : 71.14 at 5% level.

Varietal differences in magnesium content

In *Amaranthus Sp., peddathotakura* contained a greater amount of Mg than *koyyathotakura,* but the difference was not significant. The changing pattern of this mineral was similar in both varieties i.e., Mg content increased from stage I to stage II and decreased from stage II to stage III. In *Hibiscus Sp., erragogu* contained a greater amount of Mg at stage II and III where as *tellagogu* contained a greater amount of Mg at stage II, but the difference was not significant. The changing pattern of this mineral in both varieties of *Hibiscus Sp.,* was not similar.

Calcium and Mg increased as the plant matured from 15 days to 30 days, whereas P content decreased continuously as the plant matured from 15 days to 45 days. Many factors such as soil composition and pH, water availability to the plant, weather conditions prevailing during the growth of the plant and the variety of the plant can affect the uptake of minerals by plants.

Conclusions

The present study showed that calcium content was increased from stage I to stage II in *gangabayalakura* and *tellagogu. Peddathotakura* contained the highest amount of calcium at stage III. Significant differences in calcium content were not observed between the varieties. Phosphorus content was greater at the initial stages of growth for all the leafy vegetables (except *gangabayalakura*) and decreased continuously on maturity. Magnesium content was increased in *koyyathotakura, peddathotakura, gangabayalakura* and *palak* during maturation, up to second stage.

The differences observed between the mineral contents of the two varieties of the same species do not necessarily indicate that the variety with higher amounts of some minerals has a more efficient mechanism for absorption. It may merely mean that the variety has a more branched root system and thus may explore its soil more efficiently.[12,13] The differences may also be due to genetically controlled mechanisms of mineral nutrition, especially those concerned with absorption and translocation of a particular element [14].

Reddy *et al.*[15] reported very low availability of iron from 14 locally available and commonly consumed green leafy vegetables, by invitro studies, indicating that the large amounts of oxalates in the green leafy vegetables may be responsible for the low availability. Furthermore, they also reported a wide variation in the total iron content of green leafy vegetables. Khader and Rama[16] concluded in their study that the optimum period to consume leafy vegetables is between stage I and stage II when the mineral content is highest.

Acknowledgements

We are grateful to Prof. Vijaya Khader, Director, Centre of Advanced Studies, Rajendranagar for permitting the research work to be carried out.

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