QUALITY ATTRIBUTES OF SELECTED LEAFY VEGETABLES

By

MAYA MATHEW

THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Home Science

(FOOD SCIENCE & NUTRITION)

Faculty of Agriculture

Kerala Agricultural University

Department of Home Science

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR - 680 656

KERALA, INDIA

2000

DECLARATION

I hereby declare that this thesis entitled "**Quality attributes of selected leafy vegetables"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara
2-5-2000

MAYA MATHEW

CERTIFICATE

Certified that this thesis, entitled "**Quality attributes of selected leafy vegetables**" is a record of research work done independently by **Ms.Maya Mathew,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

V Indira

Dr.V. INDIRA
Chairperson, Advisory Committee
Associate Professor & Head
Department of Home Science
College of Horticulture
Vellanikkara

Vellanikkara
2-5-2000

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Ms.Maya Mathew,** a candidate for the degree of **Master of Science in Home Science (Food Science and Nutrition),** agree that the thesis entitled **"Quality attributes of selected leafy vegetables"** may be submitted by Ms.Maya Mathew, in partial fulfilment of the requirement for the degree.

Dr.V.Indira
(Chairperson, Advisory Committee)
Associate Professor & Head
Department of Home Science
College of Horticulture
Vellanikkara

Dr.A. Augustine
Associate Professor
AICRP on M & AP
College of Horticulture
Vellanikkara

Dr.Salikutty Joseph
Associate Professor
Department of Olericulture
College of Horticulture
Vellanikkara

Dr.V. Usha
Associate Professor
Department of Home Science
College of Horticulture
Vellanikkara

EXTERNAL EXAMINER
(Dr. D. MALATHI)

ACKNOWLEDGEMENT

Words are not always enough to express our feelings. Yet, there are times when we have to rely upon them. So, let me pen a few words of gratitude, because at this moment of accomplishment, I feel grateful to many. I recall how often I have been distressed, dismayed and hands have reached to help and voices called that kept me unafraid. It would be rather impossible to list out the names of all those who have helped me in one way or another, but a few names need special mention.

With a deep sense of gratitude, I express my heartfelt thanks and indebtedness to Dr.V.Indira, Associate Professor and Head of the Department of Home Science, College of Horticulture, Vellanikkara and Chairperson of my advisory committee for her valuable guidance, constant encouragement, ever willing help, lasting patience and the love and concern extended to me throughout the course of study and research work. But for her, I would not have been able to undertake this investigation successfully.

I am thankful to Dr.A.Augustin, Associate Professor (Biochemistry), AICRP on M & AP and member of my advisory committee for providing me the lab facilities, his constructive criticisms and valuable advice at the time when I needed them most.

I am also thankful to Dr.Salikutty Joseph, Associate Professor, Department of Olericulture and member of my advisory committee for the valuable suggestions and the interest she showed in the progress of this study.

I also feel grateful to Dr.V.Usha, Associate Professor, Department of Home Science and member of my advisory committee for the help extended to me for the preparation of the thesis.

I am grateful to Dr.P.V.Prabhakaran, Associate Dean, College of Horticulture for all the valuable suggestions in carrying out the statistical analysis.

I am thankful to Smt.Gracemma Kurian, Assistant Professor, Department of Agricultural Statistics, College of Horticulture, Vellanikkara and Shri.S.Krishnan, Assistant Professor, Department of Agricultural Statistics for their suggestions in carrying out the statistical evaluation.

I am also thankful to Dr.R.Vikraman Nair, Former Head of the Department of Agronomy for providing the lab facilities.

May I express my gratitude to Dr.A.I.Jose, former Associate Dean of the College of Horticulture, for all the help rendered by him for the smooth running of the study.

May I express my sincere gratitude to all the teaching and non-teaching staff of my department. I thankfully, remember, all the small and big helps extended to me by my seniors and juniors as well.

Special thanks are due to my dearest friends, Raji, Suman, Mini, Maya, T., Annie, Anju, Divya, Sulaja, Mole, P. and Rani for their warm company, support and encouragement. I also thank my juniors, Saina, Vandana, Sabeena and Shiji for their company.

With immense pleasure I thank all my friends, both inside and outside the campus and especially Smt.Jijiamma for their help and encouragement.

The help rendered by Smt.Joicy, T. John to carry out the statistical analysis is sincerely acknowledged. I also express my sincere thanks to Mr.Joy, J.M.J. Computer Center, Thottappady for the neat typing of the manuscript.

The award of KAU Fellowship is duly acknowledged.

I also take this opportunity to express my gratitude to my father and mother, Tom and Leena and Joe and Sneha for their keen interest in me, constant prayers, encouragements and understanding throughout the endeavour.

Above all, I thank God Almighty for blessing me with good teachers, friends and family and enabling me to complete this work successfully.

Maya Mathew

To my Parents

CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

INTRODUCTION

Vegetables being rich in nutrients, occupy a prominent position among foods and a distinct place in the balanced diet. Green leafy vegetables abound in our country are known to be the most inexpensive source of several vital nutrients. Leafy vegetables are appreciated because, they not only supply the protective nutrients and add variety to a monotonous diet, but also have an attractive taste, pleasing appearance and aroma.

The commonly consumed green leafy vegetables in India such as, amaranth, drumstick, spinach, etc., are termed as 'poor man's luxury' due to their unassuming way of production, response to basic health needs, their wide range of choices and essential cheapness. The severity of micronutrient malnutrition widely prevalent in India can be easily reduced, if the consumption of green leafy vegetables is actively promoted, especially among the low income groups of the population. The affluent lot can also benefit by eating these vegetables as these contain antioxidants which offer protection against many chronic diseases like heart disease and certain types of cancers (Saxena, 1999).

Green leafy vegetables are one of the best sources of vitamin C, riboflavin and iron for vegetarians. They are a rich source of beta carotene, folic acid, calcium, and vitamin K. Leafy vegetables are also a good source of dietary fibre, particularly soluble fibre and fatty acids (α linolenic acid) which has hypocholesterolaemic and hypotriglyceridaemic effects in humans. The dry matter of leafy vegetables are good in proteins also (Saxena, 1999).

A daily intake of at least 100 g of fresh green leafy vegetables is recommended by the nutrition experts (Reddy, 1999). Besides the commonly consumed leafy vegetables in India, a great variety of less familiar green leafy vegetables are also used locally in different parts of the country. The lack of

knowledge especially on the nutritive value of these leafy vegetables among the public in general is a main draw back in their production and consumption.

No systematic study has so far been conducted in Kerala to evaluate the important quality parameters like nutrient composition, anti-nutritional factors and acceptability of different leafy vegetables. Hence the present study on the quality attributes of leafy vegetables was attempted with the following objectives.

1) To analyse the nutrient composition and antinutritional factors of different leafy vegetables.
2) To assess the organoleptic qualities of the leafy vegetables.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Literature relevant to the study entitled 'Quality attributes of selected leafy vegetables' is reviewed in this chapter under the following sections.

1. Nutritional importance of leafy vegetables
2. Composition of leafy vegetables
3. Anti-nutritional factors in leafy vegetables
4. Seasonal variation in the composition of leafy vegetables
5. Organoleptic evaluation of leafy vegetables

2.1 Nutritional importance of leafy vegetables

Leafy vegetables are chiefly the green leaves of certain species of plants which have no poisonous alkaloids and do not cause any gastrointestinal disturbance, when they are consumed as food (Aman, 1969).

A wide variety of leaves like amaranth, drumstick, mint, curryleaf, palak, fenugreek etc. are used as vegetables in India. Green leafy vegetables are in general the cheapest source of protective nutrients like calcium, iron, beta-carotene, riboflavin, folic acid and ascorbic acid, all of which are essential for growth and maintenance of normal health (Devadas and Saroja, 1979, Mohidean *et al.*, 1982, Ramadasmurthy and Mohanram, 1984, Bressani *et al.*, 1986, Gopalan *et al.*, 1989, Luthra and Sadana, 1995). Despite their availability all the year round, leafy vegetables are not consumed in sufficient quantities or frequently enough to prevent the deficiencies of iron, vitamin A, riboflavin, folic acid and vitamin C (Emiru, 1971). Vijayaraghavan (1996) indicated that green leafy vegetables like spinach (palak), amaranth, creeper spinach (*Basella alba*), drumstick leaves, agathi (*Sesbania grandiflora*) etc., which are affordable by the rural or urban poor are ubiquitous in India and they are the major inexpensive dietary sources of provitamin A. The most rational and sustainable long term solution to control vitamin A deficiency and to improve vitamin A nutriture of individuals is to ensure

regular inclusion of provitamin A rich foods in the daily diet (Vijayaraghavan, 1996; Kowsalya and Chandrasekhar, 1999).

The commonly consumed green leafy vegetables in India such as spinach, amaranth, fenugreek, mustard, drumstick, mint, radish leaves, coriander leaves, curry leaves etc. are rich and inexpensive sources of beta-carotene and hence, the most convenient way of ensuring adequate vitamin A intake is to include green leafy vegetables in the diet (Bressani *et al.*, 1986; Gopalan, 1989; NIN, 1993; Vijayaraghavan, 1994; Thimmayamma and Pasricha, 1996). Inclusion of 30-50 g of green leafy vegetables like amaranth in the daily diet can meet the daily requirement of vitamin A (Gopalan *et al.*, 1989; Reddy, 1999).

The carotenoid content of several dark green vegetables is found to be associated with a lower risk of various epithelial cancers (Reddy, 1999).

Devadas and Saroja (1979), conducted a study on the availability of iron and beta-carotene from amaranth among children and indicated that *Amaranthus* species are excellent sources of iron and beta-carotene and daily inclusion of amaranth in the diet of children could help to alleviate iron and vitamin A deficiencies. Beegum and Pereria (1990) reported that the daily inclusion of about 50-80 g of amaranth in our diet would considerably help to meet the Recommended Dietary Allowance (RDA) of vitamins and minerals. Among the leafy vegetables amaranth is the best to improve the iron nutritional status of adolescents (Devadas *et al.*, 1992)

Chekkurmanis, one of the popular green leafy vegetables in South India, commonly known as multi-vitamin and multi-mineral packed leafy vegetable, is very high in nutritive value as compared to the annual vegetables such as amaranthus, Ceylone spinach, water leaf, spinach and palak (Ramachandran *et al.*, 1980).

According to Peter (1979) and Nautiyal and Raman (1987) drumstick leaves are more nutritious than most of the commonly used vegetables. Apart from calcium, phosphorus, iron and trace minerals like copper and iodine, drumstick leaves also contain tocopherols (vitamin E), estrogenic substances and some important enzymes (Gopalan, 1982). These leaves are good sources of protective nutrients which are essential for healthy vision, bones, blood and skin. According to Manay and Shadaksharaswamy (1995), drumstick leaves are considered useful in scurvy and catarrhal affliction.

The young shoots and tender leaves of 'Chaya' an underexploited vegetable are reported to be high in protein, calcium, iron, thiamin, riboflavin, niacin and ascorbic acid.(National Academy of Sciences (NAS) 1975). According to Imungi and Potter (1983) Cowpea leaves are rich in minerals like iron, calcium, phosphorus and zinc.

Islam *et al.* (1987) identified *Atriplex triangularis* leaves as a viable candidate for introduction as a new leafy vegetable particularly in parts of the world were high salinity and desertification are serious problems. Even though, these contain only moderate quantities of protein, ascorbic acid and vitamin A, they have the potential of making a significant impact on the dietary intake of the population living on deserts and saline land.

The unconventional leafy vegetables like drumstick leaves, math, katemath, bharangi and kawala, found in the forest and cultivable waste land of Konkan region contained comparatively higher amounts of crude protein, crude fat, ash, crude fibre and total carbohydrate (Shingade *et al.*, 1995).

Almazan and Begum (1996) analysed peanut greens to determine the nutritional quality and reported variation in the nutrient and anti-nutrient concentrations of different varieties of peanut greens grown under different production methods.

Results of the study conducted by Kowsalya and Mohandas (1999) indicated that cauliflower leaves are rich in macro and micro nutrients. The leaves are an excellent source of anti-oxidants like beta-carotene, vitamin C and minerals like iron, selenium, copper and zinc that are related to anti-oxidant enzymes.

Four wild leafy vegetables in Coted'Ivoire viz. *Ceiba pentandra, Gewia carpinifolia, Hibiscus congestiflorus* and *Triplochiton scleroxylon* were analysed by Herzog *et al.* (1993) and the leaves were found to be good in iron and calcium.

Survey conducted by Uiso and Johns (1996) in Tarime District of Tanzania revealed that the leaves of cultivated or wild species of *Crotalaria brevidens* were eaten at least weekly by 69 per cent of the respondents and provided better nutritional contribution in their diet.

Owing to the high nutritive value of green leafy vegetables, several preservation techniques and products based on dried leaves have been formulated. Fathima and Begum (1998) reported microwave drying as a highly suitable method for greens such as amaranth, where as it is moderately suitable for shepu and fenugreek and less suitable for coriander and mint. Dried powder of green leafy vegetables, a rich source of iron and beta-carotene was exploited in preparation of snack products by Kushwaha *et al.* (1998) and the results showed that spinach leaf powder and cauliflower leaf powder can be used to alleviate the problem of micronutrient deficiencies.

Lakshmi and Vimala (1998) conducted studies for the development of nutritious dehydrated green leafy vegetable powders and blends using amaranth (*Amaranthus gangeticus*), curry leaves (*Murraya koenigis*), gogu (*Hibiscus cannabinus*) and mint (*Mentha spicata*). Amaranth powder was found to be rich in proteins, calcium, iron, magnesium and zinc. Curryleaf powder was found to be rich in fibre, ascorbic acid, beta-carotene and copper while gogu and mint powders were fair sources of all the nutrients.

In order to make green leafy vegetables available to Armed Forces deployed at high altitudes, deserts and seas, instant vegetable-dhal curry mixes based on spinach (*Spinacia oleraceae*), fenugreek (*Trigonelia foenum graecum*), drumstick leaves (*Moringa oleifera*), khatipalak (*Rumex vesicarius*) and shepu (*Peucedanum graveoleus*) were developed at the Defence Food Research Laboratory, Mysore (Palki *et al.*, 1998). Premavalli *et al.* (1998) analysed two instant savoury mixes based on fenugreek leaves and chakota leaves with turdhal and green gram dhal with suitable spice mixtures which have been developed to supplement the vitamins, minerals and proteins in the packed rations of Armed Forces. According to the authors, these products contained 28 and 15 per cent fat and 13 and 25 per cent protein and had good stability during storage.

Inorder to incorporate green leafy vegetables in the food supplements of children in the low socioeconomic groups of Banglore and Mysore as a source of iron and vitamin A, Rau *et al.* (1998), formulated six food products, viz., uppittu, bisbele bhath, mixed pulses, sandwich, chapathi and dhokla. The study revealed that an amount of 50 g of green leafy vegetables could be incorporated in these preparations to obtain an acceptable product. The amount needed to provide the entire day's requirement as found to be still higher.

2.2 Composition of leafy vegetables

The bulk of green leafy vegetables available in India, is comprised of water within the range of 73.1 to 91.1 per cent (Kaur and Manjrekar, 1975; Jijiamma, 1989).

Philip *et al.* (1981) reported that the moisture content of curry leaves is 66.3 per cent.

The moisture content of ten unconventional leafy vegetables found in the forest and cultivable wasteland of Konkan was studied by Shingade *et al.* (1995) and indicated that the moisture content varied from 76.4 to 91.9 per cent.

Nambiar and Seshadri (1998) analysed sixteen green leafy vegetables consumed frequently by the rural and tribal population of the Western region of India for moisture and reported that it varied from 78.4 and 92.5 per cent, the highest being in *Basella rubra*.

Neeliyara (1998) analysed the moisture content of edible leaves of five winged bean genotypes available in Kerala and reported that it varied from 59 to 61.1 per cent.

Longvah (2000) reported the moisture content of green leafy vegetable from North-East India as 85 per cent.

Sreeramulu (1982) conducted a study on the chemical composition of some green leafy vegetables grown in Tanzania and reported that the moisture content of these vegetables varied from 75.6 per cent to 90.8 per cent, the minimum being in *Moringa oleifera* and the maximum in *Portulaca oleracea*. The moisture content of *Alternanthera sessils*, *Basella alba* and *Ipomoea acquatica* was found to be 80.8 per cent, 90.2 per cent and 90.3 per cent respectively while that of Amaranthus varieties varied from 82.2 per cent to 86.2 per cent. The moisture content of *Basella alba* and *Talinum triangulare* grown in Northern parts of Nigeria was found to be 93.9 per cent and 94.1 per cent respectively (Faboya, 1983).

The water content of popular Chinese green leafy vegetables was found to vary from 89.5 to 96.8 per cent (Wills *et al.*, 1984a). According to Wills *et al.* (1984b) Australian green leafy vegetables had a moisture content of 86.8 to 92.9 g $100\ g^{-1}$.

The moisture content of different green leafy vegetables like *Atriplex triangularis*, spinach, mustard greens, *Amaranthus hypochondriacus*, *Chenopodium quinoa*, celosia, *Pterocarpus mildbraedii*, tender tamarind leaves *Allium tuberosum*, *Amaranthus tricolor*, 'Arka Suguna' a pure line selection

amaranth from Taiwanese introduction, Arve the local control and *Ipomoea acquatica* was analysed by various authors and reported that the values ranged from 70.5 to 92.5 per cent (Wills *et al.*, 1984a; Islam *et al.*, 1987; Prakash *et al.*, 1993; Akpanyung *et al.*, 1995; Shingade *et al.*, 1995; Shankaracharya, 1998; Varalakshmi *et al.*, 1998).

Green leafy vegetables are a good source of protein and the dry matter of leaves contain as much protein as legumes (Reddy, 1999).

Amaranthus species are known to contain high levels of protein (Mugerwa and Bwabye, 1974). A high yielding short duration type of *Amaranthus* belonging to *amaranthus gangeticus* L. released as an improved strain by Tamil Nadu Agricultural University (TNAU), Coimbatore as CO-2 contained 8.5 g of protein per 100 g of edible matter (Rajagopal *et al.*, 1977). Reddish green keera is reported to contain more protein than *Amaranthus* green (Kerala Agricultural University (KAU) 1984). On dry weight basis, CO-3 culture amaranthus contained 12.5 per cent protein (Mohideen *et al.*, 1985).

According to Castanedac *et al.* (1986) the protein content of *Amaranthus* is similar to that of spinach. George (1986) indicated higher protein content in red pigmented lines of amaranth while lower protein content (1.7 g 100 g^{-1}) in 'Arka Suguna' a new multicut amaranth variety was reported by Varalakshmi *et al.* (1998) as against the control 'Arve' (4 g 100 g^{-1}). Awoyinka et al. (1995) reported high level of crude protein in cassava leaves, compared to amaranthus.

The protein content of different green leafy vegetables like chekkurmanis, amarnanth, spinach, drumstick leaves, tender tamarind leaves and coriander leaves and curry leaves were analysed by Menon (1980), Ramachandran *et al.* (1980), Philip *et al.* (1981), Gopalan *et al.* (1989), Prakash *et al.* (1993),

Shingade *et al.* (1995), Raja *et al.* (1997) and Shankaracharya (1998) and reported that the values varied from 1.4 g to 6.8 g 100 g^{-1} of leaves.

The protein content of *Chenopodium album*, *Cicer arietinum*, *Brassica campestris* and *Spinacea oleracea* leaves ranged from 2.29 to 31.5 per cent (Awasthi and Abidi, 1985).

The protein content of *Atriplex triangularis* leaves was found to be 2.9 per cent compared to 3.1 per cent of spinach and 2.1 per cent of mustard green (Islam *et al.*, 1987). According to Bressani *et al.* (1988) chiplin contained higher amounts (7.6%) of protein than amaranth (4.4%) and spinach (2.8%).

According to Gupta *et al.* (1989), protein content in amaranth, drumstick, fenugreek and pumpkin leaves varied from 25.1 per cent to 28.5 per cent on dry weight basis (DWB), while in colocasia and neem it was in lower range of 15.7 to 18 per cent.

Nutritive value of four varieties of tribal greens found in the weaning food of tribal children was analysed by Chandrasekharan *et al.* (1990) and they reported that Seekaisappu (*Acacia concinna*), *Gurukaku* (Trianthema), Sokathi (*Chenopodium*) and Silkasi (*Amaranthus*) contained 3.9, 1.7, 3.8 and 3.8 g 100 g^{-1} of protein respectively.

According to Prakash *et al.* (1993), protein content in *Chenopodium* ranged from 2.7-6 per cent and in *Celosia* from 2.8-5.1 per cent. Prakash *et al.* (1995) analysed 22 accessions belonging to five species of *Celosia* for proteins and reported that the values varied between 2.1 and 5.9 per cent. According to Neeliyara (1998) the protein content of the leaves of five winged bean genotypes varied from 3 to 4 per cent.

The maximum crude protein content among the ten unconventional leafy vegetables found in the forest and cultivable wasteland of Konkan, was

observed to be 7 per cent in drumstick leaves, while *Tricholepis ampelxicaulis* and phodsi contained the lowest amount of 1.8 per cent and 1.3 per cent respectively (Shingade *et al.*, 1995). The protein content of green leafy vegetables from North-East India which varied from 3.1 to 4.9 g $100g^{-1}$ was comparable to that of other commonly consumed green leafy vegetables like amaranth, brussel sprouts, fenugreek leaves and mustard leaves (Longvah, 2000).

Ifon and Bassir (1980), Wills *et al.* (1984a) and Cnewya (1985), analysed the green leafy vegetables in Nigeria, China and Kenya respectively and reported that the protein content varied from 0.3 to 36 per cent.

Mosha *et al.* (1995) found that the crude protein content of Tanzanian leafy vegetables like amaranth, cowpea, peanut, pumpkin and sweet potato was in the range of 20.64-46.56 per cent.

Aletor and Adeogun (1995) reported the mean crude protein content of Nigerian leafy vegetables on dry weight basis as 19.3 g 100 g^{-1}, while Akpanyung *et al.* (1995) reported 25.84 per cent protein on dry weight basis in *Pterocarpus mildbraedii* another Nigerian leafy vegetable.

Eight green vegetables commonly grown in Dar es Salaam was analysed by Raja *et al.* (1997) for crude protein and reported that it ranged between 1.03 to 5.23 per cent on fresh weight.

According to Wallace *et al.* (1998), the protein content of the leaves of *Xanthosomas mafaffa, Ipomoea involucrata, Launaea taxaracifolia*, four non-conventional leafy vegetables in Ghana, ranged between 2.6 and 3.42 per cent.

Although the total quantity of protein is limited in green leafy vegetables, certain leaves contain proteins of good quality (Pike and Brown, 1970). Fafunso and Bassir (1976) reported high quality protein in Tete (*Amaranthus hybridus*), Ewedu (*Corchorus olitorius*), Igbo (*Solanum africana*), Ogunmo

(*Solanum nudiflorum*), Gbure (*Talinum triangulare*) and Ewuro (*Vernonia amygdalina*). The authors also indicated that the biological value of proteins from four leafy vegetables viz. *Talinum triangulare, Solanum africana, Celosia argentea* and *Amaranthus hybridus* were in the range of 83.2 to 84.1 per cent. The true digestability values of the proteins in the four green leafy vegetables were almost similar and ranged from 80 per cent in *Celosia argentea* to 82.6 per cent in *Amaranthus hybridus*. The protein efficiency ratio of leaf proteins varied from 1.58 to 1.61.

Awasthi and Abidi (1985) reported that *Chenopodium album, Cicer arietinum, Brassica campestris* and *Spinacia oleracea* leaves are qualitatively potential source of protein. Certain amino acids like methionine and tryptophan present in these green vegetables were in the range of 0.054-0.11 g 16 g^{-1} N and 0.119-0.835 g 16 g^{-1} N.

The amino acid composition of certain *amaranthus* species was evaluated by (Vijayakumar and Shunmugavelu, 1985) and reported that these are rich in certain essential amino acids.

Nag and Matai (1991) estimated the amino acid composition of the cytoplasmic fraction of leaf protein from *Ailanthus excelsa* and reported an excellent balance of essential amino acids in leaf proteins.

Free amino acid content in certain unconventional leafy vegetables was analysed by Handique(1993) and detected twelve free amino acids including seven essential amino acids in various concentrations.

Crude fat of leafy vegetables, though present in lower quantities, has a special significance because of the presence of carotenoids (provitamin A), vitamin E and vitamin K and some polyunsaturated fatty acids among its major constituents (Davidson *et al.*, 1973).

According to Philip *et al.* (1981) and Shankaracharya (1998), the fat content of curry leaves and tender tamarind leaves varied from 0.5 to 2.1 per cent.

Lipid composition of eight varieties of Amaranthus was determined by Lorenz and Hwang (1985) and reported that free lipid content varied from 5.69 to 7.23 per cent and bound lipids from 0.42 to 0.91 per cent.

Lucas (1988) determined the ether extract of *Amaranthus, Basella alba* and *Talinum triangulare* and indicated the fat content as 2.6, 7.2 and 14.9 per cent respectively on the basis of dry matter.

Hundred gram of green leafy vegetables like amaranth, gogu and fenugreek provide on an average 0.34 g of fat and these leaves contain high amounts of alpha-linoleic acid(National Institute of Nutrition (NIN) 1990).

Murcia *et al.* (1992) reported the total lipid content of raw spinach as 0.61 per cent. Shingade *et al.* (1995) estimated the fat content of ten unconventional leafy vegetables and found that these were poor sources of fat which ranged between 0.2 and 0.9 per cent. The maximum crude fat was observed in drumstick leaves (0.96%), *Amaranthus tricolor* (0.8%) and Kawala (0.7%) while the rest of the vegetables contained 0.4 per cent of crude fat.

Neeliyara (1998) observed a fat content of 0.6 to 0.7 per cent in the leaves of five winged bean genotypes available in Kerala.

Fat content of green leafy vegetables from North-East India varied from 0.4 to 1.9 per cent(Longvah, 2000).

Different green leafy vegetables grown in Nigeria were analysed for fat content by Ifon and Bassir (1980), Achinewhu *et al.* (1995), Akpanyung *et al.* (1995) and Aletor and Adeogun (1995) and reported that it varied from 2.7 per cent to 22.6 per cent on dry weight basis.

Wills *et al.* (1984a) indicated low fat content in Chinese vegetables. Fat content of *Amaranthus tricolor* and *Ipomoea acquatica* varied from 0.4 and 0.5 g 100 g^{-1} of edible portion.

Crude fat content of Tanzanian vegetables was in the range of 2.57 to 4.34 per cent, the lowest being in amaranthus and the highest in cowpea leaves (Mosha *et al.*, 1995).

The predominant fatty acids of spinach was analysed by Murcia *et al.* (1992) and reported that the fatty acids in this leafy vegetable are palmitic (16:0), hexadecadienoic (16:2), hexadecenoic (16:1), stearic and hexadecatrienoic (18:0 and 16:3), oleic (18:1), linoleic (18:2) and linolenic (18:3) acids.

The predominant fatty acid of *Chenopodium* was found to be from the omega 3 series and out of the total fatty acids, *Chenopodium album* contained 4.33 per cent of fatty acids of omega 3 series (Guerrero and Isasa, 1997).

Dietary fibre, the sum of polysaccharides and lignin which are not digested by endogeneous secretions of human gastrointestinal tract, is effective in reducing the incidence of obesity, hypercholesterolemia, heart disease, diverticular disease and colon disease (Trowell, 1976). According to Reddy (1999) benefits of dietary fibre can be had by increased consumption of green leafy vegetables which also increases the faecal bulk and prevents constipation.

Kaur and Manjrekar (1975) studied the chemical composition of green leafy vegetables available in Northern India and found that the crude fibre of mustard greens, spinach, mint and coriander leaves are 1.0, 0.9, 1.0 and 1.2 per cent respectively.

Biochemical analysis of CO-2 *Amaranthus* revealed that it had 1.3 g of crude fibre (Rajagopal *et al.*, 1977). CO-3 culture *Amaranthus* contained 17.4 per cent crude fibre on a dry weight basis (Mohideen *et al.*, 1985). *Amaranthus*

hypochondriacus and *Amaranthus edulis* were found to have a high content of fibre thus making them less palatable while CO-1 (*Amaranthus dubius*) and CO-2 (*Amaranthus gangeticus*) types presented a low crude fibre content and both were found to be highly palatable (Vijayakumar and Shunmugavelu, 1985).

John *et al.* (1987) observed 2.3 g of total dietary fibre in 100 g of *Amaranthus tricolor*, while Bressani *et al.* (1988) and Shingade *et al.* (1995) reported 1.3 per cent to 1.8 per cent fibre content in this leafy vegetable. Lucas (1988) and Mosha *et al.* (1995) indicated that crude fibre content of amaranth on dry weight basis varied from 9.1 to 21.25 per cent.

The fibre content of chekkurmanis leaves, curry leaves, drumstick leaves and tender tamarind leaves was found to be 2.5, 6.4, 0.9 and 1.9-3 per cent respectively (Ramachandran *et al.* (1980), Philip *et al.* (1981), Gopalan (1982), Shankaracharya (1998).

Gupta and Wagle (1988) reported that the crude fibre content of green leafy vegetables ranged from 7.2 to 13.95 per cent.

Lucas (1988) found that crude fibre content of *Basella alba* and *Talinum triangulare* were 14.1 per cent and 9.61 per cent of dry matter respectively.

Ghol and cowpea leaves contained 1.6 per cent and 2.1 per cent crude fibre respectively (Gopalan *et al.*, 1989).

According to Gupta *et al.* (1989) the tender leaves of amaranth, colocasia, drumstick, fenugreek, neem and pumpkin are good sources of neutral detergent fibre and acid detergent fibre.

Crude fibre content of four varieties of tribal greens found in the weaning food of tribal children viz., Seekaisappu (*Acacia concinna*), Gurukaku (*Trianthema*), Sokathi (*Chenopodium*) and Silkasi (*Amaranthus*) was 2.9, 1.1, 2.2

and 0.9 g 100 g^{-1} respectively. The low fibre content would have been the reason for including these greens in the infants diet as it will not irritate the delicate gastro intestinal tract of the infant (Chandrasekhar *et al.*, 1990).

Total dietary fibre content of 4 green leafy vegetables viz. amaranth, spinach, gogu and bacchali varied from 1.6 to 2.6 g per cent (NIN, 1994a). The study also revealed that green leafy vegetables had 0.8 to 1.3 g per cent of the soluble fibre.

According to Shingade *et al.* (1995), the species with more succulent growth contained less fibres than woody perrennials. *Ipomoea acquatica* contained 1.4 per cent crude fibre. Bharangi (2.4%), Kawala (2.4%), drumstick leaves (2.2%) and cowpea leaves (2.1%) recorded high fibre content while spinach (0.7%) and phodsi (1.0%) were low in crude fibre.

Leaves of *Chenopodium* species had high fibre contents ranging from 4-6 g 100 g^{-1} (Guerrero and Isasa, 1997).

Neeliyara (1998) reported that the fibre content in five genotypes of winged bean leaves varied from 16.8 to 19.4 per cent on dry weight basis.

Rao and Ramulu (1998) analysed the most commonly consumed green leafy vegetables for their dietary fibre and its fractions, and indicated that majority of them contained 2.5 to 6.6 g per cent Total Dietary Fibre (TDF), 1.6 to 5.1 g of Insoluble Dietary Fibre (IDF) and 0.9 to 1.5 g per cent Soluble Dietary Fibre (SDF). However, *Alternanthera sessils* (8.0 g %), *Sesbania grandiflora* (8.4 g %), drumstick leaves (9.0 g %), tender tamarind leaves (10.6 g %) and curry leaves (16.3 g %) contained relatively higher contents of dietary fibre. All the green leafy vegetables, except tender tamarind leaves (11%), *Alternanthera sessils* (13%) and curry leaves (18%), the SDF content as percentage of TDF was more than 20 per cent of TDF and it ranged from 21-38 per cent.

The fibre content of Nigerian green leafy vegetables was reported to vary from 8.5 to 20.9 per cent (Ifon and Bassir,, 1980). According to Aletor and Adeogun (1995), the mean crude fibre content of 17 dry leafy vegetable species in Nigeria was 15.3 g 100 g^{-1} while the fresh counter parts contained 3.2 g 100 g^{-1}. Fibre content of *Pterocarpus mildbraedii* found in Nigeria was found to be 7.56 per cent on dry weight basis (Akpanyung *et al.*, 1995).

According to Sreeramulu (1982), *Cassia tora, Gynandropsis gynandra, Solanum nigrum, Moringa oleifera* and *Basella argentea,* the leaf vegetables grown in Tanzania had low fibre contents of 11.8, 8, 8.3, 5.7 and 7 g 100 g^{-1} dry weight respectively. Fibre content of *Alternanthera sessils, Basella alba* and *Ipomoea acquatica* were 10.4, 7 and 12.3 g 100 g^{-1} dry weight.

The dietary fibre content of the green leafy vegetables grown in Australia, ranged from 1.7 to 4.5 g 100 g^{-1} with highest being in brussel sprouts and broccoli (Wills *et al.*, 1984b).

Dietary fibre content of Chinese vegetables varied from 1.1 to 4.6 g 100 g^{-1}, being highest in *Amaranthus tricolor. Ipomoea acquatica* had 3 g 100 g^{-1} of dietary fibre (Wills *et al*., 1984a).

According to Bressani *et al.* (1988) fibre content of spinach is 0.7 per cent and chiplin leaves have more fibre than *Amaranthus* and spinach.

Fibre contents of *Xanthosomas mafaffa, Ipomoea involucrata, Launaea taxaracifolia* and *Euphorbia hirta,* four Ghanian non-conventional leafy vegetables ranged between 1.15 to 7.73 per cent (Wallace *et al.*, 1998).

Carbohydrates in leafy vegetables differ from non-leafy vegetables in that it is stored in the form of starchy grains (Aman, 1969).

Rao *et al.* (1979) and Ramachandran *et al.* (1980) analysed the carbohydrate content of *Trianthema portulacastrum*, *Amaranthus tristis*, drumstick and chekkurmanis leaves and reported that these leaves contained 1.6, 6.4, 2.9 and 11.6 g 100 g^{-1} of carbohydrates respectively.

John *et al.* (1987) and Gopalan *et al.* (1989) reported the starch content in *Amaranthus tricolor* and *Amaranthus gangeticus* as 0.73 g 100 g^{-1} and 6.1 g 100 g^{-1} edible portion respectively. The carbohydrate content of amaranth was 42.4 per cent on dry weight basis (Mosha *et al.*, 1995).

According to Shingade *et al.* (1995), the unconventional leafy vegetables contained more carbohydrates than the conventional sources. Thus drumstick leaves (11.5%), bharangi (10%), kawala (8.9%), *Amaranthus spinosus* (7.8%) and takala (7.8%) were superior in carbohydrate contents when compared to math, spinach, ghol, cowpea, phodsi, *Ipomoea acquatica* and dhandhgi. *Amaranthus tricolor* contained 3.7 per cent carbohydrates and *Ipomoea acquatica* contained 3.5 per cent carbohydrates.

The leaves of *Chenopodium* species contained low proportions of available carbohydrates (Guerrero and Isasa, 1997).

Neeliyara (1998) observed 27.5 to 31.4 per cent of starch in winged bean leaves on dry weight basis.

Ifon and Bassir (1980) reported the carbohydrate content of some Nigerian green leafy vegetables as 51.0-66.1 per cent. Many of the green leafy vegetables grown in Tanzania are also found to be good sources of carbohydrates (Sreeramulu, 1982). Wills *et al.* (1984a) analysed the nutrient composition of Chinese vegetables and found that *Amaranthus tricolor* had a starch content of 0.2 g 100 g^{-1} of the edible portion, while *Ipomoea acquatica* contained no starch. According to Achinewhu *et al.* (1995), total carbohydrate content of leafy vegetables in Nigeria, ranged from 24.6-51.4 per cent.

Green leafy vegetables are rich in minerals especially iron and calcium (Menon, 1980; Philip *et al.*, 1981; Gopalan, 1982; Smith, 1982; Nordeide *et al.*, 1996). Other minerals like phosphorus, magnesium, sodium, potassium, copper, iodine, sulphur and boron are also detected in these vegetables. Average calcium and iron contents of green leafy vegetables were found to be 300 mg 100 g^{-1} and 4.7 mg 100 g^{-1} respectively (Reddy, 1999).

Moringa oleifera is a good source of calcium, phosphorus and iron (Devadatta and Appanna, 1957; Malik *et al.*, 1969; Peter, 1979; Gopalan, 1982; Nautiyal and Raman, 1987; Shingade and Chavan, 1996). According to Swaminathan (1974), Rao *et al.* (1979), Menon (1980) and Gopalan (1982), the calcium, phosphorus and iron contents of drumstick leaves are 440 mg, 7 mg and 7.6 mg per cent respectively. Besides calcium and phosphorus, copper and iodine are also present in fairly good amounts in these unconventional leafy vegetables (Gopalan, 1982). In addition to high amounts of calcium, iron, phosphorus, potassium and magnesium, *Moringa oleifera* is rich in sulphur (179.35 mg 100 g^{-1}), zinc and boron (41.63 ppm) (Shingade and Chavan, 1996).

Amaranthus species are known to contain high levels of calcium (Mugerwa and Bwabye, 1974; Castenedac *et al.*, 1986). According to Swaminathan (1974), iron and calcium contents of *Amaranthus tricolor* on fresh weight basis are 21.4 mg 100 g^{-1} and 0.5 g 100 g^{-1} respectively while that of *Amaranthus spinosus* are 22.9 mg 100 g^{-1} and 0.8 g 100 g^{-1} respectively.

Biochemical analysis of CO-2 amaranthus (*Amaranthus gangeticus* L.) revealed that it contained 39.8 mg of phosphorus, 379 mg of potassium, 310 mg of calcium and 19 mg of iron in 100 g of edible matter and CO-3 culture amaranthus contained 0.84 g iron, 2.48 g calcium, 0.47 g phosphorus, 1.35 g magnesium and 3.2 g potassium 100 g^{-1} on dry weight basis (Rajagopal *et al.*, 1977; Mohideen *et al.*, 1985).

According to Menon (1980) amaranth contained 397 mg calcium and 25.5 mg of iron. The ash content of *Amaranthus* is 19.38 per cent of dry matter and the calcium, phosphorus and iron contents are 5.41 g, 0.26 g and 642.58 mg 100 g^{-1} of dry matter respectively (Lucas, 1988).

Amaranthus gangeticus contained 2.7 g of minerals per 100 g which consisted of 397 mg calcium, 83 mg phosphorus and 25.5 mg iron, while every 100 g edible portion of *Amaranthus tricolor* also contained 2.7 g minerals which consisted of 397 mg calcium, 3.49 mg iron and 341 mg potassium (Gopalan *et al.*, 1989). However Shingade and Chavan (1996) reported that, *Amaranthus tricolor* is comparatively high in phosphorus, potassium, calcium and magnesium and micronutrients like iron and boron. Varalakshmi *et al.* (1998) compared the phosphorus, calcium, potassium, magnesium, iron and sulphur content of a new multicut amaranth 'Arka Suguna' with the control variety 'Arve' and indicated that 'Arka suguna' had higher mineral content than the control variety.

According to Kaur and Manjrekar (1975), ash contents of fresh mustard greens, spinach, mint and coriander leaves varied from 1.7 to 2.0 per cent, the highest being in coriander, followed by mint, spinach and mustard greens. The mineral content of curry leaves is reported to be 4.2 per cent (Philip *et al.*, 1981). Awasthi and Abidi (1985) reported that total ash in nine green leafy vegetables, commonly grown in Eastern Uttar Pradesh, varied from 12.66 to 25.82 per cent. According to Gupta and Wagle (1988), total minerals in green leafy vegetables varied from 12.54 to 26.16 per cent. Gupta *et al.* (1989) estimated the ash content of amaranth, colocasia, drumstick, fenugreek, neem and pumpkin leaves and indicated that it varied from 15.7 to 28.5 per cent.

Ifon and Bassir (1979), tabulated the mineral contents of *Abelmoschus esculentus, Corchorus olitorius, Talinum triangulare, Amaranthus hybridus, Piper guinense, Ocimum basilicum, Cucurbita pepo, Vernonia amygdalina, Telfaria occidentalis* and *Marsdenia latifolia* and reported that 100 g of dry leaves

contained sodium (34 to 280 mg), potassium (1430 to 6100 mg), calcium (1080 to 3620 mg), magnesium (45 to 2220 mg), manganese (15 to 115 mg), iron (30 to 59 mg), copper (1 to 2.5 mg), zinc (6 to 13.5 mg), sulphur (230 to 590 mg), phosphorus (210 to 710 mg) and chlorine (140 to 700 mg).

Calcium and iron contents of leaves like *Mentha spicata*, *Rumex acetosa*, coriander leaves, palak (*Beta vulgaris*), spinach, chekkurmanis, *Solanum nigrum*, *Gynandropsis gynandra*, *Amaranthus hybridus*, colocasia, drumstick, fenugreek, neem, pumpkin, *Acacia concinna*, trianthema, chenopodium and tender tamarind leaves were analysed by various authors and reported that the calcium content varied from 0.43 g to 48 g and iron varied from 2 to 70 mg 100 g^{-1} of leaves (Swaminathan, 1974; Rao *et al.*, 1979; Choudhary and Rajendran, 1980; Menon, 1980; Ramachandran *et al.*, 1980; Cnewya, 1985; Bawa and Yadav, 1986; Gupta *et al.*, 1989; Chandrasekhar *et al.*, 1990 and Shankaracharya, 1998).

Total iron content in fourteen rare Indian green leafy vegetables ranged from 3 mg 100 g^{-1} in *Portulaca oleracea* to 32.5 mg 100 g^{-1} in *Merrania emerginata* (Reddy and Kulkarni, 1986).

Chawla *et al.* (1988) reported that, total iron content in leaves like *Amaranthus spinosus*, *Colocasia antiquorum*, *Moringa oleifera*, fenugreek, *Peucedanum graveolus* and *Spinacia oleracea* ranged from 5.1 mg to 16 mg 100 g^{-1}.

Phosphorus content of nine green leafy vegetables commonly grown in Eastern Uttar Pradesh varied from 0.34 to 1.43 per cent (Aswathi and Abidi, 1985). Leaves like lalo, *Acacia concinna*, trianthema, chenopodium, amaranthus and tender tamarind leaves contained 0.48 to 1.4 per cent of phosphorus (Bawa and Yadav, 1986; Chandrasekhar *et al.*, 1990 and Shankaracharya, 1998). On dry weight basis, phosphorus content of *Basella alba* and *Talinum triangulare* were reported to be 0.24 g 100 g^{-1} and 0.22 g 100 g^{-1} (Faboya, 1983), while Lucas

(1988) reported 0.23 g 100 g^{-1} and 0.41 g 100 g^{-1} of phosphorus in these vegetables.

Atriplex triangularis leaves are low in iron, calcium and zinc, but contained seventeen times more sodium than spinach. However, the potassium content of these leaves are low compared to other leafy vegetables (Islam *et al.*, 1987).

Total minerals in green leafy vegetables varied from 12.54 to 26.16 per cent (Gupta and Wagle, 1988). Shingade and Chavan (1996) observed that *Amaranthus tricolor, Moringa oleifera, Cassia tora* and *Clerodendrum serratum* contained comparatively high amounts of phosphorus, potassium, calcium and magnesium. *Chenopodium* species are found to be high in minerals compared with other green leafy vegetables (Guerrero and Isasa, 1997).

Neeliyara (1998) analysed the calcium and iron contents of the leaves of five winged bean genotypes grown in Kerala and reported mean calcium and iron contents of 245.46 mg and 2.2 mg 100 g^{-1} of leaves respectively.

The green leafy vegetables from North-East India analysed by Longvah (2000) contained fairly good amount of calcium with values between 100 mg 100 g^{-1} and 267 mg 100 g^{-1}. Iron content of these leaves varied from 4.4 mg 100 g^{-1} whereas the phosphorus content ranged between 23 mg 100 g^{-1} and 57 mg 100 g^{-1}.

Oyejola and Bassir (1975) studied the iron content in leafy Nigerian plants and the content varied from 190 mg in Vernonia amygdalina to 1010 mg kg^{-1} dry matter in *Solanum incanum*.

Ash contents of *Alternanthera sessils, Amaranthus gangeticus,* Amaranthus spinosus, *Amaranthus viridis, Basella alba, Ipomoea acquatica* and *Moringa oleifera*, the leafy vegetables grown in Tanzania are 13, 20.3, 24.4, 15.1, 20.3, 16.5 and 0.5 g 100 g^{-1} respectively on dry weight basis (Sreeramulu, 1982).

The twenty one Nigerian leafy vegetables analysed by Smith (1982) contributed significant proportion of zinc, iron and calcium to the traditional Nigerian diets and these leaves contained 0.3 to 1.9 mg zinc, 1.4 to 12.3 mg iron and 70 to 280 mg calcium 100 g^{-1}.

Faboya (1983) analysed some green leafy vegetables commonly found in Western parts of Nigeria, viz. *Corchorus olitorus, Celosia argentea, Amaranthus caudatus, Solanaceae macrocarpus, Vernonia amygdalina, Basella alba, Talinum triangulare, Hibiscus esculentus* and *Telferiria occidentalis* and these contained ash (11-25 g), sodium (0.11-0.76 mg), potassium (0.36-1.55 mg), calcium (0.24-0.73 mg), phosphorus (0.18-0.39 mg), magnesium (0.66-1.76 mg), iron (0.35-0.56 mg), zinc (0.04-0.12 mg) and manganese (0.03-0.12 mg) per gram of dry matter. Magnesium was the most abundant mineral in these leafy vegetables, the highest was in *Celosia argentea* and lowest in *Corchorus olitonius*. The author also reported that the red stalked varieties of both *Amaranthus caudatus* and *Celosia argentea* contained slightly higher amount of magnesium.

Wills *et al.* (1984a) studied the nutrient composition of Chinese vegetables and reported that all the non-Brassica leafy vegetables had useful levels of iron ranging from 0.9 to 1.7 mg 100 g^{-1}. The level of potassium was higher in *Amaranthus tricolor*, garland chrysanthemum and watercress containing about 600 mg 100 g^{-1}. Calcium content was found to be greater than 100 mg 100 g^{-1} in mustard, cabbage, *A. tricolor* and garland chrysanthemum.

According to Bawa and Yadav (1986), ash content of green leafy vegetables consumed by Sokoto population varied from 7 to 18.6 per cent.

On dry weight basis, calcium and iron contents of *Basella alba* and *Talinum triangulare* consumed in Western parts of Nigeria are 0.58 mg and 0.48 mg 100 g^{-1} and 0.37 and 0.39 mg 100 g^{-1} respectively (Faboya, 1983), while

Lucas (1988) observed that these leaves contained 2.17 g and 0.78 g of calcium and 401 and 331 mg of iron on dry weight basis.

Nutritive value of four wild leafy vegetables in Coted'Ivoire viz. *Ceiba pentandra*, *Grewia carpinifolia*, *Hibiscus congestiflorus* and *Triplochiton scleroxylon* was studied by Herzog *et al.* (1993) and reported that these leaves are good sources of iron and calcium.

The average ash content of seventeen leafy vegetable species found in Nigeria was 17.4 g 100 g^{-1} dry matter (Aletor and Adeogum, 1995). The authors also reported that these dry vegetables on an average contained 3.7, 3.8, 2.5 and 1.2 g 100 g^{-1} of potassium, sodium, calcium and phosphorus respectively, and the corresponding values for fresh samples are 4.4, 6, 0.9 and 0.8 g 100 g^{-1}. Copper was found to be the least abundant mineral in all the samples.

Green vegetables grown in Dar es Salaam are also found to be rich in macro minerals (Raja, 1997). The predominant metal present in all vegetables is potassium, followed by calcium. Among the micro minerals, iron is the predominant one and varied from 3.09 to 53.04 mg 100 g^{-1}.

Reddy and Kulkarni (1986) studied the availability of iron from fourteen rare Indian green leafy vegetables and reported that the available iron ranged from 44 mg 100 g^{-1} in *Amaranthus polygamous* to 0.7 mg 100 g^{-1} in *Chenopodium album*.

Chawla *et al.* (1988) studied the *in vitro* availability of iron in various green leafy vegetables like *Amaranthus spinosus*, *Colocasia antiquorum*, *Moringa oleifera*, fenugreek, *Peucedanum graveoleus* and *Spinacia oleracea* and reported that the values ranged from 2.8 per cent to 4.6 per cent of total iron.

Leafy vegetables contain considerably more carotenoids than tuberous vegetables and fruits and is mainly deposited in the leaves, which have a higher

relative beta-carotene content than stalks (Speek and Schreuss, 1988). It is observed that the concentration of carotene is directly proportional to the intensity of the green colour. Lightly coloured vegetables such as lettuce and cabbage are hence poor sources of carotene (Reddy, 1999).

The beta-carotene content of leaves like *Amaranthus tricolor*, agathi, curryleaves, *Amaranthus spinosus*, *Moringa oleifera*, *Coriandrum sativum*, *Mentha spicata*, *Beta vulgaris*, mustard greens, spinach, *Rumex acetosa*, tender tamarind leaves and fenugreek leaves are in the range of 1100 to 9000 µg 100 g^{-1} (Swaminathan, 1974; Kaur and Manjrekar, 1975; Renquist *et al.*, 1978; Rao *et al.*, 1979; Choudhary and Rajendran, 1980; Jayarajan *et al.*, 1980; Menon, 1980; Shankaracharya, 1998; Reddy, 1999).

Chekkurmanis leaves contain 9510 IU of vitamin A in 100 g of fresh leaves (Ramachandran *et al.*, 1980) while Philip *et al.* (1981) reported the carotene content of curry leaf as 12600 IU 100 g^{-1}.

Erandankeera contained more vitamin A than *Amaranthus* white (KAU, 1984). CO-3 amaranthus contained 11.04 mg of carotene in 100 g of fresh matter (Mohideen *et al.*, 1985). 'Arka suguna', a pure line selection amaranth, from Taiwanese introduction, is rich in vitamin A (Varalakshmi *et al.*, 1998).

Carotenoid content of *Amaranthus hypochondriacus*, *Chenopodium quinoa* and Celosia varied from 12-20, 9-19 and 10-15 mg 100 g^{-1} respectively (Prakash *et al.*, 1993).

The beta-carotene content of palak, bacchali, amaranth, drumstick, agathi and gogu ranged from 1.8 mg to 14.1 mg 100 g^{-1} and its leaf concentrates contained higher levels of beta-carotene (NIN, 1993). According to NIN (1994b), the beta-carotene content and percentage beta-carotene were higher in medium textured leaves than in the tender and coarse samples.

Beta carotene content of fresh leaves of Bathua (*Chenopodium album*) and fenugreek (*Trigonella foenum* graecum) ranged from 19.0 to 24.64 mg 100 g^{-1} dry weight (Yadav and Sehgal, 1997).

Nambiar and Seshadri (1998), analyzed sixteen green leafy vegetables of the Western region of India, consumed frequently by the rural and tribal population and found that seven out of the sixteen are rich sources of beta-carotene, contributing more than 5000 µg per 100 g fresh weight. Study conducted by Reddy (1996) in seventeen commonly consumed and twenty one less familiar green leafy vegetables revealed that beta-carotene was the most predominant pro-vitamin A in all green leafy vegetables constituting 30 to 50 per cent of the total carotene except in fenugreek leaves which contained more than 80 per cent of beta-carotene. Amaranth, fenugreek leaves, tulasi, botala benda and ponnanganti contained 8 to 10 mg 100 g^{-1} of beta-carotene while hibiscus and colocasia contained about 5 mg 100 g^{-1}. The beta-carotene content of thirty six green leafy vegetables collected and consumed by tribals of five districts from Eastern ghats, Andhrapradesh were found to be in between 5.21 and 14.05 mg percent (Rajyalakshmi *et al.*, 2000).

Beta-carotene content of tropical leafy vegetables viz. *Manihot utilisma*, *Basella alba*, *Talinum triangulare*, *Colocasia esculentata* and *Carica papaya* varied from 1.9 mg to 17.4 mg 100 g^{-1} fresh matter (Renquist *et al.*, 1978).

Among the Chinese vegetables studied by Wills *et al.* (1984a), *Allium tuberosum*, contained the highest amount of beta-carotene as the major carotene component. Seven of the nine leafy vegetables studied contained more than 1000 µg 100 g^{-1}.

Carotene content of indigenous green leafy vegetables in Kenya exceeded 7000 µg 100 g^{-1} (Onewya, 1985).

According to Bushway and Bureau (1986), the most prevalent carotenoid in lettuce is beta-carotene and the greenest outer layer had the highest vitamin A activity.

Islam *et al.* (1987) observed 2690 IU of vitamin A in 100 g of Atriplex triangularis leaves.

In Brassica species, beta-carotene accounted for about 99 per cent of active pigment (Rodrigues and Penteado, 1989).

According to Peter (1979), drumstick leaves have an equal amount of vitamin A (11,300 IU 100 g^{-1}) as carrots. Drumstick contained the highest level of carotene among green leafy vegetables (Gopalan, 1982).

A study conducted by Kowsalya and Chandrasekhar (1999) among ten commonly consumed leafy vegetables viz., drumstick leaves, ponnanganti, spinach, arakeera, kuppakeera, pulichakeera, sirukeera, manathakali leaves, mulakeera and agathi before and after cooking revealed that drumstick leaves in its raw form had maximum total carotene and beta-carotene. Reddy (1996) also analysed the carotenoid content of seventeen commonly consumed and twenty one less familiar green leafy vegetables and found that drumstick and agathi leaves had the higher concentration of beta-carotene (15-20 mg 100 g^{-1}).

Mean beta-carotene content of 5 native Brazilian leafy vegetables viz. *Amaranthus viridis*, *Lepidum pseudodidymum*, *Xanthosoma* spp., *Sonchus oleraceus* and *Portulaca oleracea* varied from 14.1 to 110 mg 100 g^{-1} and these leaves contained 4.99 to 62.9 retinol equivalents per g of the leaves (Mercadante and Amaya, 1990).

The beta-carotene contents of 14 commonly eaten green leafy vegetables in Bangladesh, ranged between 5400 and 16000 µg 100 g^{-1} (Rahman *et al.*, 1990).

The common leafy vegetables available in Machakos District, Kenya, had high values of beta-carotene and satisfied more than 100 per cent of the daily requirements for retinol (Mwajumwa *et al.*, 1991).

According to Nordeide *et al.* (1996), leaves of *Amaranthus viridis*, a cultivated leafy vegetable in Southern Mali, are reported to be rich in beta-carotene (3290 µg 100 g^{-1}).

Yang *et al.* (1996) analysed carotenoid content of several dark green leafy vegetables, viz. *Malva crispa, Ipomoea acquatica, Spinacia oleracea, Apium graneolens, Lactuca sativa, Basella alba* and *Pisum sativum* grown and harvested in Chengdu, China which are associated with a lower risk of various epithelial cancers and reported to be high in beta-carotene content of 0.04 to 9.36 mg 100 g^{-1}.

Leaves of *Chenopodium album* collected from locations of Almaria of Spain contained high proportion of carotenoids (12.5 mg 100 g^{-1}) (Guerrero and Isasa, 1997).

Green leafy vegetables are rich in vitamin C, which is required to keep the gums in a healthy condition (Menon, 1980, Gopalan *et al.*, 1989).

Some green leafy vegetables like spinach, amaranth, fenugreek, mustard, drumstick, mint, coriander etc. are equally good source of vitamin C as fruits (Sreeramulu *et al.*, 1983a; Thimmayamma and Pasricha, 1996).

The ascorbic acid content of raw amaranth was found to vary from 96 to 99 mg 100 g^{-1} (Devadas *et al.*, 1973; Gopalan *et al.*,1989) while Mohideen *et al.* (1985) reported that CO-3 amaranthus culture contained 35.9 mg of ascorbic acid in 100 g of fresh matter. Varalakshmi *et al.* (1998) stated that leaves and tender stems of amaranth are rich in vitamin C.

Drumstick leaves are reported to be richer in ascorbic acid (220 mg 100 g^{-1}) than tomato, radish, carrot and peas (Peter, 1979, Menon, 1980, Nautiyal and Raman, 1987, Gopalan *et al.*, 1989). According to Shingade *et al.* (1995) drumstick leaves contained 229.9 mg per cent of vitamin C.

Chandrasekhar *et al.* (1990) analysed four varieties of tribal greens found in the weaning food of tribal children viz., *Acacia concinna*, trianthema, *Chenopodium* and amaranthus and the vitamin C content of these leaves varied from 99 to 175.2 mg 100 g^{-1}.

According to Placida and Meena (1991), ascorbic acid content of sauropus leaves is 280 mg 100 g^{-1} and therefore these leaves can be recommended especially to the low income groups as a regular and cheap source of vitamin C.

Prakash *et al.* (1993) reported that vitamin C content of different green leafy vegetables varied from 0.05 to 0.26 per cent. Shingade *et al.* (1995) observed a low ascorbic acid content in kankong (48.8 mg 100 g^{-1}) and bharange leaves (45.1 mg 100 g^{-1}).

Vitamin C contents of fresh leaves of Bathua (*Chenopodium album*) and fenugreek (*Trigonella foenum graecum*) varied from 220.97 to 377.65 mg per cent (Yadav and Sehgal, 1997).

Neeliyara (1998) observed a mean vitamin C content of 12.16 mg 100 g^{-1} in five genotypes of winged bean leaves. According to Reddy (1999) amaranth, agathi, mustard leaves, drumstick leaves and broccoli contain adequate amounts of vitamin C in the range of 120-220 mg 100 g^{-1}.

Wide variation was observed in the ascorbic acid content for different samples of the same green leafy vegetable in Malaysia. The average ascorbic acid content of the vegetables studied varied from 29 mg 100 mg^{-1} in *Diplazium esculentum* to 643 mg 100 g^{-1} in *Pieroccocus corniculatus*. Most of the vegetables,

especially those with dark green leaves had significant amounts of ascorbic acid (Cadwell, 1972).

Ifon and Bassir (1979) analysed ten commonly eaten green leafy vegetables in Nigeria and reported an ascorbic acid content of 20.6 to 160.2 mg 100 g^{-1} dry matter while Keshinro and Ketiku (1979) reported the mean ascorbic acid levels of 31 to 63 mg 100 mg^{-1} in some Nigerian leafy vegetables like *Celosia argentea* (green), *Celosia argentea* (red), *Amaranthus chorostachys, Basella alba, Talinum triangulare* and *Vernonia amygdalina*. According to Achinewhu *et al.* (1995) the indigenous leafy vegetables found in Nigeria are high in ascorbic acid and the content varied from 23-232 mg 100 g^{-1} sample.

Miner's lettuce, a wild edible plant which grows prolifically in western USA contained 33 per cent of the adult recommended dietary allowance of ascorbic acid (Schelstraete and Kennedy, 1980).

Values for total vitamin C in fresh leaves of *Amaranthus hybridus, Celosia argentea, Corchorus olitorius, Hibiscus esculentus, Solanum* sp. and *Talinum triangulare* and cowpea leaves ranged from 410 to 588 mg 100 g^{-1} (Ajayi *et al.*, 1980; Imungi and Potter, 1983). Ascorbic acid content of *Atriplex triangularis* leaves (40.2 mg 100 g^{-1}) is comparable to that of mustard green and is much higher than that of spinach (Islam *et al.*, 1987).

Sreeramulu *et al.* (1983b) analysed the vitamin C content of sixteen Tanzanian wild green leafy vegetables and reported that the content varied from 2 to 204 mg 100 g^{-1}, with *Moringa oleifera* being the richest source of vitamin C. Fresh foliage of fenugreek contained 276 mg 100 g^{-1} of ascorbic acid and that of *Polygonum plebium* 58 mg 100 g^{-1} on Fresh Weight Basis (FWB) (Sreeramulu *et al.*, 1983a). Vitamin C content in selected Tanzanian leafy vegetables viz., amaranth, cowpea, peanut, pumpkin and sweet potato leaves varied from 43.78 to 89 mg 100 g^{-1} of fresh vegetable (Mosha *et al.*, 1995).

According to Wills *et al.* (1984a), the level of vitamin C, in watercress and mustard cabbage, two popular Chinese green leafy vegetables is about 100 mg 100 g^{-1} and are therefore good sources of vitamin C. All other Chinese vegetables including *Amaranthus tricolor* and *Ipomoea acquatica* are also considered as useful sources of vitamin C.

Mwajumwa *et al.* (1991) analysed the most common locally available leafy vegetables in Machakos District, Kenya, and obtained high values of ascorbic acid. Most of these vegetables satisfied more than 100 per cent of the daily requirements for ascorbic acid for an adult male. The ascorbic acid content in three indegenous Kenyan leafy vegetables viz., *Amaranthus hybridus, Gynandropsis gynandra* and *Solanum nigrum* varied from 123.8 mg in *Amaranthus hybrids* to 189.2 mg 100 g^{-1} fresh weight in *Gynandropsis gynandra* (Mathooka and Imungi, 1994).

2.3 Anti-nutritional factors in green leafy vegetables

Despite the high level of nutrients, the main constraint to the nutritive value of green leafy vegetables is the presence of some anti-nutritional factors like oxalates and nitrates in the leaves (Sadik, 1971; Singh and Saxena, 1972; Cheeke and Bronson, 1980; Gupta and Wagle, 1988). Besides these, the presence of phytates and hydrocyanic acid are also reported in certain leaves.

Oxalate levels in foods are of concern, because, free oxalates bind essential dietary divalent minerals, primarily calcium and make them nutritionally unavailable. The absolute amounts of minerals are therefore of little value, unless considered in relation to the oxalic acid content. The calcium oxalates formed may accumulate resulting in oxalurea or kidney stones (James, 1968; Singh *et al.*, 1971; Gopalan *et al.*, 1989; Sukumar, 1997).

However Oke (1969) opined that there is little danger associated with the ingestion of oxalate containing plants. In most Western societies, free oxalates in the food does not pose a problem, because the calcium intake exceeds the oxalic acid intake, as much as ten fold (Hodgkinson, 1977).

In contrast to the above findings, Singh (1973) observed a higher oxalate intake when compared to calcium, among the people residing in certain rural areas of India. According to Fassett (1973), a very high intake of oxalate containing foods plus a simultaneously low calcium and vitamin D intake over a prolonged period of time only will cause any chronic effects. The oxalate content in the diet is a significant factor in adequate calcium metabolism (Marderosian *et al.*, 1979).

Certain plants such as rhubarb (*Rheum rhaponticum*) and spinach (*Spinacea oleracea*) are known to contain rather high levels of oxalic acid. However, there is little evidence to substantiate the claim that the ill effects produced by the ingestion of these leaves is due to the presence of oxalic acid (Liener, 1980).

According to Reddy (1999) certain green leafy vegetables such as spinach, amaranth and gogu are rich in oxalic acid and hence individuals prone to renal calculi should avoid such foods.

The usual human dietary intake of nitrate is about 100 mg per day (White, 1975). The nitrate may get converted into nitrite and nitrosamines in the body (Tannenbaum *et al.*, 1978). Only in such circumstances, the level of nitrate in the diet is of concern. Normally, dietary nitrate is excreted in the urine without further conversion (Tannenbaum, 1979).

Deutsch (1977) pointed that, healthy adults need not be concerned about the presence of nitrate and oxalate compounds, in green leafy vegetables, as the leafy greens make up only a fraction of the daily intake of these anti-nutritional

factors. More than 100 g of daily fresh green intake is needed to raise the nitrate and oxalate levels. According to Deutsch (1977) and Marderosian *et al.* (1979), oxalates and nitrates become more of a problem, when the plants are grown under stress.

Experiments conducted on adult humans by Pingle and Ramasasthri (1976) showed that calcium in amaranthus leaves is poorly absorbed when given along with milk and indicted the high oxalate content as the probable reason for the poor absorption of calcium. Marderosian (1979) also indicated that 40 per cent of the oxalate in Amaranthus is in free form and is available for binding with calcium from other sources contained in a diet.

According to Loon and Klaveren (1991), the largest contribution to the total nitrate intake of the Dutch population came from leafy vegetables (28%).

In Andhra Pradesh, the nitrate content of the leafy vegetables contributed to 1.38 per cent of the total nitrate intake (Gundimeda *et al.*, 1993).

The total oxalate content of various *Amaranthus* species as reported by various authors varied from 3.6 per cent to 12.78 per cent on dry weight basis (Sreevastava and Krishnan, 1959; Schmidt *et al.*, 1971; Singh, 1973; Mugerwa and Bwabye, 1974; Mugerwa and Stafford, 1976; Mallika, 1987; Vityakan and Standal, 1989). Marderosian *et al.* (1979) reported a mean oxalate content of 0.75 per cent in amaranth on fresh weight.

The total oxalate content of different vegetable types of the *Amaranthus* species as reported by various authors varied from 0.3 per cent to 1.92 per cent on fresh weight basis (Devadas, 1989; Prakash and Pal, 1991; Prakash *et al.*, 1993; Thamburag *et al.*, 1994; Shingade *et al.*, 1995). George *et al.* (1989) and Thamburaj *et al.* (1994) observed higher oxalate contents in red varieties of *Amaranthus* when compared to green varieties.

Schmidt *et al.* (1971) reported an average total oxalate content of 10.62 per cent, 2.81 per cent and 1.5 per cent in *Basella alba, Ipomoea acquatia* and *Brassica oleracea* respectively.

Ndyanab (1974) studied the oxalate content of some commonly grazed pasture forages in Uganda and reported that the forages which contained high levels of calcium and nitrogen also contained high levels of total oxalates but low levels of soluble oxalate.

Gupta and Wagle (1988) observed an oxalate content of 8.69 per cent in spinach, while oxalate content varied from 0.87 to 3.93 per cent in chenopodium and celosia (Prakash *et al.*, 1993; Prakash *et al.*, 1995).

Aletor and Adeogun (1995) analysed the anti-nutrient components of seventeen leafy vegetable species found in Nigeria and observed that the dry vegetables generally had higher phytate and oxalate values than fresh ones.

According to Shingade *et al.* (1995), the unconventional leafy vegetables in general contained less oxalates as compared to cultivated vegetables, thereby indicating good palatability and safe use in human diet. The authors observed the lowest oxalic acid content of 16.9 mg 100 g^{-1} in phodsi.

Guerrero and Isasa (1997) analysed the oxalic acid content of leaves of Chenopodium species and found moderate levels of oxalic acid and oxalic/(Ca+Mg) ratio in the leaves.

Shankaracharya (1998) found that the tender leaves of tamarind contain 196 mg 100 g^{-1} of oxalic acid and observed a calcium/oxalate ratio of 1:1 at pH 4.5.

Wallace *et al.* (1998) studied the antinutritional composition of four non-conventional leafy vegetables viz. *Xanthosomas maffafa, Euphorbia hirta,*

Launcea taxarcifolia and *Ipomoea involucrata* grown in Ghana and observed lower concentrations of oxalates, phytates, tannins, alkaloids and saponins in all the leaves.

Schmidt *et al.* (1971) reported an average nitrate content of 0.67 per cent in *Amaranthus cruentus*. Devadas (1982) studied the nitrate content of 25 genotypes of vegetable amaranthus and reported that the content varied from 0.25 to 0.70 per cent on dry weight basis. The author also observed that among the eight species, the lowest nitrate content was in *Amaranthus dubius*. Prakash *et al.* (1993) found a nitrate content of 0.31 to 0.92 per cent in *A. hypochondriacus*. Ebeling *et al.* (1995) analysed some wild species of Amaranthus viz., *A. retroflexus, A. viridis, A. palmeri* and *A. blitoides* for antinutritional factors and reported that the nitrate content varied from 0.34 to 2 per cent in the leaves.

Gupta and Wagle (1988) reported a nitrate content of 5.36 per cent in Spinach. Nitrate content of leafy vegetables in Andhra Pradesh, varied from 30 to 270 mg/kg and contributed to 1.38 percent of the total nitrate intake (Gundimeda *et al.*, 1993).

According to Prakash *et al.* (1993), nitrate content in *Chenopodiom auinva* and *Celosia* varied from 0.26 to 0.51 per cent and 0.19 to 0.46 per cent respectively.

Marderosian *et al.* (1979) and Mallika (1987) observed that the oxalate content of amaranth increased with maturity.

Schmidt *et al.* (1971) observed that in *Amaranthus* and *Basella*, total leaf oxalate was 25 per cent higher when they were grown in more fertile soil, while in Brassica and Ipomoea, the content was not affected.

Singh *et al.* (1973), observed wide variation in the total and insoluble oxalate contents of leaves of bathua vegetables (*Chenopodium album* and

(*Chenopodium murale*) which were collected from ten different sites, thus suggesting the influence of soil nutrient on the oxalate content of leaves.

Kurien *et al.* (1976) and Singh *et al.* (1985) observed a direct influence of nitrogen fertilization on the oxalic acid content.

Palis and Bustrillos (1976) reported that nitrate accumulated significantly in the edible portions with increased fertilizer levels.

Vogtmann *et al.* (1984) indicated a very low risk of high nitrate concentration in leafy vegetables even with an overdose of composted farm yard manure, compared with a nitrogen equivalent NPK application.

According to Vera *et al.* (1992) lower rates of fertilizers should be recommended commercially to reduce the nitrate concentration in leafy vegetables such as spinach.

Sukumar (1997), reported that nitrate content of *A. tricolor* with the application of NPK fertilizer varied from 0.17 to 0.74 per cent.

Zandstra (1989) opined that many plants especially leafy vegetables, accumulate nitrate under low light conditions, as the rate of uptake of nitrate exceeds its rate of reduction to nitrite.

Wu and Wang (1995) observed that leaf nitrate concentration increased with shading intensity and nitrogen concentration in the nutrient solution in a non recirculating system, and decreased by harvesting in the late afternoon on a clear day and by harvesting when younger and increasing concentration of potassium and calcium in the nutrient solution.

2.4 Seasonal variation in the composition of leafy vegetables

Amaranth is the most common leafy vegetable grown during summer and rainy season in India (Varalakshmi *et al.*, 1998). Devadas *et al.* (1969) studied the seasonal variations in the nutrient content of *Amaranthus flavus* during three seasons viz. south west monsoon, north east monsoon and cold weather. The results indicated that the level of moisture, protein and ascorbic acid was highest during north east monsoon while the mineral content was found to be least during north east monsoon. Calcium, phosphorus and iron contents were found to be highest during cold weather while moisture and protein contents were least during cold weather.

Mean nitrate levels of amaranth vegetable types over two growing seasons remained constant (0.08% fresh weight) and was similar to the other leafy garden vegetables (Marderosian *et al.*, 1979).

According to Mallika (1987) the oxalic acid levels in amaranthus greens become high when grown under dry conditions.

Jijiamma (1989) compared the quality of red and greentypes of *Amaranthus tricolor* during summer and rainy seasons and observed better quality leaves during summer season. The study also indicated that ascorbic acid and fiber contents were higher during rainy season in both the varieties. Jijiamma and Prema (1993) observed better acceptability for red amaranthus grown during summer.

A systematic study on seasonal variations in the carotene profile of selected leafy vegetables indicated that, agathi, ceylon bacchali and gogu had the highest beta-carotene in summer season (March-June). Amaranth, bacchali, palak and pudina have high beta-carotene in rainy season (July-October) and colocassia, drumstick and fenugreek were high in β-carotene in winter months (November-February) (NIN, 1991).

2.5 Organoleptic evaluation

Quality is the ultimate criterion of the desirability of any food product to the consumer. Overall quality depends on quantity, nutritional and other hidden attributes and sensory quality (Ranganna, 1977).

According to Bodyfelt *et al.* (1988), measuring the sensory properties and determining the importance of these properties as a basis for predicting acceptance by the consumers represent major accomplishments for sensory evaluation. For consumers, the perceivable sensory attributes like colour, appearance, feel, aroma taste and texture are the deciding factors in food acceptance (Pal *et al.*, 1995).

Islam *et al.* (1987) conducted a study on the sensory evaluation of *Atriplex triangularis* leaves and reported that these leaves rated similar to spinach in all the four quality attributes viz. colour, flavour, texture and overall acceptability. In the study, it was also revealed that *Atriplex triangularis* leaves are accepted more than mustard greens.

Padmavathi and Rao (1990), used *Sauropus androgynus* leaves in the recipes traditionally prepared with common leafy vegetables in Andhra Pradesh and found that the preparations were highly palatable and acceptable.

Alleman *et al.* (1996) evaluated six *amaranthus* genotypes in South Africa, for taste and acceptability as a source of nutrition. Acceptability of the leaf material for human consumption was tested for both taste and texture. According to them, *A. tricolor* and *A. hypochondriacus* had the best tasting, significantly better than that of *A. cruentus* and among the *A. hybridus* cultivars. *A. tricolor* had best texture.

Fathima and Begum (1998) found that microwave drying affected certain physical characteristics like colour, appearance and odour in the green leafy

vegetables like coriander, mint, fenugreek, amaranth and shepu. Acceptability scores for microwave dried coriander and mint were low for flavour and colour, but microwave dried amaranth had scores similar to that of fresh.

Neeliyara (1998) studied the acceptability of the leaves of five genotypes of winged beans using score card. Among the quality attributes, doneness had obtained the highest scores in all the genotypes and texture obtained the least score.

Rau *et al.* (1998) formulated six food products viz. uppittu, bisibele bhath, mixed pulses, sandwich, chapathi and dhokla incorporating green leafy vegetables and determined their acceptability by sensory evaluation. Incorporation of 50 g of leaves in different products were found to be acceptable.

Kala *et al.* (1998) compared the sensory attributes of microwave cooked and conventionally cooked (boiling/pressure cooking) green leafy vegetables like Amaranth (*Amaranthus gangeticus*), kilkeerai (*Amaranthus tricolor*), shepu (*Peucedanum graveolans*) and spinach (*Spinacia oleracea*). Results of the sensory analysis showed that only the colour of cooked greens was significantly affected due to cooking methods and microwave cooked greens were preferred to conventionally cooked greens.

Snack items viz. namakpara, kachari, biscuit and besan sev prepared by incorporating spinach leaf powder and cauliflower leaf powder were also found to be acceptable upon sensory evaluation (Kushwaha *et al.*, 1998).

Vegetable dhal curry mixes developed at Defence Food Research Laboratory, Mysore scored 8.2 to 8.8 over all acceptability score on 9 point hedonic scale (Palki *et al.*, 1998). The reconstituted savoury mixes formulated at Defence Food Research Laboratory, Mysore, viz. spice methi dhal mix and spice chakota mix had sensory scores of 7.2 and 7.5 respectively on 9 point hedonic scale (Premavalli *et al.*, 1998).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The methods used to evaluate the quality attributes of the selected leafy vegetables are given under the following heads.

1. Selection of leafy vegetables
2. Collection of samples
3. Nutrient analysis of leafy vegetables
4. Analysis of anti-nutritional factors in leafy vegetables
5. Organoleptic evaluation of leafy vegetables
6. Statistical analysis

3.1 Selection of leafy vegetables

Eight leafy vegetables available and maintained in the Department of Olericulture, College of Horticulture, Vellanikkara, were selected for the study.

The leafy vegetables selected are

I) Kankong (*Ipomoea acquatica* Forsk.)

ii) Basella (*Basella rubra* L.)

iii) Waterleaf (*Talinum triangulare* Willd.)

iv) Arakeera (*Amaranthus tristis* Roxb.)

v) Centella (*Centella asiatica*)

vi) Horse purslane (*Boerhaavia diffusa* L.)

vii) Akshara keera (*Alternanthera ficoidea* L.) (red)

viii) Bengal keera (*Alternanthera ficoidea* L.) (green)

Amaranthus tricolor L. was selected as the control variety.

Plate 1-3 shows the different leafy vegetables selected for the study.

Leafy vegetables selected for the study

Plate 1. Bengalkeera, Kangkong, Centella

Plate 2. Aksharakeera, Arakeera, Amaranth


BENGAL KEERA
KANG KONG
HYDROCOTYL


ARAKEERA
AMARANTH

Plate 3. Basella, Horse purslane, Water leaf


BASELLA
HORSE PURSLANE
WATER LEAF

3.2 Collection of samples

From each of the leafy vegetables selected for the study, leaf samples were collected during summer and rainy seasons. During each season the samples were collected twice at an interval of 15-20 days. Similarly *Amaranthus tricolor* L. was also collected during rainy and summer seasons at an interval of 15-20 days.

3.3 Nutrient analysis of leafy vegetables

Leaf samples of the eight selected leafy vegetables and also the control variety were analysed for different nutrients like

1. Moisture
2. Protein
3. Fat
4. Fibre
5. Starch
6. Soluble carbohydrates
7. Calcium
8. Iron
9. Phosphorus
10. Beta-carotene and
11. Vitamin C

3.3.1 Moisture

Moisture content of the selected leafy vegetables was estimated using the method of A.O.A.C. (1980).

To determine the moisture content, ten gram of the fresh leaf sample was weighed into a weighed moisture box and dried in an oven at 100 to 105°C and cooled in a desiccator. The process of heating and cooling was repeated till

constant weight was achieved. The moisture content of the sample was calculated from the loss in weight during drying.

3.3.2 Protein

To estimate the protein content, nitrogen content was estimated by Microkjeldhal digestion and distillation method as described by Jackson (1958) which was then multiplied with a factor of 6.25 to get the protein content.

The fresh leaf samples were dried in an oven and then powdered. The moisture free sample (0.1 g) was digested with 15 ml of concentrated sulphuric acid, after adding 0.5 g copper sulphate in a digestion flask until the colour of the sample converted to green and digestion was complete. The digested sample was diluted with distilled water and then distilled with 40 per cent sodium hydroxide. The distillate was collected into 2 per cent boric acid containing mixed indicators and then titrated against 0.02 N sulpuric acid. The nitrogen content of the dried sample was calculated from the titre value and then converted to fresh weight basis.

3.3.3 Fat

The fat content of the samples was estimated using the method of A.O.A.C. (1955).

The fresh leaf samples were oven dried and powdered. Five gram each of the sample were weighed accurately into a thimble and placed in a soxhlet apparatus and extracted with anhydrous ether until the green colour of the sample was completely extracted by the solvent. The ether extract was filtered into a weighed conical flask and the ether was then removed by evaporation. The flask with the residue was dried in an oven at 80-100°C, cooled and weighed. Fat content of the sample was calculated from the weight of the ether extract, and then converted to fresh weight basis.

3.3.4 Crude fibre

Crude fibre content of the samples was estimated by acid-alkali digestion method as suggested by Chopra and Kanwar (1978).

Two gram of the dried and powdered leaf sample was boiled with 200 ml of 1.25 per cent sulphuric acid for thirty minutes. It was filtered through a muslin cloth and washed with boiling water and again boiled with 200 ml of 1.25 per cent sodium hydroxide for thirty minutes. Again it was filtered through a muslin cloth and washed with sulphuric acid, water and alcohol. The residue was transferred to a pre weighed ashing dish, dried, cooled and weighed. The residue was then ignited for thirty minutes in a muffle furnace at 600°C, cooled in a desiccator and reweighed. The fibre content of the sample was calculated from the loss in weight on ignition and then converted to fresh weight basis.

3.3.5 Starch

The starch content was analysed colorimetrically using anthrone reagent as suggested by Sadasivam and Manikam (1992).

The powdered and dried sample (0.1 g) was homogenized in eighty per cent ethanol to remove sugars, centrifuged and the residue was retained and washed repeatedly with hot eighty per cent ethanol. The residue was dried over a water bath and added 5 ml water and 6.5 ml fifty two per cent perchloric acid and extracted at 0°C for twenty minutes, centrifuged and supernatant was saved. The extraction was repeated using fresh perchloric acid. The supernatants were pooled and made up to 100 ml. Pipetted 0.1 ml of the supernatant made up to 1 ml, added 4 ml of anthrone reagent, heated for eight minutes, cooled rapidly and the intensity of green colour was read at 630 nm. A standard graph was prepared using serial dilutions of standard glucose solution. From the standard graph, glucose content of the sample was obtained and converted to fresh weight basis. This value was multiplied by a factor of 0.9 to arrive at the starch content.

3.3.6 Soluble carbohydrates

The soluble carbohydrate content was analysed colorimetrically using anthrone reagent (Sadasivam and Manikam, 1992).

The powdered and dried sample was homogenized in hot eighty per cent ethanol and centrifuged to extract the soluble sugars. The residue was washed repeatedly with hot eighty per cent ethanol and centrifuged. The washings were collected and allowed to evaporate. Five ml of water and 6.5 ml of fifty two per cent perchloric acid were added and kept for twenty minutes at 0°C. Pipetted 0.1 ml of supernatant and made up to 1 ml, added 4 ml anthrone reagent, heated for eight minutes cooled rapidly and the intensity of green colour was read at 630 nm. A standard graph was prepared using standard glucose at serial dilutions and glucose content was found out from the standard graph and converted to fresh weight basis.

3.3.7 Calcium and Iron

For estimating the calcium and iron contents of the samples, diacid extract of the samples were prepared and were estimated in an Atomic Absorption Spectrophotometer (Perkin-Elmer, 1982).

Two gram of the dried and powdered sample were digested with 12 ml of 2:1 diacid (two parts nitric acid : 1 part perchloric acid). The diacid extract was made up to 100 ml and used directly for estimation in an Atomic Absorption Spectrophotometer.

3.3.8 Phosphorus

The phosphorus content was analysed colorimetrically after preparing a diacid extract, by vanadomolybdophosphoric yellow colour method in nitric acid medium (Jackson, 1973).

Two gram of dried and powdered plant sample were pre digested with 12 ml of 2:1 diacid and volume made up to 50 ml. Five ml of the aliquot were pippeted in to a 25 ml volumetric flask, and five ml of nitric acid – vanadate molybdate reagent and made up to 25 ml. After 10 minutes the intensity of yellow colour was read at 470 nm in a spectrophotometer. A standard graph was prepared using serial dilutions of standard phosphorus solution. From the standard graph the phosphorus content of the samples were estimated and converted to fresh weight basis.

3.3.9 Beta-catotene

Beta-carotene content was estimated by the method of A.O.A.C. (1970) using saturated n-butanol.

Five gram of powdered and dried sample were placed in a 125 ml glass flask and added 50 ml water saturated n-butanol from pipette. The flask was stoppered tightly, shook well for one minute and kept overnight, protected from sunlight. Decanted the supernatant, pipetted 0.5 ml of the supernatant and diluted with 10 ml water saturated butanol and read the colour intensity in a spectrophotometer at 435.8 nm. Beta-carotene content of the sample was calculated from the reading and converted to fresh weight basis.

3.3.10 Vitamin C

The vitamin C content of the fresh samples was estimated by the method of A.O.A.C. (1955) using 2,6 dechlorophenol indophenol dye.

One gram of the fresh sample was extracted in four per cent oxalic acid using a mortar and pestle and made up to 100 ml. Five ml of the extract was pippeted, added 10 ml of 4 per cent oxalic acid and titrated against the dye. Ascorbic acid content of the fresh sample was calculated from the titre value.

3.3.11 Calculation of Average nutritive value

Average nutritive value of the leaves was calculated by the following formula suggested by Grubben (1977)

$$\text{Average nutritive value} = \frac{\text{Protein (g)}}{5} + \text{Fibre (g)} + \frac{\text{Calcium (mg)}}{100} + \frac{\text{Iron(mg)}}{2} + \text{Beta carotene (mg)} + \frac{\text{Vitamin C (mg)}}{40}$$

3.4 Analysis of anti-nutritional factors in leafy vegetables

The anti-nutritional factors like oxalates and nitrates in the leaves were analysed during summer and rainy seasons. The samples were collected twice during each season at an interval of 15-20 days. Both oxalate and nitrate contents in the samples were estimated colorimetrically as suggested by Marderosian *et al.* (1979).

3.4.1 Oxalate

The dried plant material was powdered and 0.5 g of the sample was added to 10 ml of distilled water and added 10 ml of citric acid reagent. The sample was extracted by shaking for 10 minutes at room temperature. The extract was filtered and the precipitate dissolved in 50 ml of 0.4 N hydrochloric acid by shaking for 10 minutes. The sample was filtered and two ml of the filtrate was added to two ml of diluted iron ferron reagent and the absorbance read at 540 nm in a spectrophotometer. The oxalate content of the dried sample was calculated from a standard graph and converted to fresh weight basis.

3.4.2 Nitrate

One gram of the powdered and dried plant material was extracted in 100 ml of distilled water for thirty minutes, filtered and twenty ml of the filtrate was pipetted into an iodine flask. Twenty ml of 0.1 per cent 3,4 dimethyl phenol was added to it followed by 40 ml of concentrated sulphuric acid. Flask was glass stoppered and allowed to stand for 10 minutes. After this 200 ml of distilled water was added and the samples were held for thirty minutes. The contents were steam distilled and 25 ml of distillate were collected in a volumetric flask containing five ml of 6.5 per cent sodium hydroxide. The colour intensity of the sample was measured spectrophotometrically at 430 nm using sodium hydroxide and water as blank. The nitrate content of the dried sample was calculated from a standard graph and converted to fresh weight basis.

3.5 Organoleptic evaluation

Organoleptic evaluation of the fresh leaves of the selected leafy vegetables and that of the control variety was conducted after cooking at the laboratory level during rainy and summer season by collecting samples at an interval of 15-20 days.

3.5.1 Selection of judges

A series of acceptability trials were carried out using simple triangle tests at the laboratory level to select a panel of ten judges between the age group of 18-35 years as suggested by Jellenik (1985).

3.5.2 Preparation of the samples for acceptability studies

The fresh leaves (100 g) were washed thoroughly in water to remove the adhering dirt and cut into small pieces using a stainless steel knife. Heated 10 g coconut oil and spluttered mustard. Added 25 g of scraped coconut, 1½

teaspoonful chillipowder and a little salt. Added the leaves, sprinkled a little water and cooked under a low flame.

3.5.3 Sensory evaluation

Acceptability trials of the cooked leafy vegetables were conducted using the score card (Swaminathan, 1974) by the selected ten judges. The score card developed for the study is presented in Appendix I. Five quality attributes like appearance, colour, flavour, texture and taste were included as the quality attributes. Each of the above mentioned quality attributes was assessed by a five point hedonic scale.

3.6 Statistical analysis

Analysis of data was conducted by using statistical techniques such as analysis of variance, Duncan's multiple range test (DMRT), Kruskelwallis test and cluster analysis.

RESULTS

4. RESULTS

The results pertaining to the study entitled 'Quality attributes of selected leafy vegetables' are presented under the following headings.

1. Nutritional composition of leafy vegetables
2. Anti-nutritional factors in leafy vegetables
3. Acceptability of the leafy vegetables

4.1 Nutritional composition of leafy vegetables

Eight leafy vegetables, available and maintained in the Department of Olericulture, College of Horticulture, Vellanikkara, were analysed for eleven nutrients, i.e., moisture, protein, fat, fibre, starch, soluble carbohydrates, calcium, iron, phosphorus, beta carotene and vitamin C during summer and rainy reasons. The nutrients present in these eight leafy vegetables were compared with *Amaranthus tricolor* L. which was selected as the control variety. The results of the nutrient composition of the selected leafy vegetables are presented in Tables from 1 to 12.

4.1.1 Moisture

The moisture content of the selected leafy vegetables are given in Table 1. The mean moisture content ranged from 78.98 per cent in bengal keera to 92.78 per cent in basella leaves. The control variety *Amaranthus tricolor* L. had a mean moisture content of 86.66 per cent which was found to be higher than arakeera (85.11%), aksharakeera (80.67%), bengal keera (78.98%) and centella (84.90%). The mean moisture content of kangkong (87.88%), basella (92.78%), water leaf (92.67%) and horse purslane (87.22%) was found to be higher than the control variety.

Table 1. Moisture content of different leafy vegetables (g 100 g^{-1})

Sl.No.	Variety	Summer	Rainy	Mean
1	Aksharakeera	82.42 ^{e}	78.92 ^{c}	80.67 ^{e}
2	Arakeera	85.11 ^{d}	85.11 ^{b}	85.11 ^{cd}
3	Basella	92.19 ^{a}	93.37 ^{a}	92.78 ^{a}
4	Bengal keera	77.85 ^{f}	80.11 ^{c}	78.98 ^{f}
5	Centella	85.67 ^{d}	84.13 ^{b}	84.90 ^{d}
6	Horse purslane	87.92 ^{bc}	86.53 ^{b}	87.22 ^{c}
7	Kang kong	88.53 ^{b}	87.24 ^{b}	87.88 ^{e}
8	Water leaf	92.88 ^{a}	92.47 ^{a}	92.67 ^{a}
Control	*Amaranthus tricolor* L.	86.43 ^{cd}	86.89 ^{b}	86.66 ^{bc}

Values having different superscripts differ significantly at 5% level

On the basis of Duncan's Multiple Range Test (DMRT), the different leafy vegetables were classified into seven groups based on moisture content. Each class had only two or less members in it. *Amaranthus tricolor*, which was selected as the control variety was included in a separate group (bc) which showed that it had significant difference from all the eight leafy vegetables selected for the study with respect to moisture content.

During summer season, the moisture content of the leaves varied from 77.85 per cent to 92.88 per cent. The highest moisture content was observed in water leaf and lowest in bengal keera during summer season. The control variety had a higher moisture content (86.43%) than the four other leafy vegetables namely arakeera (85.11%), aksharakeera (82.42%), bengal keera (77.85%) and centella (85.67%) while the other four leafy vegetables had a higher moisture content than *Amaranthus tricolor* during summer season.

According to DMRT, the different leafy vegetables were classified into seven groups based on their moisture content during summer season. The control variety was grouped as a separate group (cd) which showed that the leafy vegetables selected for the study are significantly different from the control variety with respect to moisture content during summer season.

The moisture content of the leaves during rainy season ranged from 78.92 per cent to 93.37 per cent in aksharakeera and basella leaves respectively. The moisture content of kangkong (87.24%), basella (93.37%) and waterleaf (92.47%) was found to be higher than the control variety (86.89%) while horse purslane (86.53%), arakeera (85.11%), aksharakeera (78.92%), bengal keera (80.11%) and centella (84.13%) had a lower moisture content than the control variety during rainy season.

Statistically the different leafy vegetables were arranged into three groups on the basis of moisture content of the leaves during rainy season (Table 1). *Amaranthus tricolor* was included in the second group (b) with four other leafy vegetables namely arakeera, bengal keera, centella and horse purslane. This indicated that *Amaranthus tricolor* had no significant difference with these four leafy vegetales with respect to moisture. The members of other two groups (a & c) had significant difference between themselves.

The mean moisture content of eight leafy vegetables with that of *Amaranthus tricolor* is shown in Figure 1.

Analysis of variance test indicated that there was significant variation between the leafy vegetables with respect to moisture during summer (F value = 76.92) as well as rainy season (F value = 16.14) at one per cent level. However, the variation with respect to moisture content of the leaves between summer and rainy seasons was found to be insiginificant (F value = 0.70).

4.1.2 Protein

The crude protein content of leafy vegetables on fresh weight basis during summer and rainy seasons and the mean crude protein content are presented in Table 2.

The mean protein content of the leaves varied from 1.20 g to 3.13 g 100 g^{-1}. The highest value was observed in kangkong and the lowest in basella leaves. The control variety had the highest protein content (3.19 g%) than all the other eight leafy vegetables selected for the study.

Table 2. Protein content of different leafy vegetables (g 100 g^{-1})

Sl.No.	Variety	Summer	Rainy	Mean
1	Aksharakeera	3.61^{a}	2.59^{b}	3.10^{ab}
2	Arakeera	2.23^{f}	2.46^{b}	2.35^{cd}
3	Basella	1.48^{g}	0.92^{c}	1.20^{e}
4	Bengal keera	3.18^{b}	2.39^{b}	2.79^{abc}
5	Centella	2.28^{f}	2.64^{b}	2.46^{bcd}
6	Horse purslane	2.80^{c}	1.34^{e}	2.07^{d}
7	Kang kong	2.88^{d}	3.39^{a}	3.13^{ab}
8	Water leaf	1.51^{g}	1.04^{e}	1.28^{e}
Control	*Amaranthus tricolor* L.	3.03^{c}	3.34^{a}	3.19^{a}

Values having different superscripts differ significantly at 5% level

Statistically, the various leafy vegetables including the control variety were differentiated into seven categories. The categories ab and e had two members each. The leafy vegetables included in these two categories were not significantly different from each other, but different from the leafy vegetables of other categories statistically. Amaranthus was included in the first group as a single entity which indicated that it had significant difference from all the other leafy vegetables selected for the study.

The protein content during summer and rainy seasons were found to be lowest in basella leaves (1.48% and 0.92%). The highest protein content was observed in aksharakeera (3.61%) during summer season and in kangkong (3.39%) during rainy season.

The protein content of amaranth (3.03%) was found to be more than all the other leafy vegetables during summer season except in aksharakeera (3.61%) and bengal keera (3.18%), while in rainy season, the protein content of the control

variety was found to be highest (3.34%) than all the other leafy vegetables except kangkong (3.39%).

DMRT classified the different leafy vegetables on the basis of protein content during summer into seven groups. Each group consisted of only one member except the groups f and g which had two members each. *Amaranthus tricolor* was included in the third group (c) as the sole member and this indicated that the control variety had statistically significant difference from all the other leafy vegetables selected for the study, with respect to protein content during summer season.

During rainy season, the different leafy vegetables were grouped into three groups based on protein content, each group containing two, three or more leafy vegetables. The leafy vegetables belonging to the same group had no significant difference between themselves but they differed from the leafy vegetables of other groups. The control variety which had a protein content of 3.34 g 100 g^{-1} was included along with kangkong.

The mean protein content of eight leafy vegetables with that of *Amaranthus tricolor* is shown in Figure 2.

The results of the statistical analysis indicated that there was significant variation in the protein content at 5 per cent level between the leafy vegetables during summer (F value = 1041.52) as well as rainy (F value = 42.11) seasons. But no significant variation was observed in the protein content of the leaves between summer and rainy season (F value = 1.92).

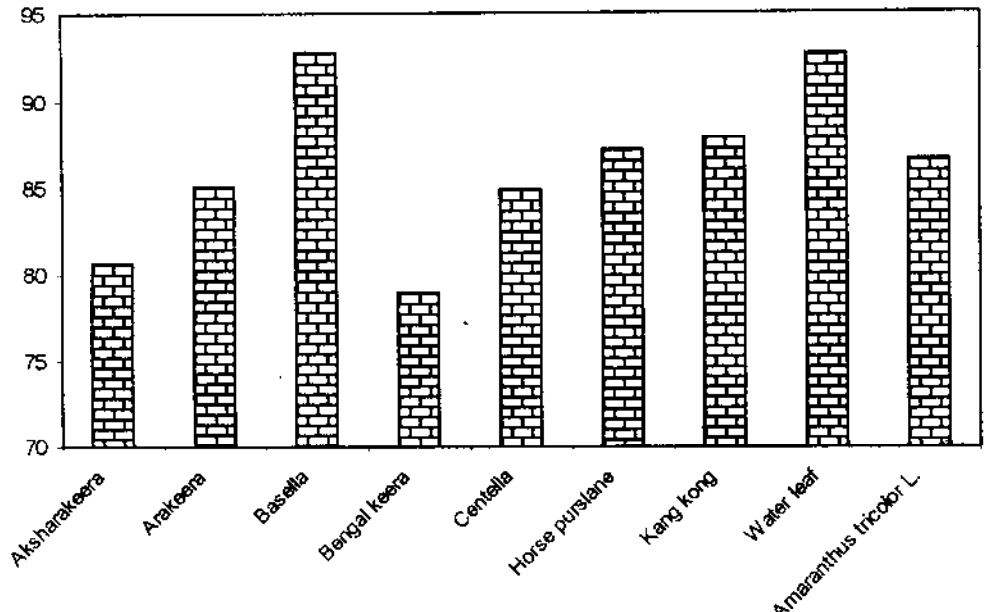


Fig.1. Mean moisture content of different leafy vegetables (g 100 g^{-1})

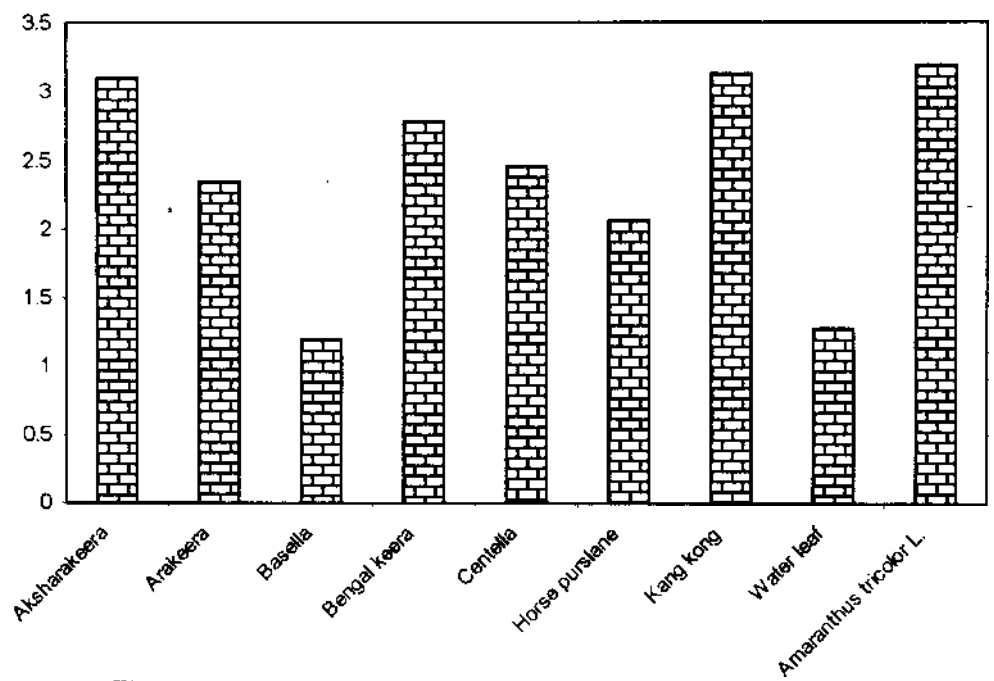


Fig.2. Mean protein content of different leafy vegetables (g 100 g^{-1})

4.1.3 Fat

Table 3. Fat content of different leafy vegetables (g 100 g^{-1})

Sl.No.	Variety	Summer	Rainy	Mean
1	Aksharakeera	0.57^{a}	0.72^{a}	0.65^{a}
2	Arakeera	0.33^{bc}	0.33^{c}	0.33^{bc}
3	Basella	0.15^{d}	0.24^{ef}	0.19^{d}
4	Bengal keera	0.30^{c}	0.23^{ef}	0.27^{c}
5	Centella	0.37^{b}	0.40^{b}	0.39^{b}
6	Horse purslane	0.29^{c}	0.30^{cd}	0.29^{c}
7	Kang kong	1.14^{d}	0.22^{f}	0.18^{d}
8	Water leaf	0.34^{bc}	0.25^{def}	0.30^{c}
Control	*Amaranthus tricolor* L.	0.32^{bc}	0.29^{cde}	0.30^{c}

Values having different superscripts differ significantly at 5% level

The mean fat content of the leafy vegetables on fresh weight basis are furnished in Table 3. As revealed in the table, the mean fat content in the leaves of different leafy vegetables ranged from 0.18 per cent in kangkong to 0.65 per cent in aksharakeera. The control variety, *Amaranthus tricolor* L. was found to have a mean fat content of 0.30 per cent. This value was found to be higher than five leafy vegetables viz. kangkong (0.18%), basella (0.19%), waterleaf (0.39%), horsepurslane (0.29%) and bengal keera (0.27%) and the other three leafy vegetables viz. arakeera (0.33%), aksharakeera (0.64%) and centella (0.39%) had higher fat content than the control variety.

On the basis of DMRT, the different leafy vegetables were arranged into five categories. The four leafy vegetables including the control variety which had a content in between 0.27 per cent and 0.30 per cent were included in the third category (c). It showed that *Amaranthus tricolor*, had no significant difference from these leafy vegetables in its mean fat content, and the rest of the leaves namely, kangkong, basella, akshara keera, centella and arakeera were significantly different from the control variety with respect to their fat content.

When the selected leafy vegetables were analysed during summer and rainy seasons, it was found that during summer season, the fat content ranged from 0.15 to 0.57 g 100 g^{-1}. The lowest and the highest fat content were found respectively in basella and aksharakeera. The control variety, *Amaranthus tricolor* was found to have a value of 0.32 g 100 g^{-1}, during summer season, which was lower than, water leaf (0.34%), arakeera (0.33%), aksharakeera (0.57%) and centella (0.37%) while the other four varieties had a lower fat content than the control variety during summer season.

On the basis of fat content of leafy vegetables during summer season, they were classified into five groups on the basis of DMRT. *Amaranthus tricolor* was included in the third group (bc) along with arakeera and water leaf which showed that statistically these three leafy vegetables are significantly different from the leafy vegetables of category a, b, c and d.

The fat content of the leaves during rainy season varied from 0.22 g 100 g^{-1} in kangkong to 0.72 per cent in aksharakeera. The control variety had a value of 0.29 g 100 g^{-1} during rainy season, which was found to be lower than most of the other varieties except kangkong, basella and waterleaf.

Statistically, the different leafy vegetables were grouped into eight groups, each harbouring only one leafy vegetable except the seventh group (ef) which had two members in it. The control variety was included in a separate group namely (de) which showed that *Amaranthus tricolor* is significantly different from all the other leafy vegetables on the basis of fat content during rainy season.

The mean fat content of eight leafy vegetables with that of *Amaranthus tricolor* is shown in Figure 3.

The Analysis of variance with respect to fat content indicated significant variation between the leafy vegetables during both seasons [F value = 61.943

(summer) and 120.869 (rainy)], but the variation in fat content was found to be insignificant (F value = 0.52) between summer and rainy seasons.

4.1.4 Fibre

The fibre content of the leafy vegetables during summer and rainy seasons and the mean fibre content of the leaves are presented in Table 4.

The mean fibre content of the leafy vegetables varied from 0.92 per cent to 4.08 per cent. The highest and lowest fibre contents were observed in centella leaves and waterleaves respectively. The mean fibre content of the control variety (1.56%) was found to be lower than that of horse purslane (2.39%), aksharakeera (2.35%), bengal keera (3.04%) and centella (4.08%). All the other leafy vegetables had lower fibre content than amaranth.

On the basis of the fibre content, the leafy vegetables were grouped statistically into five classes. The fourth group (cd) contained four leafy vegetables namely, arakeera, basella and kangkong and the control variety *Amaranthus tricolor*. The leafy vegetables included in the same class were not significantly different from each other but different from leafy vegetables of other classes statistically.

The fibre content of the leaves during summer season ranged from 1.18 (kangkong) to 5.94 g 100 g^{-1} (centella).

Table 4. Fibre content of different leafy vegetables (g 100 g^{-1})

Sl.No.	Variety	Summer	Rainy	Mean
1	Aksharakeera	2.16^{c}	2.53^{b}	2.35^{bc}
2	Arakeera	1.89^{cd}	0.87^{f}	1.38^{cd}
3	Basella	1.53^{de}	0.78^{f}	1.55^{cd}
4	Bengal keera	3.11^{b}	2.96^{a}	3.04^{ab}
5	Centella	5.94^{a}	2.22^{c}	4.08^{a}
6	Horse purslane	3.31^{b}	1.46^{e}	2.39^{bc}
7	Kang kong	1.18^{e}	1.80^{d}	1.49^{cd}
8	Water leaf	1.45^{e}	0.69^{f}	0.92^{d}
Control	*Amaranthus tricolor* L.	1.72^{cd}	1.40^{e}	1.56^{cd}

Values having different superscripts differ significantly at 5% level

Except three leafy vegetables viz. kangkong (1.18%), basella (1.53%) and water leaf (1.45%) all the other varieties had higher fibre content that the control variety during summer season.

Statistically, the different leafy vegetables were classified into six groups on the basis of fibre content during summer season. The first group (a) included only centella leaves. *Amaranthus tricolor* was included along with arakeera which showed that the control variety is significantly different from all the other leafy vegetables except arakeera.

During rainy season, the fibre content of leaves varied from 0.69 to 2.96 g 100 g^{-1}. The lowest and highest fibre contents were observed in waterleaf and bengal keera respectively. The fibre content of the control variety was found to be 1.40 g 100 g^{-1} which was found to be higher than the fibre content of basella (0.78%), water leaf (0.69%) and arakeera (0.87%) and lower than kangkong (1.80%), horse purslane (1.46%), aksharakeera (2.53%), bengal keera (2.96%) and centella (2.22%).

On the basis of fibre content of leafy vegetables during rainy season, the leafy vegetables were grouped statistically into six groups. All the groups contained one variety each, except the group e & f which had two and three members each, respectively. *Amaranthus tricolor* was included along with horse purslane. This showed that *Amaranthus tricolor* is statistically different from all the other leafy vegetables except horse purslane in the fibre content during rainy season.

The mean fibre content of eight leafy vegetables with that of *Amaranthus tricolor* is depicted in Fig.4.

Analysis of variance test indicated significant variation between the leafy vegetables with respect to fibre content during summer (F value = 98.623) and rainy

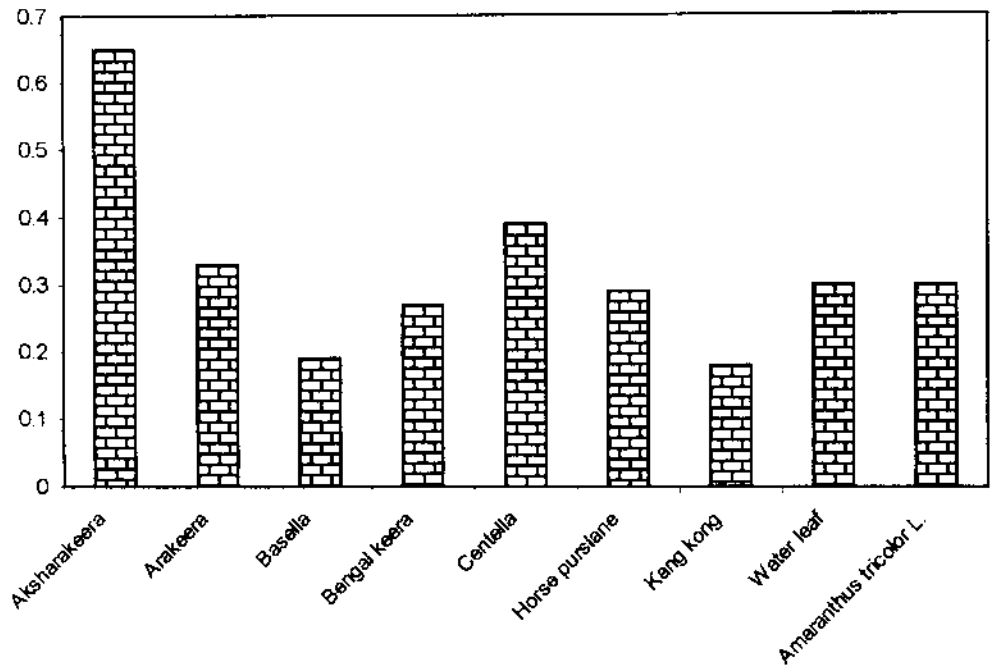


Fig.3. Mean fat content of different leafy vegetables (g 100 g^{-1})

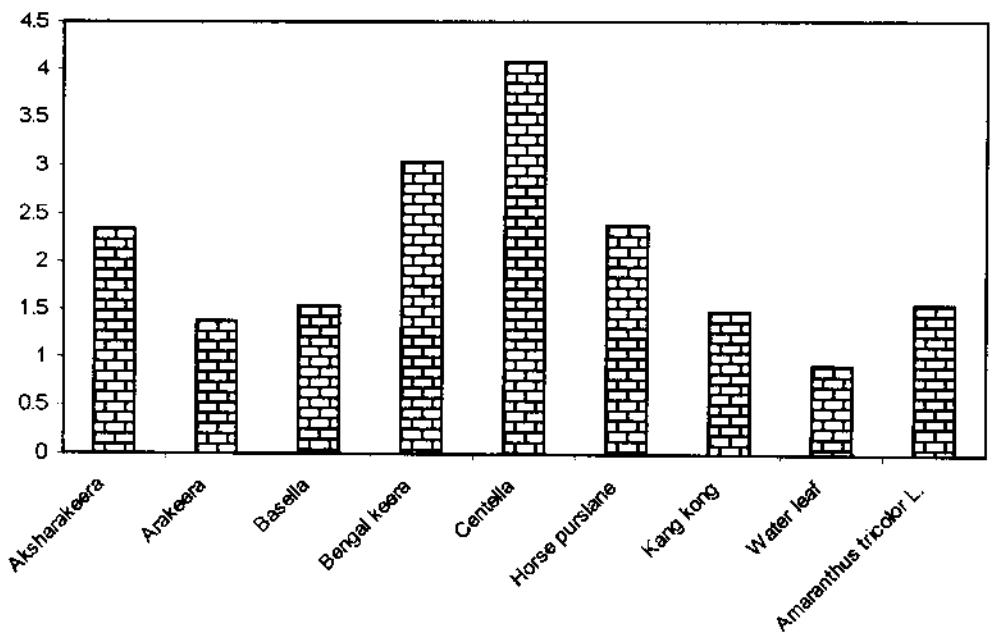


Fig.4. Mean fibre content of different leafy vegetables (g 100 g^{-1})

seasons (F value = 84.92) at 1 per cent level. The variation in the fibre content between summer and rainy seasons was found to be insignificant (F value = 3.4).

4.1.5 Starch

Starch content of eight leafy vegetables and the control variety was estimated and the results are furnished in Table 5. The mean starch content of leafy vegetables ranged between 0.07 per cent and 1.70 per cent. Bengal keera was found to have the highest amount and water leaf, the lowest. The control variety was found to have a mean value of 0.17 per cent. Except waterleaf (0.07%) and centella (0.14%), all other leafy vegetables had an higher starch content than the control variety.

Statistically, the various leafy vegetables were differentiated into five categories. The category c had five members including *Amaranthus tricolor*. These five leafy vegetables were not significantly different from each other, but different from the leafy vegetables of other classes statistically. All the other four leafy vegetables were included in four separate groups which indicated that these leafy vegetables were significantly different from each other with respect to starch content.

Table 5. Starch content of different leafy vegetables (g 100 g^{-1})

Sl.No.	Variety	Summer	Rainy	Mean
1	Aksharakeera	0.42^{b}	2.71^{a}	1.56^{ab}
2	Arakeera	0.42^{b}	0.24^{d}	0.33^{c}
3	Basella	0.22^{c}	0.39^{d}	0.31^{c}
4	Bengal keera	0.60^{a}	2.79^{a}	1.70^{a}
5	Centella	0.04^{d}	0.25^{d}	0.14^{c}
6	Horse purslane	0.21^{c}	1.65^{b}	0.93^{abc}
7	Kang kong	0.13^{cd}	1.15^{c}	0.64^{bc}
8	Water leaf	0.12^{cd}	0.03^{d}	0.07^{c}
Control	*Amaranthus tricolor* L.	0.20^{c}	0.14^{d}	0.17^{c}

Values having different superscripts differ significantly at 5% level

When the leaf samples were analysed during summer season, the starch content ranged from 0.04 (centella) to 0.60 g per cent (bengal keera). The starch content of basella (0.22%), horse purslane (0.21%), arakeera (0.42%), aksharakeera (0.40%) and bengal keera (0.60%) was found to be higher than the control variety (0.20%).

DMRT classified the leafy vegetables into five groups on the basis of their starch content during summer season. *Amaranthus tricolor* was included in the third group (c) along with basella and horsepurslane which means that *Amaranthus tricolor* is significantly different from the leafy vegetables namely, aksharakeera, arakeera, bengal keera, centella, kangkong and water leaf with respect to their starch content during summer season.

During rainy season, the starch content ranged between 0.03 per cent to 2.79 per cent. The highest starch content was reported in bengalkeera and the lowest in waterleaf. The control variety was reported to have a value of 0.14 per cent during rainy season. Aksharakeera (2.710%), arakeera (0.236%), basella (0.390%), bengalkeera (2.790%), centella (0.247%), horsepurslane (1.653%) and kangkong (1.150%) had an higher starch content than the control variety.

Statistically, the various leafy vegetables were differentiated into four categories. The categories a & d had two and five members each. *Amaranthus tricolor* was included along with four other leafy vegetables namely, arakeera, basella, centella and waterleaf on the basis of their starch content during rainy season. This showed that the starch content of *Amaranthus tricolor* was not significantly different from these four leafy vegetables included in third group.

The mean starch content of eight leafy vegetables with that of *Amaranthus tricolor* is given in Figure 5.

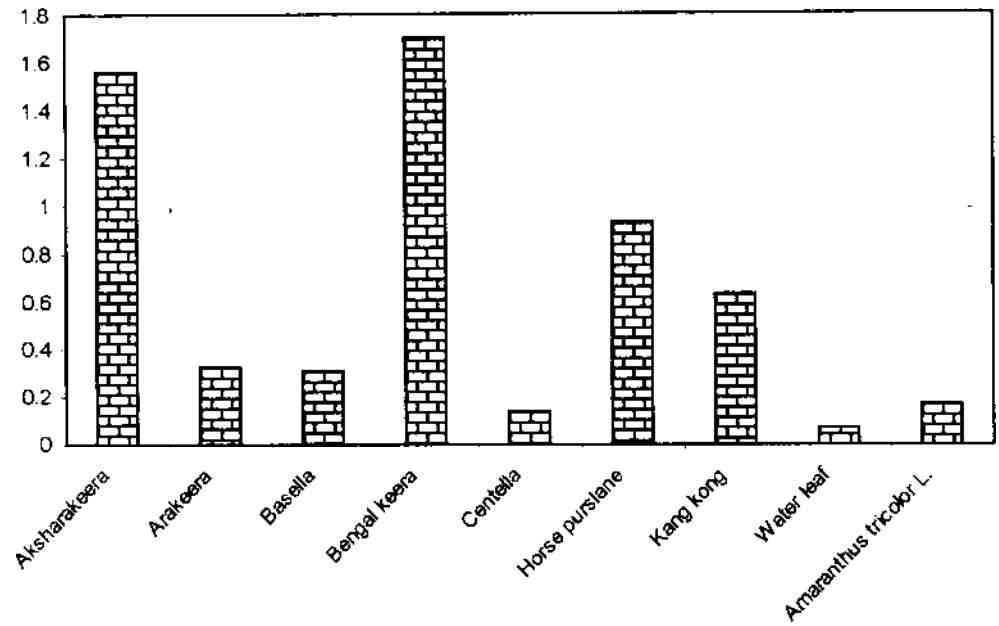


Fig.5. Mean starch content of different leafy vegetables (g 100 g^{-1})

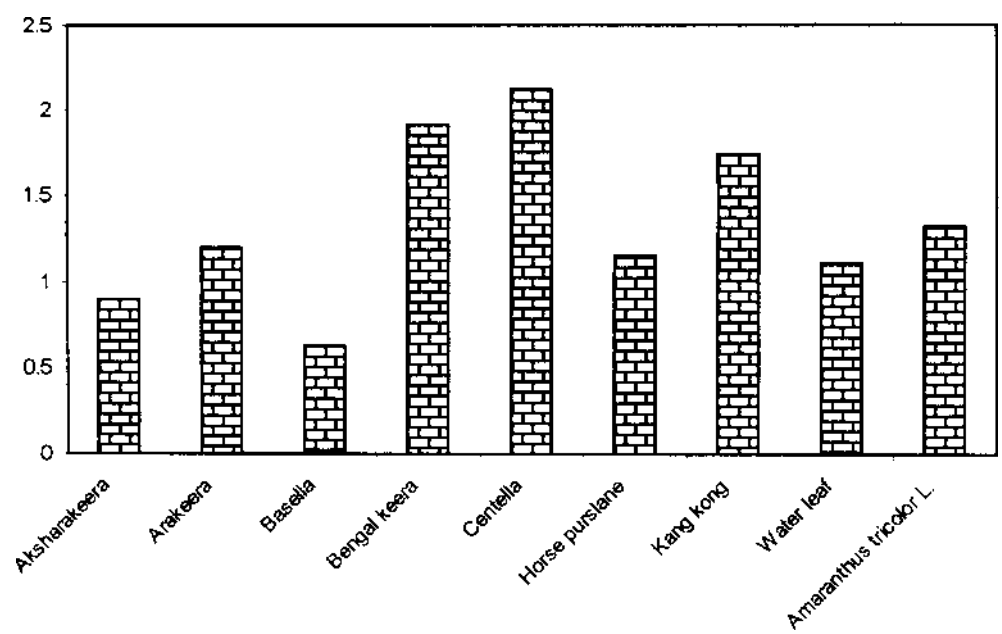


Fig.6. Mean soluble carbohydrate content of different leafy vegetables (g 100 g^{-1})

Analysis of variance revealed significant variation in starch content (1% level) between the leafy vegetables during rainy (F value = 98.329) and summer (F value = 14.679) seasons. Significant variation (5% level) was also observed in the starch content of the leaves between summer and rainy seasons (F value = 5.33).

4.1.6 Soluble carbohydrates

The mean soluble carbohydrate content of the leaves, and the soluble carbohydrate content during summer and rainy seasons are furnished in Table 6. The mean soluble carbohydrate content of leafy vegetables varied from 0.63 to 2.12 g 100 g^{-1} with basella leaves having the lowest and centella leaves with the highest value. The mean soluble carbohydrate content of the control variety was found to be 1.32 g 100 g^{-1}. The mean soluble carbohydrate content of kangkong (1.74%), horsepurslane (1.56%), bengal keera (1.91%) and centella (2.12%) was found to be higher than amaranth while the rest of the leaves namely, basella (0.63%), water leaf (1.11%), arakeera (1.20%) and aksharakeera (0.90%) had lower soluble carbohydrate content.

Table 6. Soluble carbohydrate content of different leafy vegetables (g 100 g^{-1})

Sl.No.	Variety	Summer	Rainy	Mean
1	Aksharakeera	1.42^{bc}	0.38^{d}	0.90^{de}
2	Arakeera	1.08^{cd}	1.32^{b}	1.20^{cde}
3	Basella	0.71^{d}	0.55^{d}	0.63^{e}
4	Bengal keera	2.47^{a}	1.34^{c}	1.91^{ab}
5	Centella	1.83^{b}	2.41^{a}	2.12^{a}
6	Horse purslane	1.05^{cd}	1.26^{bc}	1.15^{cde}
7	Kang kong	2.36^{a}	1.11^{bc}	1.74^{abc}
8	Water leaf	1.21^{cd}	1.01^{c}	1.11^{cde}
Control	*Amaranthus tricolor* L.	1.30^{c}	1.34^{b}	1.32^{bcd}

Values having different superscripts differ significantly at 5% level

The different leafy vegetables were classified into seven groups according to their soluble carbohydrate content on the basis of DMRT. The control

variety was included as a separate group namely bcd and it showed that *Amaranthus tricolor* had significant difference from the other leafy vegetables in soluble carbohydrate content.

During summer season, the soluble carbohydrate content of the leaves varied from 0.71% in basella to 2.47% in bengal keera. The soluble carbohydrate content of the control variety (1.32%) was found to be higher than basella (0.71%), water leaf (1.2%), horse purslane (1.05%) and arakeera (1.08%) and lower than kangkong (2.36%), aksharakeera (1.42%), bengal keera (2.47%) and centella (1.83%) leaves.

Statistically the various leafy vegetables were differentiated into six categories on the basis of soluble carbohydrate content during summer season.

The soluble carbohydrate content of the leaves during rainy season varied between 0.38 per cent to 2.41 per cent, the highest value was noted in centella leaves and the lowest in aksharakeera during rainy season. Except centella (2.41%), all other leafy vegetables had a lower soluble carbohydrate content during rainy season with bengal keera having the same content of soluble carbohydrate as that of the control variety.

Statistically, the different leafy vegetables were classified into five groups on the basis of soluble carbohydrate content during rainy season. The group a included the best leafy vegetable namely centella. The group b was found to occupy three leafy vegetables including the control variety. This indicated that soluble carbohydrate content of *Amaranthus tricolor*, was not significantly different from the other two leafy vegetables namely arakeera and bengal keera.

The mean soluble carbohydrate content of eight leafy vegetables with that of *Amaranthus tricolor* is shown in Figure 6.

Analysis of variance test indicated that there was significant variation between the leafy vegetables with respect to soluble carbohydrate during summer (F value 14.679) and rainy seasons (F value 44.680) at five per cent level. No significant variation was seen in the leafy vegetables between summer and rainy seasons (F value 1.8).

4.1.7 Calcium

Calcium content of the eight leafy vegetables was analysed on fresh weight basis and compared with the control variety, *Amaranthus tricolor* and the values are furnished in Table 7. From the table, it can be seen that the mean values ranged from 13.42 mg 100 g^{-1} in basella to 135.20 mg 100 g^{-1} in bengal keera.

Table 7. Calcium content of different leafy vegetables (mg 100 g^{-1})

Sl.No.	Variety	Summer	Rainy	Mean
1	Aksharakeera	58.97 ^{c}	136.53 ^{a}	97.75 ^{b}
2	Arakeera	56.66 ^{c}	83.92 ^{c}	70.29 ^{cd}
3	Basella	14.46 ^{e}	12.38 ^{f}	13.42 ^{f}
4	Bengal keera	122.26 ^{a}	148.13 ^{a}	135.20 ^{a}
5	Centella	38.13 ^{d}	63.56 ^{d}	50.85 ^{de}
6	Horse purslane	50.80 ^{c}	114.25 ^{b}	82.53 ^{bc}
7	Kang kong	28.80 ^{d}	31.13 ^{ef}	29.96 ^{ef}
8	Water leaf	17.81 ^{e}	42.30 ^{e}	30.06 ^{ef}
Control	*Amaranthus tricolor* L.	78.84 ^{b}	139.81 ^{a}	109.32 ^{ab}

Values having different superscripts differ significantly at 5% level

The control variety *Amaranthus tricolor*, had a calcium content of 109.33 mg 100 g^{-1}. Except bengal keera all the other leafy vegetables had a lower calcium content than the control variety.

DMRT classified the different leafy vegetables on the basis of mean values for calcium into eight groups. The two leafy vegetables namely kangkong and waterleaf were included in the same category namely 'ef' which indicated that there is no significant difference statistically in the calcium content of these two

leafy vegetables. Other varieties were included in separate groups. It showed that all the leafy vegetables are statistically different from each other. The control variety was also included in a separate entity (ab). This means that all the leafy vegetables were statistically different from the control variety in calcium content.

The calcium content of leafy vegetables during summer season ranged between 14.46 mg to 122.26 mg 100 g^{-1}. The lowest value was obtained in basella (14.48 mg 100 g^{-1}) and the highest in bengal keera (122.26 mg 100 g^{-1}). During summer season amaranthus had 78.84 mg of calcium per 100 g and only bengal keera had higher values than the control variety, with respect to calcium in summer season.

On the basis of DMRT, the different leafy vegetables were arranged into five groups on the basis of calcium content during summer season. *Amaranthus tricolor* was included in the second group as the sole member of that group which indicated that all the other leafy vegetables are significantly different from the control variety. The members of different groups had significant difference between themselves on the basis of the calcium content during summer season.

During rainy season, the calcium content of the control variety amaranth was found to be 139.81 mg 100 g^{-1} and for the other eight leafy vegetables, the values varied from 12.38 mg (basella) to 148.13 mg (bengal keera) per 100 g of the leafy vegetable. Only bengal keera contained higher values than *Amaranthus tricolor*.

Statistically, the different leafy vegetables were classified into seven groups. The group (a) included the best three leafy vegetables including *Amaranthus tricolor*. This showed that calcium content of the control variety was not significantly different from the two leafy vegetables namely kangkong and water leaf included in group (a), during rainy season.

The mean calcium content of eight leafy vegetables with that of *Amaranthus tricolor* is shown in Figure 7.

Statistical analysis indicated significant variation in calcium content between the leafy vegetables during summer (F value 106.819) as well as rainy (F value 62.282) seasons, at 1 per cent level. The variation with respect to calcium content of leaves between summer and rainy seasons (F value 13.64) was also found to be significant (at 1% level).

4.1.8 Phosphorus

The mean values of phosphorus of different leafy vegetables and the control variety are given in Table 8. The phosphorus content of all the leaves during summer and rainy seasons are also presented in the table. The mean values ranged from 5.60 mg to 13.84 mg per 100 g of leaves. The highest mean value was obtained in kangkong and the lowest in waterleaf. The phosphorus content of control variety amaranth (12.59 mg 100 g^{-1}) was found to be higher than all the other leafy vegetables, except kangkong.

The different leafy vegetables were classified into three groups according to their phosphorus content on the basis of DMRT. The control variety was included in the first group with higher phosphorus content namely (a) along with kangkong and it showed that *Amaranthus tricolor* and kangkong were significantly different from the other varieties of leafy vegetables in phosphorus content.

During summer season, the phosphorus content ranged between 2.43 mg to 4.78 mg 100 g^{-1} with waterleaf having lowest and arakeera with the highest value. The phosphorus content of amaranth during summer season was found to be 4.66 mg 100 g^{-1}. The phosphorus content of all the other leafy vegetables except arakeera was found to be lower than the control variety.

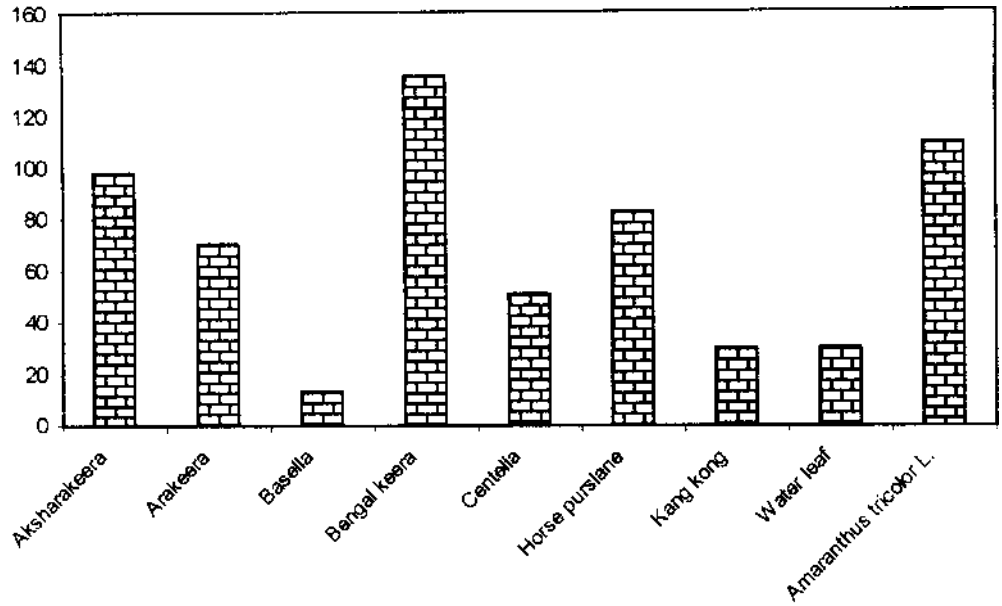


Fig.7. Mean calcium content of different leafy vegetables (mg 100 g^{-1})

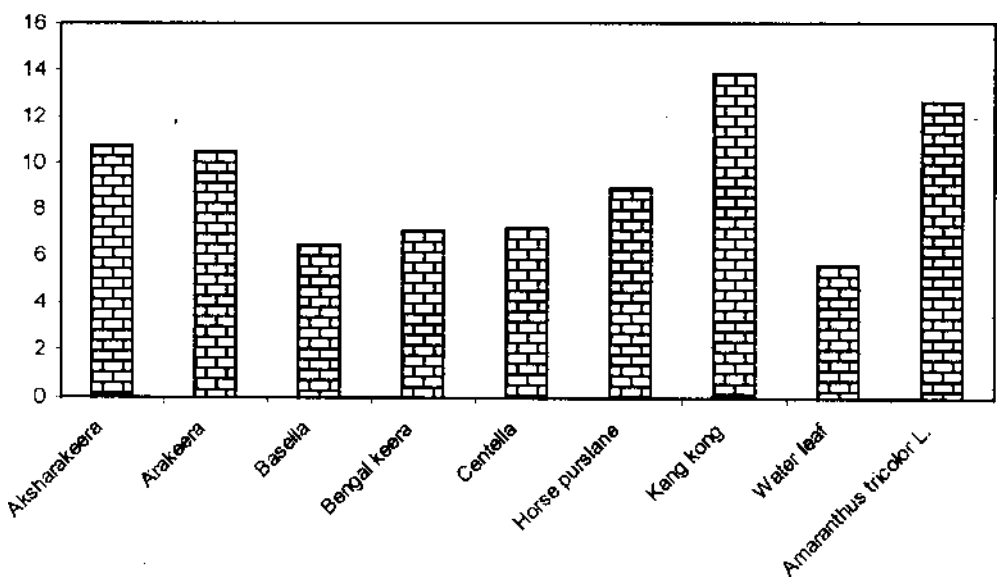


Fig.8. Mean phosphorus content of different leafy vegetables (mg 100 g^{-1})

Table 8. Phosphorus content of different leafy vegetables (g 100 g^{-1})

Sl.No.	Variety	Summer	Rainy	Mean
1	Aksharakeera	4.13 ^{ab}	17.31 ^{bc}	10.72 ^{ab}
2	Arakeera	4.78 ^{a}	16.15 ^{bcd}	10.47 ^{ab}
3	Basella	3.07 ^{c}	9.89 ^{e}	6.48 ^{b}
4	Bengal keera	4.13 ^{ab}	10.01 ^{e}	7.07 ^{b}
5	Centella	3.26 ^{bc}	11.10 ^{de}	7.18 ^{b}
6	Horse purslane	4.23 ^{ab}	8.76 ^{e}	8.88 ^{ab}
7	Kang kong	3.30 ^{bc}	24.39 ^{a}	13.84 ^{a}
8	Water leaf	2.43 ^{c}	8.76 ^{e}	5.60 ^{b}
Control	*Amaranthus tricolor* L.	4.66 ^{a}	20.51 ^{ab}	12.59 ^{a}

Values having different superscripts differ significantly at 5% level

On the basis of phosphorus content, the leafy vegetables were statistically classified into four categories during summer season each group containing 2 or 3 members. The control variety was categorised as the first group (a) along with arakeera which indicated that all the other leafy vegetables except arakeera are significantly different from the control variety on the basis of phosphorus content during summer season.

The phosphorus content of the leaves during rainy season ranged between 8.76 (horsepurslane and waterleaf) to 24.39 mg 100 g^{-1} in kangkong. The control variety contained 20.51 mg 100 g^{-1} and the phosphorus content of leafy vegetables selected for the study except kangkong was found to be lower than the control variety.

DMRT classified the different leafy vegetables into six groups on the basis of phosphorus content during rainy season. All the groups except the last group (e), contained only one member each. Thus kangkong was placed in group (a), control variety in group (ab), aksharakeera in group (bc), arakeera in group (bcd) and centella in group (de). The members of group (e) were basella, bengalkeera, horsepurslane and waterleaf. Thus it can be seen that during rainy

season all the leafy vegetables except kangkong had significantly lower phosphorus content than the control variety.

The mean phosphorus content of the eight leafy vegetables with that of *Amaranthus tricolor* is shown in Figure 8.

Analysis of variance indicated that the variation with respect to phosphorus content between leafy vegetables in summer (F value 6.349) as well as rainy seasons (F value 8.786) was significant at one per cent level. Significant variation existed in the leafy vegetables between seasons (F value 40.68) with respect to phosphorus content.

4.1.9 Iron

Iron content of leafy vegetables and the control variety on fresh weight basis are presented in Table 9. The mean iron content of leafy vegetables ranged between 5.16 to 34.76 mg 100 g^{-1}. The highest value was obtained in kangkong and the lowest in basella leaves. The control variety, *Amaranthus tricolor*, had been found to have an iron content of 26.74 mg 100 g^{-1}. Except kangkong, all the other leafy vegetables had lower iron content than the control variety.

Table 9. Iron content of different leafy vegetables (mg 100 g^{-1})

Sl.No.	Variety	Summer	Rainy	Mean
1	Aksharakeera	5.75 ^{bc}	40.96 ^{ab}	23.36 ^{abc}
2	Arakeera	3.63 ^{bcd}	16.79 ^{cd}	10.21 ^{cd}
3	Basella	2.07 ^{d}	8.25 ^{d}	5.16 ^{d}
4	Bengal keera	5.64 ^{bc}	37.08 ^{ab}	21.36 ^{abcd}
5	Centella	3.58 ^{bcd}	37.08 ^{ab}	20.33 ^{abcd}
6	Horse purslane	3.18 ^{cd}	22.85 ^{bcd}	13.02 ^{bcd}
7	Kang kong	38.40 ^{a}	31.13 ^{abc}	34.76 ^{a}
8	Water leaf	1.84 ^{d}	11.75 ^{cd}	6.88 ^{d}
Control	*Amaranthus tricolor* L.	6.88 ^{b}	46.60 ^{a}	26.74 ^{ab}

Values having different superscripts differ significantly at 5% level

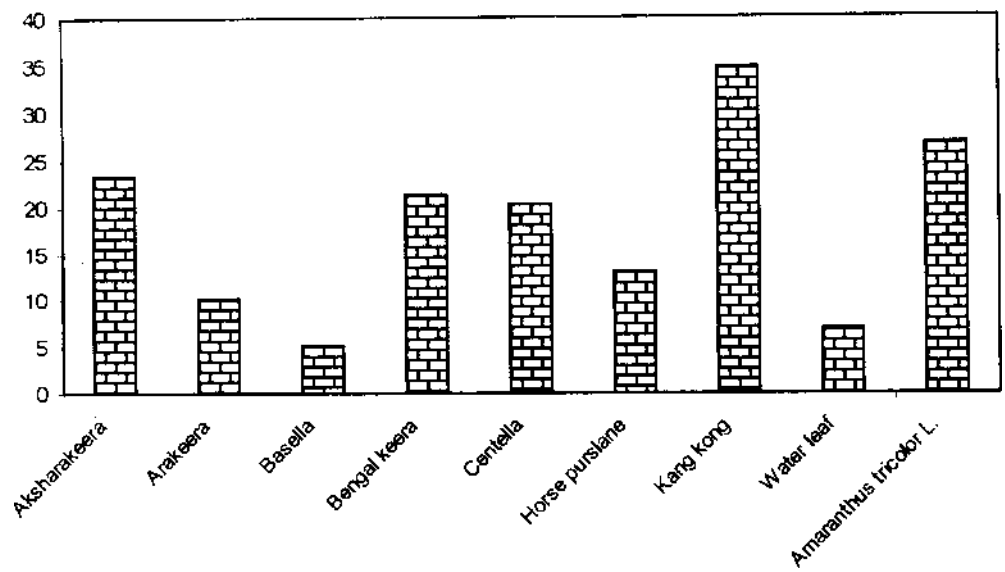


Fig.9. Mean iron content of different leafy vegetables (mg 100 g^{-1})

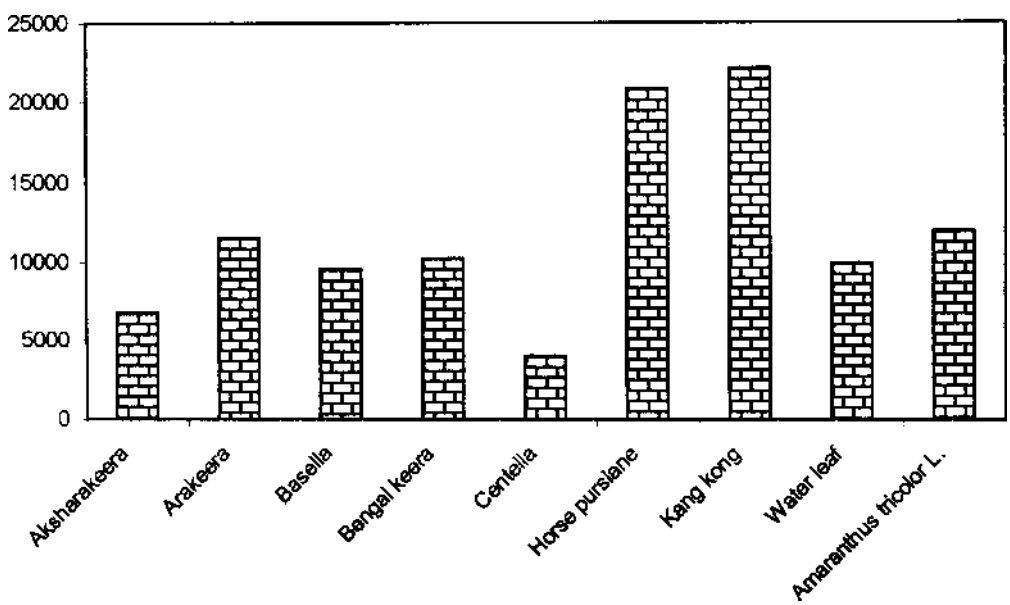


Fig.10. Mean beta-carotene content of different leafy vegetables (µg 100 g^{-1})

DMRT classified the leafy vegetables into seven classes. Two categories namely, abcd and d had two members each. *Amaranthus tricolor* was included in a separate group namely ab, which showed that the control variety is significantly different from other leafy vegetables in iron content statistically.

Iron content of leaves during summer season was found to range between 1.84 mg to 38.4 mg in waterleaf and kangkong respectively. *Amaranthus tricolor* had 6.88 mg of iron per 100 g of leaves during summer season and only kangkong had higher iron content than the control variety during summer season.

DMRT classified the different leafy vegetables into six categories on the basis of iron content during summer season. *Amaranthus tricolor* was included in a separate group (b), which showed that the control variety had significant difference from all the other leafy vegetables with respect to iron content during summer season.

During rainy season, the iron content of the leaves ranged between 8.25 mg to 40.96 mg with basella having the lowest and aksharakeera having the highest value. The iron content of the control variety was found to be the highest (46.60 mg 100 g^{-1}), than all the other leafy vegetables during rainy season.

According to DMRT, there were six categories of leafy vegetables based on the iron content during rainy season. The control variety was categorised as the best group (a) and the sole member of that group. This showed that the other leafy vegetables were statistically different from the control variety with respect to iron content during rainy season.

The mean iron content of eight leafy vegetables with that of *Amaranthus tricolor* is given in Figure 9.

Significant variation in iron content was observed (at 1% level) between the leafy vegetables during summer (F value 124.145) as well as rainy seasons

(F value 5.007), and between seasons in different leafy vegetables with respect to iron (F value 14.52).

4.1.10 Beta carotene

The mean beta carotene content of the leafy vegetables estimated on fresh weight basis are furnished in Table 10. The beta carotene content of the leafy vegetables during summer and rainy seasons are also furnished in the same table.

Table 10. Beta carotene content of different leafy vegetables (µg 100 g^{-1})

Sl.No.	Variety	Summer	Rainy	Mean
1	Aksharakeera	4977.01 [a]	8540.88 [c]	6758.94 [c]
2	Arakeera	16330.19 [a]	6806.91 [c]	11568.55 [abc]
3	Basella	3901.25 [a]	15241.77 [a]	9571.51 [bc]
4	Bengal keera	5733.80 [a]	14793.19 [ab]	10263.50 [abc]
5	Centella	4482.96 [a]	3531.87 [d]	4007.42 [c]
6	Horse purslane	29308.04 [a]	12365.64 [b]	20836.84 [ab]
7	Kang kong	35361.00 [a]	81933.27 [c]	22147.13 [a]
8	Water leaf	11236.34 [a]	8728.89 [c]	9982.61 [abc]
Control	*Amaranthus tricolor* L.	15063.97 [a]	8937.36 [c]	12000.66 [abc]

Values having different superscripts differ significantly at 5% level

The mean beta carotene content of 100 g of leaves ranged from 4007.42 µg to 22147 µg. The highest mean beta carotene content was observed in kangkong leaves and the lowest in centella. The control variety had been found to have a mean beta carotene content of 12000.66 µg 100 g^{-1}. kangkong and horse purslane contained an higher beta carotene content than the control variety.

According to DMRT, the different leafy vegetables were grouped into five categories. The leafy vegetables belonging to the same group had no significant difference between themselves but they differ from the leafy vegetables of other classes. The control variety was included along with three other leafy vegetables namely arakeera, bengalkeera and waterleaf in category abc. This shows that there

is no significant difference in the beta carotene content of these leafy vegetables, but they are significantly different from other leafy vegetables.

When the leafy vegetables were analysed during summer and rainy seasons, it was found that the beta carotene content ranged from 3901.25 (basella) to 35361 (kangkong) µg $100g^{-1}$ during summer season. *Amaranthus tricolor* contained 15063.97 µg 100 g^{-1} of beta carotene during summer season. The beta carotene content of kangkong, horsepurslane and Arakeera was found to be higher than the control variety.

Statistically, all the leafy vegetables including *Amaranthus tricolor* was categorised in a single group (a) on the basis of their beta carotene content during summer season, which showed that statistically there is no significant difference in the beta carotene content of the leafy vegetables selected for the study during summer season.

During rainy seson, the beta-carotene values varied from 15241.77 to 3531.87 µg 100 g^{-1} with basella having the highest and centella having the lowest values. The control variety contained 8937.36 µg 100 g^{-1} beta carotene during rainy season on fresh weight basis. Basella (15241.77 µg 100 g^{-1}), horsepurslane (20836.84 µg 100 g^{-1}) and bengal keera (14793.19 µg 100 g^{-1}) contained more beta carotene than *Amaranthus tricolor* during rainy season.

According to DMRT, the leafy vegetables selected for the study were classified into five groups, on the basis of beta carotene content during rainy season. The control variety was included in the fourth group (c) along with four other leafy vegetables namely, aksharakeera, arakeera, kang kong and water leaf, which indicated that there is no significant difference in their beta carotene content during rainy season.

The mean beta carotene content of eight leafy vegetables with that of *Amaranthus tricolor* is given in Figure 10.

The analysis of variance test revealed that the variation in beta carotene content of the leafy vegetables during summer as well as rainy season (F value 14.34) and between seasons (F value 1.12) were insignificant.

4.1.11 Vitamin C

The mean vitamin C content of the leafy vegetables varied from 51.77 mg to 127.27 mg 100 g^{-1}. The highest mean vitamin C content was observed in centella leaves and the lowest in bengal keera. The vitamin C content of the control variety was found to be 123.51 mg 100 g^{-1} on FWB. Except centella, the vitamin C content of all the other leafy vegetables was found to be lower than the control variety.

On the basis of vitamin C content, the leafy vegetables were statistically classified into six categories, the first group (a), third group (b) and the sixth group (d) accomodating only one leafy vegetable each. The control variety was included in category 'ab' along with two other leafy vegetables namely arakeera and basella. This shows that these three varieties are not statistically different from each other but different from other leafy vegetables.

Table 11. Vitamin C content of different leafy vegetables (mg 100 g^{-1})

Sl.No.	Variety	Summer	Rainy	Mean
1	Aksharakeera	57.00 ^{d}	70.47 ^{c}	63.74 ^{cd}
2	Arakeera	100.86 ^{b}	106.87 ^{b}	103.86 ^{ab}
3	Basella	84.31 ^{c}	141.52 ^{a}	112.91 ^{ab}
4	Bengal keera	24.29 ^{e}	79.24 ^{c}	51.77 ^{d}
5	Centella	132.90 ^{a}	121.64 ^{ab}	127.27 ^{a}
6	Horse purslane	78.19 ^{c}	77.63 ^{c}	77.91 ^{c}
7	Kang kong	70.66 ^{cd}	82.02 ^{c}	76.34 ^{c}
8	Water leaf	82.54 ^{c}	121.64 ^{ab}	102.09 ^{b}
Control	*Amaranthus tricolor* L.	110.46 ^{b}	136.55 ^{a}	123.51 ^{ab}

Values having different superscripts differ significantly at 5% level

The vitamin C content of the leaves when analysed during summer varied from 24.29 mg (bengal keera) to 132.90 mg 100 g^{-1} (centella). The control variety had a vitamin C content of 110.46 mg 100 g^{-1}. Only centella leaves contained higher vitamin C values than the control variety.

On the basis of the vitamin C content, the leafy vegetables were grouped statistically into six classes during summer season. The second and third groups namely 'b' and 'c' had two and three members respectively. *Amaranthus tricolor* was grouped along with arakeera which showed that the control variety is statistically different from all the other leafy vegetables selected for the study except arakeera in its vitamin C content during summer season.

The vitamin C content of the leaves during rainy season varied from 70.47 mg to 141.52 mg 100 g^{-1}. The highest vitamin C value was found in basella leaves and the lowest in aksharakeera. *Amaranthus tricolor* contained 136.55 mg of vitamin C per 100 g during rainy season which was found to be higher than all the other leafy vegetables except basella leaves.

Statistically, the different leafy vegetables were grouped into four groups on the basis of vitamin C content during rainy season. The group A included the control variety, *Amaranthus tricolor* along with basella which were grouped as the best leafy vegetable with respect to vitamin C content during rainy season. All the other leafy vegetables are statistically different from the control variety.

The mean vitamin C content of the eight leafy vegetables with the that of *Amaranthus tricolor* is given in Figure 11.

Statistical analysis indicated significant variation in vitamin C content of the leaves during summer (F value 35.598) and rainy season (F value 14.34) (at 1% level) and between seasons (F value 7.31) (at 5% level).

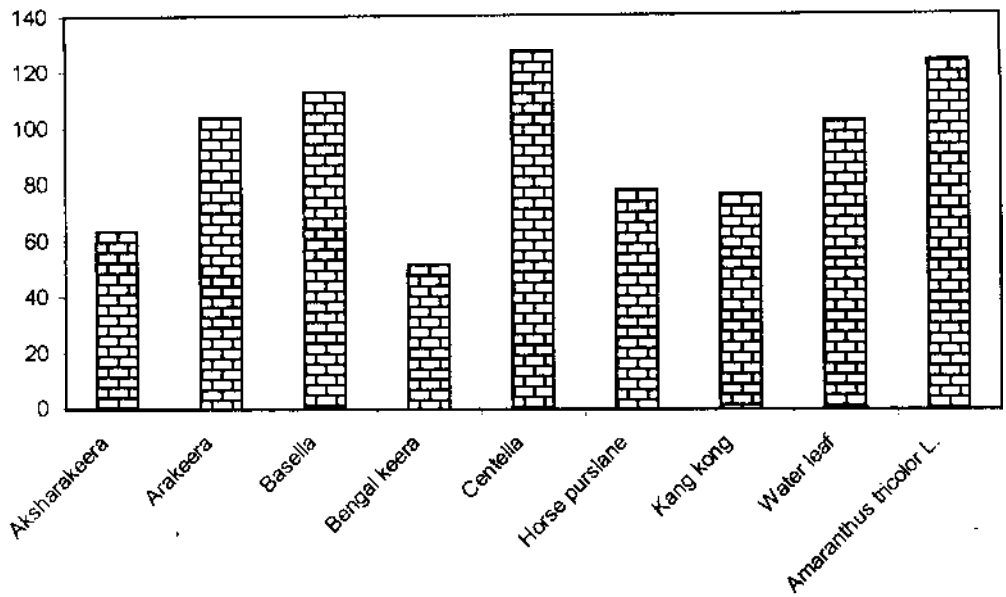


Fig.11. Mean vitamin C content of different leafy vegetables (mg 100 g^{-1})

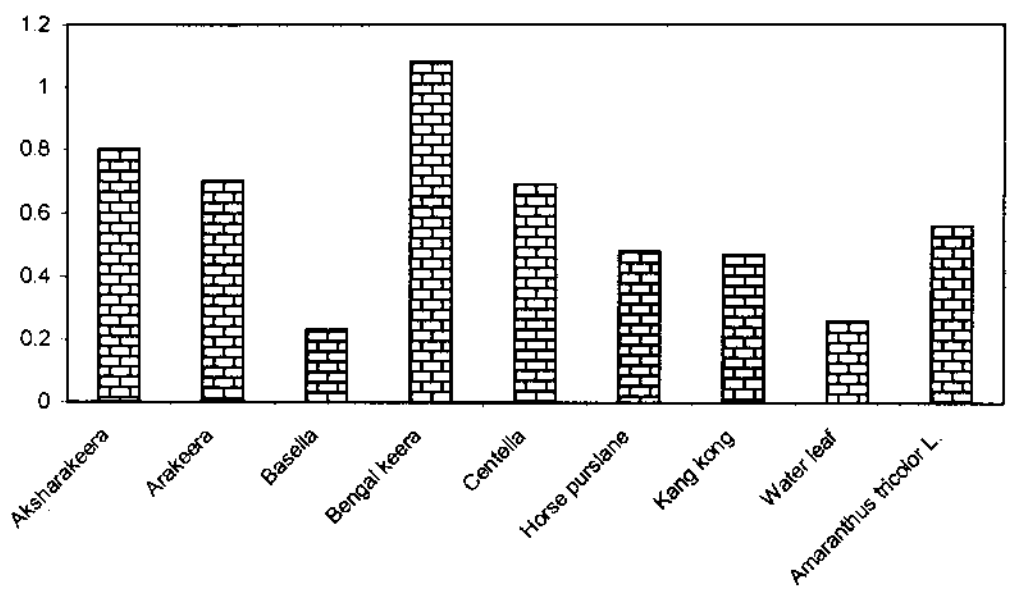


Fig.12. Mean oxalate content of different leafy vegetables (g 100 g^{-1})

4.1.12 Average nutritive value

The average nutritive value of the leafy vegetables varied from 16.32 to 37.65. The highest value was obtained for the control and the lowest for horse purslane. Average nutritive value of the leafy vegetables during summer and rainy seasons, as well as the mean value are provided in Table 12.

Table 12. Average nutritive value of different leafy vegetables

Sl.No.	Variety	Summer	Rainy	Mean
1	Aksharakeera	12.75	35.20	23.98
2	Arakeera	23.57	20.07	21.82
3	Basella	9.20	24.03	16.62
4	Bengal keera	14.13	40.24	27.19
5	Centella	16.37	28.50	22.44
6	Horse purslane	15.23	17.41	16.32
7	Kangkong	31.70	29.41	30.56
8	Water leaf	15.85	21.29	18.57
Control	*Amaranthus tricolor* L.	35.29	40.02	37.66

During summer season, average nutritive value of the leafy vegetables varied from 9.20 in basella to 35.29 in the control variety. Kangkong came next to the control variety, with an average nutritive value of 31.7.

During rainy season also, the highest average nutritive value belonged to the control variety (40.02). Horse purslane had the lowest average nutritive value during rainy season (17.41).

It can be seen that, for most of the leafy vegetables, the average nutritive value during rainy season, was higher than the summer season. Exceptions were arakeera and kangkong, for which only a slight increase in average nutritive value was observed during summer season.

4.2 Anti-nutritional factors in leafy vegetables

The leafy vegetables selected for the study were analysed for anti-nutritional factors namely oxalate and nitrate contents and the values obtained were compared with the oxalate and nitrate contents of the control variety, *Amaranthus tricolor* L. and the results are furnished below.

4.2.1 Oxalate

The mean oxalate content of the selected leafy vegetables are given in Table 13. The oxalate content of the leafy vegetables during summer and rainy seasons are also given in the same table.

The mean oxalate content of the leaves varied from 0.23 g to 1.08 g 100 g^{-1}. The highest oxalate content was found to be present in bengal keera and the lowest in basella leaves. The oxalate content of *Amaranthus tricolor* was found to be 0.56 g 100 g^{-1}. Four leafy vegetables namely aksharakeera (0.80%), arakeera (0.70%), bengal keera (1.08%) and centella (0.69%) had higher oxalate contents than the control variety.

According to DMRT, the different leafy vegetables were categorised into four groups based on oxalate content. Except the first group (a), all the other groups consisted of two or three members. The control variety was placed in the third group (c), along with horse purslane and kangkong. Thus, the leafy vegetables selected for the study except these two leafy vegetables differed significantly from *Amaranthus tricolor* in oxalate content.

When the leafy vegetables were analysed during summer and rainy seasons for oxalate contents, it was found that during summer season, the oxalate content varied from 0.27 g in basella leaves to 1.25 g 100 g^{-1} in bengal keera. *Amaranthus tricolor* contained 0.62 g of oxalate per 100 g of leaves. Four leafy

vegetables namely aksharakeera (0.78%), arakeera (0.86%), bengal keera (1.25%) and centella (0.68%) had higher oxalate content than control variety.

The different leafy vegetables were classified into six groups during summer season, on the basis of oxalate content. The control variety belonged to the fourth group (d) along with centella leaves. All the other leafy vegetables had statistically significant difference from the control variety with respect to oxalate content.

During rainy season, the oxalate content of the leafy vegetables ranged between 0.18 per cent in basella leaves to 0.91 per cent in bengal keera. The control variety had higher oxalate contents during rainy season than basella (0.18%), horsepurslane (0.45%), kangkong (0.43%) and water leaf (0.23%).

DMRT classified the different leafy vegetables into eight groups based on their oxalate content during rainy season. Each group had only one member except the last group (g) which consisted of basella and water leaf. The fifth group contained the control variety, *Amaranthus tricolor*. On the basis of oxalate content during rainy season, all the leafy vegetables differed significantly from the control variety.

The mean oxalate content of eight leafy vegetables with that of *Amaranthus tricolor* is given in Figure 12.

Table 13. Oxalate content of different leafy vegetables (g 100 g^{-1})

Sl.No.	Variety	Summer	Rainy	Mean
1	Aksharakeera	0.78^{c}	0.83^{b}	0.80^{b}
2	Arakeera	0.86^{b}	0.53^{d}	0.70^{b}
3	Basella	0.27^{f}	0.18^{g}	0.23^{d}
4	Bengal keera	1.25^{a}	0.91^{a}	1.08^{a}
5	Centella	0.68^{d}	0.70^{c}	0.69^{d}
6	Horse purslane	0.50^{e}	0.45^{ef}	0.48^{c}
7	Kang kong	0.51^{e}	0.43^{f}	0.47^{c}
8	Water leaf	0.28^{f}	0.23^{g}	0.26^{d}
Control	*Amaranthus tricolor* L.	0.62^{d}	0.50^{dc}	0.56^{c}

Values having different superscripts differ significantly at 5% level

The analysis of variance with respect to oxalate contents indicated significant variation between the varieties during summer (F value = 163.179) as well as rainy (F value = 206.976) seasons. However, the variation in oxalate content was found to be insignificant between summer and rainy seasons (F value = 0.02).

4.2.2 Nitrate

Nitrate content of eight leafy vegetables and the control variety was estimated and the results are furnished in Table 14. The mean nitrate content ranged between 0.11 per cent in basella leaves to 0.35 per cent in kangkong. *Amaranthus tricolor* which was selected as the control variety had the highest (0.68%) mean nitrate values than all the other leafy vegetables selected for the study.

On the basis of the mean nitrate content the different leafy vegetables were grouped into four groups namely, a, b, bc and c. The control variety was included as the sole member of the first group a. The other two groups except 'bc' had also only one member each. Thus the leafy vegetables selected for the study differed significantly from the control variety in the mean nitrate content.

The nitrate content of the leaves during summer season varied from 0.11 per cent to 0.53 per cent. The highest value was observed in kangkong and the lowest in basella leaves. The control variety had the same (0.53%) nitrate content as that of kangkong.

According to DMRT, the different leafy vegetables were grouped into five categories during summer season. All the groups except 'bc' contained two members each. The control variety was included in the first group 'a', along with kangkong, which showed that the leafy vegetables selected for the study except kangkong differed significantly from the control variety, *Amaranthus tricolor* during summer season.

During rainy season, the nitrate content ranged from 0.11 g to 0.54 g 100 g^{-1} in basella leaves and bengal keera respectively. The control variety had the highest nitrate content (0.83%) during rainy season than all the other leafy vegetables selected for the study.

The different leafy vegetables selected for the study were categorised into seven groups, based on nitrate content during rainy season. The last group 'e' contained three members, where as all the other groups contained only one member. The control variety, belonged to the first group 'a', showing that all the other leafy vegetables differed significantly from the control, in nitrate content during rainy season.

The mean nitrate content of eight leafy vegetables with that of *Amaranthus tricolor* is given in Figure 13.

Table 14. Nitrate content of different leafy vegetables (g 100 g^{-1})

Sl.No.	Variety	Summer	Rainy	Mean
1	Aksharakeera	0.20^{cd}	0.19^{cde}	0.20^{bc}
2	Arakeera	0.43^{ab}	0.13^{e}	0.28^{bc}
3	Basella	0.11^{d}	0.11^{e}	0.11^{c}
4	Bengal keera	0.32^{bc}	0.54^{b}	0.43^{b}
5	Centella	0.49^{ab}	0.15^{c}	0.32^{bc}
6	Horse purslane	0.12^{d}	0.36^{c}	0.24^{bc}
7	Kang kong	0.53^{a}	0.17^{de}	0.35^{bc}
8	Water leaf	0.20^{cd}	0.33^{cd}	0.27^{bc}
Control	*Amaranthus tricolor* L.	0.53^{a}	0.83^{a}	0.68^{a}

Values having different superscripts differ significantly at 5% level

Analysis of variance revealed significant variation in nitrate content (1%) between the varieties during summer (F value = 8.699) and rainy (F value = 20.018) seasons. The variation in nitrate content between summer and rainy season (F value = 0.02) was found to be insignificant.

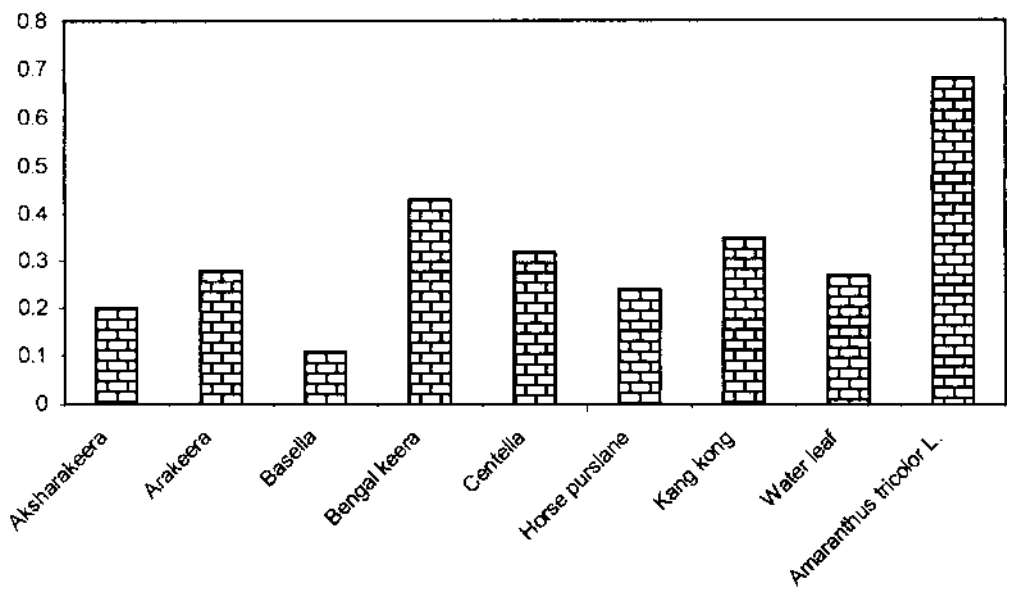


Fig.13. Mean nitrate content of different leafy vegetables (g 100 g^{-1})

4.3 Acceptability of the leafy vegetables

The acceptability studies of the leafy vegetables during summer and rainy season were assessed by score card method. Each character was scored using a five point hedonic scale by a panel of ten judges for five quality attributes namely, appearance, colour, flavour, texture and taste. The scores obtained for the acceptability test were compared with the score for *Amaranthus tricolor* which was selected as the control variety. The five quality attributes were described as a five point scale and the total score was obtained out of twenty five. The mean scores obtained for different leafy vegetables during summer and rainy season are furnished in Tables 15 and 16 respectively.

From Table 15, it can be seen that the mean scores for appearance was highest in arakeera (4.15) and lowest in aksharakeera (3.25) among the eight leafy vegetables selected for the study. The control variety obtained a highest score (4.55) than all the other leafy vegetables for appearance during summer season.

For the second quality attribute namely colour, the mean scores ranged from 3.2 to 4 during summer season. The lowest score was assigned to water leaf and the highest for aksharakeera. However, the control variety, *Amaranthus tricolor* had the highest score (4.5), when the quality colour was examined.

The scores for flavour, varied from 2.8 (centella) to 4 (arakeera). The control variety had a mean score of 3.95, during summer season which was found to be the highest.

In texture, the scores varied from 2.55 to 4.05, with horsepurslane and arakeera having the highest and lowest scores respectively, during summer season. The control variety had a mean score of 3.9.

The mean scores for taste during summer season were found to be highest for kangkong (3.95) and lowest for horsepurslane (3.05). *Amaranthus tricolor* had the highest score of 4.25 for the quality attribute taste, during summer season.

When the total scores for all the quality attributes were considered, the scores ranged from 16.30 to 18.90, with water leaf and arakeera having the lowest and highest scores respectively, during summer season. The control variety was found to be the best in acceptability with an highest score of 21.15.

Statistical analysis of the data revealed that significant difference at one per cent level (probability 0.0002) existed in the acceptability of the leafy vegetables selected for the study during summer season.

As can be seen from Table 16, during rainy season the mean scores for appearance varied from 3 (horse purslane) to 3.65 (basella). The control variety obtained the highest mean score (4.75) during rainy season.

In colour, the centella was found to have the highest score (3.15) while arakeera had the lowest score (2.8). The control variety had the highest mean score (4.3) for colour during rainy season.

The mean scores for flavour varied from 2.8 for horsepurslane to 3.45 for bengal keera. The control variety had the highest score of 4.2 for the third attribute namely flavour during rainy season.

The mean scores for texture ranged in between 2.25 and 3.85 during rainy season. The highest score was for bengalkeera and the lowest for horsepurslane. *Amaranthus tricolor*, had a mean score of 3.8, during rainy season.

The score for taste varied from 2.65 for kangkong to 3.85 for aksharakeera and the control variety.

Taking the total scores for the different quality attributes of leafy vegetables selected for the study, it was found that the scores varied from 14.25 (bengal keera) to 17.85 during rainy season, the highest total score was obtained for bengal keera and the lowest for horsepurslane. The control variety had the highest total score of 20.9 than all the other leafy vegetables selected for the study during rainy season.

When the data was analysed statistically, it was found that there is significant difference at one per cent level (probability 0.002) in the overall acceptability of the leafy vegetables selected for the study during rainy season.

Table 15. Organoleptic evaluation of leafy vegetables during summer season

Sl.No.	Variety	Mean score					
		Appearance	Colour	Flavour	Texture	Taste	Total
1	Aksharakeera	3.25	4.00	3.55	3.30	3.15	18.55
2	Arakeera	4.15	3.70	4.00	4.05	3.60	18.90
3	Basella	3.85	3.70	3.25	3.95	3.55	18.30
4	Bengal keera	3.60	3.95	3.70	3.90	3.50	18.55
5	Centella	3.60	3.85	2.80	2.55	3.85	16.65
6	Horse purslane	3.60	3.35	3.35	3.25	3.05	16.65
7	Kang kong	3.60	3.35	3.40	3.65	3.95	17.95
8	Water leaf	3.40	3.20	3.10	3.30	3.25	16.30
Control	*Amaranthus tricolor*	4.55	4.50	3.95	3.90	4.25	21.15

Table 16. Organoleptic evaluation of leafy vegetables during rainy season

Sl.No.	Variety	Mean score					
		Appearance	Colour	Flavour	Texture	Taste	Total
1	Aksharakeera	3.25	3.10	3.15	3.60	3.85	16.20
2	Arakeera	3.45	2.80	2.90	3.20	3.10	15.65
3	Basella	3.65	3.45	3.20	3.40	3.75	17.50
4	Bengal keera	3.50	3.55	3.45	3.85	3.65	17.85
5	Centella	3.55	3.95	3.35	2.50	3.60	16.95
6	Horse purslane	3.00	3.20	2.80	2.25	2.90	14.25
7	Kang kong	3.55	3.65	3.20	3.65	2.64	16.80
8	Water leaf	3.60	3.75	3.40	2.50	3.15	16.60
Control	*Amaranthus tricolor*	4.75	4.30	4.20	3.80	3.85	20.90

Cluster analysis of the leafy vegetables

On the basis of cluster analysis arakeera, centella, horse purselane and kangkong were grouped along with the control variety in the first cluster. Basella and waterleaf were placed in cluster II, while aksharakeera and Bengal keera were placed in cluster III.

The cluster means of cluster I for protein, soluble carbohydrates, phosphorus, beta-carotene and nitrates were 3.32 g 100 g^{-1}, 1.51 g 100 g^{-1}, 10.59 g 100 g^{-1} and 14112.12 µg 100 g^{-1} respectively.

In cluster II, the cluster means for moisture and vitamin C contents were 92.73 per cent and 107.5 mg 100 g^{-1} respectively.

The cluster means of cluster III for fat, fibre, starch, calcium, iron and oxalate were 0.46 per cent, 2.70 per cent, 1.63 per cent, 116.48 per cent 22.36 per cent and 0.94 per cent respectively.

Considering the inter cluster distance, it can be seen that the members of cluster I and cluster III differ very much. This may be due to the higher oxalate content of aksharakeera and bengal keera.

When the intra cluster distance was considered, more variation was observed among the members of cluster I. This may be due to the more number of leafy vegetables included in this cluster. Members of cluster II viz. basella and water leaf exhibited the least intra cluster distance, showing similarity in chemical composition.

DISCUSSION

5. DISCUSSION

The study on "Quality attributes of selected leafy vegetables" was attempted to assess the nutritional composition, antinutritional factors and the acceptability of eight varieties of leafy vegetables. The commonly consumed leafy vegetables viz., Amaranth (*Amaranthus tricolor*) was taken as the control variety to compare the various quality attributes of the eight unconventionally used leafy vegetables.

The leafy vegetables were analysed for different nutrients like moisture, protein, fat, fibre, starch, soluble carbohydrates, calcium, iron, phosphorus, beta carotene and vitamin C. The anti-nutritional factors like oxalates and nitrates present in these leafy vegetables were also analysed. The acceptability of the leafy vegetables was assessed through organoleptic evaluation, using score card, based on a five point hedonic scale, for different parameters like appearance, colour, flavour, texture and taste. All the above attributes were assessed during summer and rainy seasons. The results of the study are discussed under the following headings.

1. Nutritional composition of leafy vegetables
2. Anti-nutritional factors in leafy vegetables
3. Acceptability of leafy vegetables

5.1 Nutritional composition of leafy vegetables

The mean moisture content of eight leafy vegetables ranged from 78.98 to 92.78 per cent. The control variety had a moisture content of 86.66 per cent. The moisture content of selected leafy vegetables including the control variety was found to be in accordance with the values reported by Kaur and Manjrekar (1975), Sreeramulu (1982) Wills *et al.* (1984a), Wills *et al.* (1984b), Islam *et al.* (1987), Jijiamma (1989), Prakash *et al.* (1993), Akpanyung *et al.* (1995), Shingade *et al.* (1995), Shankaracharya (1998), Varalakshmi (1998), Nambiar and Seshadri (1998)

and Longvah (2000) for different leafy vegetables. However, Philip *et al.* (1981) and Neeliyara (1998) observed lower moisture content in curry leaves (66.3%) and winged bean leaves (59.8%) respectively.

The mean moisture content of all the leaves was found to be significantly different from each other except horse purslane and kangkong, as well as water leaf and basella in which the moisture content was found to be almost similar. The moisture content of *Amaranthus tricolor*, was also found to be significantly different from all the other leafy vegetables selected for the study. The mean moisture content of selected leaves was found to be higher than the moisture content of leafy vegetables commonly used by Keralites like amaranth (87.0%), chekkurmanis (73.6%), drumstick leaves (75.9%), curry leaves (63.8%) etc. as reported by Gopalan *et al.* (1989).

When the leaves were analysed during two seasons, it was found that most of the leafy vegetables differed significantly in moisture content during rainy as well as summer seasons, but the variation between two seasons was found to be insignificant. During summer season, the moisture content of arakeera and centella as well as basella and waterleaf was found to be almost similar. The moisture content of arakeera was found to be similar in summer and rainy seasons. The moisture content of amaranth was found to be 86.43 and 86.89 per cent during summer and rainy seasons respectively. These values were found to be significantly different from all the other leafy vegetables during summer and from aksharakeera, basella, bengalkeera and water leaf during rainy season.

Among the different leafy vegetables studied, the control variety was found to be the best with respect to its mean protein content (3.19%) which was found to be significantly different from all the other leafy vegetables selected for the study. The mean protein content of the leaves varied from 1.20 per cent in basella leaves to 3.13 per cent in kangkong on FWB. This was found to be almost similar to the protein content of chekkurmanis, amaranth, spinach, drumstick

leaves, curry leaves and *Atriplex triangularis* leaves as reported by various authors like Peter (1979), Menon (1980), Ramachandran *et al.* (1980), Philip *et al.* (1981), Islam (1987),.Gopalan *et al.* (1989), Prakash *et al.* (1993), Shingade *et al.* (1995), Raja *et al.* (1997) and Shankaracharya (1998). However, the protein content of the leaves was found to be lower than the values reported by NAS (1975), Kantha *et al.* (1978) and Neeliyara (1998) who reported a protein content of 5.7 to 15 per cent, 4.5 to 11.8 per cent and 3 to 4 per cent in various genotypes of winged bean leaves on DWB. Bressani *et al.* (1988) reported the protein content of amaranth as 4.4 per cent which was found to be higher than the protein content of *Amaranthus tricolor*, the control variety selected for the present study (3.19%).

Regarding the mean protein content in different leaves, no significant variation was observed between aksharakeera and kangkong and also between basella and waterleaf. All the other leafy vegetables differed significantly in protein content. During summer season, the protein content of Arakeera and centella as well as basella and waterleaf was found to be similar. During rainy season, kangkong leaves could be grouped along with the control variety having the highest protein content. Next came aksharakeera, arakeera, bengalkeera and centella whereas the third group consisted of basella, horsepurslane and waterleaf.

The leafy vegetables differed between themselves in protein content during both seasons while the variation in protein content was found to be insignificant between the seasons. This finding is in accordance with the results of Jijiamma(1989)in which the author observed that seasonal variation had no effect on the protein content of red and green Amaranthus.Protein content of amaranth was 3.03 per cent and 3.34 per cent during summer and rainy seasons respectively. In summer, all the leafy vegetables differed significantly from the control variety with aksharakeera and bengalkeera having higher protein content than the control variety. During rainy season the protein content of kangkong and amaranth was observed to be almost similar with the highest protein content and all the other

Kaur and Manjrekar (1975), Ramachandran *et al.* (1980), Philip *et al.* (1981), Gopalan (1982), Bressani *et al.* (1988), Gaopalan *et al.* (1989), NIN (1995a), Shingade *et al.* (1995) and Shankaracharya (1998) for various leafy vegetables like mustard greens, spinach, mint, coriander leaves, chekkurmanis leaves, curry leaves, amaranth, gogu, bacchali and tender tamarind leaves in which the fibre content varied from 0.7 to 6.4 per cent. Similar values were reported by Wills *et al.* (1984a), Wills *et al.* (1984b) and Aletor and Adeogun (1995) for the leafy vegetables in Australia,China and Nigeria respectively. However, Guerrero and Isasa (1997) observed a slightly higher fibre content (4 to 6%) for chenopodium leaves.

The fibre content of kangkong (*Ipomoea acquatica*) in the present study (1.49%) was found to be similar to the fibre content of *Ipomoea acquatica* leaves as reported by Shingade *et al.* (1995). However, the fibre content of kangkong and *Amaranthus tricolor* was lower than the values (3 and 4.6%) reported by Wills *et al.* (1984b) for the fibre content of kangkong leaves and amaranth leaves cultivated in Australia. This may be due to the variation in the time of harvest of the leaves or in the selection of edible portion of the leaves.

When the fibre content of the leafy vegetables during summer was considered, centella got the highest value of 5.94 per cent. Arakeera was significantly similar to the control variety. Bengalkeera and horsepurslane as well as kangkong and waterleaf were significantly similar in fibre content. All other leafy vegetables exhibited significant difference between themselves.

During rainy season, the highest fibre content was observed for bengalkeera (2.96%). Horse purslane had similar fibre content as that of the control variety. Arakeera, basella and water leaf were also found to be similar with the lowest fibre content among the different leaves. No significant variation was seen in fibre content between summer and rainy seasons which was in accordance with the results obtained by Jijiamma(1989) in red and green Amaranthus.

The mean starch content of the leafy vegetables was in between 0.07 per cent and 1.70 per cent with bengalkeera having the highest content and waterleaf having the lowest. The control variety *Amaranthus tricolor*, contained only 0.17 per cent of starch. This finding is in line with the finding of Wills *et al.* (1984b) for *Amaranthus tricolor*, in which the authors observed a starch content of 0.2 per cent. However, John *et al.* (1987) observed a higher starch content of 0.73 per cent in *Amaranthus tricolor*. Contradictory to the present findings of 0.64 per cent starch in kangkong, Wills *et al.* (1984a) reported the absence of starch in kangkong leaves grown in China.

Starch content during summer season was highest in bengalkeera and lowest in centella. Aksharakeera and arakeera got similar values for starch content. Basella and horse purslane were significantly similar to the control variety. Variation between kangkong and waterleaf was also found to be insignificant with respect to starch content.

The highest starch content during rainy season was observed in bengalkeera which was significantly similar to aksharakeera. The control variety was significantly similar to arakeera, basella, centella, kangkong and waterleaf.

Significant variation was observed in the starch content of the leaf varieties, between the two seasons with most of the leafy vegetables having higher starch content during rainy season. Exceptions were arakeera, waterleaf and the control variety, with only slight increase during summer season.

The mean soluble carbohydrate content of the selected leafy vegetables varied from 0.63 to 2.12 per cent with the control variety having a value of 1.32 per cent on fresh weight basis. This was higher than the total sugar contents in ten Indian green leafy vegetables including several varieties of amaranth and drumstick leaves reported by Rao *et al.* (1979) which varied from 2.78 g 100 g^{-1} to 4.78 g 100 g^{-1} on dry weight basis. It can be seen that the soluble carbohydrate

content of the leafy vegetables was in general higher than the starch content of the leafy vegetables. This is supported by the observations of Rao *et al.* (1979) who reported higher content of sugar compared to starch, in the leafy vegetables studied. The highest soluble carbohydrate content was observed in centella and the lowest in basella. All the leafy vegetables except arakeera, horse purslane and waterleaf differed significantly among themselves in mean soluble carbohydrate content.

In summer, the highest soluble carbohydrate content was observed in bengalkeera, which was similar to the content present in kangkong. Arakeera, horse purslane and waterleaf were also statistically similar in soluble carbohydrate content. All other leafy vegetables including the control variety showed significant variation among themselves.

Soluble carbohydrate content during rainy season was highest in centella and the lowest in aksharakeera which was significantly similar to basella. Arakeera and bengalkeera were significantly similar to the control variety, amaranth. Horse purslane and kangkong also showed significant similarity in soluble carbohydrate content during rainy season.

Between the two seasons, no significant variation was seen in the soluble carbohydrate content of the leafy vegetables.

The mean calcium content of the leafy vegetables varied from 13.42 mg 100 g^{-1} to 135.20 mg 100 g^{-1}on fresh weight basis. The highest and lowest values were for bengalkeera and basella. These observations were found to be almost similar to the reported values of 70 to 280 mg g^{-100} in several green leafy vegetables by Smith (1982) and in mustard, cabbage, amaranth and garland chrysanthemum grown in China by Wills *et al.* (1984b). In contrast to the findings of the present study, Swaminathan (1974), Rao *et al.* (1979), Gopalan (1982) and Menon (1990) observed 440 mg of calcium in 100 g of drumstick leaves. The

calcium content of *Amaranthus tricolor* was found to be lower than the values reported by Swaminathan (1974) and Gopalan *et al.* (1989) (397 mg 100 g^{-1}) in amaranth and by Reddy (1999) in various green leafy vegetables and Aletor and Adeogun (1995) in Nigerian leafy vegetables.

The calcium content of various green leafy vegetables like amaranth, basella, waterleaf and winged bean leaves when expressed on dry weight basis varied from 24 mg 100 g^{-1} to 5410 mg 100 g^{-1} [Ifon and Bassir (1979), Faboya (1983), Lucas (1988) and Neeliyara (1998)]. The calcium content of the green leafy vegetables in the present study was found to be in accordance with these values.

Significant variation in calcium content was also observed between summer and rainy seasons with highest calcium during rainy season. This was found to be contradictory to the findings of Jijiamma (1989) in which the author observed significantly high calcium content during summer season in Amaranthus.

The variation observed in various green leafy vegetables with respect to calcium content may be due to the variation in the locality or due to varietal difference.

With respect to mean phosphorus content, kangkong got the highest value of 13.84 mg 100 g^{-1} and basella got the least value of 6.48 mg 100 g^{-1}. The control variety came nearest to kangkong with a mean content of 12.59 mg 100 g^{-1}.

The phosphorus content of the leafy vegetables analysed in the present study is in accordance with the phosphorus content of drumstick leaves reported by Swaminathan (1974), Rao *et al.* (1979), Menon (1980) and Gopalan (1982). However, the values obtained in the present study are lower than the phosphorus content in *Amaranthus gangeticus* leaves as reported by Rajagopal *et al.* (1977), Mohideen *et al.* (1985) and Gopalan *et al.* (1989) and the phosphorus content of amaranth, lalo, *Acacia concinna*, trianthema, chenopodium, amaranth and tender

tamarind leaves as reported by Faboya (1983), Awasthi and Abidi (1985), Bawa and Yadav (1986), Lucas (1988), Chandrasekhar *et al.* (1990) and Shankaracharya (1998).

However, the present results were higher than the values of 0.21 to 0.71 mg 100 g^{-1} phosphorus on dry weight basis as reported by Ifon and Bassir (1979).

During summer season, the highest phosphorus content was observed in arakeera and lowest in water leaf.

In rainy season, the highest phosphorus content was for kangkong and the lowest for horsepurslane and waterleaf.

Significant variation was seen in the phosphorus content of the leafy vegetables during the two seasons. An increase in phosphorus content for all leafy vegetables was observed during rainy season which was found to be contradictory to the findings of Jijiamma (1989).

The control variety, *Amaranthus tricolor* was the second best with respect to iron content kangkong leaves came out as the best with an iron content of 34.75 mg 100 g^{-1} and basella had the lowest iron content (5.16 mg 100 g^{-1}).

The iron content of the leafy vegetables observed in the present study was in accordance with the iron content of different leafy vegetables like drumstick, chekkurmanis, *Beta vulgaris*, coriander, *Mentha spicata*, trianthema, chenopodium, *Amaranthus spinosus*, colocasia, fenugreek amaranth analysed in different parts of the country in which the values varied from 2 to 32.5 mg 100 g^{-1} [Swaminathan (1974), Choudhary and Rajendran (1980), Ramachandran *et al.* (1980), Reddy and Kulkarni (1986), Chawla *et al.* (1988), Chandrasekhar *et al.* (1990) and Shankaracharya (1998). The iron content of the control was also found to be almost similar to the values reported by Swaminathan (1974) and Menon

(1980). The iron content of arakeera was found to be much less than the iron content of arakeera reported by Gopalan (1989)(38.5 mg 100 g^{-1}).

All the leafy vegetables except bengalkeera and centella as well as basella and waterleaf differed significantly in the mean iron content.

Kangkong leaves showed the highest iron content during summer season also, whereas the lowest iron content was observed in waterleaf. Aksharakeera and bengalkeera, arakeera and centella as well as basella and waterleaf showed almost similar iron content during summer season.

During rainy season, the control variety amaranth exhibited the highest iron content of 46.6 per cent. Aksharakeera, bengalkeera and centella as well as arakeera and waterleaf showed statistically similar values during rainy season.

Significant variation was seen in the iron content of leafy vegetables during the two seasons which was found to be contradictory to the findings of Jijiamma (1989) in Amaranthus leaves in which the author observed that season does not influence the iron content of Amaranthus leaves. There was a remarkable increase in the iron content of all the leafy vegetables except kangkong during rainy season.

The higher calcium, phosphorus and iron content during rainy season in the selected leafy vegetables may be due to increased availability as well as uptake of minerals by the plants during rainy season.

Regarding beta-carotene content, the best leafy vegetable in the present study was identified as kangkong, with a mean conent of 22147.13 µg 100 g^{-1} and centella had the least value of 4007.42 µg 100 g^{-1}. The control variety came nearest to kangkong with a mean content of 12000.66 µg 100 g^{-1}.

The results were almost similar to the beta carotene content of different leafy vegetables such as amaranth, *Amaranthus spinosus*, drumstick, coriander, curry leaves, *Mentha spicata*, *Beta vulgaris*, mustard greens, spinach, agathi, *Rumex acetosa*, tender tamarind leaves and fenugreek leaves and reported by various authors like Swaminathan (1974), Kaur and Manjrekar (1975), Renquist *et al.* (1978), Rao *et al.* (1979), Choudhary and Rajendran (1980), Jayarajan *et al.* (1980), Menon (1980), Nambiar and Seshadri (1998), Shankarcharya (1998) and Reddy (1999). The findings were also in accordance with the values reported by Wills *et al.* (1984a) for Chinese leafy vegetables, Cnewya (1985) for Kenyan leafy vegetables, Rahman *et al.* (1990) for fourteen green leafy vegetables commonly consumed by the people of Bangladesh and Nordeide *et al.* (1996) for *Amaranthus viridis* a cultivated leafy vegetable in Southern Mali.

The mean beta carotene content of the control variety *Amaranthus tricolor* obtained in the present study was more than twice the values reported by Gopalan *et al.* (1989) (5520 µg 100 g^{-1}). This may be due to the varietal difference.

During summer season also the highest beta carotene content was observed in kangkong and the lowest in basella. No significant variation was observed between the leafy vegetables in beta-carotene content.

In rainy season, the highest beta-carotene content was observed in basella and the lowest in centella. Aksharakeera, arakeera, kangkong and waterleaf were grouped along with the control during rainy season. All the other leafy vegetables differed significantly during rainy season.

Variation in beta-carotene of the leafy vegetables between the two seasons was found to be insignificant. On the contrary (NIN, 1991) reported variation in beta-carotene content for certain leaves during summer, rainy and winter seasons.

The mean vitamin C contents in the different leafy vegetables ranged from 51.77 mg 100 g^{-1} in bengalkeera to 127.27 mg 100 g^{-1} in centella. The control variety came as second best leafy vegetable with respect to the mean vitamin C content. The vitamin C content of the various leafy vegetables observed in the present study was lower than the values reported by Peter (1979), Menon (1980), Nautiyal and Raman (1987), Gopalan *et al.* (1989) and Shingade *et al.* (1995) for drumstick leaves in which the vitamin C content varied from 220 to 229.9 mg 100 g^{-1}. However, the vitamin C content of most of the leafy vegetables was found to be similar to the values reported by Chandrasekhar *et al.* (1990) for tribal greens in which the content varied from 99 to 175.2 mg 100 g^{-1}, Placida and Meena (1991), Yadav and Sehgal (1997) and Reddy (1999) also reported high vitamin C content of 280 mg 100 g^{-1} in sauropus leaves, 220.97 to 377.65 mg 100 g^{-1} in bathua and fenugreek leaves and 120 to 220 mg 100 g^{-1} in amaranth, agathi, mustard, drumstick and broccoli leaves.

The vitamin C content of the control variety was found to be slightly higher than that was reported by Devadas *et al.* (1973), Gopalan *et al.* (1989) and Mosha *et al.* (1995) in which the values varied from 89 to 99 mg 100 g^{-1}. The ascorbic acid content obtained (76.34 mg 100 g^{-1}) was also found to be higher than the values reported by Shingade *et al.* (1995) (48.8 mg 100 g^{-1}) in kangkong leaves.

Several authors like Cadwell (1972), Keshinro and Ketiku (1979), Sreeramulu *et al.* (1983a), Wills *et al.* (1984b), Mathooka and Imungi (1994) and Achinewhu *et al.* (1995) from various parts of the world also reported almost similar vitamin C contents in different leafy vegetables, analysed in the present study.

Contradictory to the present findings, Neeliyara (1998) observed a very low vitamin C content of 12.16 mg 100 g^{-1} in five winged bean genotypes grown in Kerala.

During summer, highest vitamin C content was observed in centella and lowest in bengalkeera. The control variety was found to be statistically similar to arakeera during summer. Basella, horsepurslane and waterleaf were also found to have similar vitamin C content during summer.

Highest vitamin C content during rainy season was observed in basella, which was statistically similar to the control variety. Centella and waterleaf were found to have similar amount of vitamin C during rainy season. Aksharakeera, bengalkeera, horsepurslane and kangkong were also found to be statistically similar with respect to vitamin C content during rainy season.

Significant variation was observed in the vitamin C content of the leafy vegetables during summer and rainy seasons. There was an increase in the vitamin C content of most of the leafy vegetables during rainy season. This is in accordance with the finding of Jijiamma and Prema (1993) who observed higher ascorbic acid contents in Amaranth varieties during rainy season. This may be due to increased uptake of nutrients during rainy season by the plants.

5.2 Anti-nutritional factors in leafy vegetables

The mean oxalate content of the leafy vegetables in the present study varied from 0.23 g 100 g^{-1} to 1.08 g 100 g^{-1}. This finding was found to be in accordance with the mean oxalate content of different *Amaranthus* species as reported by Devadas *et al.* (1989), Prakash and Pal (1991), Prakash *et al.* (1993), Thamburaj *et al.* (1994) and Shingade *et al.* (1995), in which the values varied from 0.3 to 1.92 per cent. The control variety, *Amaranthus tricolor*, had an intermediate oxalate content of 0.56 g 100 g^{-1}, which was found to be slightly lower than the value of 0.75 per cent reported by Marderosian *et al.* (1979).

The average total oxalate content of basella and kangkong as reported by Schmidt *et al.* (1971) (2.81 and 1.5%) was slightly higher than the findings of the present study (0.23 and 0.47%).

The differences may be due to variation in soil fertility as stated by Schmidt *et al.* (1971) and Singh *et al.* (1973).

Highest oxalate content in summer and rainy season was observed in bengalkeera and the lowest in basella. Basella was statistically similar to waterleaf during summer and rainy seasons, in oxalate content. Horse purslane and kangkong as well as centella and amaranth were similar in oxalate content during summer. During rainy season, all leafy vegetables except basella and waterleaf differed significantly among themselves in oxalate content.

The variation in oxalate content between summer and rainy seasons was found to be insignificant.

The highest mean nitrate content was observed in the control variety (0.68%) and the lowest in basella (0.11%). The nitrate content of the selected leafy vegetables ranged between 0.11 and 0.43 per cent.

The nitrate content of amaranth in the present study was found to be in accordance with the value of 0.67 per cent obtained by Schmidt *et al.* (1971) for *Amaranthus cruentus* and by Prakash *et al.* (1993) for *Amaranthus hypochondriacus* (0.31 to 0.92%). However, Ebeling *et al.* (1995) observed a slightly higher nitrate content in the wild species of amaranthus.

The differences in nitrate content may be due to variation in soil fertility and in shading intensity as obseved by Kurien *et al.* (1976), Singh *et al.* (1985), Zandstra (1989) and Wu and Wang (1995).

Regarding the mean nitrate content, all the leafy vegetables except the control variety and bengalkeera was found to be having almost similar values.

Nitrate content during summer season was highest in the control variety along with kangkong. Aksharakeera and waterleaf, arakeera and centella as well as basella and horse purslane were similar in nitrate content during summer.

The control variety had the highest nitrate content during rainy season also. Arakeera, basella and centella were similar during rainy season with low nitrate value. All the other leafy vegetables were significantly different during rainy season. The nitrate content of all other leafy vegetables had statistically significant variation.

There was no significant variation in the nitrate content of the leafy vegetables, between summer and rainy seasons.

5.3 Organoleptic evaluation of leafy vegetables

The acceptability of the eight selected leafy vegetables and the control variety was determined using score card method. Attributes such as appearance, colour, flavour, texture and taste were the various criteria evaluated for this purpose.

Wide variation was seen in the acceptability of various leafy vegetables, but the control variety obtained the highest total score during both summer and rainy seasons. Among the selected leafy vegetables, the highest score was for arakeera during summer and bengalkeera during rainy season. The least acceptable leafy vegetables were waterleaf during summer and horse purslane during rainy seasons.

During both seasons, the attribute appearance had got the highest score. Next came colour, followed by flavour during rainy season and taste during summer. The least scores were for texture followed by taste during rainy season and for texture followed by flavour during summer.

This agrees with the observation of Neeliyara (1998) who got the least score for texture, when acceptability tests were conducted for the leaves of winged bean genotypes.

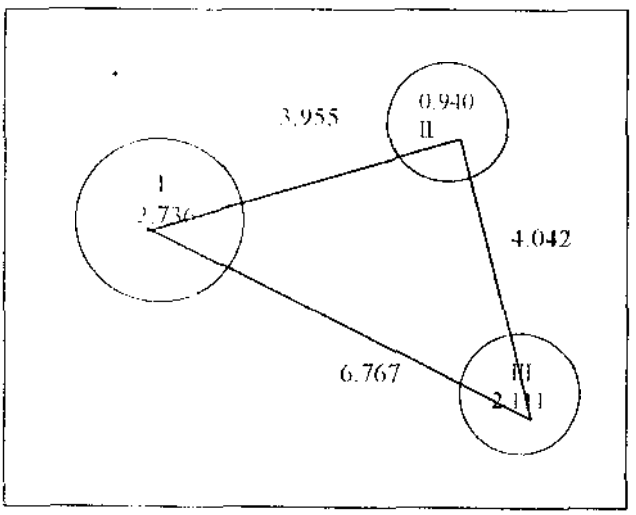
The overall acceptability of the different leafy vegetables during summer and rainy seasons suggested that the leafy vegetables are more acceptable during summer. Jijiamma and Prema (1993) also observed better acceptability for red and green Amaranthus during summer and rainy seasons.

The lower scores obtained for the selected leafy vegetables compared to the control variety may be due to the unfamiliarity of these less commonly used leafy vegetables.

Cluster analysis of the leafy vegetables

Hierarchial Euclidean Cluster Analysis was carried out to find out homogeneous groups of the leafy vegetables based on the nutrient and antinutrient composition of the selected leaves. Based on the analysis the leafy vegetables were grouped into three clusters as shown below

Figure 14. Cluster analysis of leafy vegetables



Cluster I : Arakeera, centella, horsepurslane, kangkong and amaranth

Cluster II : Basella and waterleaf

Cluster III : Aksharakeera and bengalkeera

The average intra and inter cluster distance matrix is shown in Table 17 and represented in Figure 14.

Table 17. Average intra and inter cluster distance matrix

Cluster No.	I	II	III
I	2.736		
II	3.955	0.940	
III	4.042	6.767	2.111

Note:- Values along the principal diagonal indicate the average distance of cluster members from cluster centroids.

The members of cluster I were high in protein, soluble carbohydrates, phosphorus, beta-carotene and nitrate content. The mean value of protein for the first cluster was 3.32 g 100 g^{-1}. Within the cluster, the protein content of the cluster members varied from 2.07 to 3 19 g 100 g^{-1}. Cluster mean for soluble carbohydrate content in cluster I was 1.506 g 100 g^{-1} which varied from 1.15 to 2.12 g 100 g^{-1} among the cluster members. Phosphorus content of cluster I was in between 7.18 mg and 13.84 mg 100 g^{-1} with a cluster mean of 10.592 mg 100 g^{-1}. For beta-carotene, the highest value in the cluster was 22147.13 µg 100 g^{-1} and the lowest was 4007.42 µg 100 g^{-1}. The cluster mean for beta-carotene content was 14112.12 µg 100 g^{-1}. The mean nitrate content for cluster I was 0.374 g 100 g^{-1}. The highest and lowest values for nitrate content within the cluster was 0.68 and 0.24 g 100 g^{-1}

The members of cluster II had high moisture and vitamin C contents, with cluster means of 92.725 per cent and 107.5 mg 100g^{-1} respectively. Moisture content of the cluster members varied from 92.78 to 92.67 per cent whereas the vitamin C content varied from 112.91 to 102.09 per cent.

Aksharakkera and bengal keera, the members of cluster III were high in fat, fibre, starch, calcium, iron and oxalate contents. The cluster means for these nutrients were 0.46 percent, 2.70 per cent, 1.63 per cent, 116.48 per cent, 22.36 per

cent and 0.94 per cent respectively. The fat content of the cluster members was in between 0.27 and 0.65 g per cent, fibre 2.35 and 3.04 g per cent, starch 1.56 and 1.7 g per cent, calcium 97.75 and 135.2 mg per cent, iron 21.36 and 23.36 mg per cent and oxalates 0.70 and 1.08 g per cent.

The first cluster which included the control, *Amaranthus tricolor* was highest in four nutrients.

Five leafy vegetables namely arakeera, centella, horse purslane and kangkong including the control variety *Amaranthus tricolour* may be considered as the best group with highest protein, soluble carbohydrates, phosphorus, beta-carotene and low oxalate content.

SUMMARY

6. SUMMARY

The study on "Quality attributes of selected leafy vegetables" was made to evaluate the nutrient and anti-nutrient composition as well as the acceptability of eight selected leafy vegetables along with the control variety amaranth, maintained in the Department of Olericulture, College of Horticulture, Kerala Agricultural University, Vellanikkara, Trichur. The eight leafy vegetables selected were aksharakeera, arakeera, basella, bengalkeera, centella, horsepurslane, kangkong and waterleaf.

The nutrient constituents such as moisture, protein, fat, fibre, starch, soluble carbohydrates, calcium, iron, phosphorus, beta carotene and vitamin C and the anti-nutrient constituents like oxalates and nitrates were estimated in the eight selected leafy vegetables along with the control during summer and rainy seasons. The acceptability of the selected leafy vegetables and control variety was also evaluated after cooking.

The study revealed that the mean moisture content of the selected leafy vegetables varied from 78.98 per cent to 92.78 per cent. The control variety had a moisture content of 86.66 per cent. The mean protein content of the leafy vegetables was in the range of 1.2 to 3.13 per cent on FWB and that of amaranth was 3.19 per cent. The mean fat content varied from 0.18 to 0.65 per cent on FWB. The control variety had a mean fat content of 0.30 per cent. Amaranthus had a low fibre content (1.5%) and the mean fibre content of the other leafy vegetables varied from 0.92 to 4.08 per cent.

The mean starch content of the eight leafy vegetables varied from 0.07 to 1.70 per cent with the control variety having a starch content of 0.17 per cent.

Soluble carbohydrate content of the leaf varieties was found to be higher than the starch content. It varied from 0.63 to 2.12 per cent in the selected leafy

vegetables on FWB. The control variety had a soluble carbohydrate content of 1.32 per cent.

Among the microelements, the calcium content varied from 13.42 to 135.2 mg per cent on FWB in the eight selected leafy vegetables, with Amaranth having a calcium content of 109.33 mg per cent.

The mean iron content of leafy vegetables ranged between 5.16 and 34.76 mg per cent on FWB. The control variety, had been found to have an iron content of 26.74 mg per cent.

Beta carotene and vitamin C are two vitamins abundant in fresh leafy vegetables. The mean beta carotene content of the leaves ranged from 4007.42 µg per cent to 22147 µg per cent. The control variety had a mean beta carotene content of 12000.66 µg per cent on FWB. The mean vitamin C content of the leafy vegetables varied from 51.77 mg per cent to 127.27 mg per cent, with the control variety having a mean vitamin C content of 123.51 mg per cent.

Average nutritive value of the leafy vegetables varied from 16.32 to 37.65 with *Amaranthus ticolor* having the highest and horse purslane with the lowest value.

Statistical analysis indicated significant variation between the leafy vegetables during summer and rainy seasons for all the different nutrients analysed.

Considering the anti-nutritional factors in leafy vegetables, the oxalate content varied from 0.23 to 1.08 per cent in the selected leafy vegetables on FWB. The control variety had a mean oxalate content of 0.56 per cent. The nitrate content of the leafy vegetables ranged between 0.11 per cent and 0.35 per cent on FWB, with Amaranth having a mean nitrate content of 0.68 per cent. The anti-nutritional factors in different green leafy vegetables when analysed during rainy and summer

seasons indicated significant variation in the oxalate and nitrate content between the leafy vegetables during summer as well as rainy season. However, the variation in oxalate and nitrate contents was found to be insignificant between summer and rainy seasons.

The acceptability of the selected leafy vegetables as well as the control was assured using a five point hedonic scale by ten judges. The attributes evaluated were appearance, colour, flavour, texture and taste. The total scores ranged from 16.3 to 18.9 for the selected leaves during summer and from 14.25 to 17.85 during rainy season. The control variety obtained total scores of 21.15 and 20.90 during summer and rainy seasons respectively. Significant variation existed between the leafy vegetables in acceptability. The leafy vegetables grown during summer was found to be more acceptable, organoleptically.

REFERENCES

REFERENCES

Achinewhu, S.C., Ogbonna, C.C. and Hart, A.D. 1995. Chemical composition of indigenous wild herbs, spices, fruits, nuts and leafy vegetables used as food. *Pl. Fds hum. Nutr.* **48**(4)

Ajayi, S.O., Oderinde, S.F. and Osibanjo, O. 1980. Vitamin C losses in cooked fresh leafy vegetables. *Fd Chem.* **5**:243-247

Akpanyung, E.O., Udoh, A.P. and Akpan, E.J. 1995. Chemical composition of the edible leaves of *Pterocarpus mildbraedii*. *Pl. Fds hum. Nutr.* **48**(3):209-215

Aletor, V.A. and Adeogun, O.A. 1995. Nutrient and anti-nutrient components of some tropical leafy vegetables. *Fd Chem.* **53**(4):3775-379

Alleman, J., Heever, E.V.D. and Viljoen, J. 1996. Evaluation of Amaranthus as a possible vegetable crop. *Appl. Pl. Sci.* **10**(1):1-4

Almazan, A.M. and Begum, F. 1996. Nutrients and antinutrients in peanut greens. *J. Fd Composition Analysis* **9**(4):375-383

Aman. 1969. *Medical Secretes of your food.* Indo American and Dr.M.A.Kline Memorial Hospital Charities Trust. P.307-390

A.O.A.C. 1955. *Official and Tentative Methods of Analysis.* 8th ed. Association of Official Agricultural Chemists, Washington, D.C.

A.O.A.C. 1970. *Official Methods of Analysis.* 11th ed. Association of Official Analytical Chemists, Washington, D.C.

A.O.A.C. 1980. *Official Methods of Analysis.* 13th ed. Association of Official Analytical Chemists, Washington, D.C.

Awasthi, C.P. and Abidi, A.B. 1985. Biochemical composition and nutritive value of some common leafy vegetables. *Prog. Hort.* **17**(2):118-121

Awoyinka, A.F., Abegunde, V.D. and Hdewusi, S.R.A. 1995. Nutrient content of young cassava leaves and assessment of their acceptance as a green vegetable in Nigeria. *Pl. Fds hum. Nutr.* **47**(1):21-28

Bawa, S.F. and Yadav, S.P. 1986. Protein and mineral contents of green leafy vegetables consumed by Sokoto population. *J. Sci. Fd Agric.* **37**(5):504-506

Beegum, A. and Pereira, S.M. 1990. The betacarotene content of Indian edible green leaves. *Indian J. med. Res.* **261**(1):677-697

Bodyfelt, F.W., Tobias, J. and Trout, G.M. 1988. *The Sensory Evaluation of Dairy Products*. AVI Publishing Co., New York

Bressani, R., Elias, L.G. and Bosque, C. 1988. The supplementary value of amaranth leaves to cereal grain based diets. *Amaranth News L.* **1**:1

Bressani, R., Ibanez, E. and Gonzalez, J.M. 1986. Small scale integrated Agricultural production – Family Farm. *Fd Nutr. Bull.* **8**(3):30-36

Bushway, R.J. and Bureau, J.L. 1986. HPLC determination of carotenoids in fruits and vegetables. *J. Fd Sci.* **51**(1):128-130

Cadwell, M.J. 1972. Ascorbic acid content of Malaysian leafy vegetables. *Ecol. Fd Nutr.* **1**(4):313-317

Castanedac, L., Surrez, G.R. and Valadezi, A. 1986. Evaluation of amaranth (*A. hypochordriacus*) as vegetable, in comparison with spinach (*Spinacia oleracea* L.). *Amaranth News L.* **3**:3

Chandrasekhar, U., Vasanthamani, G. and Thomas, A.K. 1990. Infant feeding and weaning practices among Irulas of Attapadi hills and Lambas of Katchuvadi hills. *Indian J. Nutr. Dietet.* **27**:175

Chawla, S., Saxena, A. and Seshadri, S. 1988. *In vitro* availability of iron in various green leafy vegetables. *J. Sci. Fd Agric.* **46**(1):125-27

Cheeke, P.R. and Bronson, J. 1980. Feeding trials with amaranthus grain, forage and leaf protein concentrates. *Proc. Second Amaranth Conf.*, Rodale Press, Inc. 33. East Minor Street, Emmaus. P.5-11

Chopra, S.L. and Kanwar, J.S. 1978. *Analytical Agricultural Chemistry.* Kalyani Publishers, Ludhiana

Choudhary, B. and Rajendran, R. 1980. Pusa Jyoti - a highly nutritive palak. *Indian Hort.* **25**(2):5

Cnewya, J.A. 1985. Identification and nutritional importance of indigenous green leafy vegetables in Kenya. *Acta Hort.* **153**:99

Davidson, S., Passmore, R. and Brook, J.F. 1973. *Human nutrition and dietetics.* Churchil Livingstone, Edinburgh

Deutsch, J.A. 1977. Genetic variation of yield and nutritional value in several *Amaranthus* species used as a leafy vegetable. Ph.D. thesis, Cornell University, Ithaca, New York

Devadas, R.P., Anuradha, V. and Chandrasekhar, U. 1969. Seasonal variations in the nutrient content of *Amaranthus flavus. Indian J. Nutr. Dietet.* **6**:305

Devadas, R.P., Chandrasekhar, U. and Kumari, K.S. 1973. Availability of iron from *Amaranthus* cooked in two different utensils. *Indian J. Nutr. Dietet.* **10**:223

Devadas, R.P., Murthy, N.K., Elizabeth, N. 1992. Absorption of iron from amaranthus to undernourished adolescents. *Am. J. clin. Nutr.* **53**(7):310-317

Devadas, R.P. and Saroja, S. 1979. Availability of iron and ß carotene from amaranth to children. *Proc. Second Amaranth Conf.*, Rodale Press, Inc. 33. East Minor Street, Emmaus, p.15-21

Devadas, V.S. 1982. Screening for non-bolting type of amaranthus suited for year round planting. M.Sc.(Hort.) thesis, Kerala Agricultural University, Trichur, Kerala

Devadas, V.S., Nair, M.V. and Peter, K.V. 1989. Genetic variability, correlation and path coefficient analysis in vegetable amaranthus. *Amaranth News l.*. 1(2):2-9

Devadatta, S.C. and Appanna, T.C. 1957. Availability of calcium in some of the leafy vegetables. *Proc. Ind. Acad. Sci.* **39**(6):236-242

Emiru, A. 1971. The cornea in Kwashiorkor. *Tropi. Geogr. Med.* **1**:118-134

Faboya, O.O.P. 1983. The mineral content of some green vegetables commonly found in the western part of Nigeria. *Fd Chem.* **12**(3):213-216

Fafunso, M. and Bassir, O. 1976. Protein quality of local vegetables: the comparitive assessment of the protein quality of Nigerian leafy vegetables with that of soyabean. *Pl. Fds Man.* **2**:1-41

Fassett, D.W. 1973. *Toxicants Occurring Naturally in Foods.* National Academy of Science, National Research Council, Washington, D.C. p.346-362

Fathima, A. and Begum, K. 1998. Dehydration characteristics of microwave dried greens. IFCON '98. 4th International Food Convention, Mysore, November 23-27. *Abstract of Poster Papers*, p.21

George, S.T. 1986. Studies on some important yield contributing and nutritive characters in leafy amaranth (*Amaranthus* spp.). Ph.D. thesis, Indian Agricultural Research Institute, New Delhi

George, S.T., Barat, G.K., Sivakami, N. and Choudhary, B. 1989. Source and variability for nutritive aspects in amaranth (*Amaranthus* sp.). *Indian J. agric. Sci.* **59**(4):274-275

Gopalan, C., Sastri, B.V.R. and Balasubramanian, S.C. 1989. *Nutritive value of Indian Foods*. National Institute of Nutrition, ICMR, Hyderabad. P.11-35

Gopalan, I. 1982. Nutrient rich drumstick leaves. *Nutr.* **16**(2):28-30

*Grubben, G.J.H. 1977. Tropical vegetables and their genetic resources.

*Guerrero, J.L.G. and Isasa, M.E.T. 1997. Nutritional composition of leaves of *Chenopodium* species (*C. album* L., *C. murale* L. and *C. opuliforum* Sharaedar). *Int. J. Fd Sci. Nutr.* **48**(5):321-323

Gundimeda, U., Naidu, A.N. and Krishnaswamy, K. 1993. Dietary intake of nitrate in India. *J. Fd Composition Analysis* **6**(3):242-249

Gupta, K., Barat, G.K., Wagle, D.S. and Chawala, H.K.L. 1989. Nutrient content and antinutritional factors in conventional and non-conventional leafy vegetables. *Fd Chem.* **31**(1):105-116

Gupta, K. and Wagle, P.S. 1988. Nutritional and antinutritional factors of green leafy vegetables. *J. agric. Fd Chem.* **36**(3):472-474

*Handique, A.K. 1993. Free amino acid content in non-conventional leafy vegetables. *Crop Res.* **6**(1):189-193

*Herzog, F., Farah, Z. and Amado, R. 1993. Nutritive value of four wild leafy vegetables in Cote d' Ivoire. *Int. J. Vitamin Nutr. Res.* **63**(3):234-238

Hodgkinson, A. 1977. *Oxalic acid in biology and medicine*. Academic Press, New York.

Ifon, E.T. and Bassir, O. 1980. The nutritive value of some Nigerian leafy green vegetables. Part 2: The distribution of protein, carbohydrates, crude fat, fibre and ash. *Fd Chem.* **5**(3):231-235

Imungi, J.K. and Potter, N.N. 1983. Nutrient contents of raw and cooked cowpea leaves. *J. Fd Sci.* **48**(4):1252-1254

Islam, M.N., Genuario, R.R. and Pappas, M. 1987. Nutritional and sensory evaluation of *Atriplex triangularis* leaves. *Fd Chem.* **25**(4):279-284

Jackson, M.L. 1973 *Soil Chemical Analysis*. Prentice Hall of India (Pvt) Ltd., New Delhi

*James, L.F. 1968. Serum electrolyte, acid base balance and enzyme changes in acute *Halogeton glomeratus* poisoning in sheep. *Can. J. Comp. med.* **32**:539-543

Jayarajan, P., Reddy, V. and Mohanram, M. 1980. Effect of dietary fat on absorption of beta carotene from green leafy vegetables in children. *Indian J. med. Res.* **71**(1):53-56

Jellenik, G. 1985. *Sensory Evaluation of Food. Theory and Practice*. Ellis Horwood Ltd. Chichester England and VCH Verlagsgesellschaft mbH, Weinheim, Federal Republic of Germany, p.204

Jijiamma, N.C. 1989. Nutritional profile of amaranthus as influenced by post harvest handling. M.Sc.(Home Science) thesis, Kerala Agricultural University, Thrissur

Jijiamma, N.C. and Prema, L. 1993. Effect of maturity, position of leaves and post harvest storage on the nutritional composition and organoleptic qualities of amaranthus. *J. trop. Agric.* **31**:219-226

John, K.C., Gourley, L. and Lee, A.P. 1987. Dietary fibre and starch contents of some South East Asian vegetables. *J. agric. Fd Chem.* **35**(2):319-321

Kala, A., Narasimhan, S. and Prakash, J. 1998. Nutrient contents and sensory attributes of microwave versus conventionally cooked greens. IFCON '98. 4th International Food Convention, Mysore, November 23-27. *Abstract of poster papers*, p.119

Kantha, S.S., Hettiarachchy, N.S., Herath, H.M.W. and Wickramanyake, T.W. 1978. Studies on the nutritional characteristics of winged bean tubers and leaves. *Proc. 34th Ann. Sessions*. Sri Lanka Assoc. Advt. Sci., **34**(1):70

KAU. 1984. Screening germplasm collection of *Amaranthus* for yield, quality and adaptability. KAU Research Report 1984. Kerala Agricultural University, Vellanikkara, Trichur, p.300

Kaur, B. and Manjrekar, S.P. 1975. A study on the chemical composition of green leafy vegetables available in Northern India. *Indian Fd Packer.* **29**(3):71-72

Keshinro, O.O. and Ketiku, A.O. 1979. Effect of traditional cooking methods on the ascorbic acid content of some Nigerian leafy and fruit vegetables. *Fd Chem.* **4**:303-310

Kowsalya, S. and Chandrasekhar, U. 1999. Cooking losses of carotene from selected green leafy vegetables and absorption of carotenes in adults. *Nutr. Soc. India* XXXII Annual Meeting Nov. 25-26, 1999. Scientific Programme and Abstracts of National Institute of Nutrition, Hyderabad, India.

Kowsalya, S. and Mohandas, S. 1999. Acceptability and nutrient profile of cauliflower leaves (*Brassica oleracea*, var. botrytis). *Indian J. Nutr. Dietet.* **17**(9):9-12

Kurien, T., Main, S.B., Indira, P. and Ramanujam, T. 1976. Regulation of the levels of cyanogenic glucosides in cassava. *J. Root Crops.* **2**(2):39-43

Kushwaha, A., Shukla, P. and Raghuvanshi, R.S. 1998. Development of iron and ß-carotene rich snacks for young children. IFCON '98. 4th International Food Convention, Mysore, November 23-27. *Abstracts of poster papers*. p.214

Lakshmi, B. and Vimala, V. 1998. Development of nutritions dehydrated green leafy vegetable powder blends. IFCON '98. 4th International Food Convention, Mysore, November 23-27. *Abstracts of poster papers*. p.124

Liener, I.E. 1980. *Toxic constituents of plant food stuffs*. Academic Press, INC. III Fifth Avenue, New York. P.453

Longvah, T. 2000. Nutritive value of North-East Indian plant foods. *Nutr. News* **21**(1)

*Loon, A.J.M.V., Klaveren, J.D.V. 1991. Nitrate intake of the Dutch population. *Voeding*. **52**(4):96-100

Lorenz, K. and Hwang, Y.S. 1985. Lipids in amaranthus. *Nutr. Rep. int.* **31**(1):83-89

Lucas, E.O. 1988. The potential of leaf vegetables in Nigeria. *Outlook Agric.* **17**(4):163-168

Luthra, G. and Sadana, B. 1995. Nutritional evaluation of Sags prepared from bathu, carrot and radish leaves. *Indian Fd Packer* **49**(1):33-38

*Malik, M.Y., Sheik, A.A. and Shah, W.H. 1969. Chemical composition of indigeneous fodder leaves (*M. pterygosperma*). *Pakistan J. Sci.* **19**(4):171-174

Mallika, V.K. 1987. Genome analysis in the genus *Amaranthus*. Ph.D. thesis, Kerala Agricultural University, Trichur, Kerala.

Manay, N.S. and Shadaksharaswamy, M. 1995. *Foods-Facts and Principles*. New Age International (P) Ltd. Publishers, New Delhi, p.217

Marderosian, A.D., Beutler, J., Pfender, W., Chambers, J., Yoder, R., Weinsteiger, E. and Senft, J. 1979. Nitrate and oxalate content of vegetable amaranth. *Proc. Second Amaranth Conf.*, Rodale Press, Inc. 33. East Minor Street, Emmaus, p.31-40

Mathooka, F.M. and Imungi, J.K. 1994. Ascorbic acid changes in three indigenous Kenyan leafy vegetables during traditional cooking. *Ecol. Fd Nutr.* **32**:239-245

Menon, K. 1980. What is great about greens? *Nutrition* **14**(1):20

*Mercadante, A.Z. and Amaya, D.B.R. 1990. Carotenoid composition and vitamin A value of some native Brazilian green leafy vegetables. *Int. J. Fd Sci. Technol.* **25**(2):213-219

Mohideen, M.K., Rangaswami, P., Metha, V.A., Shunmughavelu, K.G. and Muthukrishnan, C.R. 1985. A note on CO-3 Amaranthus. *S. Indian Hort.* **33**(2):127-128

Mohideen, M.K., Shanmugavelu, K.G. and Muthukrishnan, C.R. 1982. A new amaranthus for clipping. *Indian Hort.* **27**:17-18

Mosha, T.C., Pace, R.D., Adeyeye, S., Mtebe, K. and Laswai, H. 1995. Proximate composition and mineral content of selected Tanzanian vegetables and the effect of traditional processing on the retention of ascorbic acid, riboflavin and thiamin. *Pl. Fds hum. Nutr.* **48**(3):235-245

*Mugerwa, J.S. and Bwabye, R. 1974. Yield, composition and *in vitro* digestibility of *Amaranthus hybridus* sub sp. *incurratus*. *Trop. Grasslands.* **8**(1):49-43

*Mugerwa, J.S. and Stafford, W. 1976. Effect of feeding oxalate rich amaranthus on bovine serum calcium and oxalate levels. *E. Afriz. Agric. For. J.* **42**(1):71-75

Murcia, M.A., Vera, A. and Carmona, F.G. 1992. Effect of processing methods on spinach : proximate composition in fatty acids and soluble protein. *J. Sci. Fd Agric.* **59**(4):473-476

Mwajumwa, L.B.S., Kahangi, E.M. and Imungi, T.A. 1991. The prevalence and nutritional value of some Kenyan indigenous leafy vegetables from three locations of Machakos District. *Ecol. Fd Nutr.* **26**(4):275-280

Nag, A, and Matai, S. 1991. *Ailanthus excelsa* Roxb. (*Simaroubacae*) A promising source of leaf protein. *Indian J. Nutr. Dietet.* **28**(5):138

Nambiar, V.S. and Seshadri, S. 1998. A study on β-carotene content of some green leafy vegetables of Western India by high performance liquid chromatography. *J. Fd Sci. Technol.* **35**:365-367

NAS. 1975. *Underexploited Tropical Plants with Promising Economic Value.* National Academy of Sciences, Washington, D.C.

Nautiyal, B.P. and Raman, K.G. 1987. Moringa (drumstick) – an ideal tree for social forestry : growing conditions and uses – Part-I. *My forest* **23**(1):53-58

*Ndyanab, W.K. 1974. Oxalate content of some commonly grazed pasture forages of Land and Acholi districts of Uganda. *E. Afric. agri. For. J.* **39**:215

Neeliyara, A.M. 1998. Nutritive value and acceptability of winged bean genotypes (*Psophocarpus tetragonolobus* L.). M.Sc. (Home science) thesis, Kerala Agricultural University, Thrissur

NIN. 1990. Invisible fat in vegetables. Annual Report 1990-91. National Institute of Nutrition, Hyderabad, p.49

NIN. 1991. Carotene content of foods. Annual report, 1991-92. National Institute of Nutrition, Hyderabad, India. p.56-57

NIN. 1993. Leaf concentrate as a source of beta-carotene and other micronutrients. Annual Report, 1993-94. National Institute of Nutrition, Hyderabad, p.67-69

NIN. 1994a. Dietary fibre in foods. Annual Report, 1994-95. National Institute of Nutrition, Hyderabad, India. p.135

NIN. 1994b. Carotene content of foods. Annual Report, 1994-95. National Institute of Nutrition, Hyderabad, India. p.135-136

Nordeide, M.B., Hatloy, A., Folling, M., Lied, E. and Oshang, A. 1996. Nutrient composition and nutritional importance of green leaves and wild food resources in an agricultural district, Koutiala, in Southern Mali. *Int. J. Fd. Sci. Nutr.* **47**(6):455-468

*Oke, O.L. 1969. *World Rev. Nutr. Dietet.* **10**:262-303

Oyejola, A.O. and Bassir, O. 1975. The physiological availability of the iron content of some Nigerian leafy vegetables. *Pl. Fds. hum. Nutr.* **1**:177-183

Padmavathi, P. and Rao, M.P. 1990. Nutritive value of *Sauropus androgynus* leaves. *Pl. Fds. hum. Nutr.* **40**(2):107-113

PAG. 1973. Symposium on legumes and green leafy vegetables in the nutrition of the infant and young child. Bulletin III. p.25-30

Pal, D., Sachdeva, S. and Singh, S. 1995. Methods for determination of sensory quality of foods. A critical appraisal. *J. Fd Sci. Technol.* **32**:27-30

*Palis, R.K. and Bustrillos, A.R. 1976. Nitrate reductase and nitrate accumulation in some leafy vegetables. *Philippine J. Crop Sci.* **1**:195-205

Palki, P.E., Pandit, S.S. and Arya, S.S. 1998. Development and storage stability of instant vegetable dhal curry mixes. IFCON. 98. 4th International Food Convention, Mysore, November 23-27. *Abstracts of poster papers*. p.19

Perkin-Elmer. 1982. Analytical methods for Atomic Absorption Spectrophotometry. p.1-14

Peter, K.V. 1979. Drumstick – A multipurpose vegetable. *Indian Hort.* **23**(4):17-18

Philip, J., Peter, K.V. and Gopalakrishnan, P.K. 1981. Curry leaf – a mineral packed leafy vegetable. *Indian Hort.* **25**(4):2-3

Pike, R.L. and Brown, M.L. 1970. *Nutrition : An Integrated Approach.* Wiley Eastern Pvt. Ltd., New Delhi, p.34

Pingle, U. and Ramasasthri, B.V. 1976. Absorption of calcium from a leafy vegetable rich in oxalates. *Br. J. Nutr.* **39**:119

Placida, V. and Meena, V. 1991. Evaluation of new recipes and estimation of vitamin C and protein content of sauropus plant. *Indian J. Nutr. Diet.* **28**(9):245

Prakash, D., Nath, P. and Pal, M. 1993. Analysis of nutritional contents in Amaranthus, Chenopodium and Celosia leaves. Golden Jubilee Symposium, Horticultural Society of India, Banglore, May 24-28. *Abstract of Papers*, p.375

Prakash, D., Nath, P. and Pal, M. 1995. Composition and variation in vitamin C, carotenoids, protein, nitrate and oxalate content in Celosia leaves. *Pl. Fds hum. Nutr.* **47**(3):221-226

Prakash, D. and Pal, M. 1991. Nutritional and antinutritional composition of vegetable and grain amaranth leaves. *J. Sci. Fd Agric.* **57**:573-583

Premavalli, K.S., Madhura, C.V. and Arya, S.S. 1998. Minor nutrient quality of dehydrated green leafy vegetables. IFCON'98. 4th International Food convention, Mysore, November 23-27. *Abstracts of Poster papers*, p.118

Rahman, M.M., Wahed, M.A. and Ali, M.A. 1990. Beta carotene losses during different methods of cooking green leafy vegetables in Bangladesh. *J. Fd. Composition analysis* **3**(1):47-53

Raja, T.K., Othman, O.C. and Bahemukha, T.E. 1997. Levels of crude proteins and some inorganic elements in selected green vegetables of Dar es Salaam. *J. Fd Sci. Technol.* **34**(5):419-422

Rajagopal, A., Muthukrishnan, C.R., Mohideen, M.K. and Syed, S. 1977. CO-2 Amaranthus – An early vigorous variety. *S. Indian Hort.* **25**(3):102

Rajyalakshmi, P., Laxmi, K.V. and Padmavathi, T.V.N. 2000. Carotene content in edible forest green leafy vegetables using HPLC and effect of processing on per cent retention of beta carotene. National conference on sustainable food production problems and prospects in global context, Thrissur, 22nd March. Abstracts. P.15

Ramachandran, C., Peter, K.V. and Gopalakrishnan, P.K. 1980. Chekkurmanis – A multivitamin leafy vegetable. *Indian Hort.* **25**(1):17-18

Ramdasmurthy, V. and Mohanram, M. 1984. *Your Health and Nutrition.* National Institute of Nutrition, Hyderabad, p.

Ranganna, S. 1977. *Manual of analysis of Fruit and Vegetable Products.* Tata McGraw – Hill Publishing Company Limited, New Delhi

Rao, P.G., Mallikarjuna, K. and Rao, G.G. 1979. Nutritional evaluation of some green leafy vegetables. *Indian J. Nutr. Dietet.* **17**(9):9-12

Rao, P.U. and Ramulu, P. 1998. Dietary fibre. Research highlights. *Nutr. News* **19**(2):8

Rau, A.G., Bolakil, L.D. and Puttaraj, S. 1998. Development of food products incorporated with green leafy vegetables and their acceptability. IFCON'98. 4th International Food Convention, Mysore, November 23-27. *Abstracts of poster papers.* p.9

Reddy, C.V.K. 1999. Greens for good health. *Nutrition* **33**(3):3-8

Reddy, V. 1996. Dietary approaches to combat vitamin A deficiency. *Proc. Nutr. Soc. India*. National Institute of Nutrition, Hyderabad, India. **43:**21-26

Reddy, N.S., Kulkarni, M.S. 1986. *In vitro* availability of iron from the selected uncommon green leafy vegetables available at Parbhani. *Nutr. Rep. Inter.* **34**:859-862

Renqvist, U.H., Vreeze, A.C.D., Evenhuis, B. 1978. The effect of traditional cooking methods on carotene content in tropical leafy vegetables. *Indian J. Nutr. Dietet.* **15**(5):154-158

*Rodrigues, M.R.S. and Penteado, M.V.C. 1989. Carotenoids with provitamin A activity in leafy vegetables. *Revista-de Farmacia-e-Bioguimica-da-Universidade-de-Sao-Paulo*. **25**(1):39-52

Sadasivam, S. and Manikam, A. 1992. *Biochemical Methods for Agricultural Sciences*. Wiley Eastern Ltd., New Delhi and Tamil Nadu Agricultural University, Coimbatore

Sadik, 1971. Oxalate contents of some leafy vegetables. *Paper Sem. Agric. Res.* Institute of Tropical Agriculture, Ibadan

Saxena, R. 1999. How green is your diet? *Nutrition* **33**(3):9

Schmidt, D.R., Mac Donald, H.A. and Brockman, F.I. 1971. Oxalate and nitrate content of four tropical leafy vegetables grown at two soil fertility levels. *Agron. J.* **63**(4):559-561

*Schelstraete, M. and Kennedy, B.M. 1980. Composition of miners lettuce (*Montia pertoliata*). *J. Am. dietet. Assoc.* 77(1):21-25

Shankaracharya, N.B. 1998. Tamarind-Chemistry, technology and uses – A critical appraisal. *J. Fd Sci. Technol.* **35**(3):193-208

Shingade, M.Y. and Chavan, K.N. 1996. Unconventional leafy vegetables as a source of minerals. *Van Vigyan* **34**:1-6

Shingade, M.Y., Chavan, K.N. and Gupta, D.N. 1995. Proximate composition of unconventional leafy vegetables from the Konkan region of Maharashtra. *J. Fd Sci. Technol* **32**(5):429-431

Singh, P.P., Sharma, D.C. and Mongia, S.P. 1971. Clinical aspects of oxalate metabolism. *Indian Med. Gaz.* **11**(8):29-36

Singh, P.P. 1973. The oxalic acid content of Indian food. *Qual. Pl. Mater. Veg.* **22**(3-4):335-347

Singh, P.P. and Saxena, S.N. 1972. Effect of maturity on the oxalate and cation content of six leafy vegetables. *Indian J. Nutr. Dietet.* **9**:269-276

Singh, P.P., Sharma, D.C. and Saxena, N. 1973. Variation in oxalate and mineral contents of bathua vegetables (*Chenopodium album* L. and *Chenopodium murale* L.) collected from different places. *Indian J. Nutr. Dietet.* **10**(2):84-90

Singh, U.C., Sudararajan, S. and Veeraragavatham, D. 1985. Effect of split application of nitrogen on certain qualitative characters of amaranthus (*Amaranthus tristis* L.) W.CO.3. *South Indian Hort.* **33**(4):230-233

Smith, I.F. 1982. Leafy vegetables as sources of minerals in Southern Nigerian diets. *Nutr. Rep. Int.* **26**(4):679-688

Speek, A.J. and Schreuss, W.H.P. 1988. Total carotenoid and beta carotene content of Thai vegetables and effect of processing. *Fd Chem.* **27**(3):245-257

Sreeramulu, N. 1982. Chemical composition of some green leafy vegetables grown in Tanzania. *J. Pl. Fd.* **4**(3):139-141

Sreeramulu, N., Banyikwa, F.F. and Srivastava, V. 1983a. Loss of ascorbic acid due to wilting in some green leafy vegetables. *J. Pl. Fds.* **5**:215-219

Sreeramulu, N., Ndossi, G.D. and Mtotomwema, K. 1983b. Effect of cooking on the nutritive value of common food plants of Tanzania. 1. Vitamin C in some of the wild green leafy vegetables. *Fd Chem.* **10**:205-210

Sreevastava, S.K. and Krishnan, P.S. 1959. Oxalate content of plant tissues. *J. Sci. Industr. Res.* **18**:146-168

Sukumar, D. 1997. Effect of NPK and frequency of cuttings on yield and quality in *Amaranthus tricolor* L. M.Sc.(Hort.) thesis. Kerala Agricultural University, Thrissur, Kerala.

Swaminathan, M. 1974. *Essentials of food and nutrition.* Vol.II. Ganesh and Company, Madras, p.480-481

*Tannenbaum, S.R. 1979. Nitrate and nitrite. Origin in humans. *Science.* **205**:1332-1335

*Tannenbaum, S.R., Fett, D., Young, V.R., Land, P.D. and Bruce, W.R. 1978. Nitrite and nitrate as formed by endogenous synthesis in human intestine. *Science* **200**:1487-1489

Thamburaj, S., Suresh, J. and Seralatham, A. 1994. Screening amaranthus germplasm for oxalic acid content. *South Indian Hort.* **42**(1):22-25

Thimmayamma, B.V.S. and Pasricha, S. 1996. Balanced diet. *Text book of Human Nutrition.* (Ed. Bamji, M.S., Rao, N.P. and Reddy, V.) Oxford & IBH Publishing Co., New Delhi, p.182

Trowell, H.C. 1976. Definition of dietary fibre and hypothesis that it is a protective factor in certain diseases. *Am. J. clin. Nutr.* **26**:417-427

Uiso, F.C. and Johns, T. 1996. Consumption patterns and nutritional contribution of *Grotalaria brevidens* (mitoo) in Jasime District, Tanzania. *Ecol. Food. nutr.* **35**(1):59-69

Varalakshmi, B., Naik, G., Reddy, P.V.V. and Pandey, S.C. 1998. 'Arka Suguna'. New multicut amaranth. *Indian Hort.* **42**(4):14-15

*Vera, A., Carmona, F.G. and Murcia, M.A. 1992. Nitrate level in vegetables by ion chromatography. *Biochemical Soc. Tans.* **20**(4):371

Vijayakumar, M. and Shunmugavelu, K.G. 1985. A comparison on the aminoacid composition of leaves and seeds of certain Amaranthus types. *Amaranth News. L.* 1:3

Vijayaraghavan, K. 1996. Vitamin A deficiency. *Text book of Human Nutrition.* (Ed. Bamji, M.S., Rao, N.P. and Reddy, V.) Oxford & IBH Publishing Co., New Delhi, p.294

Vityakon, P. and Standal, B.R. 1989. Oxalate in vegetable amaranth forms, contents and their possible implication for human health. *J. Sci. Fd Agric.* **48**(4):469-474

*Vogtmann, H., Temperli, A.T., Kunsch, U., Eichenberger, M. and Ott. P. 1984. Accumulation of nitrates in leafy vegetables grown under contrasting agricultural systems. *Biol. Agric. Hort.* **2**(1):51-68

Wallace, P.A., Marfo, E.K. and Plahar, W. 1998. Nutritional quality and antinutritional composition of four non-conventional leafy vegetables. *Fd Chem.* **61**(3):287-291

White, J.W. 1975. Relative significance of dietary sources of nitrate and nitrite. *J. Agric. Fd Chem.* **23**:886-891

Wills, R.B.H., Lim, J.S.K. and Greenfield, G.H. 1984b. Composition of Australian foods. 23. Brassica vegetables. *Fd Technol. Aust.*i **36**(4):176-177

Wills, R.B.H., Wong, A.W.K., Scriven, F.M. and Greenfield, G.H. 1984a. Nutrient composition of Chinese vegetables. *J. Agric. Fd Chem.* **32**(2):413-416

*Wu, J.T. and Wang, V.P. 1995. Effects of some environmental factors on nitrate content of Chinese cabbage (*Brassica chinensis* L.). *J. Chinese agric. Chem. Soc.* **33**(2):125-133

Yadav, S.K. and Sehgal, S. 1997. Effect of home processing and storage on ascorbic acid and beta-carotene content of Bathua (*Chenopodium album*) and fenugreek (*Trigonella foenum graecum*) leaves. *Pl. Fds hum. Nutr.* **50**(3):239-247

Yang, Y., Huang, C.Y., Peng, S.S. and Li, J. 1996. Carotenoid analysis of several dark-green leafy vegetables associated with a lower risk of cancers. *Biomedical environmental Sci.* **9**(4):386-392

Zandstra, M.B. 1989. Nitrate accumulation in vegetables and its relationship to quality. *An. appl. Biol.* **115**(3):553-561

* Originals not seen

APPENDIX-I

Organoleptic evaluation of leafy vegetables

No.	Character	Description	Score	1	2	3	4	5
I	Appearance	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
II	Colour	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
III	Flavour	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					
IV	Texture	Highly tender	5					
		Slightly tender	4					
		Neither tender nor fibrous	3					
		Slightly fibrous	2					
		Fibrous	1					
V	Taste	Excellent	5					
		Good	4					
		Fair	3					
		Poor	2					
		Very poor	1					

QUALITY ATTRIBUTES OF SELECTED LEAFY VEGETABLES

By

MAYA MATHEW

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Home Science

(FOOD SCIENCE & NUTRITION)

Faculty of Agriculture

Kerala Agricultural University

Department of Home Science

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR - 680 656

KERALA, INDIA

2000

ABSTRACT

The study entitled 'Quality attributes of selected leafy vegetables' was undertaken to estimate the nutrient composition, anti-nutritional factors and organoleptic qualities of eight leafy vegetables, along with the control variety, *Amaranthus tricolor* L. available and maintained in the Department of Olericulture, College of Horticulture, Vellanikkara. All the above attributes were evaluated during summer and rainy seasons.

The leaves were analysed for moisture, protein, fat, fibre, starch, soluble carbohydrates, calcium, phosphorus, iron, beta-carotene and vitamin C. The results revealed that among the different constituents, the mean protein content of the control variety was found to be significantly higher than the other leafy vegetables. All the leafy vegetables were found to be rich in iron, beta-carotene and vitamin C. The mean fibre, soluble carbohydrate and vitamin C contents were highest in centella, whereas bengalkeera had the highest mean value for starch and calcium. The highest phosphorus, iron and beta-carotene contents were in kangkong leaves. Except the beta-carotene content during summer season, all the other constituents of the different leafy vegetables varied significantly during summer and rainy seasons. However, significant increase in the calcium, phosphorus, iron and vitamin C contents were observed during rainy season.

The average nutritive values computed on the basis of the nutrient content of the leafy vegetables, revealed that kangkong had the highest nutritive value among the leafy vegetables selected for the study. The average nutritive value of the leaves was also found to be higher during rainy season.

The anti-nutritional factors namely, oxalates and nitrates in the leaves were also analysed during summer and rainy seasons. The results revealed that bengal keera and *Amaranthus tricolor* L. had the highest oxalate and nitrate contents respectively than the other leafy vegetables. Variation in both the anti-nutritional

factors was also observed between the leafy vegetables during summer and rainy seasons. However, the variation was found to be insignificant between the two seasons.

Based on the nutrient composition and anti-nutritional factors, the leafy vegetables were grouped into three clusters, each cluster containing similar leafy vegetables. Cluster I contained arakeera, centella, horse purslane and kangkong along with the control variety amaranth. Basella and waterleaf constituted cluster II and aksharakeera and bengalkeera constituted cluster III.

Results of the organoleptic evaluation indicated significant variation in acceptability between the leafy vegetables during summer and rainy seasons and the leafy vegetables were found to be more acceptable during summer season. Among the different leaves the control variety (*Amaranthus tricolor* L.) was found to be more acceptable.