NUTRITIONAL PROFILE OF SELECTED GREENS

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled **"Nutritional profile of selected greens"** 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.

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VINEETHA KUMARAN

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ABBREVIATIONS

AOAC	-	Association of Official Analytical Chemist
Ca	-	Calcium
CSIR	-	Council for Scientific and Industrial Research
EDTA	-	Ethelene diamine tetra acetic acid
Fe	-	Iron
GLV	-	Green leafy vegetables
H_2O_2	-	Hydrogen peroxide
H_2SO_4	-	Sulphuric acid
IIHR	-	Indian Institute of Horticultural Research
K	-	Potassium
NH_4Cl	-	Ammonium chloride
NIN	-	National Institute of Nutrition
OD	-	Optical Density
P	-	Phosphorus

Introduction

INTRODUCTION

Green leafy vegetables occupy an important place among the food groups as they provide adequate amounts of many vitamins and minerals for human nutrition. They are the cheapest of all vegetables and are within the reach of poor man. They are the richest source of provitamin A, vitamin C, riboflavin, folic acid, calcium, iron, anti oxidants and anti carcinogenic substances.

Green leafy vegetables are currently reckoned as an important adjunct for maintenance of good health and beneficial in protecting against some degenerative diseases and micronutrient deficiencies. In addition to their intrinsic nutritive value, their easy way of production, response to basic health needs, wide range of choices and cheapness give them the prerogative of a poor man's luxuary.

At present, India is a home for about 40 per cent of malnourished children in the world, although its share of the world's population is only 20 per cent (Kalloo and Pandey, 2002). Studies carried out have revealed that the meagre intake, low purchasing power and lack of knowledge of the potentials of low cost protective foods such as leafy vegetables has been the root cause of this condition. In India the per capita consumption of greens ranged between 48-66 g by adults and adolescence (Prabha *et al.*, 2002). Experts recommend a daily intake of atleast 100 g of fresh greens (Reddy, 1999).

Leaves of amaranth, drumstick and pumpkin form an inevitable part of Kerala dishes. Besides these, there are a number of minor leaves which are highly productive, acceptable and as nutritious as the widely consumed ones.

Food based strategy, to combat micronutrient malnutrition prevalent among the vulnerable segment of the population involves special consideration of identifying optimal food sources of micronutrients and ensuring their availability.

With the above considerations in mind an investigation on "Nutritional Profile of Selected Greens" was undertaken with the following objectives.

1) To determine the nutritional and antinutritional composition of the selected greens
2) To estimate the acceptability of these leaves.

Review of Literature

2. REVIEW OF LITERATURE

Literature relevant to the study entitled 'Nutritional profile of selected greens' is reviewed in the present chapter under the following heads:

1. Nutritional importance of leafy vegetables
2. Composition of leafy vegetables
3. Novel products from leaves
4. Uses of leafy vegetables

2.1 NUTRITIONAL IMPORTANCE OF LEAFY VEGETABLES

Leafy vegetables are chiefly the green leaves of certain species of plants which has no poisonous alkaloids and do not cause any gastrointestinal disturbance when they are consumed as food (Aman, 1969). In Indian traditional menus, leafy vegetables occupy a very important place. A wide variety of leafy vegetables like amaranth, drumstick, mint, curry leaf, palak, fenugreek etc. are used as vegetables in India.

Leafy vegetables are inexpensive and at the same time nutritious. They are particularly rich in mineral nutrient, iron and contain good amount of calcium which is necessary for proper growth of bones. They are also rich in vitamin A, which keeps the eyes and skin in a healthy condition (Menon, 1980). The leaves of amaranthus are excellent source of β-carotene, Fe, Ca, protein and vitamin C and other trace elements and contain linolenic acid and palmetic acid which are unsaturated fatty acids. The leafy greens of all the cole crops are some of the richest source of easily available vitamin A and vitamin C as well as calcium and iron which help to prevent various nutritional deficiency diseases (Gopalan, 1982a). Swaminathan (1987) suggested that the green leafy vegetables being fair source of protein containing about 2-7 per cent and rich sources of pro-vitamin A and vitamin C and good sources of folic acid and calcium, are excellent supplements to poor cereal diets.

Moringa leaves are one of the richest known source of vitamin A and several other vitamin and mineral nutrients. They also contain certain estrogenic

substances and some enzymes which are important constituents of some pharmaceutical preparations. Scientists advice the intake of leafy moringa to prevent vitamin A deficiency and anaemia. Antiscorbutic value of moringa leaves has been well established (Gopalan, 1982b). These leaves are good source of protective nutrients which are essential for healthy vision, bones, blood and skin. According to Manay and Shadaksharaswamy (1998) these leaves are considered useful in scurvy and catarrhal affliction.

Besides the commonly used leafy vegetables in India, a great variety of less familiar green leafy vegetables are also used locally in different parts of the country.

Saini (1975) reported that the leaves of Zimmu are rich in vitamin A, vitamin B_1, B_2, niacin, vitamin C and also minerals such as calcium, iron, magnesium, phosphorous and potassium. Trianthema and celosia are reported to be high in vitamin B_1 and B_6 (Rao and Tulpule. 1980). Chekkurmanis is one of the popular green leafy vegetables in South India, commonly known as multi-vitamin and multi-mineral packed leafy vegetables. It is very high in nutritive value as compared to annual vegetables such as amaranth, ceylone spinach, waterleaf, spinach and palak (Ramachandran *et al.*, 1980).

Chandrasekhar and Chitra (1990) found that the leafy vegetable *Thadikeera* consumed by the tribal communities of Nilgiris are good source of Ca and Fe. The colocasia leaves are vastly superior to that of cabbage and the protein content is about 40 per cent in excess and mineral content about 80 per cent in excess (Nayar, 1992).

The unconventional leafy vegetables like Math, Katemath, Kawala and Bharangi 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). The young leaves of cactus are low in protein but they can serve as a very good source of roughage and hence they are used as a nutritious vegetable and salad dish (Singh and Felker, 1998). The nutritive value of wild leafy vegetables of Ladakh are as nutritious as cultivated leafy vegetables like palak and methi (Chaurasia *et al.*, 2000).

Bharathi and Umamaheshwari (2001) analysed ten nontraditional leafy vegetables growing in and around fields, canals and waste lands of Andhra Pradesh and showed that they are good sources of moisture, proteins, crude fibre, β-carotene and ascorbic acid, more over these leaves contained less fat and moderate amount of oxalic acid.

Leafy vegetables are classical mineral rich food containing Ca, Fe, P and K in great quantities in leaf cells. On an average 250 g of greens contain 2,000-10,000 I.U. of vitamin A, enough to meet the daily needs of a person (Peter, 1992). A daily intake of atleast 100 g of fresh green leafy vegetable is recommended by the nutrition experts (Reddy, 1999).

Green leafy vegetables contain antioxidants which offer protection against many chronic diseases like heart disease and certain types of cancers (Saxena, 1999). A study conducted by Padma *et al.* (1999) indicated that the maximum levels of antioxidants can be derived from the consumption of raw vegetables and fruits rather than cooked ones.

The leaves of cauliflower are excellent source of antioxidants like β-carotene, vitamin C and minerals like iron, selenium, copper and zinc that are related to antioxidant enzymes (Kowsalya and Mohandas, 1999).

Thus enhanced use of the leafy vegetables could be of great significance towards solving the problem of malnutrition.

2.2 COMPOSITION OF LEAFY VEGETABLES

The bulk of green leafy vegetables available in India, comprises of 73.1 to 91.1 per cent of moisture (Jijiamma, 1989). The Ceylon spinach is a leafy vegetable growing wild in Assam which is reported to have high moisture content (Saikia and Shadeque, 1994). The moisture content of edible leaves of five winged bean genotypes available in Kerala varied from 59-61.1 per cent (Neeliyara, 1998). Thangaraj and Shanmugasundaran (2000) reported the moisture content to be about 85 per cent in

coriander leaves. The leafy vegetables of North East India contains 85 per cent moisture (Longvah, 2000). Bharathi and Umamaheshwari (2001) analysed the moisture content of the ten leafy vegetables and reported that it ranged from 60.99-90.17 g 100 g^{-1} and highest moisture content was seen in *Payilaku* (*Trianthema portulacastrum*).

Leafy vegetables are generally, poor source of protein as they contain less than 2 per cent protein (Gopalan *et al.*, 1989) but some workers had reported more than 2 per cent of protein in some uncommon leaves (Murugesan and Lakshmi, 1991; Shingade *et al.*, 1995; Bharathi and Umamaheshwari, 2001).

Fokou and Domngang (1989) investigated the protein efficiency ratio, biological value and net protein utilization in leafy vegetables widely consumed in Africa and found that these proteins of vegetable origin have high potency in promoting growth.

Ramphal (1992) reported the protein content of tender leaves of agathi, colocasia, coriander, mint and radish to be 8.4 g, 3.9 g, 3.3 g, 4.8 g, 3.8 g per 100 g respectively. Cassava leaves have superior quantities of protein (6.8 g 100 g^{-1}) but S-containing amino acids and histidine contents were found to be low (Babu and Nambisan, 1993).

Mathew (2000) studied the fat content of nine under exploited leafy vegetables and found that the mean fat content in the leaves ranged from 0.18 per cent to 0.65 per cent.

Crude fat of leafy vegetables, though present in lower quantities has a special significance because of the presence of carotenoids (pro vitamin A), vitamin E and vitamin K and some polyunsaturated fatty acids among its major constituents (Davidson *et al.*, 1973). NIN (1999) suggested that an average 60 g of green leafy vegetable provide 0.1 g of linolenic acid. The highest fat content was observed in Thummikera (*Lucas aspera*) and fat content ranged from 2.85 g to 6.25 g per 100 g on dry weight basis in the ten unconventional leafy vegetables of Nellore and Prakasam districts of Andhra Pradesh (Bharathi and Umamaheshwari, 2001).

Dietary fibre, a sum of polysaccharides and lignin which are not digested by endogeneous secreations of human gastro intestinal tract, is effective in reducing the incidence of obesity, hypercholesterolemia, heart diseases, diverticular diseases and colon diseases (Trowell, 1976). Gupta and Wagle (1988) reported that the crude fibre content of green leafy vegetables ranged from 7.2 to 13.95 per cent.

The fibre content of the leaves of chekkurmanis, curry leaves, drumstick and tender tamarind were found to be 2.5, 6.4, 0.9 and 3 per cent respectively (Ramachandran *et al.*, 1980; Philip *et al.*, 1981; Gopalan, 1982b; Shankaracharya, 1998) while 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. Mathew (2000) reported the highest fibre content in centella leaves out of the nine leaves analysed.

D'Souza and Kulkarni (1990) found that the seedling foliage of *Moringa oliefera* are low in fibre and ash content than mature tree leaves.

Carbohydrates in leafy vegetables differ from non leafy vegetables in that it is stored in the form of starch grains (Aman, 1969). Neeliyara (1998) observed 27.5 to 31.4 per cent of starch in winged bean leaves on dry weight basis. Mathew (2000) reported 0.7 per cent to 1.70 per cent of starch in the nine leafy vegetables analysed.

Leafy vegetables contain considerably more carotenoids than tuberous vegetables and fruits and is mainly deposited in the leaves than the stalk in the form of beta-carotene (Speek and Schrauss, 1998).

Hundred gram of drumstick leaves contains 678 mg of carotene which our body converts into vitamin A, which is essential for good vision (Gopalan, 1982b).

The ß-carotene content of palak, amaranth, drumstick, agathi and gogu leaves ranged from 1.8 mg to 14.1 mg 100 g^{-1} and its leaf concentrates contained higher levels of ß-carotene (NIN, 1994). Nambiar and Seshadri (1998) conducted a study on the ß-carotene content of 16 green leafy vegetables consumed by rural and

tribal population of the western region of India and found that they are rich source of ß-carotene. Small amounts of curry leaves added serves to give one by twentieth of the vitamin A requirement in the diet (Pathak *et al.*, 2000).

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

Some green leafy vegetables like spinach, amaranth, fenugreek, mustard and coriander leaves are equally good sources of vitamin C as fruits (Sreeramulu *et al.*, 1983). Indian spinach, Pusa Bharati provides 100 per cent more vitamin C and 15 per cent highest β-carotene than Pusa Jyothi (Sirohi, 1998).

Green leafy vegetables are rich in minerals especially iron and calcium (Menon, 1980; Philip *et al.*, 1981; Gopalan, 1982a; Smith, 1982).

Other minerals like phosphorus, magnesium, sodium, potassium, copper, iodine, sulphur and boron are also detected in leafy vegetables.

According to Lucas (1988) the calcium, phosphorus and iron contents of amaranth are 5.41 g 100 g^{-1}, 0.29 g 100 g^{-1} and 642.58 mg 100 g^{-1} of dry matter respectively.

Varalakshmi *et al.* (1998) reported that the phosphorus, calcium, potassium, magnesium, iron and sulphur content of a new multicut amaranth 'Arka Suguna' has higher mineral content than the control variety 'Arve' (*Amaranthus tricolor*).

The tender leaves of tamarind are a good source of calcium and also contain about 28 per cent tartaric acid (Chempakam and Peter, 2000).

The nutrient composition of leafy vegetables varies on the basis of season and maturity.

Higher ascorbic acid and fibre content were reported during rainy season in the red and green types of *Amaranthus tricolor* by Jijiamma (1989).

Agathi and gogu had highest amount of β-carotene in summer (March-June) amaranth, palak and pudina during rainy season and colocasia, drumstick and fenugreek in winter (November-February) (NIN, 1991). Different leafy vegetables significantly differed in their nutrient composition during rainy and summer seasons except β-carotene content and the average nutritive value of leaves were found to be higher during rainy season (Mathew *et al.*, 2000a).

Aman (1969) opined that for getting higher concentration of iron from leafy vegetables, it is adviced to pluck the leaves after sunset and eat by cooking them delicately.

According to Rao (1975) the tender leaves of chekkurmanis contain more protein, carbohydrate and fat than the exotic cabbage or spinach and the indigenous greens.

Giri *et al.* (1984) found that the lateral leaves of chekkurmanis of one year plant were richer in ash content, carbohydrate, protein, fat, vitamin C, riboflavin, thiamin and minerals like calcium, magnesium, phosphorous, sodium and trace elements like iron, copper and manganese. Young leaves accumulates dry matter as they mature (Banerjee, 1985).

The content of fibre and ash in the seedling foliage of *Moringa olerifera* is lesser than matured trees (D'Souza and Kulkarni, 1990) while the β-carotene content increased with maturity (NIN, 1994). There was a rise in total iron content and decrease in the percentage of total available iron with the advanced period of growth (Reddy *et al.*, 1998). Mohanalakshmi *et al.* (1998) observed that the optimum stage for harvest of amaranth is 20-30 days after sowing.

The plant materials are known to contain many antinutritional or toxic components of which nitrate occurs in abundance (National Research Council, 1973).

Nitrates present in soil and water accumulates in the plants in toxic concentration which is ingested by animals and gets converted to nitrites in the digestive tract (Singh and Govindarajan, 2001).

Excessive use of nitrogen containing fertilizers results in higher levels of nitrate in a number of vegetables such as spinach, cabbage, amaranthus, mustard green etc. A vegetable grown with fertilizers contains three to twelve times more nitrate than those grown without fertilizers (Lee *et al.*, 1971).

Zhou *et al.* (2000) reported accumulation of high levels of nitrate and nitrite by the application of nitrogeneous fertilizers in vegetables grown in China. Cabbage tend to accumulate nitrate if grown in nitrate rich soil (Singh and Govindarajan, 2001). Post harvest storage of vegetables may lead to accumulation of nitrite, arising from the reductase activity (Philipps, 1968; Heisler *et al.*, 1974).

The concentration of nitrate in plants depend upon the variety or species, plant parts, stage of maturity and genetic factor. A plant accumulating very high concentration of nitrates contain significant amount of nitrate (Zhou *et al.*, 2000).

Chan (1996) reported that excessive intake of nitrate and nitrite in the diet may cause toxic effects due to the formation of methemoglobin by oxidation of haemoglobin by nitrite. Incidence of methemoglobinemia was reported by Antia and Abraham (2000) after consuming spinach which contain high proportion of nitrate.

The vegetables with high nitrate and nitrite contents may therefore be restricted from consumption by giving proper awareness to consumers. It is reported that salted and boiled vegetables could reduce the nitrate content to 45 per cent and 60 to 75 per cent respectively (Zhou *et al.*, 2000).

Oxalic acid, a dicarboxylic acid or its salts (oxalates) are widely distributed in plant foods (Gopalan *et al.*, 1989).

Liener (1980) suggested that certain plants such as rhubarb (*Rheum rhaportium*) and spinach are known to contain rather high levels of oxalic acid. Charely (1982) reported that the Ca in spinach and other plants of this family becomes unavailable because the oxalic acid present binds the calcium in an insoluble form.

In plants, Ca accumulates especially in leaf as a complex with phytates, oxalates and organic acid (Robinson, 1987).

Ceylon spinach which is a substitute for spinach in Assam, contain high quantity of oxalates and hydrocyanic acid (Saikia and Shadeque, 1994).

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

The leafy greens of all cole crops are comparatively low in oxalates (Gopalan, 1982a).

Mathew *et al.* (2000b) reported that bengal keera has highest oxalate content while *Amaranthus tricolor* had highest nitrate content among the nine leafy vegetables analysed.

Shankaracharya (1998) reported that the tender leaves of tamarind, eaten as vegetables contain oxalic acid and showed a Ca/oxalate ratio of 1:1 at pH 4.5, indicating that the leaves are good source of Ca but oxalic acid effects their bioavailability.

Arka Suguna is a new multicut amaranth released by IIHR, Bangalore and has 1.49 per cent of oxalic acid while the control variety had 1.97 per cent of oxalic acid (Varalakshmi *et al.*, 1998).

Bamboo shoots contain thiocyanate ranging from 1.3-46.4 mg kg^{-1} which are considered to be goitrogenic in nature and prolonged consumption can increase the risk of thyroid disorder, especially in low iodine environment (NIN, 1997).

D'Souza and Kulkarni (1990) reported that the foliage of *Moringa oleifera* especially that of seedlings of 31-20 days growth are free of phenolic compounds and does not have any inhibitory effect on peptic enzymes.

Proteins of leafy vegetables like leaves of *Solanum nigrum* L, *Xanthosama* sp. and *Gnetum africanum* L. which are widely consumed in Africa have high potency to promote growth but the antinutritional factors interact negatively on these protein. The improvement in utilization of protein in *Gnetum africanum* and *Xanthosoma* sp. can be achieved by discarding harmful compounds. This can be done through the process leading to leaf protein preparation (Fokou and Domngang, 1989).

Kowsalya and Mohandas (1999) reported that raw leaves of cauliflower has antinutrients like phytate, tannins and oxalates within the range reported for leafy vegetables. It was noticed that cooking reduced the antinutrient content to one third for oxalates, but was less for phytates and marginal for tannins.

2.3 NOVEL PRODUCTS FROM LEAVES

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

Sensory quality is a combination of different senses of perception coming into play in choosing and eating a food (Ranganna, 1986). The sensory attributes like colour, appearance, feel, aroma, taste and texture are the deciding factors in food acceptance (Pal *et al.*, 1995).

Seshadri *et al.* (1996) reported that children preferred GLVs when incorporated into a cereal or a cereal/pulse based traditional recipe such as dhebra, muthia, puda, bhajia etc. of a bhaji. Similar to this result has been obtained by Devadas *et al.* (1996).

Chutnies and pickles are food adjuncts, used as side dishes in Indian meals. They serve as good appetizers and hence are prepared domestically in every household.

Satyanarayan *et al.* (2001) standardised the procedure for the preparation of instant chutneys with pudina (*Mentha spicata*) and gongura (*Hibiscus* sp.) by using

shade dried leaves and found that instant chutneys reconstituted well in cold water. After seasoning, pudina, chutney had all the characteristics of fresh chutney but in the case of gongura the reconstituted chutney had all other characteristics of fresh chutney except the mucilaginous property. The product had a shelf life of more than three months at ambient condition.

Eleyinmi and Oloyo (2001) reported that blends of utaze (*Gongronema latifolium*), Bitter leaf (*Vernonia amygdalina*) and Bitter cola (*Carcinia kola*) in the ratio 1:6:2.3 and 0:1:2 possessed characteristics similar to those of commercial hops in sorghum based large beer brewing.

Increased purchasing power, changing socio economic status and life style has contributed to the increased appreciation for taste of convenience foods.

Mathur *et al.* (1989) studied the impact of supplementing leaf concentrate incorporated snacks on haemoglobin level and found it very effective in raising haemoglobin levels. When fed at a level of 9 g dry wt day^{-1}, these snacks provided the daily requirement for iron and 45 per cent of vitamin A requirements.

Kowsalya and Mohandas (1999) found that fresh cauliflower leaves were acceptable well in its meal form namely pooriyal/kootu as well as in the incorporated recipes (10% and 20%) such as adai, vadai and chappathi.

Ready to eat extruded products developed by incorporating dried cauliflower leaf powder at 10 per cent was found to be acceptable and they had higher iron and β-carotene content at this level of incorporation (Begum *et al.*, 2000).

Shenoy *et al.* (2000) studied the possibility of incorporating dried curry leaf powder in common dishes and found higher levels of β-carotene, iron, calcium and dietary fibre in the product. Spice mixture incorporation was found to be highly acceptable.

Rekha *et al.* (2000) formulated soup mixes from Indian dill and palak and found that they were highly acceptable at 5 per cent level of incorporation.

Suman (2000) evaluated ten amaranth incorporated recipes and found cheera minced meat thoran as the most acceptable one.

Radhika and Kowsalya (2000) studied the acceptability of neem incorporated recipe by a panel of diabetic patients (non insulin dependent) and healthy subjects and found that neem roti and neem poori had greatest acceptability and neem roti possessed the least glycemic index of 64:64.

Nambiar and Seshadri (2001) studied the acceptability of fresh radish leaf incorporated products and found that *dhebera* had maximum acceptability followed by *muthia* and *handwa.*

Singh *et al.* (2000) prepared various food products including namakapara, kurmura, cake, biscuit, pakora and vada using fresh and dried spinach leaves and found higher levels of vitamin C in products prepared from fresh leaves as compared to those prepared from dried leaves.

2.4 USES OF LEAFY VEGETABLES

Leafy vegetables occupy an important place in Indian diets.

The dried leaves of moringa (drumstick leaves) are used as condiments in traditional cooking. They are reported to contain estrogenic substances and some important enzymes hence they are important constituents of some pharmaceutical preparations (Gopalan, 1982b).

A study conducted by Shyna (2001) in Thrissur district indicated that Nair and Namboothiri families prepared a special preparation called 'pathila curry' during Karkitaka month which contained ten different leaves like cowpea, ashgourd, colocasia, pumpkin, 'thazhuthama', 'kavath', 'cherukizhangu', yam, 'anathumba' and 'neyyunni' and is consumed atleast seven days during the month of Karkitaka.

Fresh green coriander leaf commonly known as Cilantro is much appreciated for culinary purpose, for preparing chutney, salads, sauces and for

flavouring curries and soups (Thangaraj and Shanmugasundaram, 2000; Saini, 2001 and Verghese, 2001).

Besides the commonly consumed leafy vegetables in India, a great variety of less familiar greens are used locally in different parts of the country. Saini (1975) reported a leaf called *Zimmu* which was taken as raw or as a flavouring substitute for garlic or onion. Jatera (*Ornanthe stolonifera*) and Jada (*Amaranthus viridis*) are herbs commonly consumed as vegetable after being cooked by Khasis of Meghalaya (Easwaran and Goswani, 1989).

Singh and Felker (1998) reported that the young leaves of cactus are served as nutritious vegetable and salad dishes.

Chandrasekhar and Chitra (1990) reported that the Kota tribes included an extract of a green leafy vegetable called Pulicha Keerai during lactation which they believed to enhance milk secreation.

The Irulas of Attapadi Hills and Lambas of Katchuvadi Hills used atleast one variety of greens as a component of weaning food (Chandrasekhar *et al.*, 1990).

The leaves of young seedlings of tamarind are eaten as a vegetable (Chempakam and Peter, 2000).

Kennedy *et al.* (2000) reported that both young and matured leaves of Ramba locally called as biriyani leaf (*Pandanus amarylifolius*) which is valued for its spicy and musk scented leaves are used in cooking along with Basmathi rice for preparing biriyani.

Materials and Methods

3. MATERIALS AND METHODS

The materials and methods used to evaluate the 'Nutritional profile of selected greens' are given under the following heads.

3.1 Selection of leafy vegetables

3.2 Collection of samples

3.3 Physico-chemical characters of the leaves

3.4 Organoleptic evaluation of leafy vegetables

3.5 Statistical analysis

3.1 SELECTION OF LEAFY VEGETABLES

Tender leaves of nine greens belonging to three different categories namely tree, conventional and spicy maintained in the kitchen garden of Department of Olericulture, College of Horticulture, Vellanikkara were selected for the study.

The tender leaves selected include

1. Tree leaves

a) Lettuce tree leaves - *Pisonia grandis*

b) Tamarind - *Tamarindus indica*

c) Ponnaviram - *Cassia occidentalis*

2. Conventional leaves

a) Cowpea - *Vigna unguiculata*

b) Pumpkin - *Cucurbita moschata*

c) Colocasia - *Colocasia esculenta*

3. Spicy leaves

a) Mint - *Mentha arvensis*

b) Coriander - *Coriandrum sativum*

c) Burmese coriander - *Eryngium foetidum*

Plates 1 to 3 show the different leafy vegetables selected for study.

a) Pisonia (Lettuce tree leaf)

b) Tamarind

c) Ponnaviram

Plate 1. Tree leaf group

a) Cowpea

b) Pumpkin

c) Colocasia

Plate 2. Conventional leaf group

a) Mint

b) Coriander

c) Burmese coriander

Plate 3. Spicy leaf group

3.2 COLLECTION OF SAMPLES

The selected leafy vegetables for the study were harvested at tender stage.

3.3 PHYSICO-CHEMICAL CHARACTERS OF LEAVES

3.3.1 Physical Characteristics of Leaves

The physical character namely the colour of the tender leaves were recorded as dark green, green, light green, yellowish green and pale green.

3.3.2 Nutrient Analysis of Leafy Vegetables

Leaf samples of nine selected greens were analysed for different nutrients in five replicates. They include

1. Moisture
2. Fibre
3. Protein
4. Starch
5. Beta carotene
6. Vitamin C
7. Calcium
8. Iron
9. Phosphorus
10. Potassium

3.3.2.1 Moisture

The moisture content was estimated by using the method of AOAC (1980) and expressed in g 100 g^{-1}.

To determine the moisture content, 10 g of fresh sample was taken in a china dish and dried at 60°C-70°C in a hot air oven. Cooled it in a desiccator and weighed. 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. The period of drying varied from 2 to 3 hrs.

3.3.2.2 Fibre

The crude fibre content was estimated by acid-alkali digestion method as suggested by Chopra and Kanwar (1978) and expressed as g 100 g^{-1} of fresh sample.

Two gram dried and powdered sample was boiled with 200 ml of 1.25 per cent sulphuric acid for 30 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 30 minutes. Repeated the filtration through muslin cloth and washed with sulphuric acid, water and alcohol in a sequential manner. Transferred the residue to a pre weighed ashing dish. The residue was ignited for 30 minutes in a muffle furnace at about 250°C, cooled in desiccator and weighed. The fibre content of the sample was calculated from loss in weight on ignition and converted to fresh weight basis.

3.3.2.3 Protein

The nitrogen content was estimated using the method suggested by Fischer (1973). 0.5 g of sample was digested in concentrated H_2SO_4 for 10 minutes and added 2-3 ml of H_2O_2 dropwise till the solution became colourless. It was made upto 100 ml with distilled water. From the working solution, 5 ml was taken and 2 ml of 10 per cent sodium hydroxide followed by 1 ml of 10 per cent sodium silicate were added and made upto 50 ml. 1.6 ml of Nessler's reagent was added and the orange colour developed was read at 410 nm. Standard graph was prepared by using 0.382 g of NH_4Cl was taken in 1 litre distilled water and from that 100 ppm, 120 ppm, 140 ppm, 160 ppm, 180 ppm, 200 ppm were read colorimetrically for the preparation of standard graph. The protein content was estimated which was then expressed in g 100 g^{-1} of fresh sample.

3.3.2.4 Starch

The starch content was estimated colorimetrically using anthrone reagent, as suggested by Sadasivam and Manikam (1992) and expressed in g 100 g^{-1} of fresh sample.

The dry powdered sample of 0.1 g was extracted with 80 per cent ethanol to remove soluble sugars. Residue was repeatedly extracted with hot 80 per cent ethanol to remove the sugars completely. The residue was dried over a water bath and added 5 ml water and 6.5 ml 52 per cent perchloric acid and extracted in the cold for 20 minutes. Centrifuged the sample and reextracted with fresh perchloric acid. The supernatant was pooled and made upto 100 ml with distilled water. Pipetted out 0.1 ml of the supernatant, made upto 1 ml with water and added 4 ml of anthrone reagent, heated for 8 minutes, cooled and read the OD at 630 nm.

A standard graph was prepared using serial dilution of standard glucose solution. From the standard graph the glucose content of the sample was estimated and converted to fresh weight basis. This value was multiplied by a factor of 0.9 to arrive at the starch content.

3.3.2.5 ß-carotene

ß-carotene content was estimated by the method of AOAC (1970) using water saturated n-butanol and expressed in µg 100 g^{-1}.

One g of fresh sample was extracted in water saturated n-butanol using a mortar and pestle and added 50 ml water saturated n-butanol. The flask was stoppered tightly. Shook well for 1 minute and kept overnight protected from sunlight. Decanted the supernatant, pipetted 0.5 ml of supernatant and diluted with 10 ml of water saturated n-butanol and read at 435.8 nm. ß-carotene content of the sample was calculated by multiplying the Optical Density (OD) value with the factor 0.16632.

3.3.2.6 Vitamin C

The vitamin C content of fresh sample was estimated by the method of AOAC (1955) using 2,6 dichlorophenol-indolephenol dye and expressed in mg 100 g^{-1}.

Five g of fresh sample was extracted with 4 per cent oxalic acid using a mortar and pestle and made upto 100 ml with distilled water. Five ml of the extract was pipetted out and added 10 ml of 4 per cent oxalic acid and titrated against the dye. Ascorbic acid content of fresh sample was calculated from the titre value.

3.3.2.7 Calcium

The calcium content was estimated using titration method with EDTA as suggested by Hesse (1971).

One g of dry powdered sample was pre digested with 12 ml of 9:4 diacid and volume made upto 100 ml with distilled water. One ml of aliquot was taken and added 10 ml water, 10 drops of hydramylamine, 10 drops of triethanolamine, 2.5 ml of NaoH and 10 drops of calcone. Then it was titrated with EDTA till the appearance of permanent blue colour. It was expressed in mg per 100 g of fresh sample.

3.3.2.8 Iron

Iron content was estimated using colorimetry method as described by Ranganna (1986).

Sample was prepared by dry ashing of 2 g of dry powdered sample which was made up to 50 ml with distilled water. To 5 ml of sample solution 0.5 ml of concentrated H_2SO_4 and 1 ml of potassium persulphate were added. The colour developed was read at 480 nm. The content of iron was expressed in mg per 100 g of sample.

3.3.2.9 Phosphorus

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

One g of dry powdered sample was pre digested with 12 ml of 9:4 diacid and volume made upto 100 ml with distilled water. 5 ml of aliquot was pippetted into 25 ml volumetric flask and 5 ml of nitric acid vandate molybdate reagent was added

and made upto 25 ml. After 30 minutes the Optical Density was read at 420 nm in a spectronic photometer. A standard graph was prepared using serial dilution of standard phosphorus solution. From the standard graph the phosphorus content of the sample was estimated and converted into fresh weight basis.

3.3.2.10 Potassium

The potassium content was estimated by using flame photometer as suggested by Jackson (1973) and expressed in mg 100 g^{-1} of fresh sample.

The dry powdered 1 g sample was digested in diacid and made upto 100 ml. One ml of sample solution was made upto 25 ml and read directly in flame photometer.

3.3.2.11 Calculation of Average Nutritive Value

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

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

3.3.3 Analysis of Antinutritional Factors in Leafy Vegetables

The nine leafy vegetables selected for study were analysed for the antinutritional factors like oxalate and nitrate.

3.3.3.1 Oxalate

Oxalate content of the samples was estimated colorimetrically using iron ferron reagent in 0.5 g of dried sample as suggested by Marderosian *et al.* (1979).

The dried plant material was powdered and 0.5 g of the sample was added to 10 ml of distilled water followed by 10 ml of citric acid reagent. The same 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.

3.3.3.2 Nitrate

Nitrate content was estimated colorimetrically using diphenol sulphonic acid in dry sample as suggested by Bharghava and Raghupathi (1993) and expressed in g 100 g^{-1} of fresh leaves.

The dry powdered sample of 0.5 g was extracted with 50 ml of water and filtered. Two ml of aliquote from water extract was taken in a porcelain dish and evaporated to dryness. Three ml of phenol disulphonic acid was added followed by 15 ml of water, cooled and washed down into a 100 ml volumetric flask. Added 1:1 ammonia till the solution developed an yellowish colour. The volume was made up and colour read at 420 nm.

A standard graph was prepared and nitrate content was calculated.

3.4 ORGANOLEPTIC EVALUATION OF LEAFY VEGETABLES

Organoleptic evaluation of fresh tender leaves was carried out at the laboratory level.

3.4.1 Selection of Judges

A series of acceptability trials were carried out using simple triangle test at the laboratory level to select a panel of ten judges between the age group of 18-30 years as suggested by Jellinek (1985).

3.4.2 Preparation of the Sample

Sensory evaluation of the tender leaves was carried out after preparing chutnies, salads, and cooking the leaves in the form of thoran. The products were prepared according to the suitability of the leaves for each preparation.

Chutnies were made from tender leaves of tamarind, mint, coriander and burmese coriander using standard recipe.

Salads were prepared from the leaves of mint, coriander and burmese coriander.

Leaves of cowpea, colocasia, pumpkin, ponnaviram and pisonia were cooked in the form of thoran. The recipes are given in Appendix I.

3.4.3 Sensory Evaluation

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

3.5 STATISTICAL ANALYSIS

Analysis of data was carried out using statistical techniques such as Kruskal Wallis one way analysis by ranks, Kandals coefficient and cluster analysis.

Results

4. RESULTS

The results pertaining to the study entitled 'Nutritional profile of selected greens' are presented under the following heads.

1) Physical characteristics of the leafy vegetables
2) Nutrient composition of leafy vegetables
3) Antinutritional factors in the leafy vegetables
4) Organoleptic evaluation of leafy vegetables
5) Cluster analysis of leafy vegetables

4.1 PHYSICAL CHARACTERISTICS OF THE LEAFY VEGETABLES

Nine leafy vegetables were analysed for their physical character namely the leaf colour. The leaf colour varied from yellowish green to dark green. The leaf colour of tree leaves varied from yellowish green (Pisonia) to dark green (Ponnaviram). All the three spicy leaves and the two conventional leaves namely pumpkin and cowpea were found to be green in colour, while the leaves of colocasia was light green in colour. The details are given in the Table 1.

Table 1. Colour of selected greens

Name of the leaf	Colour
1) <u>Tree leaves</u>	
Pisonia	Yellowish green
Tamarind	Pale green
Ponnaviram	Dark green
2) <u>Conventional leaves</u>	
Cowpea	Green
Pumpkin	Green
Colocasia leaves	Light green
3) <u>Spicy leaves</u>	
Mint	Green
Coriander leaves	Green
Burmese coriander	Green

4.2 NUTRIENT COMPOSITION OF LEAFY VEGETABLES

The selected leaves were analysed for the following nutrients namely moisture, fibre, protein, starch, beta carotene, vitamin C, calcium, iron, phosphorus and potassium. The results of the analysis are presented in the Table 2.

4.2.1 Moisture

The moisture content of the nine leafy vegetables are given in Table 2.

Kruskal wallis one way analysis by ranks revealed that the leaves differed significantly in their moisture content.

The mean moisture content varied from 72.33 per cent in ponnaviram to 85.78 per cent in colocasia leaves.

The mean moisture content in each group of leaves namely the tree, conventional and spicy indicated that pisonia had the highest moisture content (81.08%) followed by tamarind (75.22%) and ponnaviram (72.33%) in the case of tree leaves. Colocasia had the highest mean moisture content (85.78%) and pumpkin leaves (81.40%) the least among the conventional leaves. Among the spicy leaves, coriander had the highest moisture content of 81.5 per cent followed by burmese coriander (75.19%) and mint (73.46%).

The mean moisture content of the leaves is represented in Fig. 1.

4.2.2 Fibre

The mean fibre content on fresh weight basis is given in Table 2. Significant difference was seen in the fibre content of the leaves when Kruskal wallis one way analysis by ranks was carried out.

The mean fibre content of leafy vegetables varied from 0.03 per cent in pisonia to 1.44 per cent in colocasia leaves. Pisonia and ponnarivam had the lowest and highest fibre content among the tree group of leafy vegetables.

Table 2. Nutritional composition of selected greens on fresh weight basis, per 100 g

Sl. No.	Leafy vegetable	Mean									
		Moisture (g)	Fibre (g)	Protein (g)	Starch (g)	ß-carotene (µg)	Vitamin C (mg)	Calcium (mg)	Iron (mg)	Phosphorus (mg)	Potassium (mg)
1	Pisonia	81.08	0.03	3.36	0.11	3481.69	65.52	200.00	2.33	233.91	356.24
2	Tamarind	75.22	0.39	1.97	0.17	565.78	68.50	240.00	0.24	113.91	235.83
3	Ponnaviram	72.33	0.47	2.55	0.19	4913.95	523.00	280.00	2.85	149.86	199.73
4	Cowpea	84.37	0.78	6.18	0.18	4437.92	87.63	280.00	1.48	179.85	247.94
5	Pumpkin	81.40	0.38	3.63	0.21	3304.09	83.30	120.00	4.51	208.75	182.75
6	Colocasia	85.78	1.44	5.87	0.09	3133.17	32.26	160.00	1.13	131.35	427.88
7	Mint	73.46	0.24	1.12	0.17	2147.38	36.92	80.00	0.26	136.25	127.00
8	Coriander	81.57	0.27	1.26	0.31	5977.44	131.20	400.00	0.47	134.07	116.96
9	Burmese coriander	75.19	0.55	1.28	0.04	18942.53	47.63	2000.00	14.63	174.95	205.00
	H	43.997**	49.40**	49.49**	48.19**	49.83**	14.7135^{NS}	49.83**	50.23**	49.83**	49.93**

** Significant at 5 per cent level
NS - Not significant

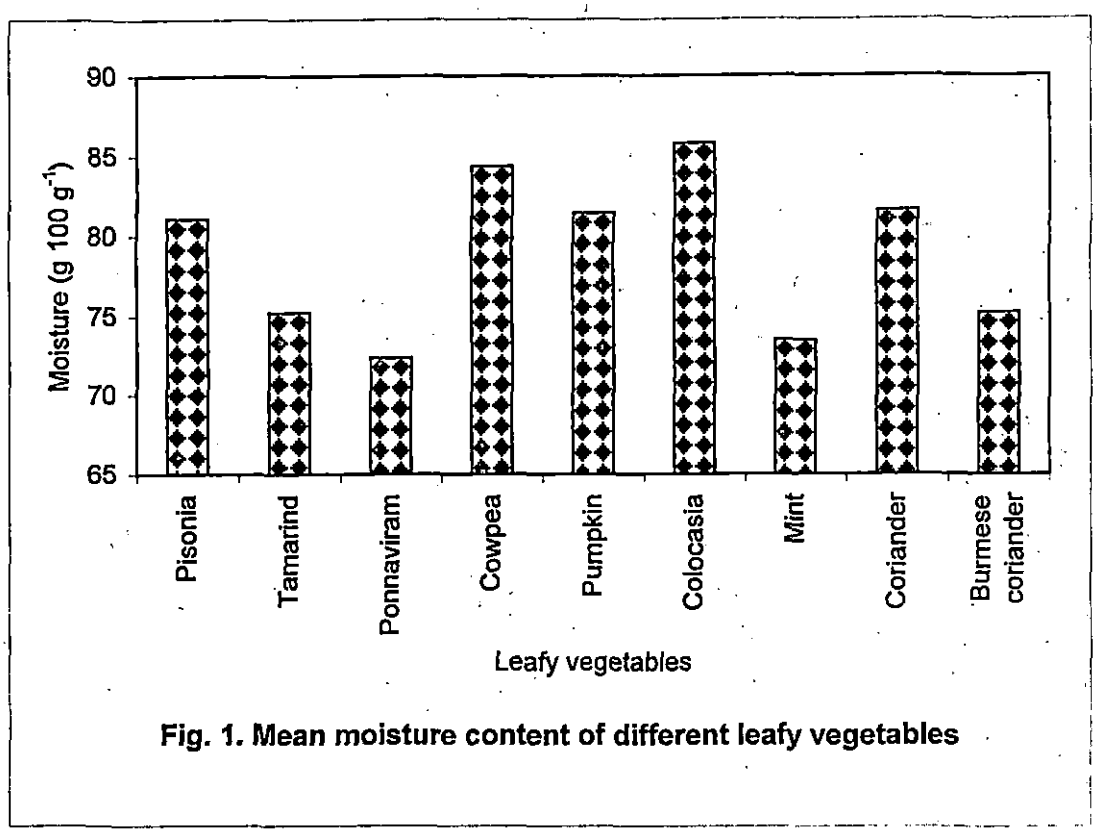

Fig. 1. Mean moisture content of different leafy vegetables

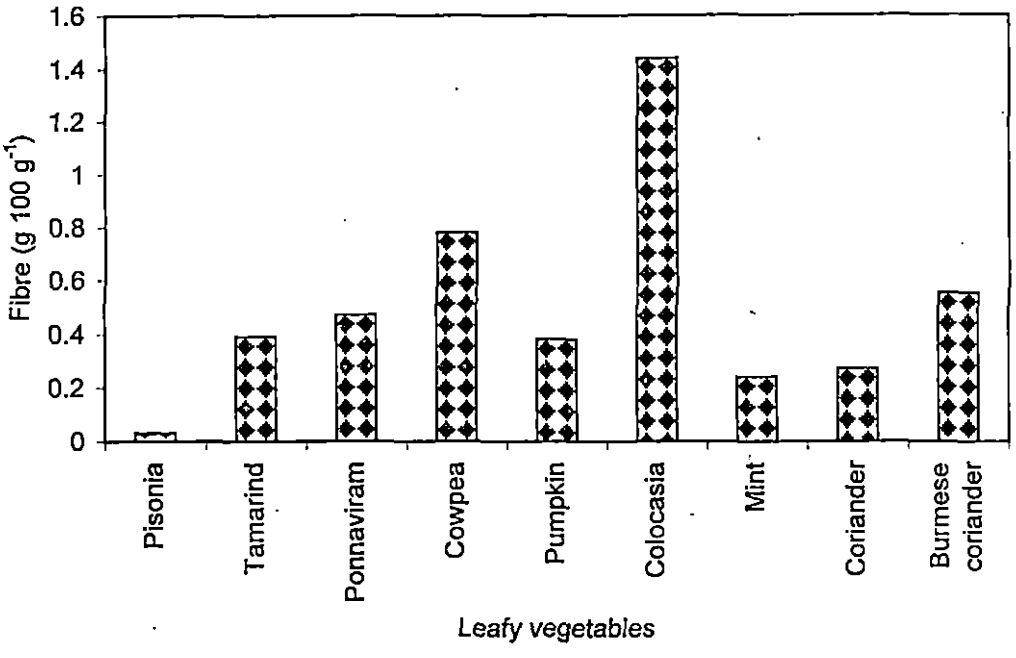

Fig. 2. Mean fibre content of different leafy vegetables

Among conventional leaves, colocasia leaves had the highest fibre (1.44%) and least was observed in the case of pumpkin leaves (0.38%). In the case of spicy leaves, mint leaves had the lowest fibre content (0.24%) where as burmese coriander had the highest (0.55%). The mean fibre content of the leaves is represented in Fig. 2.

4.2.3 Protein

From Table 2 it can be seen that the mean protein content of the leaves ranged from 1.12 per cent in mint leaves to 6.18 per cent in cowpea leaves. Statistical analysis clearly showed that there exist a significant variation in all the nine leaves analysed.

Pisonia leaves had the highest amount of protein (3.36%) in the category of tree leaves and the lowest was seen in the case of tamarind leaves (1.97%).

In the case of conventional leaves cowpea leaves (6.18%) had the highest protein and lowest content of protein was seen in the case of pumpkin leaves (3.63%). In the spicy group, burmese coriander had the highest protein content (1.28%) and the least amount was seen in the case of mint (1.12%).

The mean protein content of the leaves is represented in Fig. 3.

4.2.4 Starch

The starch content of different leafy vegetables is given in Table 2.

Significant variation existed in the starch content of the leaves. Burmese coriander had the least starch (0.04%) and highest amount was seen in the leaves of coriander (0.31%) both of which belongs to the spicy leaf group.

In the tree leaves, ponnaviram leaves (0.19%) had the highest amount and pisonia leaves (0.11%) had the least amount of starch content. In the case of conventional leaves, colocasia had the lowest amount (0.09%) and highest amount of starch was seen in pumpkin leaves (0.21%).

The mean starch content of leaves is represented in Fig. 4.

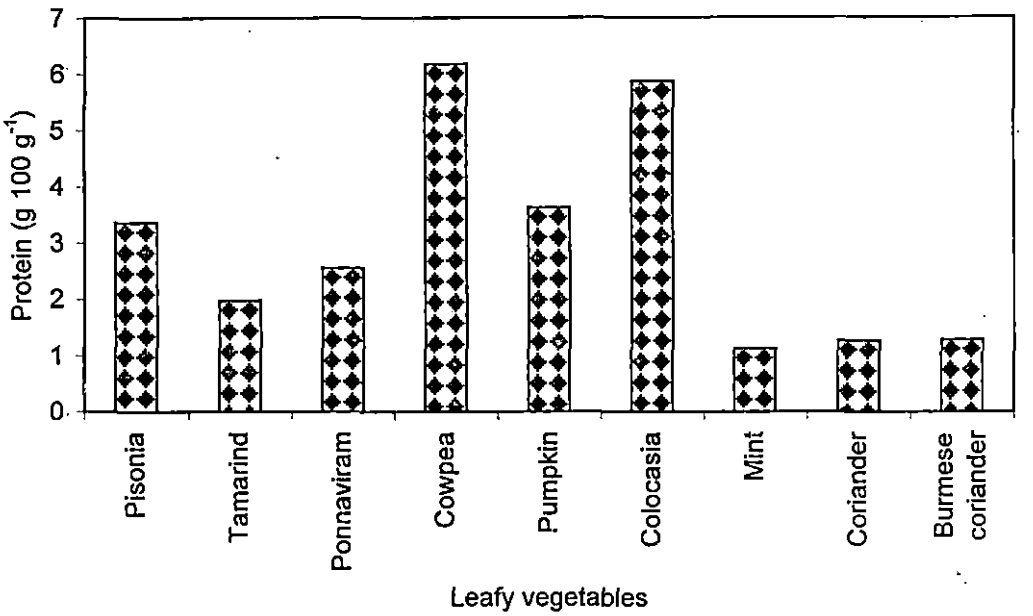

Fig. 3. Mean protein content of different leafy vegetables

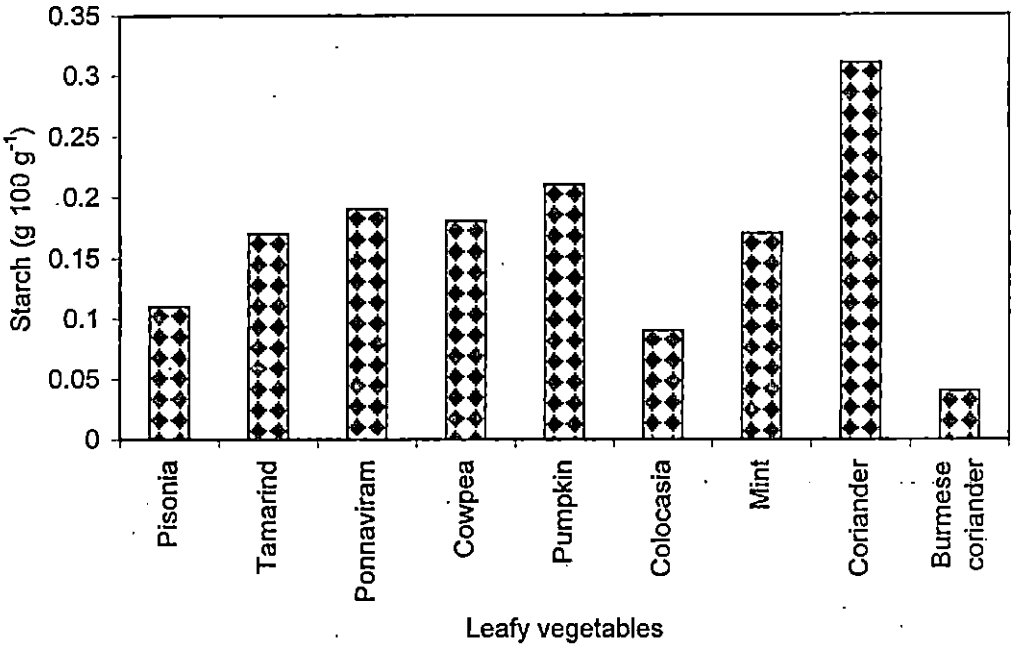

Fig. 4. Mean starch content of different leafy vegetables

4.2.5 β-Carotene

The mean beta carotene content of leaves varied from 565.78 µg to 18942.53 µg 100 g^{-1}. The highest beta carotene content was observed in burmese coriander leaves and lowest in the leaves of tamarind (Table 2). Kruskal wallis one way analysis by ranks revealed that the leaves differed significantly in the beta carotene content.

The ponnaviram leaves (4913.95 µg 100 g^{-1}) had highest beta carotene content while the lowest content was seen in tamarind leaves (565.78 µg 100 g^{-1})in the tree leaf group. In conventional leaves, cowpea leaves (4437.92 µg 100 g^{-1}) had the highest amount and the least amount of beta carotene was seen in colocasia leaves (3133.17 µg 100 g^{-1}). When the leaves belonging to spicy leaf group were compared, burmese coriander leaf (18942.53 µg 100 g^{-1}) had highest quantity of beta carotene and lowest was seen in mint leaves (2147.38 µg 100 g^{-1}).

The mean beta carotene content of the leaves is represented in Fig. 5.

4.2.6 Vitamin C

The vitamin C content of 100 g of greens are furnished in the Table 2.

No significant variation was seen in the vitamin C content of the nine leaves analysed.

The mean vitamin C content ranged from 32.26 mg in colocasia leaves to 523.00 mg 100 g^{-1} in ponnaviram leaves.

The ponnaviram leaves had the highest amount of vitamin C content and the lowest amount was seen in the case of pisonia leaves (65.52 mg 100 g^{-1}) when tree group of leaves were taken into account. Vitamin C content of colocasia leaves was low (32.26 mg 100 g^{-1}) and in the case of cowpea leaves it was very high (87.63 mg 100 g^{-1}) among the conventional leaves. In the case of leaves belonging to spicy group, coriander leaves (131.20 mg 100 g^{-1}) had highest content and mint (36.92 mg 100 g^{-1}) had the lowest vitamin C content.

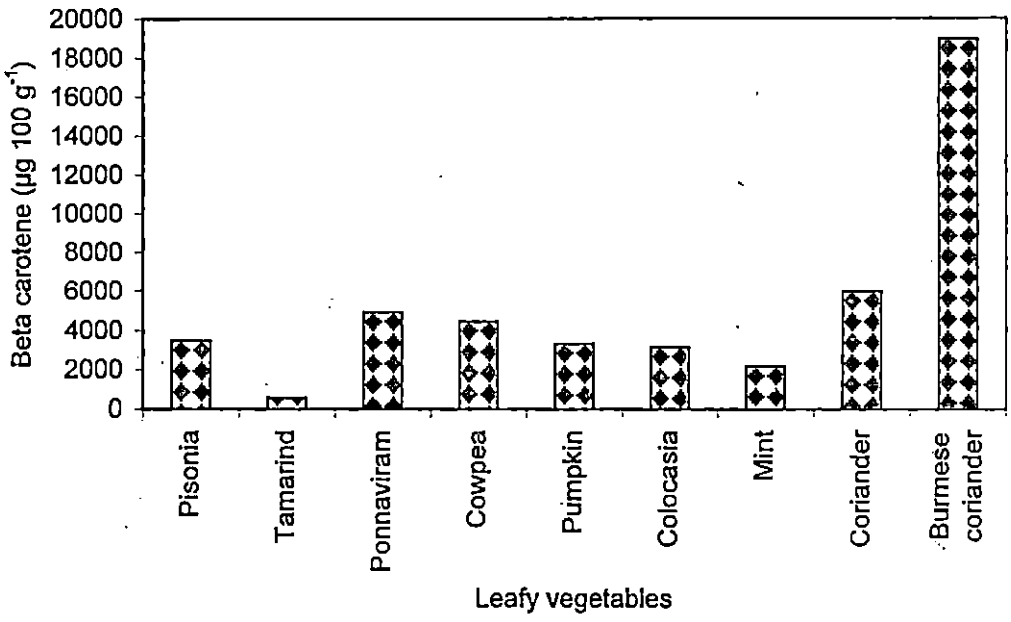

Fig. 5. Mean beta carotene content of different leafy vegetables

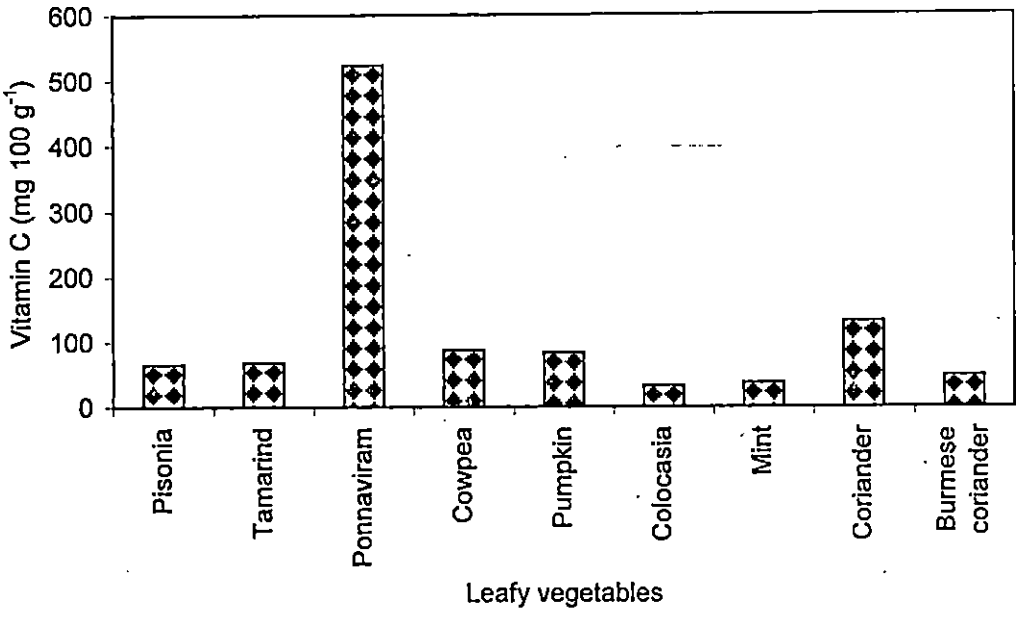

Fig. 6. Mean vitamin C content of different leafy vegetables

The mean vitamin C content of leaves are represented in Fig.6.

4.2.7 Calcium

The Table 2 shows the calcium content of the nine leafy vegetables analysed on fresh weight basis.

Statistically there exist significant variation in between the nine leafy vegetables analysed and it was seen that the tender leaves of burmese coriander had the highest amount (2000 mg 100 g^{-1}) of calcium and the lowest amount was seen in the case of mint leaves (80 mg 100 g^{-1}). Both these leaves belong to the spicy leaf group.

Ponnaviram leaves (280 mg 100 g^{-1}) had highest calcium content and lowest was in pisonia (200 mg 100 g^{-1}) in the case of tree leaves while in the conventional leaf group cowpea had the highest amount of calcium (280 mg 100 g^{-1}) and pumpkin leaves had the lowest (120 mg 100 g^{-1}).

Ponnaviram and cowpea leaves had the same amount of calcium.

The mean calcium content of the leaves is represented in Fig. 7.

4.2.8 Iron

The iron content of three different groups of leafy vegetables are given in the Table 2.

Kruskal wallis one way analysis by ranks revealed that the leaves differ significantly in the iron content. The lowest iron content was seen in tamarind leaves (0.24 mg 100 g^{-1}) and highest amount was seen in the case of burmese coriander leaves (14.63 mg 100 g^{-1}) when the nine samples were compared together. Among the leaves of tree group, ponnaviram leaves (2.85 mg 100 g^{-1}) had the highest content of iron and the least was seen in tamarind leaves (0.24 mg 100 g^{-1}). In the case of conventional group, pumpkin leaves had the highest value (4.5 mg 100 g^{-1}) and lowest was seen in the colocasia leaves (1.13 mg 100 g^{-1}). Mint had the lowest amount (0.26 mg 100 g^{-1}) and burmese coriander leaves had the highest amount of iron (14.63 mg 100 g^{-1}) in the case of spicy leaf group.

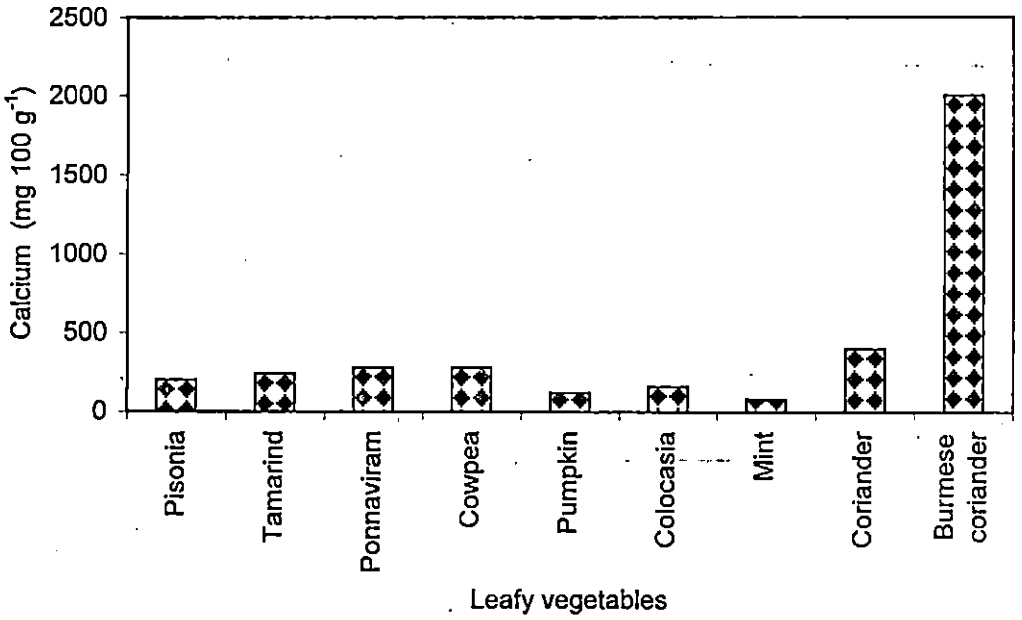

Fig. 7. Mean calcium content of different leafy vegetables

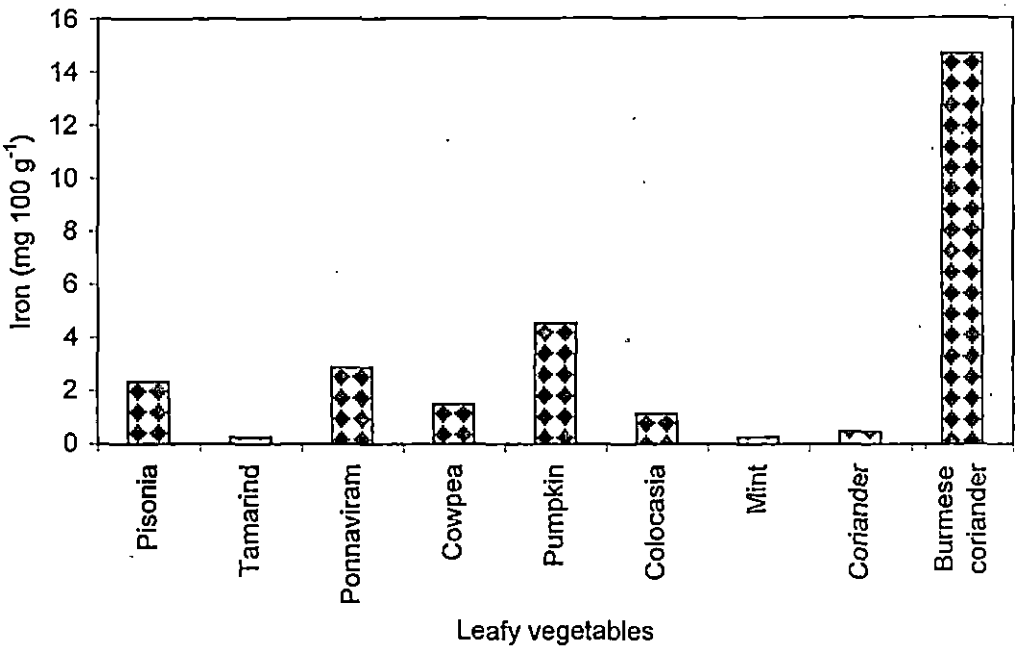

Fig. 8. Mean iron content of different leafy vegetables

The mean iron content of the leaves is represented in the Fig.8.

4.2.9 Phosphorus

The mean phosphorus content on fresh weight basis are given in the Table 2.

Significant variation was seen in different leafy vegetables analysed through Kruskal wallis one way analysis by ranks and the highest amount of phosphorus was seen in the tender leaves of pisonia (233.91 mg 100 g^{-1}) and lowest content was seen in the leaves of tamarind (113.91 mg 100 g^{-1}). Both these leaves belong to tree group.

In the case of conventional group pumpkin leaves had highest phosphorus content (208.75 mg 100 g^{-1}) and least was seen in colocasia (131.35 mg 100 g^{-1}) leaves. Among spicy leaf group, coriander leaves had the lowest phosphorus content of 134.07 mg 100 g^{-1} and Burmese coriander had highest phosphorus content of 174.95 mg 100 g^{-1}.

The mean phosphorus content of the leaves is represented in Fig. 9.

4.2.10 Potassium

Table 2 shows the mean potassium content of the greens.

Kruskal wallis one way analysis by ranks revealed that the leaves differed significantly in the potassium content.

From the table it can be seen that the leaves of coriander had the lowest amount of potassium (116.96 mg 100 g^{-1}) and the highest amount was seen in colocasia leaves (427.88 mg 100 g^{-1}).

When we compare the potassium content of the tree leaves, it can be seen that the leaves of pisonia had the highest amount of (356.24 mg 100 g^{-1}) and lower amount was seen in the case of ponnaviram leaves (199.73 mg 100 g^{-1}). Colocasia leaves (427.88 mg 100 g^{-1}) had the highest mean potassium content and pumpkin

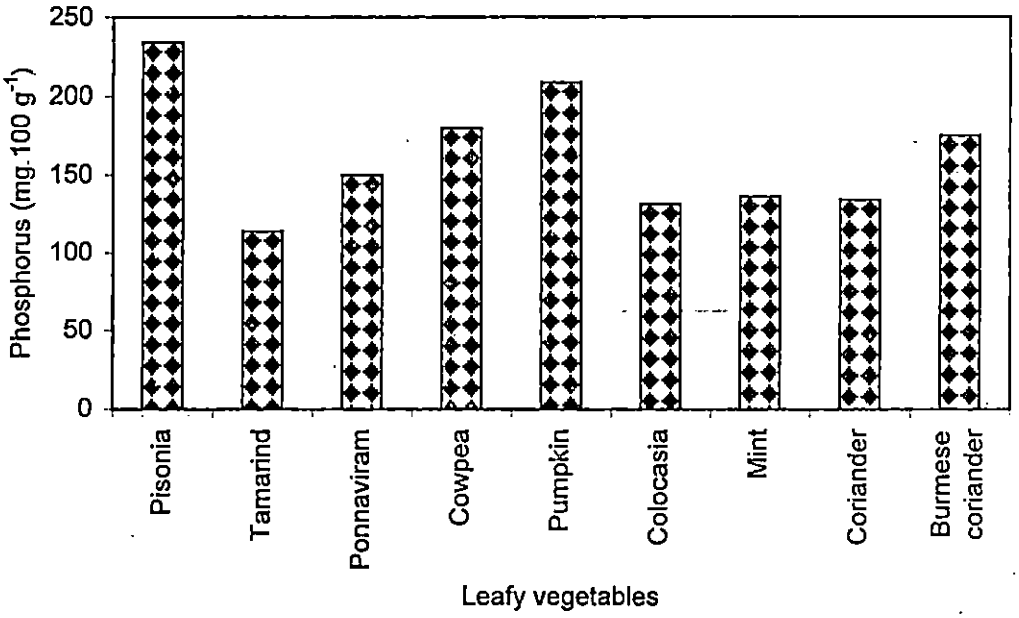

Fig. 9. Mean phosphorus content of different leafy vegetables

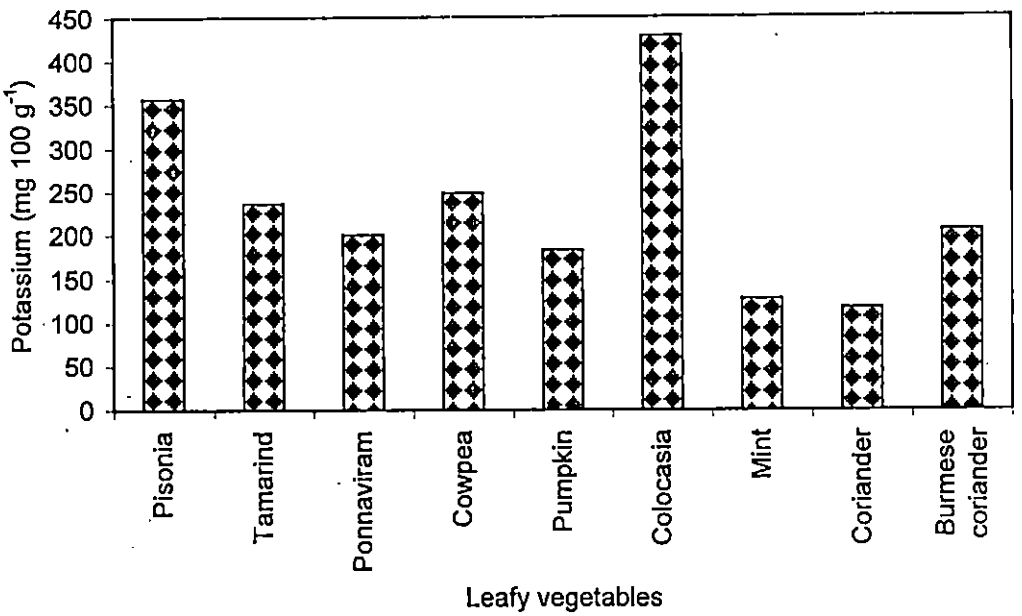

Fig. 10. Mean potassium content of different leafy vegetables

leaves (182.75 mg 100 g^{-1}) the lowest potassium among the conventional leaves. But in the case of spicy group, coriander leaves had the least amount of potassium (116.96 mg 100 g^{-1}) and burmese coriander leaves had the highest amount of potassium (205.00 mg 100 g^{-1}).

The mean potassium content of the leaves is represented in Fig.10.

4.2.11 Average Nutritive Value of the Leaves

The mean average nutritive value of the leaves are given in Table 3.

Table 3. Mean average nutritive value of different green leafy vegetables, percentage

Sl.No.	Leafy vegetable	Mean
1	Pisonia	24.54
2	Tamarind	20.23
3	Ponnaviram	37.20
4	Cowpea	27.85
5	Pumpkin	25.53
6	Colocasia	39.15
7	Mint	18.94
8	Coriander	30.04
9	Burmese coriander	63.06

H = 49.83** (** Significant at 5 per cent level)

Statistically all the nine leaves differed significantly in their average nutritive value and the highest nutritive value was obtained for burmese coriander (63.06%) and least in mint (18.94%). Both of these leaves belong to spicy leaf group.

In tree group of leaves the average nutritive value varied from 20.23 per cent in Tamarind to 37.20 per cent in ponnaviram while in the case of conventional leaves the highest average nutritive value was seen in pumpkin (25.53%) and the lowest in colocasia leaves (39.15%).

The mean average nutritive value of the leaves is represented in Fig.11.

4.3 ANTINUTRITIONAL FACTORS IN THE LEAFY VEGETABLES

The leafy vegetables selected for study were analysed for antinutritional factors namely oxalate and nitrate contents and the values are given in Table 4.

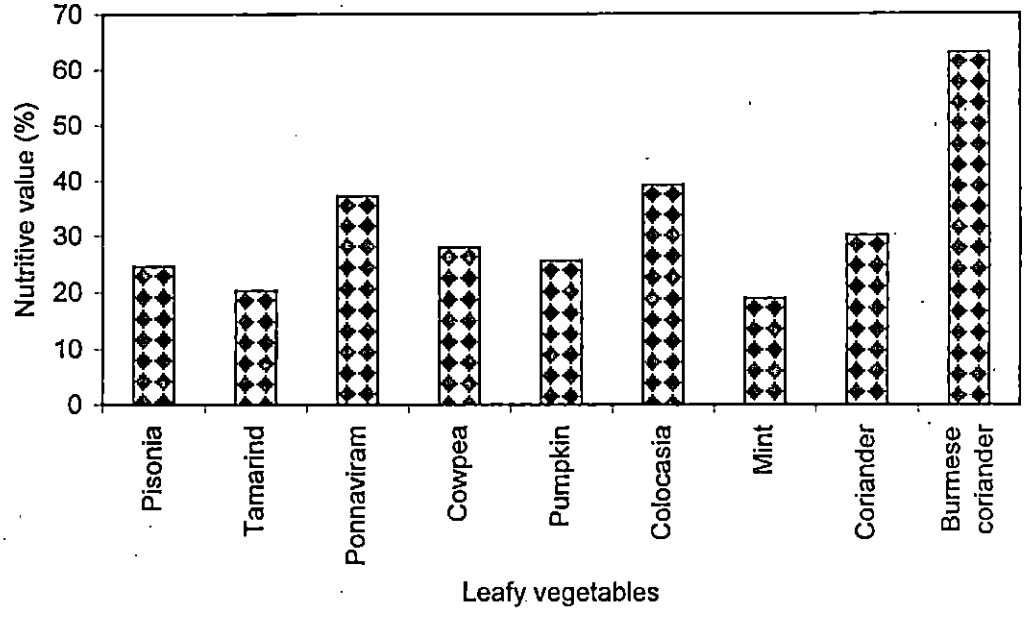

Fig. 11. Mean average nutritive value of different leafy vegetables

Table 4. Antinutritional composition of selected greens on fresh weight basis, g 100 g^{-1}

Sl. No.	Leafy vegetable	Mean	
		Oxalate	Nitrate
1	Pisonia	2.97	2.80
2	Tamarind	0.58	1.94
3	Ponnaviram	0.45	2.66
4	Cowpea	1.57	1.27
5	Pumpkin	0.75	1.57
6	Colocasia	1.40	1.44
7	Mint	0.52	3.22
8	Coriander	0.004	2.81
9	Burmese coriander	0.25	1.23
	H	0.5394^{NS}	48.165**

** - Significant at 5 per cent level
NS - Not significant

4.3.1 Oxalate

The mean oxalate content of the leaves varied from 0.004 to 2.97 g 100 g^{-1}. The highest oxalate content was seen in the case of pisonia leaves and lowest in the coriander leaves. Statistically no significant variation was seen in between the nine leaves analysed in terms of the oxalate content.

Tree leaves had a mean oxalate content of 2.97 per cent in pisonia to 0.45 per cent in ponnaviram leaves. But in the conventional leaf group, cowpea leaves had the highest amount of oxalate (1.57%) and least in the leaves of pumpkin (0.75%).

The highest amount of oxalate was seen in the leaves of mint (0.52%) in the spicy leaf group and lowest in the coriander leaves (0.004%).

The mean oxalate content of leaves are represented in Fig.12.

4.3.2 Nitrate

Nitrate content of the three different groups of leaves are given in Table 4.

The variation in the nitrate content of the leaves were highly significant when Kruskal Wallis one way analysis by ranks were carried out.

When the nitrate content of the tree group were compared, the highest content was obtained in the case of pisonia leaves (2.80%) and lowest in the leaves of tamarind (1.94%). Pumpkin (1.57%) had the highest amount of nitrate and lowest in the cowpea (1.27%) in the case of conventional leaf group.

The mean nitrate content varied from 1.23 per cent to 3.22 per cent. The nitrate content was seen to be highest in mint leaves and lowest in burmese coriander leaves, both of these belong to the spicy group.

The mean nitrate content of leaves are represented in Fig.13.

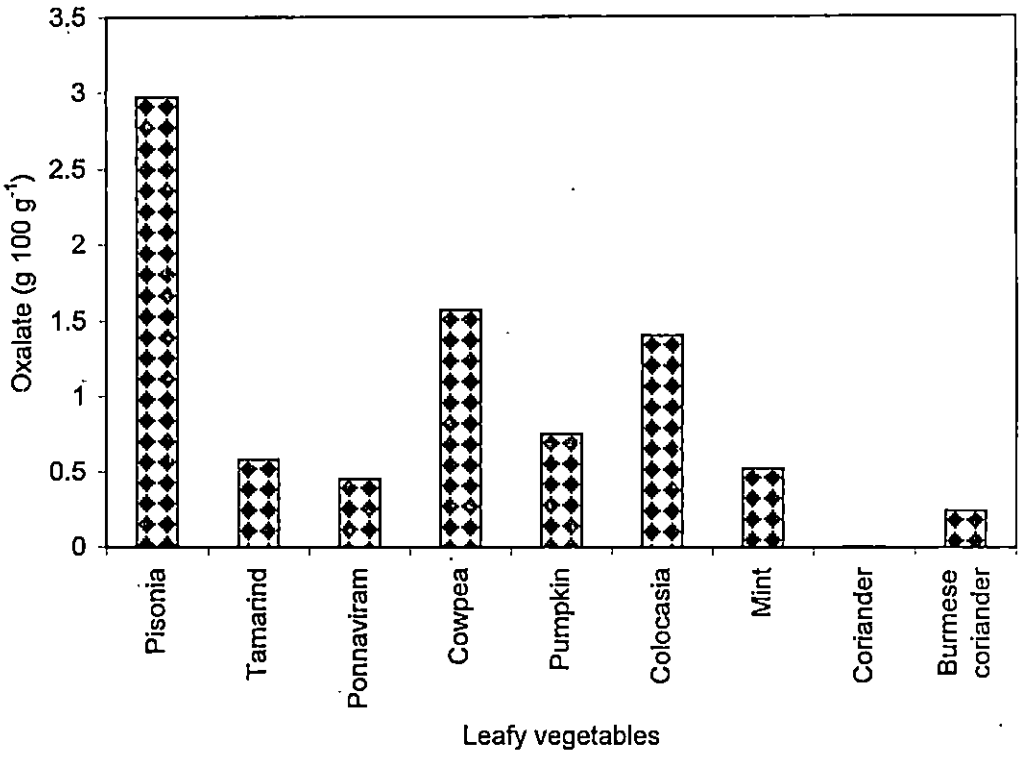

Fig. 12. Mean oxalate of different leafy vegetables

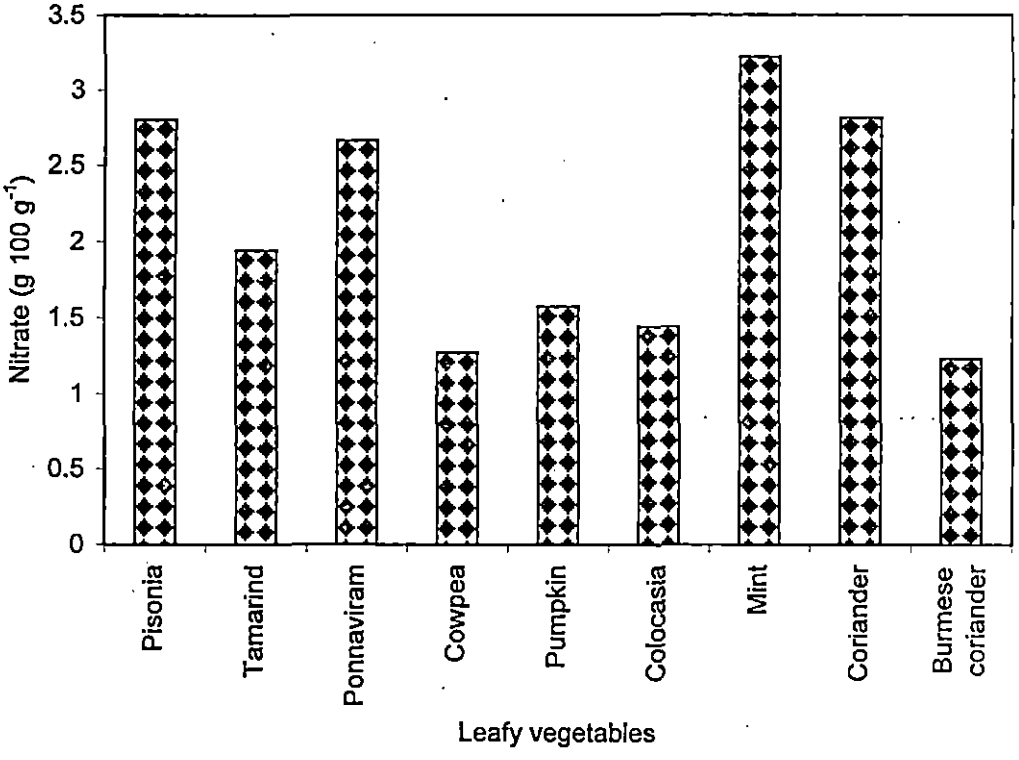

Fig. 13. Mean nitrate of different leafy vegetables

4.4 ORGANOLEPTIC EVALUATION OF LEAFY VEGETABLES

The acceptability studies of chutnies, salads and thoran were conducted by the score card method. Five quality attributes namely appearance, colour, flavour, texture and taste were scored using a five point hedonic scale by a panel of ten judges.

4.4.1 Acceptability of Chutnies

Based on the suitability of the leaves, chutnies were made from leaves of mint, coriander, burmese coriander and tamarind. The mean scores obtained for chutnies made out of these leafy vegetables are furnished in Table 5.

Table 5. Organoleptic evaluation of chutney

Sl.No.	Leaf samples	Mean scores					
		Appearance	Colour	Flavour	Texture	Taste	Total
1	Coriander	3.86	3.83	3.61	4.06	3.75	19.11
2	Mint	3.67	3.46	3.00	3.60	2.56	16.29
3	Burmese coriander	4.17	4.34	4.35	3.82	4.34	21.02
4	Tamarind	3.58	3.01	3.70	3.71	3.63	17.64
	W	0.14 ^{NS}	0.62**	0.51**	0.50**	0.70**	0.68**

** Significant at 5 per cent level
NS - Not significant

From the table, it can be seen that the mean score for appearance was highest for burmese coriander (4.17) and lowest for tamarind leaf chutney (3.58).

For the second quality attribute namely the colour, the mean scores ranged from 3.01 in tamarind chutney to 4.34 in burmese coriander chutney.

The mean scores for flavour varied from 3.00 to 4.35 for mint and burmese coriander respectively.

In the case of texture, the scores varied from 3.6 to 4.06, with mint chutney having the lowest and coriander leaf chutney having the highest score.

The mean scores for taste were found to be highest for burmese coriander chutney (4.34) and lowest for mint chutney (2.56).

The total mean scores for different quality attributes of chutnies varied from 16.29 in mint to 21.02 in burmese coriander chutney.

Kandal's coefficient of concordance was worked out to assess the acceptability of chutnies with respect to different characters like appearance, colour, flavour, texture and taste which indicated that except for appearance all other attributes were highly acceptable.

The chutnies prepared from various leafy vegetables was found to be acceptable when conceived in an overall way (W = 0.684**).

4.4.2 Acceptability of Salads

Based on the suitability, tender leaves of coriander, burmese coriander and mint were used for preparing salads. The mean scores obtained for different leafy vegetable salads are presented in the Table 6.

Table 6. Organoleptic evaluation of salad

Sl. No.	Leaf samples	Mean scores					
		Appearance	Colour	Flavour	Texture	Taste	Total
1	Coriander	4.07	4.50	4.17	4.20	4.15	21.09
2	Burmese coriander	4.04	4.03	4.30	4.18	4.19	20.74
3	Mint	4.13	4.12	4.13	4.04	3.92	20.34
	W	0.003^{NS}	0.27^{NS}	0.06^{NS}	0.06^{NS}	0.10^{NS}	0.01^{NS}

NS - Not significant

The table indicates that the mean score for appearance was highest for mint leaf salad (4.13) followed by coriander (4.07) and least score was obtained for burmese coriander (4.04) salad.

The mean score for colour was highest for coriander salad (4.50) and lowest for burmese coriander salad (4.03).

For the third quality attribute namely the flavour, the highest score was obtained for salad made out of burmese coriander (4.30) and the mint salad scored the least (4.13).

In the case of texture the coriander leaf salad had the highest score and lowest was for mint leaves. The mean score ranged from 4.04 to 4.20.

For the fifth quality attribute i.e., taste the mean score ranged from 3.92 (Mint) to 4.19 (Burmese coriander). The total mean score ranged from 20.34 in mint leaf salad to 21.09 in coriander leaf salad.

For assessing the acceptability of salads with respect to different attributes like appearance, colour, flavour, texture and taste; Kandal's coefficient of concordance was worked out which revealed that the degree of agreement with regard to all the attributes was poor.

The leafy vegetable salads were found to be unacceptable when conceived in an overall way ($W = 0.01^{NS}$).

4.4.3 Acceptability of Thoran

Depending on the suitability of the leaves, thoran was made from the leaves of pumpkin, colocasia, pisonia, cowpea and ponnaviram. The mean score obtained for different leafy vegetables are given below in Table 7.

Table 7. Organoleptic evaluation of thoran

Sl. No.	Leaf sample	Mean scores					
		Appearance	Colour	Flavour	Texture	Taste	Total
1	Pisonia	3.90	3.73	3.04	3.04	2.33	16.04
2	Ponnaviram	4.44	4.28	4.14	4.27	4.29	21.42
3	Cowpea	4.11	4.00	3.76	3.74	3.76	19.37
4	Pumpkin	4.17	4.67	3.99	3.91	3.98	20.72
5	Colocasia	4.10	4.00	4.50	3.60	3.60	19.80
	W	0.18^{NS}	0.31**	0.52**	0.34**	0.66**	0.44**

** Significant at 5 per cent level

From the table, it can be seen that the mean score for appearance was highest for ponnaviram thoran (4.44) followed by pumpkin (4.17), cowpea (4.11), colocasia (4.10) leaf thorans and the least score was obtained for pisonia thoran (3.90).

When the quality attribute, colour was taken into account the pumpkin thoran scored the maximum (4.67) followed by ponnaviram thoran (4.28). Cowpea and colocasia thoran had the same score (4.00) and pisonia thoran scored the least (3.73).

The mean score for flavour varied from 3.04 to 4.50 with pisonia and colocasia leaf thoran having the lowest and highest mean scores.

Regarding texture, the mean scores ranged from 3.04 in pisonia leaf thoran to 4.27 in ponnaviram thoran. Ponnaviram leaf thoran was followed by pumpkin leaf (3.91), cowpea leaf (3.74) and colocasia leaf thoran (3.60) had the least score.

When taste was taken into account, the mean scores obtained ranged from 2.33 to 4.29. The highest score was obtained for ponnaviram thoran followed by pumpkin leaf (3.98), cowpea leaf (3.76), colocasia leaf (3.60) and least in pisonia leaf thoran (2.33).

After computing the total mean scores of all five quality attributes the ponnaviram leaf thoran obtained the highest score of 21.42 and the least (16.04) by pisonia leaf thoran.

Statistical analysis (Kandal's coefficient of concordance) indicated that except for appearance all other attributes namely, colour, flavour, texture and taste of thorans were highly acceptable.

When conceived in an overall way the preparaed leaf thorans were found to be highly acceptable (W = 0.44**).

4.5 CLUSTER ANALYSIS OF THE LEAFY VEGETABLES

In order to find out the homogeneous groups of leaves, based on the nutrient and antinutrient composition of the selected leaves Non Hierarchial Euclidean Cluster Analysis was worked out. Based on this the leaves were grouped into three clusters.

The average intra and inter cluster distance matrix is shown in Table 8 and represented in Fig.14.

Table 8. Average intra and inter cluster distance matrix

Cluster No.	I	II	III
I	1.968	-	-
II	3.718	2.452	-
III	6.101	5.875	0.000

Note : The values along the principal diagonal indicate the average distance of cluster members from cluster centroids

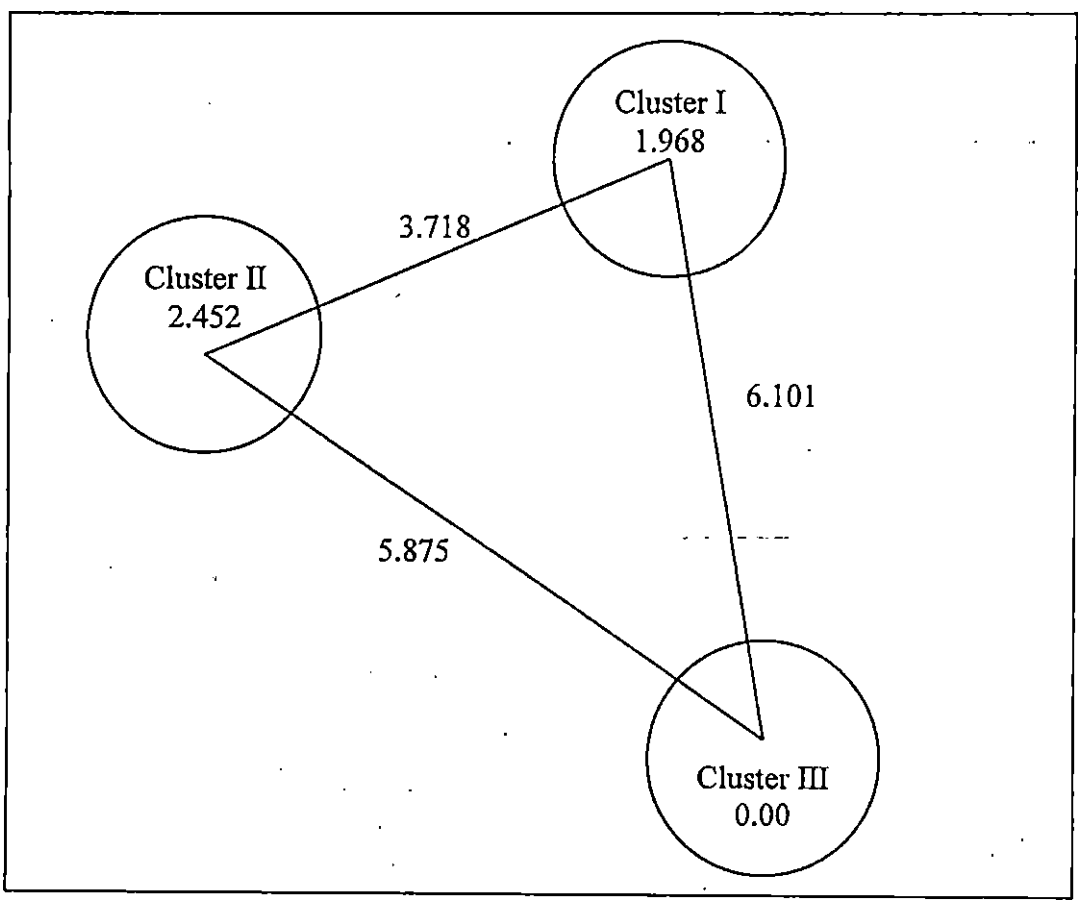

Fig.14. Cluster analysis of leafy vegetables

Table 9. Cluster mean for nutritional and antinutrition composition of selected greens, per 100 g

Cluster	Moisture (g)	Fibre (g)	Protein (g)	Starch (g)	ß carotene (µg)	Vitamin C (mg)	Calcium (mg)	Iron (mg)	Phos-phorous (mg)	Potassium (mg)	Oxalate (g)	Nitrate (g)
I	75.61	0.34	1.72	0.21	3402.07	189.50	250	0.95	133.53	169.90	0.39	2.67
II	83.32	0.66	4.76	0.15	3588.24	66.67	190	2.36	188.41	303.63	1.67	1.77
III	75.19	0.55	1.28	0.04	18942.53	47.63	2000	14.63	174.95	205.00	0.24	1.23

Cluster No.	Members
I	Tarmarind, Ponnaviram, Mint, Coriander
II	Pisonia, Pumpkin, Cowpea, Colocasia
III	Burmese coriander

Table 9 shows the cluster means for nutritional and antinutritional composition of selected greens.

The members of cluster I was found to be high in starch, vitamin C and nitrate content. These include the leaves of tamarind, ponnaviram, mint and coriander.

The mean starch content for the first cluster was 0.21 g 100 g^{-1}. Within the cluster, the starch content of the cluster members varied from 0.17 to 0.31 g 100 g^{-1}. Cluster mean for vitamin C was 189.50 mg 100 g^{-1} and within the cluster the vitamin C content varied from 36.92 to 523.00 mg 100 g^{-1}.

The mean cluster value for nitrate was 2.67 g 100 g^{-1} and the mean inner cluster values ranged from 1.94 to 3.22 g 100 g^{-1}.

Cluster II contained the leaves of pisonia, cowpea pumpkin and colocasia. They were found to be rich in protein, potassium and oxalate content with 4.76 g 100 g^{-1}, 303.63 mg 100 g^{-1} and 1.67 g 100 g^{-1} respectively as the cluster means. Within the cluster, the means varied from 3.36 to 6.18 g 100 g^{-1} (protein), 182.75 to 427.88 mg 100 g^{-1} (potassium) and 0.75 to 2.97 g 100 g^{-1} (oxalate).

The third cluster contained only one leaf namely burmese coriander and it was found to be rich in calcium, iron, beta carotene and low in oxalate and nitrate content.

The calcium, iron and beta carotene content were found to be 2000 mg, 14.63 mg and 18942.53 µg per 100 g respectively.

The third cluster (Burmese coriander leaves) which contained high amounts of calcium, iron and beta carotene and lower oxalate and nitrate content may be considered as the best group among the three clusters.

Discussion

5. DISCUSSION

The study entitled 'Nutritional profile of selected greens' was undertaken to assess the nutritional composition, antinutritional factors and the acceptability of nine different leafy vegetables.

The discussion pertaining to the study are explained under the following heads.

1) Nutritional composition of leaf vegetables.
2) Antinutritional factors in the leaf vegetables.
3) Acceptability of leaf vegetables.
4) Cluster analysis of the leaves.

5.1 NUTRITIONAL COMPOSITION OF LEAF VEGETABLES

The mean moisture content of the nine leafy vegetables analysed ranged from 72.33 to 85.78 per cent. The moisture content of the selected leaves were found to be in accordance with the values reported by Kaur and Manjrekar (1975), Sreeramulu (1982), Wills *et al.* (1984), Govindan and Shanmugasundaram (1987), Jijiamma (1989), Akpanyung *et al.* (1995), Islam *et al.* (1987), Shingade *et al.* (1995), Nambiar and Seshadri (1998), Sirohi (1998), Varalakshmi *et al.* (1998), Thangaraj and Shanmugasundaram (2000) and Sahoo *et al.* (2002) for different leafy vegetables. However, Easwaran and Goswani (1989) reported a high moisture content of 83.3 to 94.2 per cent in wild leafy vegetables grown in Meghalaya.

The moisture content of tamarind and colocasia leaves were found to agree with the values reported by Duke (1981), CSIR (1985) and Gopalan *et al.* (1989). However tender leaves of pisonia and mint had a low moisture content than reported by Gopalan *et al.* (1989) which was found to be 90.2 per cent and 84.9 per cent respectively.

This slight variation might be due to difference in the stage at which the leaf is plucked and seasonal variation as suggested by Mathew (2000).

The fibre content of the leaves varied from 0.03 per cent to 1.44 per cent. This was found to be in accordance with those reported by Easwaran and Goswani (1989), Saikia and Shadeque (1994), Gopalan *et al.* (1989) for various leafy vegetables. However Kaur and Manjrekar (1975), Ramachandran *et al.* (1980) and Mathew (2000) reported the fibre content of leaves in the range of 0.92 to 5 per cent. But when the obtained values were converted to dry weight basis the present findings were also in accordance with the range reported by Saikia and Shadeque (1994) for Ceylon spinach, Neeliyara (1998) for winged beans, Bharathi and Umamaheshwari (2001) for different G.L.V'S of Nellore and Prakasam districts of Andhra Pradesh and Verma (2001) for tender tamarind leaves. In the study the mean fibre content of colocasia leaves (1.44%) was found to be slightly lower than the value of 2.9 per cent reported by Gopalan *et al.* (1989). Similar was the case with pumpkin (0.38%), cowpea (0.78%), coriander (0.27%) and tamarind leaves (0.39%) in which the authors have reported a fibre content of 2.1, 1.2, 1.2 and 1.9 g 100 g^{-1} respectively. This difference in the fibre content of green leafy vegetables may be due to the difference in the stage at which the leaves were plucked as suggested by Giri *et al.* (1984).

Protein content of nine leaves analysed varied from 1.12. to 6.18 per cent which was in accordance with the findings of Easwaran and Goswani (1989), Saikia and Shadeque (1994), Sirohi (1998), Suman (2000), Bharathi and Umamaheshwari (2001), and Sahoo *et al.* (2002) for different green leafy vegetables. Peter (1992) reported a protein content in the range of 6.1-6.8 per cent in drumstick leaves, curry leaves and chekkurmanis. But Govindan and Shanmugasundaram (1987) observed high protein content (8.4%) for agathi leaves.

The mean protein content of pisonia leaves (3.36%) was found to be in accordance with the findings of Gopalan *et al.* (1989).

A higher protein was seen in the case of cowpea (6.18%) and colocasia leaves (5.87%) against 3.4 and 3.9 per cent respectively as reported by Gopalan *et al.* (1989).

Starch content of the nine leaves analysed varied from 0.04 per cent to 0.31 per cent. But Mathew (2000) reported that the starch content of green leafy vegetables varied from 0.07 to 1.70 per cent. However Wills *et al.* (1984) and John *et al.* (1987) observed the starch content of the leaves varied from 0.2 to 0.73 per cent.

Beta carotene content of the leaves varied from 565.78 µg 100 g^{-1} to 18942.53 µg 100 g^{-1}. This agrees with the findings of Rao *et al.* (1980), Giri *et al.* (1984), Peter (1992), Sirohi (1998), Mathew (2000), Pathak *et al.* (2000), Suman (2000) and Nambiar and Seshadri (2001) for different green leafy vegetables.

The pumpkin leaf had a beta carotene content of about 3304.09 µg 100 g^{-1} as against the findings of Chandrasekhar *et al.* (2000) in which the author observed 34780 µg of beta carotene in 100 g of leaves. Whereas in tender leaves of tamarind (250 µg) the value reported by Duke (1981) is two times less than the analysed value (565.78 µg). The beta carotene content of fresh coriander leaves (5977.44 µg 100 g^{-1}) was in agreement with the values reported by Thangaraj and Shanmugasundaram (2000) and Rao *et al.* (1980) (5200-6900 µg 100 g^{-1}). The value reported for colocasia leaves (5,920 µg 100 g^{-1}) by Gopalan *et al.* (1989) is higher than the value obtained in the present study (3133.17 µg 100 g^{-1}).

The vitamin C content varied from 32.26 mg 100 g^{-1} to 523 mg 100 g^{-1} in the nine leaves analysed. This range is in accordance with the findings of Gopalan *et al.* (1989), Mathew (2000), Suman (2000) and D'Souza and Kulkarni (1990) for different greens.

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

The vitamin C content reported for tender tamarind leaves by Gopalan *et al.* (1989) is 3 mg 100 g^{-1} while in CSIR (1985) vitamin-C content is reported to be 30 mg 100 g^{-1}. In the present study the vitamin C content obtained is 68.50 mg 100 g^{-1}.

Similarly the vitamin C content of colocasia leaves obtained in the present study (32.26 mg 100 g^{-1}) was found to be higher than the value (12 mg 100 g^{-1}) reported by Gopalan *et al.* (1989). But in the case of coriander leaves the vitamin-C content obtained in the present study was found to similar to the values reported by Gopalan *et al.*, (1989) and Thangaraj and Shanmugasundaram (2000).

Gopalan *et al.* (1989) reported that a vitamin C content of 87 mg 100 g^{-1} in mint leaves while Lakshmi and Vimala (2000) reported 42.28 mg 100 g^{-1}. The vitamin C content of mint leaves obtained in the present study was less than the values reported by the above authors. This variation might be due to the variation in the stage at which the leaves are plucked, locality and seasonal changes as reported by Jijiamma (1989) and Mathew (2000).

Calcium content of the nine leaves varied from 8 to 2000 mg 100 g^{-1}. This is in accordance with the values obtained by Chandrasekhar *et al.* (1990) for different green leafy vegetables of Attapadi and Katchuvadi Hills.

The value obtained for cowpea leaf (280 mg 100 g^{-1}) is in agreement with the calcium (290 mg 100 g^{-1}) content reported by Gopalan *et al.* (1989). The tender leaves of tamarind had a calcium content of 101 mg 100 g^{-1} (Duke, 1981, CSIR, 1985 and Gopalan *et al.*, 1989). But Verma (2001) reported the calcium content range from 160-310 mg 100 g^{-1}. The calcium content (240 mg 100 g^{-1}) of tamarind leaves in the present investigation is found to be within this range.

The calcium content of mint leaves in the present study is 80 mg 100 g^{-1} which was found to be contradictory to the findings of Gopalan *et al.* (1989) and Lakshmi and Vimala (2000) in which the author reported the calcium content of 200 mg to 280 mg 100 g^{-1} respectively in the mint leaves.

The iron content in the leafy vegetable varied from 0.24 to 14. 63 mg 100 g^{-1}. This range was in accordance with the findings of Rao *et al.* (1980), Govindan and Shanmugasundaram (1987), Saikia and Shadeque (1994), Neeliyara (1998) and Nambiar and Seshadri (2001).

An iron content of 5.2 mg 100 g^{-1} was reported by Duke (1981) for tender leaves of tamarind while Gopalan *et al.* (1989) reported the iron content to be 0.3 mg 100 g^{-1}. In the present study the iron content of tamarind leaves was found to be only 0.24 mg 100 g^{-1}.

Satyanarayan *et al.* (2001) reported an iron content of 0.159 mg 100 g^{-1} in mint leaves which was lower than the iron (0.26 mg 100 g^{-1}) content obtained at present. However Gopalan *et al.* (1989) reported a higher iron content of 5.6 mg 100 g^{-1} in mint leaves.

The iron content in pisonia was found to be 2.33 mg 100 g^{-1} which is almost similar to those reported by Gopalan *et al.* (1989) (2.6-3.6 mg 100 g^{-1}). This difference in the content might be due to the soil, climate and species variation.

Phosphorus content of the leaves varied from 113.91 to 233.91 mg 100 g^{-1} in the nine leaves analysed. This range is well within the range given by Gopalan *et al.* (1989). But it is less than the values reported by Chaurasia *et al.* (2000) for different wild leafy vegetable grown in Ladak which was found to vary from 274-574 mg 100 g^{-1}.

The phosphorus content reported for tamarind leaves by Duke (1981), CSIR (1985) and Gopalan *et al.* (1989) is 140 mg 100 g^{-1} against 113.91 mg 100 g^{-1} obtained in the present study. But this content is nearer to the range described by Verma (2001) (120-550 mg 100 g^{-1}). Coriander leaves had a higher content of phosphorus (134.07 mg 100 g^{-1}) than that reported by Gopalan *et al.* (1989) which is about 71 mg 100 g^{-1} while it was less than the value (481 mg 100 g^{-1}) suggested by Verghese (2001).

The colocasia leaves had a phosphorus content of 131.35 mg 100 g^{-1} which was almost similar to the findings of Chandraseskhar *et al.* (2000) (148 mg 100 g^{-1}). But this is less than the phosphorous content suggested by Gopalan *et al.* (1989) who reported the content to be 308 mg 100 g^{-1}.

The potassium content of the leaves varied from 116.96 to 427.88 mg 100 g^{-1} for the nine leaves analysed. This is in accordance with the findings of Peter (1992) and Sirohi (1998) for amaranth and Sahoo *et al.* (2002) for winged bean leaves.

The potassium content of fresh coriander leaves was found to be 116.96 mg 100 g^{-1}. Verghese (2001) reported and higher phosphorous content of 447 mg 100 g^{-1} in coriander leaves while Gopalan *et al.* (1989) reported a potassium content of 256 mg 100 g^{-1}.

The variation observed in the amount of minerals may be due to the variation in the locality or due to varietal difference.

5.2 ANTINUTRITIONAL FACTORS IN LEAF VEGETABLES

The mean oxalate content varied from 0.004 to 2.97 per cent in coriander leaves and pisonia leaves respectively. Except for the value obtained for tender leaves of coriander (0.004%), the rest of the findings were in accordance with the mean oxalate content of different *Amaranthus* species as reported by Devadas(1982), Prakash and Pal (1991), Shingade *et al.* (1995) and Krishnakumari (2000) in which the oxalate content varied from 0.3 to 3.13 per cent. This was also in agreement with the findings of Mathew (2000) for different leafy vegetables. But the oxalate content obtained in the present study was found to be lesser than the values reported by Mallika (1987) for *Amaranthus* species.

The highest mean nitrate content was observed in colocasia leaves and the lowest in the leaves of burmese coriander. The mean nitrate content ranged from 1.23 to 3.22 per cent. This was slightly higher than the nitrate content (0.11 to 0.67%) reported by Schmidth *et al.* (1971) for different *Amaranthus* species. While Devadas (1982) and Krishnakumari (2000) reported almost similar nitrate content of 0.58 to 2.43 per cent in *Amaranthus* species. The differences in nitrate content may be due to variation in soil fertility, in shading intensity, variety/species, plant parts, stage of maturity and genetic factors as reported by Kurien *et al.* (1976) Singh *et al.* (1985), Zandstra (1989), Wu and Wang (1995) and Zhou *et al.* (2000).

5.3 ACCEPTABILITY OF LEAF VEGETABLES

The acceptability of the nine leafy vegetables selected for the study using score card method was carried out after preparing chutnies, salads and thoran based on the suitability of the leaves. Attributes like appearance, colour, flavour, texture and taste were the various criteria used to judge the acceptability of the leaves.

Significant variation was seen in the acceptability of various leaves for all the three products prepared.

In the case of chutnies, the attribute taste obtained the highest score followed by colour, flavour, texture and the least for appearance. The attribute taste and flavour was judged best while the appearance was judged the least in the case of thoran.

The result obtained in case of chutney and thoran were in accordance with the result obtained by Suman (2000) for different amaranth incorporated recipes. But these findings were against those reported by Neeliyara (1998) for winged bean leaf thoran and Mathew (2000) for different leaf vegetable thoran, in which case highest score was for appearance and least score was for texture for the prepared products. In the case of salads, the degree of agreement with regard to all the attributes was poor and insignificant. This indicates that the overall acceptability of the salads prepared from the three leaves varies widely among the judges.

5.4 CLUSTER ANALYSIS OF THE LEAVES

Based on the chemical composition, the green leafy vegetables selected for the study were grouped into three clusters.

Cluster I comprised of the leaves of tamarind, ponnaviram, mint and coriander while cluster II contained the leaves of pisonia, pumpkin, cowpea and colocasia. Burmese coriander was categorised alone in cluster III.

The intra cluster distance of cluster II was found to be (2.452) the maximum among the three intra cluster distances. This wide variation is mainly attributable to pisonia leaves, whose oxalate and nitrate (Table 4) contents were higher in comparison with that of the leaves of cowpea, pumpkin and colocasia. In contrast, cluster I had a lesser intra cluster distance as the members of cluster I were more or less similar in their composition. As cluster III had only one member, no intra cluster distance is measurable.

Regarding the inter cluster distance cluster I and II were distinctly apart from cluster III.

From Table 9, it may be inferred that the only member of cluster III viz., burmese coriander had a very high calcium, iron and β-carotene content and lower oxalate and nitrate content. There was no much inter cluster distance between cluster I and II.

Summary

6. SUMMARY

The study entitled 'Nutritional profile of selected greens' was an attempt to throw light on the nutritional, antinutritional composition of the nine different leafy vegetables and to study the acceptability of these leaves. The leaves selected for the study were maintained in the kitchen garden of Department of Olericulture, College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur. These leaves were mainly grouped into three categories namely the tree leaves, comprising of the tender leaves of pisonia, tamarind and ponnaviram; conventional leaves consisting of tender leaves of cowpea, pumpkin and colocasia and spicy leaves including the tender leaves of mint, coriander and burmese coriander.

The moisture, fibre, protein, starch, beta carotene, vitamin C, calcium, iron, phosphorus and potassium were the nutritional constituents and oxalate and nitrate were the two antinutritional factors estimated in the above mentioned leaves. The acceptability of these leaves in the form of chutnies, salads and thoran, depending on the suitability of each leaf was evaluated using score card.

The study revealed that the mean moisture content of the leaves varied from 72.33 to 85.78 per cent. The moisture content was found to be highest in the conventional leaf group (Colocasia) and least in the tree leaf group (Ponnaviram).

The mean fibre content varied from 0.03 to 1.44 per cent. Here also the mean fibre content was found to be highest in conventional leaf group (Colocasia) and lowest in the tree group (Pisonia). The leaves of cowpea (conventional leaves) had the highest protein (6.18%) and lowest (1.12%) in the leaves of mint (spicy leaves).

The highest and lowest starch content was found in the spicy leaf group with the value ranging from 0.04 per cent (Burmese coriander) to 0.31 per cent (Coriander) when all the nine leaves were considered together.

The two vitamins present in large amount in fresh leafy vegetables are the beta carotene and vitamin C. The mean beta carotene content ranged from 565.78 in

tree (Tamarind) group to 18942.53 μg 100 g^{-1} (Burmese coriander) in spicy leaf group while the vitamin C content varied from 32.26 to 523 mg 100 g^{-1}, with tree leaves (Ponnaviram) having the highest value and the lowest value was reported in the conventional leaf group (Colocasia).

Among the minerals, the calcium content was found to vary from 80 to 2000 mg 100 g^{-1} with the highest and lowest value in the spicy leaf group (Mint and Burmese coriander respectively). The mean iron content was found to vary from 0.24 to 14.63 mg 100 g^{-1}. Lowest value was recorded for tree leaf group (Tamarind) and highest for the spicy leaf group (Burmese coriander). Phosphorus and potassium contents varied from 113.91 to 233.91 mg 100 g^{-1} and 116.96 to 427.88 mg 100 g^{-1} respectively. Out of the three leaf groups the tree group leaf had the highest (Pisonia) and lowest (Tamarind) phosphorus content, while the potassium content was highest in the conventional leaf group (Colocasia) and lowest in the spicy leaf group (Coriander).

The average nutritive value of the leaves ranged from 18.94 to 63.06 per cent and the lowest and highest value was seen in the spicy group leaves namely mint and burmese coriander respectively. Statistical analysis showed significant variation in all the nutrients estimated except in the case of vitamin C content, where no significant variation was seen among the nine leaves studies.

Antinutritional factors like oxalate and nitrate content in the nine leaf vegetables analysed varied from 0.004 to 2.97 per cent and 1.23 to 3.22 per cent respectively. The highest amount of oxalate was seen in the tree leaf species (Pisonia) and lowest in the spicy leaf (Coriander leaves).

In the case of nitrate the highest content was seen in the leaves of mint and lowest in burmese coriander leaves both of these belong to the spicy leaf group.

No significant variation was seen in the oxalate content of the nine leafy vegetables analysed.

The acceptability of the selected leafy vegetables was evaluated using five point Hedonic scale by a panel of ten judges. The appearance, colour, flavour, texture and taste were the quality attributes evaluated for each of the three products namely chutney, salad and thoran. The total mean score for chutney ranged form 16.29 for mint leaves to 21.02 in burmese coriander leaves and the chutnies were found to be highly acceptable. While the total mean scores for salads ranged from 20.34 in mint to 21.09 in coriander salad and in the case of thoran the total mean scores ranged form 16.04 in pisonia to 21.42 in ponnaviram thoran. Statistical analysis showed that no significant variation existed between the leafy vegetable salads in terms of their acceptability and the over all acceptability was the least in the case of salads but chutnies and thorans were highly acceptable.

Based on the nutritional and antinutritional composition, the leafy vegetables were grouped into three clusters.

Cluster I contained the leaves of tamarind, ponnaviram, mint and coriander; cluster II contained leaves of pisonia, pumpkin cowpea and colocasia and cluster III contained leaves of burmese coriander only. Among the three clusters, the cluster III was regarded as the best since it contained high amounts of calcium, iron and beta carotene and lower amounts of oxalate and nitrate.

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* Originals not seen

Appendices

APPENDIX I

RECIPES

Chutney

Fresh leaves - 100g

Red chillies (dry) - 4

Cloves - 2

Garlic (chopped) - 2

Salt to taste.

*Tamarind blended to paste - 1 tsp.

Fresh leaves were washed thoroughly in tap water to remove the adhering dirt. In a clean mortar pound the tamarind paste, leaves, chillies and garlic to paste with a pestle. Add salt to taste. Mix thoroughly (Anon, 1998).

*Tamarind pulp was not used in the preparation of tamarind chutney.

Salad

Fresh leaves	- 100 g
Green chillies (chopped)	- 1
Onion (finely chopped)	- 10g
Lime juice	- 1 tsp
Salt to taste.	

Thoroughly washed tender leaves were cut into fine pieces using stainless steel knife. Green chilly, onion, salt and lime juice added to it and mixed well. Optional.

Decorate with ripe tomatoes, onion, lime slices.

Thoran

Fresh leaves	- 100 g
Mustard	- 2g
Chopped onion	- 10g
Chilli powder	- 1½ teaspoon full
Salt to taste	
Coconut oil	- 10 g

Fresh leaves were washed thoroughly in water to remove the adhering dirt and cut into small pieces using a stainless steel knife. Heated 10 g of coconut oil and spluttered mustard. Added chopped onion, 1½ teaspoon full chilli powder and a little salt. Added the leaves, sprinkled little water and cooked under a low flame till done.

APPENDIX-II

ORGANOLEPTIC EVALUATION OF LEAFY VEGETABLES

SCORECARD FOR ORGANOLEPTIC EVALUATION OF LEAFY VEGETABLE RECIPES

Name :
Date :

Name of the Product:

Character	Score	A	B	C
Appearance				
Excellent	5			
Good	4			
Fair	3			
Poor	2			
Very poor	1			
Colour				
Excellent	5			
Good	4			
Fair	3			
Poor	2			
Very poor	1			
Flavour				
Excellent	5			
Good	4			
Fair	3			
Poor	2			
Very poor	1			
Texture				
Excellent	5			
Good	4			
Fair	3			
Poor	2			
Very poor	1			
Taste				
Excellent	5			
Good	4			
Fair	3			
Poor	2			
Very poor	1			

NUTRITIONAL PROFILE OF SELECTED GREENS

By

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ABSTRACT OF THE THESIS

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ABSTRACT

The study on 'Nutritional profile of selected greens' was aimed at assessing the nutritional composition, antinutritional factors and the acceptability of the nine different leafy vegetables maintained in the kitchen garden, Department of Olericulture, College of Horticulture, Vellanikkara.

The leaves were analysed for moisture, fibre, protein, starch, beta carotene, vitamin C, calcium, iron, phosphorus and potassium. It was seen that the leaves of colocasia was high in moisture, fibre and potassium while starch content was highest in coriander leaves. Phosphorus and vitamin C contents were high in the leaves of pisonia and ponnaviram respectively. The calcium, iron and β-carotene contents were found to be highest in the leaves of burmese coriander while the leaves of cowpea were found to be high in protein.

The average nutritive value was computed and it was seen that the leaves of burmese coriander had the highest average nutritive value of 63.06 per cent.

Antinutritional factors namely oxalate and nitrate were analysed. Though there was no significant difference in the oxalate content of different leaves, pisonia exhibited the highest oxalate (2.97%). Mint leaves had the highest nitrate (3.22%) content.

Results of organoleptic evaluation indicated no significant variation in the acceptability of the leaf salads. Chutnies and thoran were highly acceptable while salads were not acceptable.

Based on the nutritional and antinutritional factors, the leafy vegetables were grouped into three clusters and burmese coriander was found to be the best among the nine leaves analysed.