QUALITY EVALUATION OF SELECTED LEAFY VEGETABLES CONSUMED BY THE TRIBES OF WAYANAD DISTRICT

By

NEETHA HYDER

THESIS

Submitted in partial fulfilment of the
requirement for the degree of

Master of Science in Home Science

(FOOD SCIENCE AND NUTRITION)

Faculty of Agriculture
Kerala Agricultural University

Department of Home Science
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR - 680 656
KERALA, INDIA

2004

DECLARATION

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

Vellanikkara
7- 9- 04

NEETHA HYDER

CERTIFICATE

Certified that this thesis, entitled **"Quality evaluation of selected leafy vegetables consumed by the tribes of Wayanad district"** is a record of research work done independently by **Miss. Neetha Hyder,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

V. Indira 7/9/04

Dr. V. Indira
Chairperson, Advisory Committee
Associate professor and Head
Department of Home Science
College of Horticulture
Vellanikkara
Thrissur

Vellanikkara
7- 9- 04

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Miss. Neetha Hyder,** a candidate for the degree of **Master of Science in Home Science** with major in **Food Science and Nutrition,** agree that this thesis entitled **"Quality evaluation of selected leafy vegetables consumed by the tribes of Wayanad district"** may be submitted by **Miss. Neetha Hyder,** in partial fulfilment of the requirement for the degree.

V. Indira 7/9/04

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

7/9/04

Dr. V. Usha
Associate Professor
Dept. of Home Science
College of Horticulture
Vellanikkara
(Member)

7/9/04

Dr. S. Mini
Assistant Professor
(Biochemistry)
AINP on Medicinal
and Aromatic Plants
Vellanikkara
(Member)

Krishnakumary 7/9/04

Dr. K. Krishnakumary
Assistant Professor
Dept. of Olericulture
College of Horticulture
Vellanikkara
(Member)

25/10/04

EXTERNAL EXAMINER
Dr. M.R. Premalatha
Prof (FSN)
Home Science College and
Research Institute
Madurai – 625 104

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ACKNOWLEDGEMENT

I wish to place on record my profound sense of gratitude to my guide Dr. V. Indira, Associate professor and Head , Department of Home Science, Vellanikkara for her exceptional guidance and ever willing help rendered at all stages of this endeavour. Always looking for perfection, she corrected me several times but with understanding and forbearance.

I thankfully acknowledge Dr.V. Usha, Associate professor , Department of Home Science, Vellanikkara for her whole hearted cooperation, help and valuable suggestions during various stages of study.

I deeply express my whole hearted thanks to Dr. S. Mini, Assistant professor, AINP on Medicinal and Aromatic plants, College of Horticulture, Vellanikkara for her precious suggestions and generous support during my entire study and successful completion of this work.

I extend my gratitude to Dr. K. Krishnakumary, Assistant Professor,Department of Olericulture, College of Horticulture, Vellanikkara for her timely help, valuable suggestions and constructive criticisms.

I express my deep sense of gratitude to Sri. S.Krishnan, Assistant Professor, Department of Agrl. Statistics, College of Horticulture, Vellanikkara for his valuable suggestions and critical scrutiny of the statistical analysis.

I am deeply indebted to all my friends especially, Saleena, Jishy, Aswathy, Jyothilakshmi, Sreelekha, Anuja, Shahida, Bini, Preetha, Smitha Devi, Hena chechi, Parvathi chechi, Divya chechi and Amritha chechi.

My special thanks to Suman Chechi, Shyna chechi, Smitha chechi and Sheeja for all the help and support.

My sincere thanks to Umayba chechi (Permanent labourer, Dept. of Home Science) and Droupathi chechi (Permanent labourer, Biochemistry) for their timely help and cooperation.

The timely help and valuable suggestions rendered by my seniors and juniors especially Reena are sincerely acknowledged.

I sincerely acknowledge the gracious help rendered by Mr. Santhosh of the computer club.

The Junior Fellowship awarded by the Kerala Agricultural University is gratefully acknowledged.

I am forever indebted to my beloved Parents, Feesatha and Munna for their support, increasing encouragement, boundless affection, deep concern, prayers and personal sacrifices, which helped me to overcome many hurdles experienced during the course of time.

Above all, I bow my head before the ALMIGHTY GOD for his blessings to complete this endeavour successfully.

Neetha Hyder

ABBREVIATIONS

A.O.A.C	Association of Official Analytical Chemists
Cl.	Cluster
EDTA	Ethylene Diamine Tetra Acetic acid
Fig.	Figure
g	Gram
KAU	Kerala Agricultural University
ME	Methanol extractable
mg	Milli gram
µg	Micro gram
ml	Milli litre
NIN	National Institute of Nutrition
%	Per cent
Sl. no.	Serial number

Affectionately
Dedicated to my Family

Introduction

1. INTRODUCTION

Forests are precious endowment of nature to mankind bountifully bearing omnifarious resources of sustenance of humans, besides ensuring ecological security. The forests are the original habitats of tribal groups in India which are the repository of nutritious food that grow wild and are neither cultivated nor marketed. Tribals living as a part of nature exploited nature to meet their food demands. They depend on these natural flora especially during the lean months.

The tribal groups form an important and sizeable segment of the Indian population constituting 30 millions and they vary in terms of race, religion, culture, language, economic condition and dietary pattern. The problem of providing adequate nutrition is very important in the tribal areas as the dietary standards of tribals are low that their diet hardly provides the essentials of food elements like proteins, fats, minerals and vitamins in proper proportion.

Green leafy vegetables, which are rich in vital nutrients like vitamins and minerals, are more or less used as a staple food by the tribals. Tewari (1992) has reported more than 1650 leafy vegetables in the forests of tropical countries. The tribal population of Bihar and West Bengal were found to consume 70 varieties of leafy vegetables (Kumari, 2001). Some of their foods are uncommon to us and nutritionally superior to overcome the micronutrient malnutrition prevalent in our country and also to bring nutritionally superior varieties.

It is important at this context the exploitation of edible wild stock of flora rich in nutrients. To promote the conservation of plant foodstuffs especially the leafy vegetables consumed by the tribal communities and to bring them under cultivation for their sustainable utilization and proper documentation, the quality parameters have to be evaluated.

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

No systematic study has so far been conducted in Kerala to evaluate the important parameters like nutrient composition, anti-nutritional factors and acceptability of tribal green leafy vegetables. Hence, the present study on 'Quality evaluation of selected leafy vegetables consumed by the tribes of Wayanad district' was attempted with the following objectives.

i. To analyse the nutritional constituents, anti-nutritional factors and other chemical constituents in the leafy vegetables
ii. To assess the acceptability of the leafy vegetables

Review of Literature

2. REVIEW OF LITERATURE

Literature relevant to the study entitled 'Quality evaluation of selected leafy vegetables consumed by the tribes of Wayanad District' is reviewed under the following sections.

2.1 Nutritional importance of leafy vegetables

2.2 Composition of leafy vegetables

2.3 Anti-nutritional factors in leafy vegetables

2.4 Organoleptic evaluation of leafy vegetables

2.1 NUTRITIONAL IMPORTANCE OF LEAFY VEGETABLES

Leafy vegetables are abundant and cheapest of all vegetables within the reach of poor man and being rich in nutrients, they are classified under protective foods (Srilakshmi, 2001).

A wide variety of leafy vegetables like amaranth, drumstick, mint, curry leaf, palak, fenugreek, spinach and chekkurmanis are used as vegetables in India. The leafy greens of all the cole crops are rich sources of easily available β carotene, vitamin C, calcium and iron which help to prevent various nutritional deficiency diseases (Gopalan, 1982a). Swaminathan (1987) suggested that green leafy vegetables being fair in proteins and rich in provitamin A, vitamin C, folic acid and calcium are excellent supplements to poor cereal diet.

Moringa leaves are the richest known source of provitamin A and several other mineral nutrients (Gopalan, 1982b). Certain estrogenic substances and some enzymes important for some pharmaceutical preparations are also present in moringa leaves. The author also reported that they are good sources of protective nutrients, which are essential for healthy vision, bones, blood and skin. According to Manay and Shadaksharaswamy (1998), moringa leaves are useful to prevent scurvy and catarrhal afflictions. Chandrasekar (2003) indicated that

moringa leaves are good for reducing premature ageing and for protection against functional sterility in men and women.

According to Imungi and Potter (1983), cowpea leaves are rich in minerals like iron, calcium, phosphorus and zinc. Nayar (1992) reported that colocasia leaves are superior to that of cabbage and reported high protein and minerals in them. Singh and Felkar (1998) reported cactus leaves as a good source of roughage. Kowsalya and Mohandas (1999) indicated that cauliflower leaves are rich in macro and micronutrients. Good amount of protein, calcium and fibre are present in curry leaves (Pathak *et al.*, 2000).

Islam *et al.* (1987) identified *Atriplex triangularis* leaves for cultivation in parts of world where high salinity and desertification are serious problems. Even though these contain only moderate quantities of protein, ascorbic acid and provitamin A, they have the potential of making a significant impact on the dietary intake of the population living on desert and saline land.

Mathew (2000) and Kumaran (2003) analysed the nutritive value of leafy vegetables in Kerala and indicated that they are rich in various micro nutrients like beta carotene, vitamin C, calcium, iron and phosphorus. The authors also indicated significant variations in the nutrient content of leafy vegetables.

The leafy vegetables consumed by the Naga tribes of Nagaland and Manipur (NIN, 1988) were found to be rich in calcium, magnesium, iron and zinc. Chandrasekhar and Chitra (1990) reported that 'Thadi keerai' and 'Puliari keerai' consumed by the tribal community of Nilgiri hills are good sources of calcium, iron and ascorbic acid.

Murugesan and Ananthalakshmi (1991) analysed the leafy vegetables consumed by the Paliyar tribal group of Kodaikanal and reported Karuppu sambar keerai as good source of energy, protein, calcium, iron and phosphorus. Ceylon

spinach, a wild leafy vegetable used in Assam was found to be rich in protein and minerals (Saikia and Shadeque, 1994).

The unconventional leafy vegetables like Math, Katimath, Kawala and Bharangi found in the forest and cultivable waste lands of Konkan region contained comparitively high amounts of crude protein, crude fat, crude fibre and total carbohydrate (Shingade *et al.*, 1995). Ragu and Kapoor (1997) reported 'Senchulaku' (*Digera muricata*), an unconventional leafy vegetable of South India as a rich source of protein, iron, phosphorus, carotenoids and ascorbic acid with moderate amounts of calcium and oxalate.

The green leafy vegetables consumed by the tribes of North East India were found to be rich in iron and calcium, though low in protein and fat (Longvah, 2000). Wild leafy vegetables commonly used by the people of Ladakh were found to be nutritious as the cultivated leafy vegetables (Chaurasia *et al.*, 2000).

A study conducted by Sundriyal and Sundriyal (2001) on the nutritive value of wild edible plants of Sikkim indicated higher nutrient concentration in leaves than shoots and fruits. The authors also indicated good amount of crude fibre, vitamin C and iron in these leafy vegetables.

The underutilized leafy vegetables of Idukki, Pathanamthitta and Kottayam districts of Kerala were found to be rich in minerals and vitamins especially calcium, iron, provitamin A, vitamin C, thiamin and riboflavin (Mathew and Sivakumar, 2002).

The leafy vegetables used by the ethnic groups of North East India were reported to be good and cheap sources of proteins and minerals with low proportions of lipids and carbohydrates (Handique, 2003).

Murugkar and Subhulakshmi (2003) analysed twenty seven wild edible green leaves consumed by the Khasi tribe of Meghalaya and reported that these are good in various micronutrients and were found to be comparable with the well known common species of leafy vegetables

The wild leafy vegetables used in Kenya were found to be rich in beta-carotene, ascorbic acid, iron and calcium (Mwajumwa *et al.*, 1991).

The indigenous leafy vegetables consumed by the Kekchi people of Alta Verapaz were found to be rich in ß carotene and minerals (Booth *et al.*, 1992). Four wild leafy vegetables in Coted' Ivoire viz., *Ceiba pentandra*, *Gewia carpinifolia*, *Hibiscus congestiflorus* and *Triplochiton seleroxylon* were analysed by Herzog *et al.* (1993) and the leaves were found to be good in iron and calcium.

Wild leafy vegetables used in Nigeria were found to be good sources of crude protein, fat, total carbohydrate and ascorbic acid (Achinewhu *et al.*, 1995).

Greens like *Adansonia digitata*, *Amaranthus viridis*, *Tamarindus indica*, *Allium cepa* used in Kautiala of Southern Mali were found to be rich in energy, protein, ß carotene and minerals like calcium and iron (Nordeide *et al.*, 1996).

Wallace *et al.* (1998) studied four unconventional leafy vegetables and reported that *Euphorbia hirta* are rich in protein, fibre and minerals like calcium, copper and iron. Guerrero *et al.* (1999) studied wild leafy vegetables of Europe and reported good amount of minerals like potassium, calcium, zinc and iron in the leaves. Non conventional leafy vegetables consumed by the rural populace of Nigeria were found to be rich in iron, calcium, zinc and manganese (Barminas *et al.*, 1999).

Wild leafy vegetables consumed by the people of South Africa were reported to be rich in micronutrients, particularly beta carotene (Steyn *et al.*, 2001).

Leaves of wild *Plantago major, P. lanceolata* and *P. media* consumed in south east of Spain (Guerrero, 2001) were found to be rich in ascorbic acid and calcium with low proportions of oxalic acid. Edeoga and Gomina (2001) reported that *Hoslundia opposita*, a non-conventional leafy vegetable of Nigeria as a rich source of ascorbic acid, carbohydrate and protein.

Turan *et. al.* (2003) indicated that wild edible leaves consumed in Eastern Anatolia are rich in protein, calcium, potassium, magnesium and nitrogen. Iron, zinc, manganese and copper content of these leaves were found to be equal to or higher than those of some commonly used vegetables like spinach, pepper, lettuce and cabbage species.

Green leafy vegetables are rich sources of micronutrients and phytochemicals having antioxidant properties which offer protection against heart diseases and certain types of cancer (Saxena, 1999). According to Rajeshwari and Subhulakshmi (2004), green leafy vegetables constitute largest classes of phyto nutrients. Consumption of vegetables has been reported to reduce the incidence of major diseases like cancer, cardiovascular diseases, diabetes, cataracts and inflammatory diseases (Svilaas *et al.*, 2004).

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. Leaves of saltbush plant exhibited a high radicle scavenging activity, which may indicate a potential use of the natural compound for food preservation and medical application (Shachter and Mirsky, 2000). A study conducted by Thalang *et al.* (2001) reported that *Neptunia oleracea*, a commonly

used leafy vegetable in Thailand had high antioxidant activity followed by *Acacia pennata* and *Moringa citrifolia*.

Dried powder from the leaf of *Ipomoea aquatica* exhibited high free radicle scavenging activity of 85 per cent level against commercial antioxidant butylated hydroxy anisole (Prasak *et al.*, 2003). Rao *et al.* (2003) observed antioxidant property in curry leaves.

Beta carotene, glucosinolates and isothiocyanates are regarded as dietary protector against cancer due to their antioxidant property (Bravo, 1998). Cabbage, cauliflower, radish, spinach, mustard and methi leaves grown in Panchkula district of Haryana were found to have high amount of glucosinolates (Boora *et al.*, 1998).

Sayed *et al.* (1999) isolated the flavanoids and alkaloids from *Diplotaxis acris*, which is consumed in Sinai as salad crop and reported their radicle scavenging activity. Gins *et al.* (2001) analysed the leaves of *Amaranthus tricolor, Chrysanthemum coronarium, Nasturtium officinale* and *Lepidium meyenii* and reported considerable amounts of ascorbic acid, flavanoids, carotenoids, potassium, iron, calcium and phosphorus. According to Salucci and Stivala (2002), quercetin, which is a major flavanoid in vegetables was found to have anti carcinogenic activity.

Kaur and Kapoor (2002) reported high phenolic contents in mint, broccoli and coriander leaves which have antioxidant activity.

Pereira *et al.* (2001) analysed the alpha linolenic acid and other fatty acid content of green leafy vegetables available in Australia and reported that watercress and mint contained high amount of fatty acids. Simopoulos and Clugston (2002) found how alpha linolenic acid in green leafy vegetables desaturates and gets elongated in the body to form eicosapentaenoic acid and

docosahexaenoic acid and thus causes beneficial effect to the health and in the control of chronic diseases.

The unconventional leafy vegetables of India were found to be rich in fibre (Awasthi and Tandon,1988) and thus useful in supplementing the dietary constituents needed to prevent obesity and coronary diseases. Vadera *et al.* (2003) reported hypocholesterolemic and hypolipidemic effect of fibre from mustard and curry leaves with a potential anti atherogenic property.

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 (Jijiamma, 1989). 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.

Study conducted by Mathew (2000) indicated a moisture content of 78.98 to 92.78 per cent in unconventional leaves of Kerala. Thangaraj and Shanmugasundaram (2000) reported a moisture content of 85 per cent.in coriander leaves.

Yadav and Sehgal (2002) reported the moisture content of bathua (*Chenopodium album*) and spinach (*Spinacia oleracia*) leaves as 89.04 per cent and 91.05 per cent respectively.

Ramaswamy and Sathya (2003) reported 77.9 per cent moisture in fresh coriander leaves. Kumaran (2003) obsreved 72.33 to 85.78 per cent moisture in green leafy vegetables.

Easwaran and Goswani (1989) analysed the leafy vegetables consumed by Khasis of Meghalaya and reported that the water content of the leafy

vegetables varied from 81.0 to 94.2 per cent. The leafy vegetables consumed by the Kota community of Nilgiri hills were analysed by Chandrasekhar and Chitra (1990) and reported Thadi keerai to have a moisture content of 91 per cent.

Shingade *et al.* (1995) conducted a study on ten unconventional leafy vegetables found in forest and cultivable waste lands of Konkan region and reported that the moisture content varied from 76.4 to 91.9 per cent. Sixteen leafy vegetables consumed frequently by the rural and tribal population of Western region of India were analysed by Nambiar and Seshadri (1998) and reported a variation of 78.4 to 92.5 per cent moisture in these leaves.

The moisture content of green leafy vegetables from North East India was found to be 85 per cent (Longvah, 2000). The non traditional leafy vegetables growing in Nellore and Prakasam districts of Andhra Pradesh were analysed by Bharathi and Umamaheshwari (2001) and reported a moisture content of about 60.99 to 90.17 g 100 g^{-1}, the highest being in Paliyaku (*Trianthema portulacastrum*).

Sreeramulu (1982) conducted a study on the chemical composition of leafy vegetables grown in Tanzania and reported that the moisture content of these vegetables varied from 76.6 per cent to 90.8 per cent, the minimum being in *Moringa olerifera* and maximum in *Portulaca oleracea*. Mziray *et al.* (2001) reported a moisture content of about 85.3 to 86.5 per cent in *Amaranthus hybridus*, which were collected from four different areas of Tanzania.

The moisture content of *Basella alba* and *Talinum triangulare* grown in Northern parts of Nigeria were found to be 93.9 per cent and 94.1 per cent respectively (Faboya, 1983). The water content of *Heinsia crinita*, a leafy vegetable used in South Eastern Nigeria was reported to be 45.2 per cent (Etuk *et al.*, 1998). Ijomah *et al.* (2000) analysed five leafy vegetables of Nigeria and reported a mean moisture content of 79.4 percent. *Hoslundia opposita*, a non

conventional leafy vegetable of Nigeria provided a high moisture content of about 95 per cent (Edeoga and Gomina, 2001).

The green leafy vegetables are reported to be good sources of protein and the dry matter of leaves contain as much protein as legumes (Reddy, 1999).

The protein content of cassava leaves were reported to be 6.8 g 100 g^{-1} (Babu and Nambisan, 1993). Awoyinka *et al.* (1995) reported high level of crude protein in cassava leaves compared to amaranthus. The crude protein content of *Amaranthus sp.* were reported to be 4 g 100 g^{-1} (Hemalatha *et al.*, 1999). Suman (2000) observed 3.34 percent of crude protein in fresh amaranth.

The protein content of five winged bean genotypes available in Kerala varied from 3 to 4 per cent (Neeliyara, 1998). Raghuvanshi *et al.* (2000) analysed the protein content of some lesser known leaves like *Bauhenia purpurea* Linn., *Chenopodium album* Linn., *Fagopyrum esculentum* Moench and reported the protein content as 2.37, 4.35 and 4.93 g 100 g^{-1} respectively.

Mathew (2000) reported 1.2 to 3.13 percent protein in nine unconventional leafy vegetables of Kerala with an higher protein content in Kang Kong (*Ipomoea aquatica* Forsk.)

According to Pathak *et al.* (2000), the protein content of curry leaf is 6.1 g 100 g^{-1}. The green leaves of bathua and spinach were reported to have 42.73 per cent and 31.43 per cent of protein on dry weight basis (Yadav and Sehgal, 2002). Kumaran (2003) reported a protein content of 1.12 to 6.18 per cent in leafy vegetables belonging to the conventional, spicy and tree leaves.

Chandrasekhar *et al.* (1990) analysed the nutritive value of four varieties of tribal greens viz., Seekaisappu, Gurukaku, Sokathi and Silkasi and found that these leaves contained 3.9, 1.7, 3.8 and 3.8 g 100 g^{-1} of protein

respectively. Green leafy vegetables consumed by Paliyar tribal group of Kodaikanal were analysed by Murugesan and Ananthalakshmi (1991) and found that the protein content of the leaves ranged from 2.2 to 6.8 g 100 g^{-1}.

The maximum crude protein content among the ten unconventional leafy vegetables found in the forest and cultivable waste lands of Konkan was observed to be 7 per cent in drumstick leaves while *Tricholepis anipelxicaulis* and phodsi contained the lowest amount of 1.8 per cent and 1.3 per cent respectively (Shingade *et al.*, 1995).

Ragu and Kapoor (1997) reported that Senchulaku (*Digera muricata*) an unconventional leafy vegetable of South India is a rich source of protein.

The protein content of green leafy vegetables consumed by the tribes of North East India which varied from 3.1 to 4.9 g 100 g^{-1} was comparable to that of other commonly consumed green leafy vegetables like amaranth, brussel sprouts, fenugreek leaves and mustard leaves (Longvah, 2000).

Chaurasia *et al.* (2000) analysed the wild leafy vegetables of Ladakh and reported that the protein content of these leaves ranged from 18.3 to 31.7 per cent on dry weight basis.The non traditional leafy vegetables of Andhra Pradesh were analysed by Bharathi and Umamaheshwari (2001) and reported a protein content of 2.17 to 6.89 per cent.

Handique (2003) analysed the nutritional composition of some non conventional leafy vegetables from ethnic sources of North-East India and reported that the crude protein content of these leaves varied from 18.18 to 29.45 per cent on dry weight basis.

Murugkar and Subhulakshmi (2003) reported 21.5 per cent and 14 per cent of protein in *Plantago major* and *Diplazium esculentum* respectively that are consumed by the Khasis of Meghalaya.

The crude protein content of Tanzanian leafy vegetables like amaranth, cowpea, pumpkin and sweet potato was found to be in the range of 20.64 to 46.54 per cent (Mosha *et al.*, 1995). Eight green vegetables commonly grown in Dar es salaam was analysed by Raja *et al.* (1997) for crude protein and reported that the protein content varied from 1.03 to 5.23 per cent on fresh weight basis. *Amaranthus hybridus* grown in different locations of Tanzania exhibited a protein content in the range of 28.2 to 31.6 per cent (Mziray *et al.*, 2001).

Study conducted by Wallace *et al.* (1998) on the non conventional leafy vegetables used in Ghana reported that these leaves had a protein content between 2.6 and 3.42 per cent. Freyre *et al.* (2000) determined the nutritive value of wild under exploited vegetables and observed a higher protein content of 3.74 g 100 g^{-1} in *Portulaca oleracea* leaves.

Ijomah *et al.* (2000) reported that the leafy vegetables of Adamawa state in Nigeria contained low protein concentration (58.8 to 127.5 mg per 100 g^{-1}). Thirty non conventional leafy vegetables of Nigeria were analysed by Edeoga and Gomina (2001) and reported that *Hoslundia opposita* which was best in terms of nutritive value had a low protein content of 0.15 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). High quality protein is reported in Tete (*Amaranthus hybridus*), Euredu (*Corchorus olitoricus*), Igbo (*Solanum africana*), Ogunmo (*Salanum nudiflorium*), Gbure (*Talinum triangulare*) and Ewuro (*Vernonia amygdalina*) (Fafunso and Bassir, 1976). The true digestibility values of the proteins in four vegetables were almost similar and varied from 80 per cent in *Celosia argentea* to 82.6 per cent in

Amaranthus hybridus. The protein efficiency of leaf proteins varied from 1.58 to 1.61.

The protein efficiency ratio, biological value and net protein utilization in leafy vegetables widely consumed in Africa were found to have high potency in promoting growth (Fokou and Domngang, 1989).

The amino acid composition of cytoplasmic fraction of leaf protein from *Ailanthus excelsa* was evaluated by Nag and Matai (1991) and reported an excellent balance of essential amino acids in leaf proteins. Handique (1993) analysed the free amino acid content in certain unconventional leafy vegetables and detected twelve amino acids including seven amino acids in various concentrations.

Wallace *et al.* (1998) studied four unconventional leafy vegetables and reported methionine as the most limiting amino acid in *Xanthosomas mafaffia*, *Euphorbia hirta* and *Launaea taxaracifolia* while lysine was the most limiting amino acid in *Ipomoea involucrata*.

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

NIN (1990) suggested that leafy vegetables like amaranth, gogu and fenugreek provide an average of 0.34 per cent of fat and these leaves contain high amount of alpha linolenic acid. An average 60g of leafy vegetable provide 0.1 g of linolenic acid (NIN, 1999).

Neeliyara (1998) observed a fat content of 0.6 to 0.7 per cent in winged bean leaves. The fat content of curry leaves and tender tamarind leaves

varied from 0.5 to 2.1 per cent (Shankaracharya, 1998). Pathak *et al.* (2000) reported a fat content of one per cent in curry leaves which was found to be higher than the fat content of radish (0.3%), carrot (0.2%) and cauliflower (0.4%).

The fat content of selected leafy vegetables like cabbage, coltard, peanut, turnip and sweet potato leaves were analysed by Mosha and Gaga (1999) and indicated that the fat content varied from 1.4 to 6.5 per cent. Yadav and Sehgal (2002) reported a fat content of 5.14 and 5.05 per cent on dry weight basis in bathua (*Chenopodium album*) and spinach (*Spinacia oleracea*) leaves.

Raw leaves of *Bauhenia purpurea* Linn., *Chenopodium album* Linn., *Fagopyrum esculentum* Moench were reported to have 0.42, 0.31 and 1.11 g $100g^{-1}$ of crude fat (Raghuvanshi *et al.*, 2000). Mathew (2000) studied the fat content of nine leafy vegetables and reported a variation of 0.18 percent to 0.65 percent with *Amaranthus tristis* Roxb. having the highest value.

Chandrasekhar and Chitra (1990) analysed the fat content of leafy vegetables consumed by Kota community of Nilgiris hills and reported a fat content of 2.15 and 2.13g per cent in 'Thadi keerari' and 'Puliara keerai' respectively. The fat content of leafy vegetables consumed by the Paliyar tribal group in Kodaikanal varied from 0.2 to 1.5 per cent (Murugesan and Ananthalakshmi, 1991).

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 0.96 per cent. The author also observed a maximum crude fat content of 0.96 per cent in drumstick leaves, 0.8 per cent in *Amaranthus tricolor* and 0.7 per cent in kawala while the rest of the vegetables contained 0.4 per cent of crude fat.

Fat content of leafy vegetables consumed by the tribes of North-East India varied from 0.4 to 1.9 percent (Longvah, 2000). Chaurasia *et al.*(2000) analysed the wild leafy vegetables from Ladakh and reported a fat content in the range of 3.2 to 6.4 per cent. Bharathi and Umamaheshwari (2001) indicated that the non conventional leafy vegetables in Nellore and Prakasam districts of Andhra Pradesh had a fat content of 2.85 to 6.52 g 100 g^{-1} on dry weight basis.

The non conventional leafy vegetables viz. *Amaranthus viridis*, *Boerhavia diffusa*, *Alteranthera sessilis*, *Polygonum Chinense* and *Ipomoea aquatica* from ethnic sources of North-East India were found to be low in lipid content which varied from 2.42 to 6.00 per cent on dry weight basis (Handique, 2003).

Different green leafy vegetables grown in Nigeria were analysed for fat content by Achinewhu *et al.* (1995), Akpanyung *et al.* (1995), Aletor and Adeogun (1995) and reported a variation of 2.7 per cent to 22.6 per cent on dry weight basis. Comparitive evaluation of three local varieties of *Heinsia crinita* of South East Nigeria by Etuk *et al.* (1998) revealed low lipid levels of 1.4 percent on dry weight basis.

Tanzanian vegetables provided crude fat in the range of 2.57 to 4.34 per cent, the lowest being in Amaranthus and highest being in cowpea leaves (Mosha *et al.*, 1995)

The alpha linolenic acid content of leafy vegetables in Australia varied from 44 mg 100 g^{-1} in Chinese cabbage to 372 mg 100 g^{-1} in watercress (Pereira *et al.*, 2001).

The predominant fatty acids of spinach were analysed by Murcia *et al.* (1992) and reported that the leafy vegetables contained different fatty acids

like palmitic, hexadecadienoic, hexadecenoic, stearic, hexadecatrienioc, oleic, linoleic and linolenic acids .

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

Etuk *et al.* (1998) reported the most abundant fatty acid in *Heinsia crinita* as linolenic acid . Pereira *et al.* (2001) reported high concentration of PUFA in mint leaves with a value of 195 mg per 100g.

Dietary fibre, the sum of polysaccharides and lignin which are not digested by endogenous secretions of gastro intestinal tract are effective in reducing the incidence of obesity, hypercholesterolemia, heart diseases, diverticular diseases and colon diseases (Trowell, 1976). Increased consumption of green leafy vegetables increases the intake of dietary fibre which in turn increases the faecal bulk and thus prevents constipation. Gupta and Wagle (1988) reported a crude fibre content of 7.2 to 13.95 per cent in green leafy vegetables on dry weight basis.

The crude fibre content of *Basella alba* and *Talinium triangulare* were found to be 14.1 and 19.6 per cent of dry matter respectively (Lucas, 1988). Gupta and Wagle (1988) reported 1.6 and 2.1 per cent crude fibre in ghol and cowpea leaves respectively.

Total fibre content of four green leafy vegetables viz. amaranth, spinach, gogu and bacchali varied from 1.6 to 2.6 g per cent (NIN, 1994a). The fibre content of chekkurmanis leaves, curry leaves, drumstick leaves and tender tamarind leaves was found to be 2.5, 6.4, 0.9, 1.9-3 percent respectively (Shankaracharya, 1998). According to Rao and Ramulu (1998), *Alteranthera sessile* (8%), *Sesbania grandiflora* (8.4%), drumstick leaves (9%), tender

tamarind leaves (10.6%) and curry leaves (16.3%) contained relatively higher amount of dietary fibre. Suman (2000) reported 1.72 percent of fibre in fresh amaranth.

Leaves of Chenopodium species had a high fibre content of 4 to 6 g 100 g^{-1} (Guerrero and Isasa , 1997). Yadav and Sehgal (2002) reported the fibre content of bathua (*Chenopodium album*) and spinach (*Spinacia oleracia*) leaves as 6.53 and 7.29g per 100g respectively.

Easwaran and Goswani (1989) analysed fifteen unconventional plant foods consumed by Khasis of Meghalaya and reported 0.4 to 2.5 per cent of crude fibre in the leafy vegetables. Thadi keerai and Puliari keerai consumed by the tribal community of Nilgiris were found to have a fibre content of 0.055 to 0.1 g 100 g^{-1} respectively.(Chandrasekhar and Chitra, 1990).

Crude fibre content of four varieties of tribal greens viz. Seekai sappu, Gurukaku, Sokathi and Silkasi used by the tribal communities of Attapadi and Katchuvadi hills varied from 0.9 to 2.9 g 100 g^{-1} (Chandrsekhar *et al.*, 1990).

The leafy vegetables consumed by the Paliyar tribal group of Kodaikanal had a crude fibre content of 0.2 to 3.0 per cent. (Murugesan and Ananthalakshmi, 1991). The unconventional leafy vegetables found in the cultivable lands of Konkan region were analysed by Shingade *et al.* (1995) and reported that the species with more succulent growth contained less fibre than the woody perennials. The study revealed that bharangi (2.4%), kawala (2.4%), drumstick leaves (2.2%) and cowpea leaves (2.1%) contained high amount of fibre, while spinach (0.7%) and phodsi (1.0%) were low in fibre.

Chaurasia *et al.* (2000) reported a fibre content of 6.4 to 10.8 per cent in wild leafy vegetables of Ladakh. The fibre content of non traditional leafy

vegetables of Nellore and Prakasam districts of Andhra Pradesh varied from 4.75 to 14.53 g $100g^{-1}$ on dry weight basis (Bharathi and Umamaheshwari, 2001).

Handique (2003) analysed the non conventional leafy vegetables used in North East India like *Amaranthus viridis* , *Boerhavia diffusa, Alternanthera sessilis*, *Polygonum chinense* and *Ipomoea aquatica* and the fibre content of the leaves varied from 4.9 to14.25 per cent.

Murugkar and Subhulakshmi (2003) analysed wild edible leaves used by Khasis of Meghalaya and reported the fibre content of *Begonia roxhburghii* and *Diplazium esculentum* as 22.9g and 18.8 g100 g^{-1} respectively on dry weight basis.

According to Sreeramulu (1982), *Cassia tora, Gynandropsis gynandra, Solanum nigrum, Moringa olerifera* and *Basella argentea,* the vegetables grown in Tanzania contained 11.8, 8.0, 8.3, 5.7 and 7 per cent of fibre respectively on dry weight basis. Fibre content of *Alteranthera sessils, Basella alba* and *Ipomoea aquatica* were 10.4, 7.0 and 12.3 per cent respectively.

Dietary fibre content of Chinese vegetables varied from 1.1 to 4.6 g 100 g with the highest fibre in *Amaranthus tricolor*. *Ipomoea aquatica* had 3 g per 100 g of dietary fibre (Wills *et al.*, 1984).

The fibre content of Nigerian green leafy vegetables varied from 8.5 to 20.9 per cent (Ifon and Bassir, 1980). The mean crude fibre content of seventeen dry leafy vegetable species in Nigeria was found to be 15.3 g per 100 g, while the fresh counter parts contained 3.2 g crude fibre per 100 g (Aletor and Adeogun, 1995). Fibre content of *Pterocarpus mildbraedii* found in Nigeria was found to be 7.56 per cent on dry weight basis (Akpanyung *et al.*,1995). *Heinsia crinita*, a leafy vegetable commonly consumed in South Eastern Nigeria was found to have a fibre content of 12.5 g 100 g^{-1} of drymatter (Etuk *et al.*, 1998).

The fibre content of four unconvenetional leafy vegetables viz. *Xanthosomas mafaffa, Ipomoea involucrata, Launaea taxaracifolia* and *Euphorbia hirta* ranged in between 1.15 to 7.73 per cent (Wallace *et al.*,1998).

The most commonly consumed green leafy vegetables were analysed for their dietary fibre fractions by Rao and Ramulu (1998) and indicated that majority of them contained 2.5 to 6.6 per cent total dietary fibre (TDF), 1.6 to 5.1 g of insoluble dietary fibre (IDF), and 0.9 to 1.5 per cent of soluble dietary fibre (SDF).

Escudera *et al.* (1999) reported a total dietary fibre content of 53.81g $100g^{-1}$ in *Amaranthus muricatus* on dry weight basis.

Carbohydrates in green 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 leaves and chekkurmanis and reported that these leaves contained 1.6, 6.4, 2.9 and 11.6 g per 100 g of carbohydrate respectively.

Mosha *et al.* (1995) reported a carbohydrate content of about 42.4 per cent in amaranthus on dry weight basis. Suman (2000) reported a soluble carbohydrate content of 1.68 percent in amaranthus.

Neeliyara (1998) reported 27.5 per cent of starch in winged bean leaves on dry weight basis. The carbohydrate content of cabbage, collard, turnip, peanut and sweet potato leaves were analysed by Mosha and Gaga (1999) and reported that the carbohydrate content varied from 60.4 to 73.1 per cent.

Pathak *et al.* (2000) reported 18.7 per cent of carbohydrates in curry leaves on fresh weight basis, which is highest when compared to radish (6.8%), carrot (10.6%), and cauliflower (4.0%).

Mathew (2000) analysed the nutritional composition of selected greens like kang kong, basella, waterleaf, arakeera, centella, horse purslane, akshara keera, and bengal keera and reported that the soluble carbohydrate content of these leaves varied from 0.63 to 2.12 g 100 g^{-1} with the highest content in centella. The starch content varied from 0.07 to 1.70 percent with the highest in bengal keera.

Kumaran (2003) revealed a starch content ranging from 0.04 to 0.31 per cent in green leafy vegetables, with the highest in coriander leaves.

The leafy vegetables consumed by Khasis of Meghalaya contained 6.4 to 23.2 g 100 g^{-1}carbohydrate (Easwaran and Goswani, 1989). Murugesan and Ananthalakshmi (1991) analysed the leafy vegetables consumed by the Paliyar tribal group of Kodaikanal and reported 3.8 to 8.1 per cent carbohydrate.

Shingade *et al.* (1995) reported that the non conventional leafy vegetables like drumstick leaves, bharangi, kawala, *Amaranthus spinosus* and takala were superior in carbohydrate than the conventional leaves like math, spinach, ghol, phodsi, cowpea, *Ipomoea aquatica* and dhandhgi. *Amaranthus tricolor* contained 3.7 per cent carbohydrates and *Ipomoea aquatica* contained 3.5 per cent carbohydrates. The carbohydrate content of the wild leafy vegetables of Ladakh varied from 25.7g to 38.0g per 100g (Chaurasia *et al.*, 2000).

Handique (2003) analysed five unconventional leafy vegetables from ethnic sources of North East India and reported a carbohydrate content of 6.15 to 17.00 per cent.

Ifon and Bassir (1980) reported a carbohydrate content of 51.0 to 66.1 percent in some Nigerian green leafy vegetables. Achinewhu *et al.* (1995) indicated that carbohydrate content of the leafy vegetables in Nigeria varied from 24.6 to 51.4 percent. Edeoga and Gomina (2001) analysed non conventional leafy vegetables of Nigeria and reported 6.6 percent of carbohydrate in *Hoslundia opposita*, which was the best in terms of nutritive value among the thirty leafy vegetables investigated.

Wills *et al.* (1984) analysed the nutritional 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 aquatica* contained no starch.

The leaves of wild *Plantago major*, *Plantago lanceolata* and *Plantago medi* were analysed by Guerrero (2001) and reported low proportions of available carbohydrates, ranging from 1.99 g to 2.81g per 100g with highest in *Plantago lanceolata.*

Green leafy vegetables are rich in minerals especially iron and calcium (Gopalan, 1982a; Smith, 1982). Reddy (1999) reported an average calcium and iron content of 300 mg and 4.7mg respectively in 100 g of green leafy vegetables.

Amaranthus species are known to contain high levels of calcium (Castanedac *et al.*, 1986). According to Gopalan *et al.* (1989), iron and calcium contents of *Amaranthus gangeticus* are 25.5 mg and 397 mg per 100g respectively, while that *of Amaranthus tricolor* are 3.49mg and 397 mg per 100g respectively.

According to Hemalatha *et al.*(1999), *Amaranthus* species contained 340 mg of calcium per 100g which is greater when compared to kanni keerai

Moringa olerifera is a good source of calcium, iron and phosphorus (Nautiyal and Raman, 1987; Shingade and Chavan, 1996). According to Gopalan (1982b), the calcium, phosphorus and iron contents of drumstick leaves are 440 mg, 7 mg, and 7.6 mg respectively. In addition to calcium, iron, phosphorus, potassium and magnesium, *Moringa olerifera* is rich in sulphur, zinc and boron.

Total minerals in green leafy vegetables varied from 12.54 to 26.16 per cent (Gupta and Wagle, 1988). The ash content of amaranths, colocassia, drumstick, fenugreek, neem and pumpkin leaves varied from 15.7 to 28.5 per cent (Gupta *et al.*, 1989).

Calcium and iron contents of leaves like *Mentha spicata, Rumex acetosa*, coriander, palak, spinach, chekkurmanis, *Solamum nigrum, Gynandropsis gynandra, Amaranthus hybridus,* colocasia, drumstick, fenugreek, neem, pumpkin, *Acacia concinna*, trianthema, chenopodium and tender tamarind varied from 0.43 to 0.48 g and 2 to 70 mg 100 g^{-1} respectively (Cnewya, 1985; Bawa and Yadav, 1986; Gupta *et al.*, 1989; Chandrasekhar *et al.*, 1990 and Shankaracharya, 1998).

Yadav and Sehgal (1997) reported an iron content of 26.54 to 34.4 mg in 100g of *Spinacia oleracea* and *Amaranthus tricolour.* The iron content of bathua (*Chenopodium album*) and spinach (*Spinacia oleracia*) were reported to be 20.63 mg and 26.54 mg respectively (Yadav and Sehgal, 2002).

The 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 (Kaur and Manjrekar, 1975). The mineral content of curry leaves is reported to be 4.2 per cent (Philip *et al.*, 1981). According to Pathak *et al.*(2000), calcium, iron and phosphorus contents of curry leaves were 830 mg, 70 mg and 57 mg per 100 g respectively.

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

The iron content of *Chenopodium album* and *Spinacia oleracea* leaves varied from 20 to 26 mg 100 g^{-1}(Yadav and Sehgal, 2002).

Kumaran (2003) reported high calcium (2000 mg 100 g^{-1}) and iron (14.63 mg 100 g^{-1}) in burmese coriander. The author also indicated that pisonia leaves contained 233.91 mg of phosphorus and colocassia leaves provided 427.88 mg potassium per 100 g.

Phosphorus content of nine green leafy vegetables commonly grown in Easten Uttar Pradesh varied from 0.34 to 1.43 per cent (Awasthi and Abidi, 1985).

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

High amount of calcium (690.9 mg per 100 g), phosphorus (184.0 mg per 100 g) and iron (36.4 mg per 100 g) was found in 'Thadi keerai' consumed by the Kota community of Nilgiris (Chandrasekhar and Chitra, 1990).

The leafy vegetables consumed by the Paliyar tribal group were analysed by Murugesan and Ananthalakshmi (1991) and reported that the calcium, phosphorus and iron content in these leaves varied from 180 to 400 mg per 100 g, 20 to 80 mg per 100 g and 1.8 to 20 mg 100 g^{-1} respectively.

Shadiza (1993) analysed the non cultivated leafy vegetables of Bihar, Bengal and Orissa and reported that the calcium, phosphorus, iron, magnesium,

manganese, zinc and copper in these leaves varied from 0.63-1.42 per cent, 0.14-0.28 per cent, 0.03-0.06 per cent, 0.45-1.30 per cent, 0.005-0.210 per cent, 0.003-0.028 per cent and 0.002-0.004 per cent respectively.

Ragu and Kapoor (1997) estimated the mineral content of some unconventional leafy vegetables of South India and reported high amount of iron and phosphorus and moderate amount of calcium in Senchulaku (*Digera muricata*). Gangeeraku (*Trianthema portulacastrum*) was found to be rich in calcium and phosphorus.

Wild leafy vegetables of Ladakh analysed by Chaurasia *et al.*(2000) contained good amount of calcium with values in between 0.88-4.29 per cent. Iron content of these leaves varied from 19 mg to 120 mg per 100 g where as phosphorus content ranged from 274 mg to 574 mg per 100 g.

Longvah (2000) reported fairly good amount of calcium (100 mg to 267 mg 100 g^{-1}) in the green leafy vegetables of Ladakh. Mean iron content of these leaves was found to be 4.4 mg 100 g^{-1} whereas the phosphorus content ranged in between 23 mg 100 g^{-1} and 57 mg 100 g^{-1}.

Nutritive value of some non conventional leafy vegetables from ethnic sources of North East India was analysed by Handique (2003) and reported that total mineral in the form of ash varied from 11.80 to 16.87 per cent.

Murugkar and Subhulakshmi (2003) reported a calcium content of 0.57g to 4.61g 100g^{-1} in the leafy vegetables consumed by the Khasis of Meghalaya with *Begonia roxhburghii* having the highest amount of calcium. The iron content of *Begonia roxhburghii* and *Plantago major* were reported to be 29.51mg and 57.7 mg 100g^{-1}.

Oyejola and Bassir (1975) studied the iron content of leafy Nigerian plants and the content varied from 190 mg in *Vernonia amygdalina* to 1010 mg kg^{-1} dry matter in *Solanum incamum*. The twenty one Nigerian leafy vegetables analysed by Smith (1982) contributed significant proportion of zinc, iron and calcium to the traditional Nigerian diet 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 green leafy vegetables commonly found in Western parts of Nigeria and reported that the leaves 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.

The average ash content of seventeen leafy vegetable species found in Nigeria was found to be 17.4 g 100 g^{-1} dry matter (Aletor and Adeogun, 1995). The authors also reported that these 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 on dry weight basis.

Six non-conventional leafy vegetables consumed by the rural populace of Nigeria were analysed by Barminas *et al.* (1999) and reported that *Amaranthus spinosus* contained high level of iron (38.4 mg 100 g^{-1}). Zinc level was found to be high in *Moringa olerifera* (25.5 mg), *Adansonia digitata* (22.4 mg) and *Cassia tora* leaves (20.9 mg) per 100 g of dry weight.

Ash contents of leafy vegetables grown in Tanzania varied from 0.5 g to 24.5 g 100 g^{-1} (Sreeramulu, 1982). Green vegetables grown in Dar es Salaam were found to be rich in macro minerals (Raja *et al.*, 1997). The predominant metal present in all leaves was potassium followed by calcium. Among the micro minerals, iron was the predominant one and the content varied from 3.09 to 53.04 mg 100 g^{-1}. Mziray *et al.* (2001) analysed fresh amaranth from four sites of Dar es

Salaam and reported that the level of calcium, iron and phosphorus varied from 2062 to 2263 mg 100 g^{-1}, 108 to 128 mg 100 g^{-1} and 500 to 553 mg 100 g^{-1} respectively on dry weight basis.

Wills *et al.* (1984) 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.

Rozycki *et al.* (1997) analysed the wild leafy vegetables of Argentina and reported *Amaranthus quitensis* to have 274.3 mg calcium, 6.4 mg iron and 136.2 mg per 100 g mangnesium.

Ash contents of *Zanthomonas mafaffa, Ipomoea involucrata, Launaea taxracifolia* and *Euphorbia hirta* varied from 1.15 per cent to 7.73 per cent (Wallace *et al.*, 1998). *E. hirta* leaves contained highest concentration of calcium (175 mg %), copper (14.7 mg %)and iron (45.8 mg %).

Guerrero *et al.* (1999) analysed the mineral contents of some wild edible plants and reported that *Malva sylvestris* and *Parietaria diffusa* contained high amount of minerals. Sodium content ranged between 42.1 mg per 100 g in *Portulaca oleracea* to 884.7 mg per 100 g in *Salicornia europaea*, while potassium content ranged from 293.7 mg in *Cakile maritima* to 757.4 mg in *Malva sylvestris*. Variation in calcium content was observed with *Parietaria diffusa* (882.5 mg 100 g^{-1}) having highest value. High amount of zinc (1.98 mg%) and iron (5.82 mg%) were found in *Malva sylvestris* .

Leaves of wild *Plantago major, P. lanceolata* and *P. media* from different locations of South East Spain was analysed by Guerrero (2001) and

reported the calcium content of *P. major* as 108 mg per 100 g on fresh weight basis.

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. Light 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, curry leaves, *Amaranthus spinosus, Moringa olerifera, Coriandrum sativam, Mentha spicata, Beta vulgaris*, mustard greens, spinach, *Rumex acetosa*, tender tamarind leaves and fenugreek leaves were reported to vary from 1100 to 9000 µg 100 g^{-1} (Jayarajan *et al.*, 1980; Menon, 1980; Shankaracharya, 1998; and Reddy, 1999).

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 provitamin 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, and ponnanganni contained 8 to 10 mg 100 g^{-1} of beta carotene while hibiscus and colocassia contained about 5 mg 100 g^{-1}.

Erandan keera 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 was found to be rich in vitamin A (Varalakshmi *et al.*, 1998). Suman (2000) reported beta carotene of 15064 µg per 100 g in Amaranthus.

Chekkurmanis leaves contained 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}.

According to Bushway and Bureau (1986), the most prominent 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 carrot. Drumstick leaves contained the highest level of β carotene among the green leafy vegetables (Gopalan, 1982b).

The beta carotene content of palak, bacchali, amaranth, drumstick leaves, 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). The beta carotene content and percentage beta carotene were found to be higher as medium textured leaves than in the tender and coarse samples (NIN, 1994b).

Mathew (2000) analysed selected leafy vegetables and reported a beta carotene content of 4007 µg to 22147 µg with highest content in kang kong leaves.

The total beta carotene content of drumstick leaves and arai keerai was found to be 39.81 and 30.73 mg 100 g^{-1} (Kowsalya and Chandrasekhar, 2003). Kumaran (2003) reported a beta carotene content ranging from 565.78 to

Kumaran (2003) reported a beta carotene content ranging from 565.78 to 18942.53 µg per 100 g in leafy vegetables with the highest in burmese coriander leaves.

Su *et al.* (2002) reported the beta carotene content of sow thistle and Amaranth as 3.3 mg and 4 mg per 100 g respectively.

Nambiar and Seshadri (1998) analysed sixteen leafy vegetables of the western regions 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 on fresh weight basis.

The total carotenoids and beta carotene content of thirty six green leafy vegetables collected and consumed by tribes of five districts from Eastern Ghats, Andhra Pradesh were found to be in between 12.22-36.13 mg and 5.21-14.05 mg per 100 g respectively (Rajalakshmi *et al.*, 2001).

Bharathi and Umamaheshwari (2001) analysed the proximate composition of non traditional leafy vegetables in Nellore and Prakasam districts of Andhra Pradesh and found that the total carotenoids varied from 11.73 to 37.41 mg 100 g^{-1}.

Carotene content of indigenous green leafy vegetables in Kenya exceeded 7000 µg 100 g^{-1} (Cnewya, 1985). Mercadante and Amaya (1990) analysed five native Brazilian leafy vegetable viz. *Amaranthus viridis, Lepidum pseudodidymum, Xanthosoma* spp., *Sonchus oleraceus* and *Portulaca oleracea* and beta carotene content varied from 14.1 to 110 mg 100 g^{-1}. These leaves contained 4.99 to 62.9 retinol equivalents per g of the leaves.

The beta carotene content of 14 commonly eaten green leafy vegetables in Bangladesh, ranged in 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 requirement of retinol (Mwajumwa *et al.*, 1991).

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

The carotenoid content of several dark green leaves of China viz., *Malva crispa*, *Ipomoea acquatica*, *Spinacia oleracea*, *Apium graneolens*, *Lactuca sativa*, *Basella alba* and *Pisum sativum* were analysed by Yang *et al.* (1996) and reported that the beta carotene ranged from 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). The beta carotene content of 12 genotypes of Chinese cabbage varied from 0.88 to 1.62 mg 100 g^{-1} (Kundu *et al.*, 1998).

Nesamvuni *et al.* (2001) analysed the wild leafy vegetables of Venda, South Africa and reported a beta carotene content of Murudi (*Cleome gyanadra*) as 9.22 mg per 100 g.

The leafy vegetables from four sites of Dar es Salaam were reported to have a beta carotene content in the range of 25.2 mg to 37.3 mg per 100 g (Mziray *et al.*, 2001). Herdren *et al.* (2002) reported a beta carotene content of 1211 and 3659 µg per 100 g in leafy vegetables of Tanzania.

Some green leafy vegetables like spinach, amaranth, fenugreek, mustard, drumstick, mint, coriander are good sources of vitamin C as fruits (Thimmayamma and Pasricha, 1996).

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}.

The ascorbic acid content of raw amaranth was found to be in the range of 96 to 99 mg 100 g^{-1} (Gopalan *et al.*, 1989). Varalakshmi *et al.* (1998) stated that leaves and tender stalks of amaranth are rich in vitamin C.According to Hemalatha *et al.*(1999), the ascorbic acid content of Amaranth is 120 mg 100 g^{-1}. Suman (2000) reported a vitamin C content of 136.55 mg per 100 g in Amaranth. The vitamin C content of dhantu (*Amaranthus gangeticus*) was found to be 72.1 mg 100 g^{-1} (Premavalli *et al.*, 2001).

Gopalan *et al.* (1989) reported 220 mg of ascorbic acid in drumstick leaves which was much higher than tomato, radish, pear and carrot. 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 low income groups as a regular and cheap source of vitamin C.

Prakash *et al.* (1995) reported that vitamin C content of different green leafy vegetables varied from 0.05 to 0.26 per cent.

The fresh leaves of bathua (*Chenopodium album*) and fenugreek (*Trigonella foenum graecum*) contained ascorbic acid in the range of 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 Pathak *et al.* (2000) the vitamin C content of curry leaf is 4 mg per 100 g.

Mathew (2000) analysed eight leafy vegetables and reported an ascorbic acid content in the range of 51.77 mg to 127.27 mg per 100 g with centella having the highest value.

Nutrient analysis of the leaves of *Bauhenia purpurea* Linn, *Chenopodium album* Linn, *Fagopyrum esculentum* Moench by Raghuvanshi *et al.* (2000) indicated an ascorbic acid content of 84.93, 33.64 and 173.13 mg respectively in these leaves.

Singh *et al.* (2001) analysed the vitamin C content of selected leafy vegetables, herbs and carrots and reported highest ascorbic acid content in bengal gram leaves.

Kumaran (2003) indicated an ascorbic acid content in the range of 32.26 mg to 523 mg per 100 g in nine leafy vegetables with ponnaviram having the highest value.

The tribal greens viz. *Acacia concinna,* trianthema, chenopodium and amaranthus used by tribals of Attapadi and Katchuvadi hills were reported to have an ascorbic acid content in the range of 99 to 175.2 mg 100 g^{-1} (Chandrasekhar *et al.*, 1990).

Chandrasekhar and Chitra (1990) analysed the leafy vegetables consumed by the Kota community of Nilgiri and reported the ascorbic acid content of 'Thadi keerai' and 'Puliari keerai' as 77.8 and 53.6 mg per 100 g respectively.

Shingade *et al.* (1995) analysed the unconventional vegetables from Konkan region and reported an ascorbic acid content of 48.8 mg 100 g^{-1} in Kankong and 45.1 mg 100 g^{-1} in bharangi leaves. The non traditional leaves of

Andhra Pradesh were reported to have ascorbic acid content in the range of 22.24 mg to 119.06 mg 100 g^{-1} (Bharathi and Umamaheshwari, 2001).

Murugkar and Subhulakshmi (2003) analysed the wild edible leaves used by Khasis of Meghalaya and reported an ascorbic acid content of 469 mg per 100g in *Plantago major.*

Ten commonly eaten leafy vegetables of Nigeria were analysed and reported that the ascorbic acid content varied from 20.6 to 160.2 mg 100 g^{-1} dry matter (Ifon and Bassir, 1980). Keshinro and Ketiku (1979) reported the mean ascorbic acid levels of 31 to 63 mg 100 g^{-1} in some leafy vegetables like *Amaranthus chorostachys, Basella alba, Talinum triangulare* and *Vernonia amygdalina.* The indigenous leafy vegetables of Nigeria were reported to have high ascorbic acid content that varied from 23-232 mg 100 g^{-1} (Achinewhu *et al.*, 1995). Study on non conventional leafy vegetables of Nigeria indicated 9.75 mg 100 g^{-1} of ascorbic acid in *Hoslundia opposita* (Edeoga and Gomina, 2001).

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 olerifera* being the richest sources of vitamin C. Fresh foliage of fenugreek contained 276 mg 100 g^{-1} of ascorbic acid and that of *Polygomum plebium* 58 mg 100 g^{-1} on fresh weight basis (Sreeramulu, 1983a). Vitamin C content of 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). *Amaranthus hybridus* from four sites of Dar es Salaam Tanzania were analysed by Mziray *et al.* (2001) and reported an ascorbic acid content in the range of 455 mg to 535 mg 100 g^{-1}.

According to Wills *et al.* (1984), 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. Kundu *et al.* (1998)

analysed 12 genotypes of Chinese cabbage and reported an ascorbic acid content in the range of 7.36 to 12.11 mg per 100 g.

The ascorbic acid content in three indigenous Kenyan leafy vegetables viz., *Amaranthus hybridus, Gynandropsis gynandra* and *Solanum nigrum* varied from 123.8 mg in *A. hybridus* to 189.2 mg 100 g^{-1} fresh weight in *Gynandropsis gynanmra* (Mathooka and Imungi, 1994).

Rozycki *et al.* (1997) analysed the leafy vegetables of Argentina and reported the ascorbic acid content of Rumex sp. as 48.9 mg per 100 g.

Nutrient analysis of *Plantago major, Plantago lanceolata* and *Plantago media* from different locations of South East Spain indicated 45.1 mg 100 g^{-1} of ascorbic acid in *P. major* (Guerrero, 2001).

Phenols are bioactive compounds that has beneficial effects (Saltmarch *et al.*, 2003). Kaur and Kapoor (2002) analysd the total phenolic content of some Asian vegetables and reported that the content varied from 34 to 400 mg per 100g on fresh weight basis. Mint, bathua, broccoli and coriander, were reported to have high phenolic content.

Flavanoids, the most common group of plant phenols provide much of the flavour and colour to the fruits and vegetables. Justesen *et al.*(2000) observed a flavanoid intake of about 20-26 mg per day through the comsumption of fruit and vegetables in Denmark.

The chemical composition of *Amaranthus tricolor* cv *valentina, Chrysanthimum coronarium* cv *uzorchaty, Nasturtium officinale* cv *podmoskovny* and *Lepidium meyenni* were analysed by Gins *et al.* (2001) and *L. meyenni* was reported to have high alkaloid content of 5.85 per cent.

2.3 ANTI-NUTRITIONAL FACTORS IN LEAFY VEGETABLES.

Despite 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 (Cheeke and Bronson,1980: Gupta and Wagle, 1988).

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

Free oxalates may bind with essential divalent minerals like calcium and make them nutritionally unavailable. The calcium oxalate may accumulate resulting in oxaluria or kidney stones (Gopalan *et al.*,1989; Sukumar, 1997). According to Reddy (1999), certain green leafy vegetables are rich in oxalic acid and hence individuals prone to renal calculi should avoid such foods.

The oxalate content of different vegetable types of the *amranthus* species as reported by various authors varied from 0.3 to 1.92 per cent on dry weight basis (Devadas *et al.*, 1989; Prakash and Pal, 1991; Prakash *et al.*, 1993; Thamburaj *et al.*, 1994). However, Mallika (1987) and Vityakon and Standal (1989) observed an oxalate content of 3.6 to 12.78 per cent on dry weight in various *Amaranthus* species. 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).

Guerrero and Isasa (1997) analysed the oxalic acid content of *Chenopodium* species and found moderate levels of oxalic acid and oxalic/ (Ca+Mg) ratio in the leaves. Tender leaves of tamarind were reported to contain 196 mg $100g^{-1}$ of oxalic acid and observed a calcium /oxalate ratio of 1:1 (Shankaracharya, 1998).

High quantity of oxalates and hydrocyanic acid was found in Ceylon spinach, a wild leafy vegetable of Assam (Saikia and Shadeque, 1994).

According to Shingade *et al.* (1995), the unconventional leafy vegetables in general contained less oxalates as compared to cultivated vegetables, thereby indicating good palatability.

Mathew (2000) analysed selected leafy vegetables of Kerala and reported that the oxalic acid content of the leafy vegetables varied from 0.23 to 1.08 g with the highest in bengal keera. Kumaran (2003) reported an oxalic content of 0.004 to 2.97g in different leafy vegetables with coriander leaves having the lowest value.

According to Ndyanab (1974) the oxalate content of some commonly grazed pasture forages in Uganda was reported to have high levels of total oxalates with low levels of soluble oxalates.

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

The anti-nutritional composition of four unconventional leafy vegetables viz. *Xanthomonas maffafa, Euphorbia hirta, Launcea taxarifolia* and *Ipomoea involucrate* grown in Ghana were reported to have low levels of oxalates, phytates, tannins, alkaloids and saponins (Wallace *et al.*,1998) Anti-nutritional composition of *Amaranthus hybridus* from four locations of Dar es Salaam were studied by Mziray *et al.* (2001) and reported an oxalate content of 3383 to 4333 mg $100g^{-1}$. The leaves of wild *P. laceolata* and *P. media* from South East Spain were analysed by Guerrero (2001) and reported an oxalic acid content of 88.2 mg and 33.5mg $100g^{-1}$ respectively on fresh weight basis.

Brogren and Savage (2003) reported that the frozen commercially available spinach in New Zealand contained 736.6 mg per 100 g soluble oxalate and 220.1 mg per 100 g insoluble oxalate (wet matter). The oxalate calcium ratio of frozen spinach was reported to be 4.73.

The usual human dietary intake of nitrate is about 100 mg per 100g (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 urine without further conversion (Tannenbaum, 1979).

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

Devadas (1982) studied the nitrate content of 25 genotypes of vegetable amaranths and reported that the content varied from 0.25 to 0.7 percent on dry weight basis. The author also reported that among 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 *Amaranthus hypochondriacus.*

Gupta and Wagle (1988) reported a nitrate content of 5.36 per cent in spinach. According to Prakash *et al.*(1993), nitrate content of *Chenopodium auinva* and celosia varied from 0.26 to 0.51 and 0.46 to 0.91 per cent respectively.

Mathew (2000) analysed eight leafy vegetables and reported a variation of 0.11 to 0.35 per cent in the nitrate content with the highest in *Amaranthus tricolor* and lowest in basella leaves.

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).

Goswani *et al* (2000) analysed the nitrate content of fifteen vegetables in Assam and found that *Coriander sativam* had the highest nitrate level of 220mg per 100g.

Kulkarni *et al.* (2003) analysed nine leafy vegetables and reported that the nitrate content of these leaves ranged from 52.8 to 312.4 mg on fresh weight basis.

Among the nine leaves analysed by Kumaran (2003) high nitrate content was found in pisonia leaves (2.80%) and lowest in tamarind leaves(1.94%).

Santamaria *et al.* (1999) reported higher levels of nitrates in green leafy vegetables than bulb, root, shoot, inflorescence and tuber vegetables. The authors also indicated a daily nitrate intake of 71 mg from vegetables of which 30 per cent was derived from lettuce and swiss chard.

Anti-nutritional composition of *Amaranthus hybridus* from four locations of Dar es Salaam was studied by Mziray *et al.* (2001) and reported a nitrate content of 501 to 560 mg per 100g.

High levels of nitrate in a number of vegetables such as spinach, cabbage, amaranthus and mustard greens is due to excess use of nitrogen containing fertilizer (Lee *et al.*, 1971; Palis and Bustrillos, 1976; Vera *et al.*, 1992)

2.4 ORGANOLEPTIC EVALUATION OF LEAFY VEGETABLES

Quality is the ultimate criteria 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). Sensory quality is a combination

of different senses of perception coming into play in choosing and eating a food (Ranganna, 1986).

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 consumer 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).

Allenam *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 the authors *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 the best texture.

Kala *et el.* (1998) compared the sensory attributes of microwave cooked and conventionally cooked green vegetables viz amaranth, kilkeerai, shepu and spinach. Results showed that only the colour of cooked green was significantly affected due to cooking methods and microwave cooked greens were preferred to conventionally cooked greens. However, Fathima and Beegum (1998) and Fathima *et al.* (2001) reported that the microwave drying adversely affected the physical characteristics like the colour, appearance and odour. of the green leafy vegetables.

Neeliyara (1998) studied the acceptability of the five winged bean genotypes and reported higher acceptability in these leaves. Leafy vegetables grown in summer was found to be more acceptable than in rainy season (Mathew, 2000).

Kumaran (2003) studied the acceptability of conventional, *spicy* and tree leaves and chutney, thoran and salads prepared out of these leaves were found to be highly acceptable.

Materials and Methods

3. MATERIALS AND METHODS

The methods used to evaluate the quality attributes of the selected leafy vegetables consumed by the tribes of Wayanad District are given under the following heads.

1. Selection of the leafy vegetables
2. Analysis of chemical constituents
3. Computation of average nutritive value
4. Evaluation of acceptability
5. Statistical analysis

3 .1 SELECTION OF THE LEAFY VEGETABLES

Among the different leafy vegetables consumed by the tribal communities of Wayanad District, ten most commonly used leafy vegetables were selected for the study. The leafy vegetables were identified on the basis of a dietary survey conducted among the tribal communities of Wayanad district in the ICAR adhoc scheme entitled ' Nutrient and anti-nutrient composition of ethnic plant foods consumed by the tribes of Kerala'. The leafy vegetables selected are

i) Ambasheppu (*Bidens pilora* Linn.)
ii) Chumalacheera (*Alternanthera amabilis*)
iii) Churuli (*Diplazium esculentum*)
iv) Kandariyila (*Capsicum frutescens* Linn.)
v) Kannisoup (*Commelina benghalensis* Linn.)
vi) Kozhuppa (*Portulaca oleracea*)
vii) Murikkila (*Erythrina stricta* Roxb.)
viii) Ponnankanni (*Alteranthera triandra*)
ix) Thakara (*Cassia alata* Linn.)
x) Valiya kadaladi (*Aerva wightii* Hook)

The edible portion of the above ten leafy vegetables were collected from Wayanad district during their availability with the help of tribal people.

Plate 1 and 2 shows the different leafy vegetables selected for the study.

3.2 ANALYSIS OF CHEMICAL CONSTITUENTS

The selected leafy vegetables were analysed for the following chemical constituents.

1) Moisture
2) Protein
3) Fat
4) Crude fibre
5) Total carbohydrates
6) Calcium
7) Phosphorus
8) Iron
9) Sodium
10) Potassium
11) β carotene
12) Vitamin C
13) Phenol
14) Flavanoids
15) Methanol extractable crude alkaloid
16) Oxalates and
17) Nitrates

Ambasheppu

Chumalacheera

Churuli

Kandariyila

Kannisoup

Plate.1 GREEN LEAFY VEGETABLES

Kozhuppa

Murikkila

Ponnankanni

Thakara

Valiya kadaladi

Plate.2 GREEN LEAFY VEGETABLES

3.2.1 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.

3.2.2 Protein

The estimation of protein was done by the method of A.O.A.C (1980).

0.3 g of the sample was digested with 6 ml sulphuric acid after adding 0.4 g of copper sulphate and 3.5 g of potassium sulphate in a digestion flask until the colour of the sample is converted to green. After digestion it was diluted with water and 25 ml of 40 per cent sodium hydroxide was pumped. The distillate was collected in 2 per cent boric acid containing mixed indicators and then titrated with 0.2 N hydrochloric acid.

3.2.3 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 of the sample was 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 into fresh weight basis.

3.2.4 Crude fibre

Crude fibre content 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.

3.2.5 Total carbohydrate

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

The powdered and dried sample was hydrolysed with 5 ml of 2.5 N hydrochloric acid and then cooled to room temperature. The residue was then neutralised with solid sodium carbonate until the effervescence ceases. Made up the volume to 100 ml and centrifuged. Pipetted 0.5 ml of supernatant and made upto 1 ml, added 4 ml anthrone reagent, heated for eight minutes, cooled rapidly and the intensity of green to dark 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.

3.2.6 Calcium

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

One gram of dried and powdered sample was pre digested with 12 ml of 9:4 diacid and volume made upto 100 ml. One ml of aliquot was taken and added 10 ml water, 10 drops of five per cent hydroxylamine, 10 drops of triethanolamine and 2.5 ml of ten per cent sodium hydroxide and 10 drops of calcon. Then it was titrated using EDTA till the appearance of permanent blue colour. It was expressed in mg per 100 g of sample and converted to fresh weight basis.

3.2.7 Phosphorus

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

One gram of dried and powdered plant sample was pre digested with 12 ml of 9:4 diacid and volume made up to 100 ml. Five ml of the aliquot was pipetted into 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 sample was estimated and converted to fresh weight basis.

3.2.8 Iron

The iron content was analysed colorimetrically using ferric iron, which gives a blood red colour with potassium thiocyanate (Raghuramulu *et al.*, 2003).

To an aliquot of the mineral solution enough water was added to make up to a volume of 6.5 ml followed by one ml of 30 per cent sulphuric acid, one ml of potassium persulphate solution and 1.5 ml of 40 per cent potassium thiocyanate solution. The intensity of the red colour was measured within 20 minutes at 540 nm. A standard graph was prepared using serial dilutions of standard iron solution. From the standard graph the iron content of the sample was estimated and converted to fresh weight basis.

3.2.9 Sodium

The sodium content was estimated using flame photometer as suggested by Jackson (1973).

One gram of the dried and powdered sample was digested in diacid and made up to 100 ml. The solution was directly fed in the flame photometer and converted to fresh weight basis.

3.2.10 Potassium

The potassium content was estimated using flame photometer as suggested by Jackson (1973).

Powdered one gram of dry sample was digested in diacid and made up to 100 ml. One ml of the sample solution was made up to 25 ml and read directly in flame photometer.

3.2.11 Beta-carotene

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 was 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.

3.2.12 Vitamin C

The vitamin C content of the fresh sample was estimated by the method of A.O.A.C. (1955) using 2,6 dichlorophenol 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 pipetted, 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.

3.2.13 Phenol

The phenol content was estimated colorimetrically using the method suggested by Sadasivam and Manikkam (1992).

One gram of fresh sample was extracted with 80 per cent ethanol twice and the supernatant was pooled. Evaporated the supernatant to dryness. The residue was dissolved in a known volume of distilled water, from which one ml

was pipetted and made up the volume to 3 ml with distilled water to which 0.5 ml of Folin-Ciocalteau reagent was added. After 3 minutes, two ml of 20 per cent sodium carbonate was added and mixed thoroughly and heated for exactly one minute, cooled and measured the absorbance in spectrophotometer at 650 nm against a reagent blank. A standard graph was prepared using serial dilutions of standard catechol solutions. From the standard graph, the phenol content of the sample was estimated.

3.2.14 Flavanoids

The flavanoid content was analysed colorimetrically using the method suggested by Chang *et al.* (2002).

One gram of the fresh sample was extracted twice with 80 per cent ethanol. Pooled the supernatants and made upto 25 ml with 80 per cent ethanol. 0.5 ml of the ethanol extract was then mixed with 1.5 ml of 95 per cent ethanol, 0.1 ml of 10 per cent aluminium chloride, 0.1 ml of 1M potassium acetate and 2.8 ml of distilled water. After incubation at room temperature for 30 minutes, the absorbance of the reaction mixture was measured at 415 nm in a spectrophotometer. A standard graph was prepared using serial dilutions of standard flavanoid solution. From the standard graph the flavanoid content of the sample was estimated.

3.2.15 Methanol extractable crude alkaloid

Methanol extractable crude alkaloid content was estimated using soxhlet method suggested by Harborne (1973).

The fresh leaf sample was oven dried at 37°C and powdered. Three gram of the sample was weighed accurately into a thimble and placed in a soxhlet apparatus and extracted with 150 ml of methanol for 6 hrs. The methanol was

removed by evaporation. The flask with the residue was dried in an oven at 50-60°C, cooled and weighed. Methanol extractable crude alkaloid was calculated by substracting the weight of the methanol extract residue from the initial weight of the sample.

3.2.16 Oxalate

The oxalate content in the sample was analysed colorimetrically 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 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 filterate was added to two ml of diluted iron ferron reagent and absorbance read at 540 nm in a spectrophotometer. The oxalate content of the dried sample was calculated from the standard graph and converted to fresh weight basis.

3.2.17 Nitrate

Nitrate content was estimated colorimetrically using diphenol sulphonic acid as suggested by Bharghava and Raghupati (1993).

The dried and powdered sample of 0.5 g was extracted with 50 ml of water and filtered. Two ml of aliquot 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 yellowish colour. The volume was made up and colour was read at 420 nm. The nitrate content of the

dried sample was calculated from the standard graph and converted to fresh weight basis.

3.2 COMPUTATION OF AVERAGE NUTRITIVE VALUE

Average nutritive value of the leafy vegetable was computed using the procedure suggested by Grubben (1977).

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

3.3 EVALUATION OF ACCEPTABILITY

Organoleptic evaluation of the selected leafy vegetables was conducted after cooking at the laboratory level.

3.4.1 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).

3.4.2 Preparation of the sample 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. The leaves were sprinkled with little water and salt, and cooked under low flame.

3.4.3 Sensory evaluation

Acceptability of the cooked leafy vegetable was assessed using the score card (Swaminathan, 1974) by the selected ten judges. Five quality attributes like appearance, colour, flavour, texture and taste were evaluated using the score card. Each of the above mentioned quality attributes was assessed by a five point hedonic scale. The score card used for the sensory evaluation is given in Appendix I

3.5 STATISTICAL ANALYSIS

Data were analysed using analysis of variance, cluster analysis and Kendall's coefficient.

Results

4. RESULTS

The results pertaining to the study entitled 'Quality evaluation of selected leafy vegetables consumed by the tribes of Wayanad District' are presented under the following heads.

1. Chemical composition of leafy vegetables.
2. Acceptability of leafy vegetables.
3. Cluster analysis of leafy vegetables.

4.1 CHEMICAL COMPOSITION OF LEAFY VEGETABLES

4.1.1 Nutritional composition of leafy vegetables

Ten leafy vegetables consumed by the tribes of Wayanad District were analysed for twelve constituents i.e., moisture, protein, fat, crude fibre, total carbohydrate, calcium, phosphorus, iron, sodium, potassium, β carotene and vitamin C. The results of the nutrient composition of the selected leafy vegetables are presented in Table 1.

4.1.1.1 Moisture

The moisture content of the leafy vegetables varied from 74.84 per cent in Valiya kadaladi to 90.42 per cent in Kozhuppa.

On the basis of Duncan's Multiple Range Test (DMRT), the different leafy vegetables were classified into five groups based on moisture content. Kozhuppa with the highest moisture content was included in a separate group (a), which showed that it had significant difference from all the other leafy vegetables selected for the study. Kandariyila and Valiya kadaladi were included in two separate groups namely 'd' and 'e'. Chumalacheera, Kannisoup, Churuli, Ponnankanni and Thakara were included in a separate group (c). These five leaves were not significantly different from each other with respect to moisture content.

Table 1. Nutritional composition of leafy vegetables on fresh weight basis, per 100 g

Leafy vegetables	Moisture (g)	Protein (g)	Fat (g)	Crude fibre (g)	Total carbohydrates (g)	Calcium (mg)	Phosphorus (mg)	Iron (mg)	Sodium (mg)	Potassium (mg)	βcarotene (µg)	Vit C (mg)
Ambasheppu	85.73^{b}	3.31^{g}	0.52^{b}	0.98^{e}	2.85^{e}	144.81^{f}	61.50^{f}	70.32^{b}	5.69^{b}	633.03^{d}	1177.04^{f}	37.07^{g}
Chumalacheera	81.62^{e}	4.83^{e}	0.54^{b}	2.04^{b}	2.27^{f}	161.81^{ef}	22.86^{h}	31.58^{e}	5.26^{b}	1119.6^{b}	1465.27^{e}	222.22^{a}
Churuli	82.42^{e}	3.55^{f}	0.77^{a}	2.07^{b}	3.78^{e}	142.43^{f}	85.38^{e}	29.71^{e}	8.76^{a}	764.75^{e}	967.77^{h}	31.61^{h}
Kandariyila	78.38^{d}	5.34^{b}	0.79^{a}	1.58^{cd}	4.28^{b}	280.82^{c}	124.61^{a}	15.25^{g}	8.95^{a}	774.58^{e}	1354.37^{e}	97.32^{d}
Kannisoup	82.78^{e}	4.01^{d}	0.24^{d}	1.24^{de}	5.46^{a}	193.26^{de}	101.79^{b}	75.81^{a}	8.52^{a}	1231.37^{a}	1025.89^{g}	119.98^{c}
Kozhuppa	90.42^{a}	2.24^{h}	0.18^{d}	0.48^{f}	1.51^{h}	214.13^{d}	34.51^{g}	20.88^{f}	2.59^{c}	266.00^{f}	340.5^{i}	37.99^{g}
Murikkila	85.82^{b}	3.77^{e}	0.53^{b}	1.68^{c}	2.12^{g}	184.76^{de}	60.30^{f}	1.59^{h}	5.17^{b}	572.37^{de}	967.48^{h}	60.71^{e}
Ponnankanni	82.70^{e}	4.88^{e}	0.34^{c}	2.24^{ab}	2.35^{f}	275.40^{c}	86.35^{e}	41.42^{d}	8.67^{a}	553.63^{e}	1435.39^{d}	48.81^{f}
Thakara	81.01^{e}	5.65^{a}	0.50^{b}	1.58^{cd}	3.19^{d}	569.23^{b}	65.35^{e}	46.44^{c}	8.62^{a}	732.36^{e}	1584.29^{b}	151.79^{b}
Valiya kadaladi	74.84^{e}	5.56^{a}	0.73^{a}	2.56^{a}	3.81^{c}	669.67^{a}	83.76^{d}	70.23^{d}	8.67^{a}	1170.83^{ab}	1879.41^{a}	34.07^{gh}
Mean	82.57	4.31	0.52	1.63	3.16	283.63	72.64	40.32	7.09	781.85	1219.74	84.15

Values having different superscripts differ significantly at 5% level

54

The moisture content of the leafy vegetables is shown in Figure 1.

4.1.1.2 Protein

The crude protein content of the leafy vegetables ranged from 2.24 to 5.65 per cent (Figure 2). The highest protein content was observed in Thakara and lowest in Kozhuppa.

On the basis of protein content, the leafy vegetables were grouped statistically into eight groups. All the groups contained one leafy vegetable each except the groups 'c' and 'a', which had two members. Thakara with the maximum protein content was found to be at par with Valiya kadaladi in group'a', which had a protein content of 5.56 percent. Ponnankanni and Chumalacheera were included in group 'c' with a protein content of 4.88 percent and 4.83 percent respectively. Statistically significant variation in the protein content of other six leaves was observed.

4.1.1.3 Fat

The fat content of the leaves varied from 0.18 percent to 0.79 percent with the highest and lowest fat content in Kandariyila and Kozhuppa respectively.

The leafy vegetables were classified into four groups according to their fat content on the basis of DMRT. Group 'a' and 'b' had three and four members each. Kandariyila with the highest fat content was included along with Churuli and Valiya kadaladi in group 'a', which showed that the fat content of Kandariyila was not significantly different from Churuli and Valiya kadaladi but significantly different from other leafy vegetables. Other two groups namely 'c' and 'd' had one and two members respectively. The leafy vegetables included in the same class were not significantly different from each other but differ from the leafy vegetables of other classes.

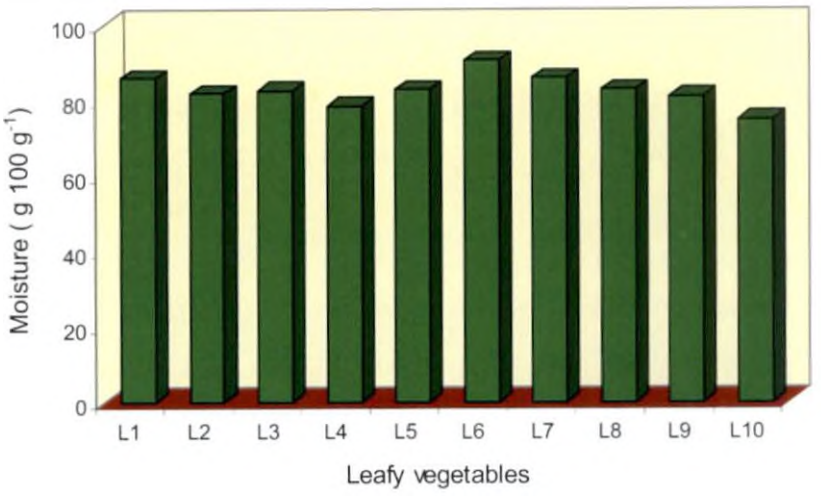

Fig. 1. Moisture content of the leafy vegetables

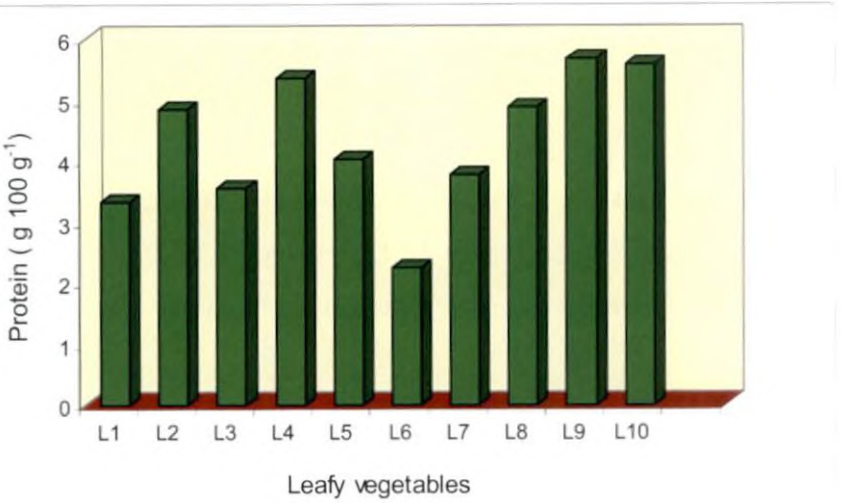

Fig. 2. Protein content of the leafy vegetables

L1 – Ambasheppu
L2 – Chumalacheera
L3 – Churuli
L4 – Kandariyila
L5 – Kannisoup
L6 - Kozhuppa
L7 - Murikkila
L8 - Ponnankanni
L9 - Thakara
L10 -Valiya kadaladi

The fat content of the leafy vegetables selected for the study is represented in Figure 3.

4.1.1.4 Crude fibre

The crude fibre content of the leafy vegetables varied from 0.48 per cent to 2.56 per cent with Kozhuppa having the lowest and Valiya kadaladi with the highest value.

Statistically the leafy vegetables were differentiated into eight groups on the basis of the fibre content. The group 'b' and 'cd' had two members each and the other groups namely 'a', 'ab', 'c', 'f', 'de' and 'e' had one member in them. Except the leaves included in 'b' and 'ab', 'cd' and 'de', 'e' and 'de', 'c' and 'cd', 'b' and 'ab' , 'a' and ab' the leafy vegetables included in other groups differed significantly with respect to fibre content.

The fibre content of the leafy vegetables are represented in Figure 4.

4.1.1.5 Total carbohydrates

As revealed in Table 1 and Figure 5, the total carbohydrate content of the leafy vegetables varied from 1.51 per cent to 5.46 per cent. Kannisoup was found to have the highest total carbohydrate content and Kozhuppa, the lowest.

Statistically, the various leafy vegetables were differentiated into eight categories. The category 'f' and 'c' had two members each and the rest six leafy vegetables were included in separate groups. The leaves included in the same group were not significantly different from each other but different from the leafy vegetables of other classes.

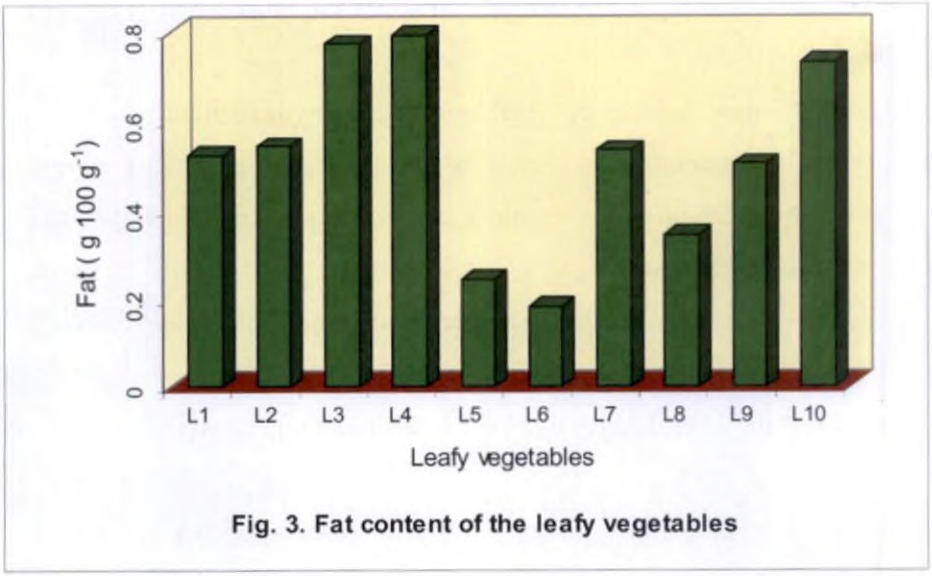

Fig. 3. Fat content of the leafy vegetables

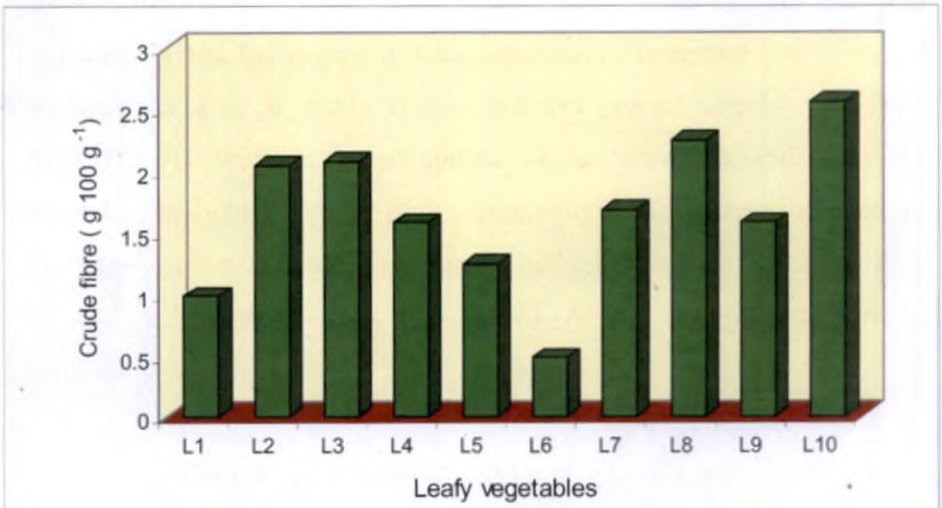

Fig. 4. Crude fibre content of the leafy vegetables

L1 – Ambasheppu
L2 – Chumalacheera
L3 – Churuli
L4 – Kandariyila
L5 – Kannisoup
L6 - Kozhuppa
L7 - Murikkila
L8 – Ponnankanni
L9 – Thakara
L10 -Valiya kadaladi

4.1.1.6 Calcium

Calcium content of the leafy vegetables varied from 142.43 mg in Churuli to 669.67 mg per 100 g in Valiya kadaladi.

Statistically the different leafy vegetables were arranged into seven groups with group 'f', 'de' and 'c' having two members in each group. Valiya kadaladi with the highest calcium content was included as the sole member of group 'a', which indicated that this leaf is significantly different from all the other leaves included in the study with respect to calcium content.

The calcium content of the leafy vegetables is illustrated in Figure 6.

4.1.1.7 Phosphorus

The phosphorus content of the leafy vegetables varied from 22.86 mg to 124.61 mg per 100g. The highest phosphorus content was observed in Kandariyila and the lowest in Chumalacheera. These two leafy vegetables were included as a single entity in two different groups namely 'a' and 'h' which indicated that the phosphorus content of the leaves differed significantly from other leaves included in the study. Altogether the ten leaves included in the study were grouped in eight categories on the basis of phosphorus content. Except group 'f' and 'c', which had two leaves each, all the other leaves were included in separate groups.

The phosphorus content of the leafy vegetables is shown in Figure 7.

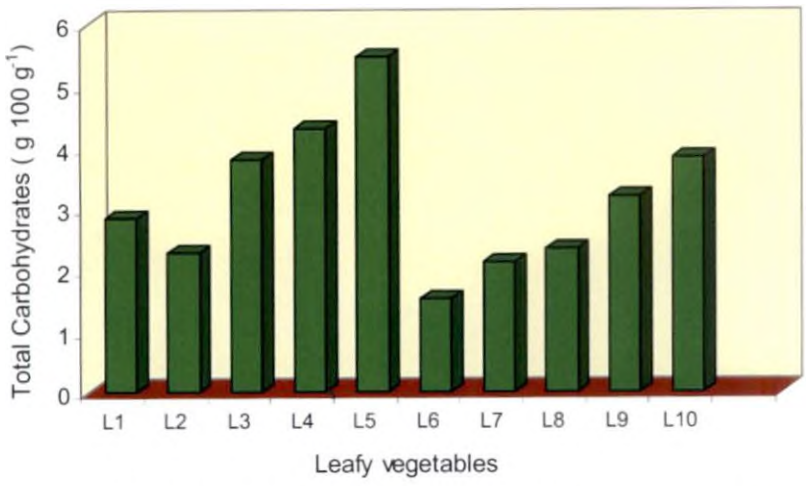

Fig. 5. Total carbohydrate content of the leafy vegetables

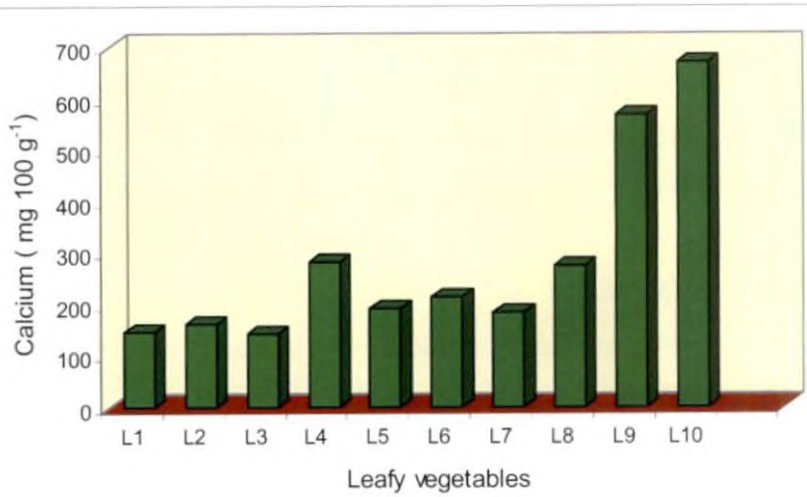

Fig. 6. Calcium content of the leafy vegetables

L1 – Ambasheppu
L2 – Chumalacheera
L3 – Churuli
L4 – Kandariyila
L5 – Kannisoup
L6 - Kozhuppa
L7 - Murikkila
L8 – Ponnankanni
L9 – Thakara
L10 -Valiya kadaladi

4.1.1.8 Iron

The iron content of the leafy vegetables varied from 1.59 mg to 75.81 mg per 100g with Kannisoup having the highest and Murikkila the lowest value(Fig. 8).

On the basis of iron content the leaves were categorized into eight groups with group 'e' and 'd' having two members each. Murikkila and Kannisoup with the lowest and highest iron content respectively were included as a single entity in two different groups. Except the leaves included in the same group, all the leafy vegetables differed significantly with respect to the iron content.

4.1.1.9 Sodium

The sodium content of the leafy vegetables varied from 2.59 mg to 8.95 mg 100 g^{-1} with the highest and lowest sodium content in Kandariyila and Kozhuppa respectively.

Statistically the various leafy vegetables were differentiated into three categories. Kandariyila with the highest sodium content was included in a separate group (a) with other five leaves namely Churuli, Kannisoup, Ponnankanni, Thakara and Valiya kadaladi indicating no significant difference in the sodium content of these leaves. The other two groups 'b' and 'c' had three and one member respectively. The leafy vegetables included in the same class were not significantly different from each other but different from the leafy vegetables of other classes.

The sodium content of the leafy vegetables is depicted in Figure 9.

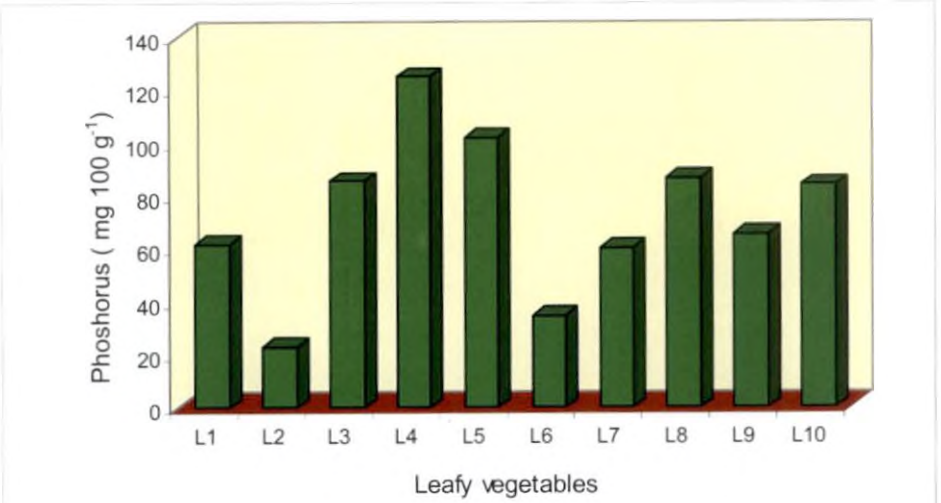

Fig. 7. Phosphorus content of the leafy vegetables

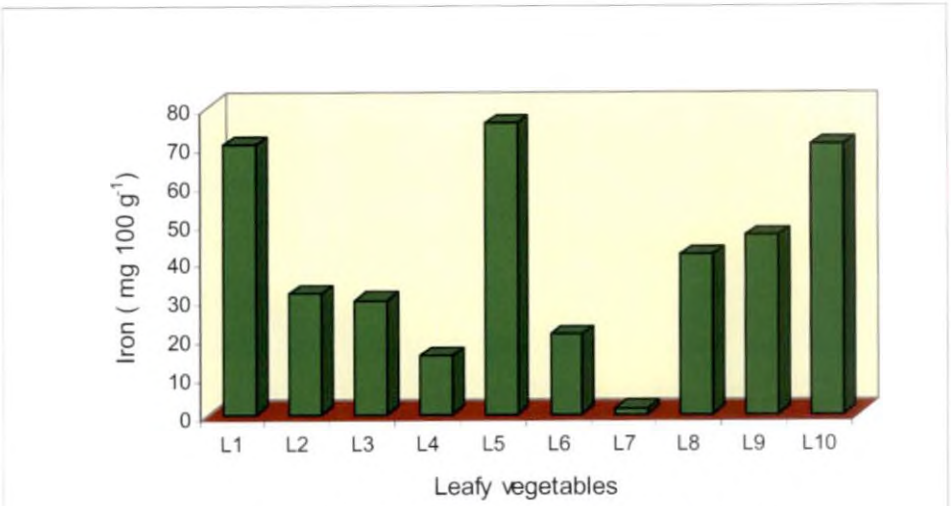

Fig. 8. Iron content of the leafy vegetables

L1 – Ambasheppu
L2 – Chumalacheera
L3 – Churuli
L4 – Kandariyila
L5 – Kannisoup
L6 - Kozhuppa
L7 - Murikkila
L8 - Ponnankanni
L9 – Thakara
L10 -Valiya kadaladi

4.1.1.10 Potassium

The potassium content of the leafy vegetables varied from 266.00 to 1231.37 mg per 100 g with Kannisoup having the highest value and kozhuppa, the lowest.

Statistically the leafy vegetables were differentiated into seven groups on the basis of the potassium content. Kannisoup with the highest potassium content was included in a separate group 'a'. The group 'c' contained three leafy vegetables. Except the leaves included in 'a' and 'ab', 'ab' and 'b', 'd' and 'de', 'de' and 'e', the leafy vegetables included in other groups differed significantly with respect to potassium content.

The potassium content of the leafy vegetables is represented in Figure 10.

4.1.1.11 β Carotene

The β carotene content of the leafy vegetables varied from 340.5 µg to 1879.41 µg per 100g. Highest β carotene was observed in Valiya kadaladi and lowest in Kozhuppa. The β carotene content of the leafy vegetables is represented in Figure 11.

Statistically the leafy vegetables were arranged into nine groups. All the groups had only one member each except for group 'h', which had two members in it namely Chuvuli and Murikkila. Significant difference was seen in the β carotene content of the leafy vegetables included in different groups except the two leaves including in group 'h'.

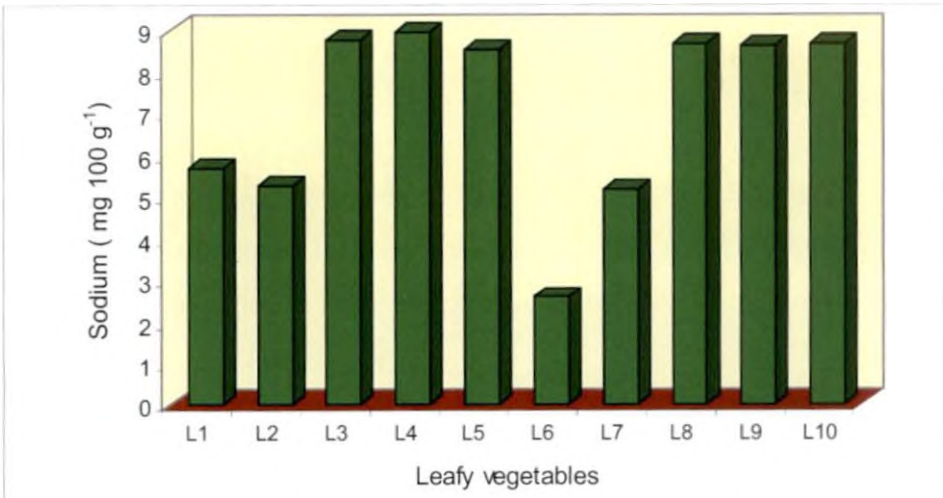

Fig. 9. Sodium content of the leafy vegetables

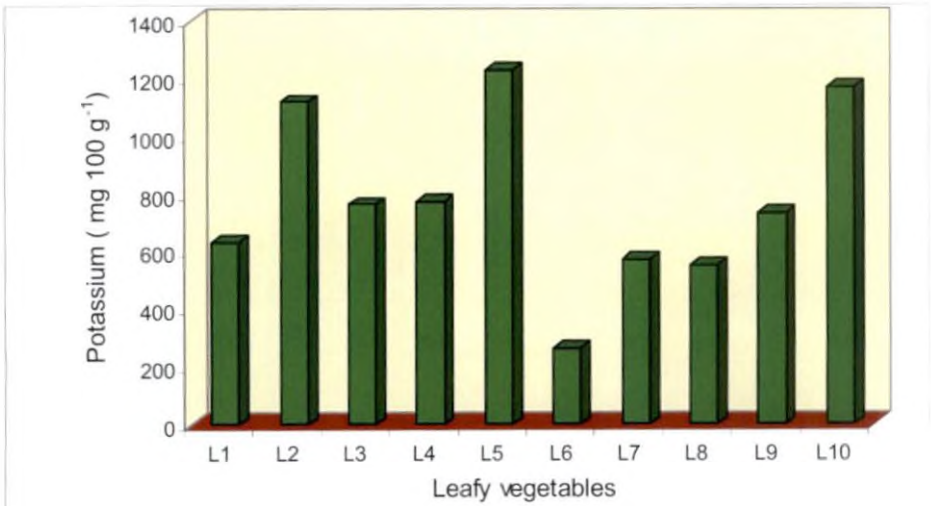

Fig. 10. Potassium content of the leafy vegetables

L1 – Ambasheppu
L2 – Chumalacheera
L3 – Churuli
L4 – Kandariyila
L5 – Kannisoup
L6 - Kozhuppa
L7 - Murikkila
L8 - Ponnankanni
L9 – Thakara
L10 -Valiya kadaladi

4.1.1.12 Vitamin C

The vitamin C content of the leafy vegetables varied from 31.61 mg in Churuli to 222.22 mg per 100 g in Chumalacheera (Figure 12).

On the basis of DMRT, the leafy vegetables were differentiated into nine categories. Category 'g' included two leafy vegetables namely Ambasheppu and Kozhuppa and the vitamin C content of these leafy vegetables were found to be at par. Significant difference was seen in the vitamin C content of the leafy vegetables included in different categories except the members included in group 'g' and 'gh', 'h' and 'gh' and 'g'.

4.1.2 Anti-nutritional factors in leafy vegetables

The anti-nutritional factors namely oxalates and nitrates of the leafy vegetables were analysed and the results are furnished in Table 2.

Table 2. Anti-nutritional factors in leafy vegetables on fresh weight basis, per 100g

Sl.no.	Leafy vegetable	Oxalate(g)	Nitrate(g)
1	Ambasheppu	0.117^{e}	0.019^{e}
2	Chumalacheera	0.143^{e}	0.030^{b}
3	Churuli	0.103^{e}	0.018^{f}
4	Kandariyila	0.300^{a}	0.031^{a}
5	Kannisoup	0.096^{e}	0.013^{i}
6	Kozhuppa	0.015^{d}	0.014^{h}
7	Murikkila	0.217^{b}	0.026^{c}
8	Ponnankanni	0.099^{e}	0.016^{g}
9	Thakara	0.248^{ab}	0.029^{b}
10	Valiya kadaladi	0.093^{e}	0.025^{d}
	Mean	0.143	0.022

Values having different superscripts differ significantly at 5% level.

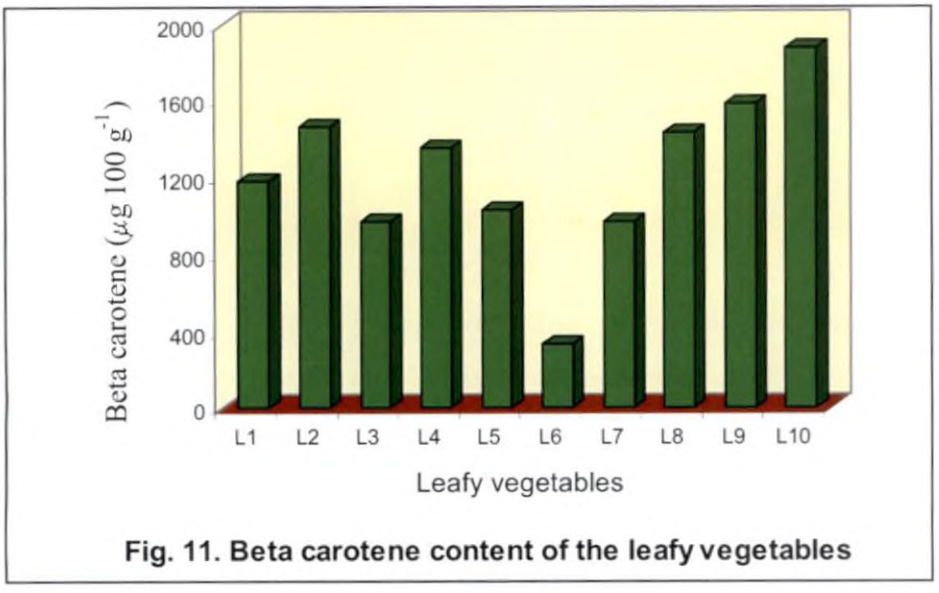

Fig. 11. Beta carotene content of the leafy vegetables

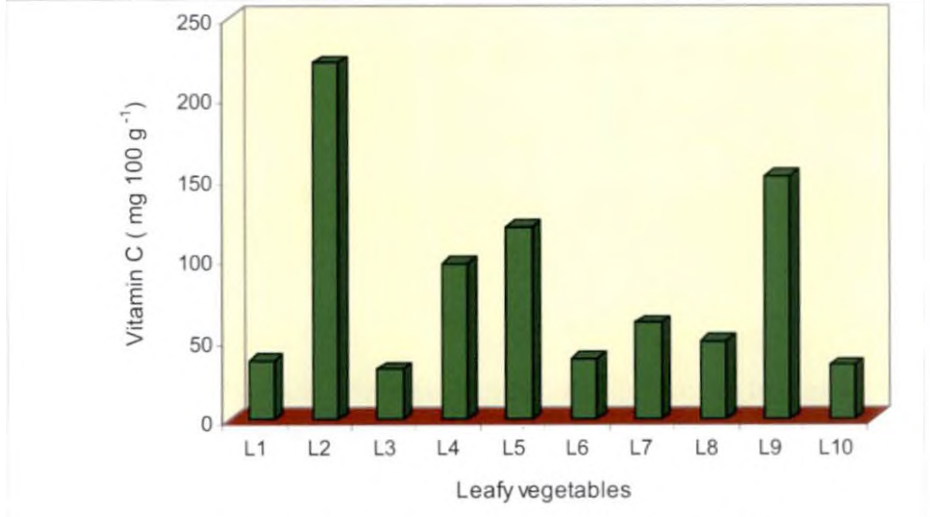

Fig. 12. Vitamin C content of the leafy vegetables

L1 – Ambasheppu
L2 – Chumalacheera
L3 – Churuli
L4 – Kandariyila
L5 – Kannisoup
L6 - Kozhuppa
L7 - Murikkila
L8 - Ponnankanni
L9 – Thakara
L10 -Valiya kadaladi

4.1.2.1 Oxalate

The oxalate content of the leafy vegetables varied from 0.015 to 0.300 per cent. The highest oxalate content was observed in Kandariyila and the lowest in Kozhuppa.

On the basis of the oxalate content, the leafy vegetables were categorized into five groups. Group 'c' with an oxalate content in the range of 0.093g to 0.117 g per 100g had six members namely Ambasheppu, Chumalacheera, Churuli, Kannisoup, Ponnankanni and Valiya kadalaadi. The other four groups had only one leafy vegetable each indicating significant difference in the oxalate content between the leafy vegetables included in most of the groups except 'a' and 'ab' and 'b' and 'ab'.

The oxalate content of the leafy vegetables is represented in Figure 13.

4.1.2.2 Nitrate

The nitrate content of the leafy vegetables varied from 0.013 to 0.031 per cent with Kandariyila having the highest value and Kannisoup having the lowest.

Statistically the different leafy vegetables were arranged into nine groups on the basis of nitrate content. All the groups had only one member each, except group 'b', which had two members namely Chumalacheera and Thakara indicating that the leafy vegetable included in this group had no significant difference among themselves but the members of the other groups had significant difference between themselves and between the leafy vegetables included in group 'b' with respect to nitrate content.

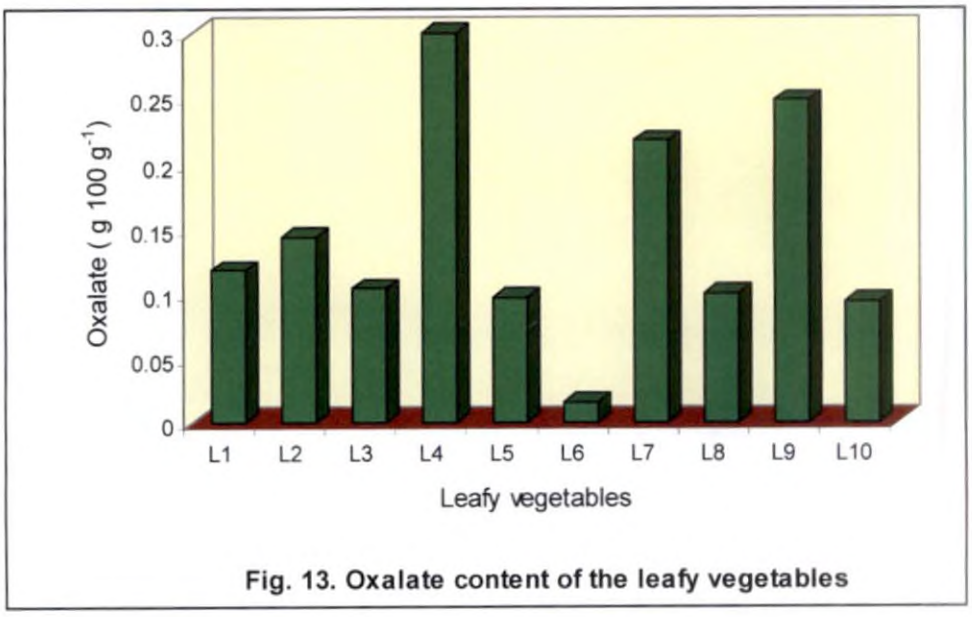

Fig. 13. Oxalate content of the leafy vegetables

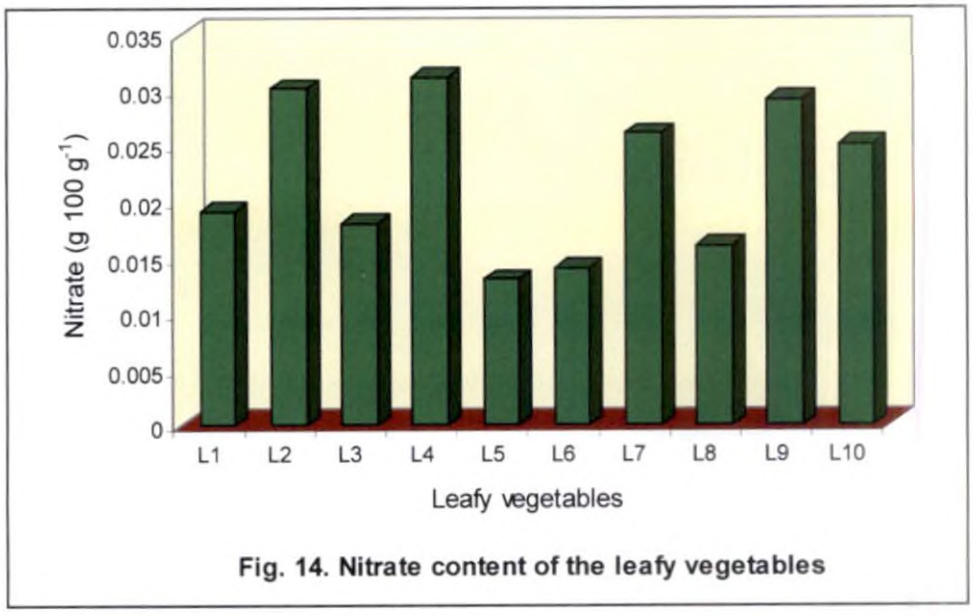

Fig. 14. Nitrate content of the leafy vegetables

L1 – Ambasheppu
L2 – Chumalacheera
L3 – Churuli
L4 – Kandariyila
L5 – Kannisoup
L6 – Kozhuppa
L7 – Murikkila
L8 – Ponnankanni
L9 – Thakara
L10 -Valiya kadaladi

The nitrate content of the leafy vegetables is depicted in Figure 14.

4.1.3 Other constituents in leafy vegetables.

Other chemical constituents like phenols, flavanoids and methanol extractable crude alkaloids present in the leafy vegetables were analysed and the results are furnished in Table 3.

Table 3. Other chemical constituents in leafy vegetables on fresh weight basis, per 100g.

Sl.no.	Leafy vegetable	Phenol(mg)	Flavanoids(mg)	ME crude alkaloids(g)
1	Ambasheppu	36.97^{c}	874.52^{b}	0.91^{f}
2	Chumalacheera	49.71^{a}	579.57^{d}	1.62^{c}
3	Churuli	11.97^{g}	539.17^{e}	1.53^{cd}
4	Kandariyila	33.47^{d}	962.56^{a}	1.99^{a}
5	Kannisoup	33.58^{d}	298.59^{g}	1.87^{ab}
6	Kozhuppa	13.02^{f}	178.12^{h}	1.40^{de}
7	Murikkila	20.35^{e}	368.02^{f}	1.29^{e}
8	Ponnankanni	38.24^{b}	640.09^{c}	1.78^{b}
9	Thakara	34.28^{d}	534.92^{e}	0.72^{g}
10	Valiya kadaladi	38.06^{b}	890.49^{b}	1.94^{a}
	Mean	30.97	586.61	1.51

Values having different superscripts differ significantly at 5% level.

4.1.3.1 Phenols

The phenol content of the leafy vegetables varied from 11.97 to 49.71 mg per 100g. Highest value was observed in Chumalacheera, which was found to be significantly different from other leafy vegetables with respect to the phenol content.

On the basis of DMRT, the leafy vegetables were differentiated into seven groups. Ponnankanni and Valiya kadaladi with a phenol content of 38.24 and 38.06mg per 100 g respectively were included in group 'b' and Kandariyila,

Kannisoup and Thakara with a phenol content in the range of 33.47 to 34.28 mg per 100 g were included in group 'd' indicating significant difference in the phenol content of the leafy vegetables between the two groups. All the other five groups had only one leafy vegetable in them indicating that the phenol content of the leafy vegetable is significantly different from each other and from the leafy vegetables included in group 'b' and 'd'.

The phenol content of the leafy vegetables is illustrated in Figure 15.

4.1.3.2 Flavanoids

The flavanoid content of the leafy vegetables varied from 178.12 to 962.56 mg per 100 g with Kandariyila showing highest value and Kozhuppa, the lowest. The flavanoid content of the selected leafy vegetable is depicted in Figure 16.

On the basis of flavanoid content of the leafy vegetables, they were statistically classified into eight categories. Each category included one leafy vegetable except group 'b' and 'e', which had two members each namely Ambasheppu and Valiya kadaladi in group 'b' and Churuli and Thakara in group 'e'. Significant difference existed in the flavanoid content of the leafy vegetables included in all the groups except the leafy vegetables included in group 'b' and 'e'.

4.1.3.3 Methanol extractable crude alkaloids

The methanol extractable crude alkaloid content of the leafy vegetables varied from 0.72 per cent in Thakara to 1.99 per cent in Kandariyila (Figure 17).

On the basis of DMRT, the leafy vegetables were differentiated into nine categories with group 'a' having two leafy vegetables namely Kandariyila

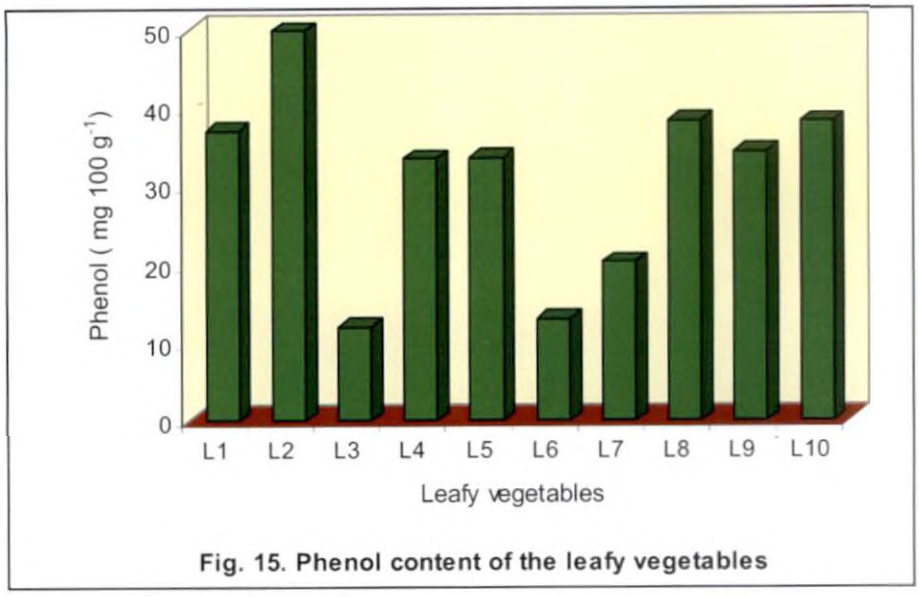

Fig. 15. Phenol content of the leafy vegetables

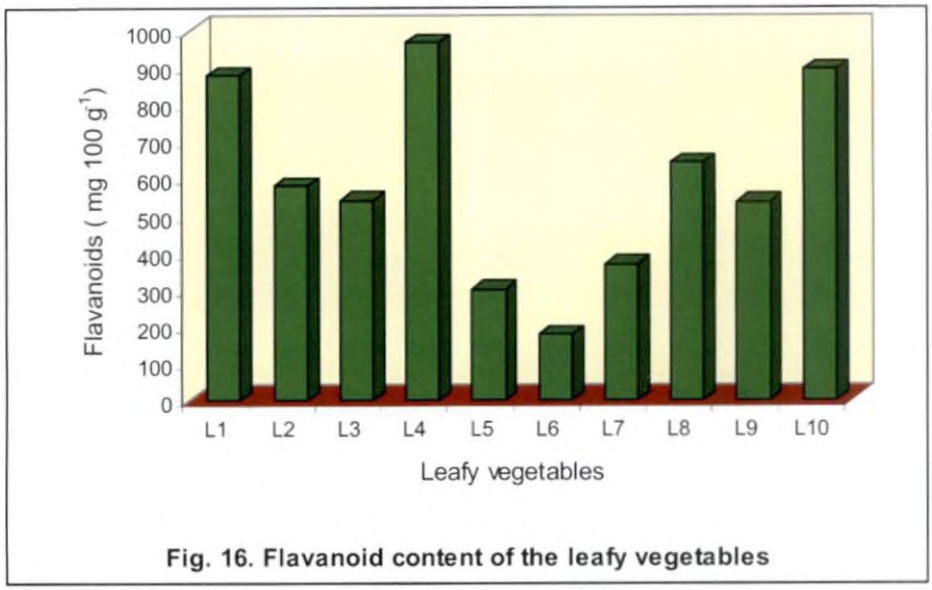

Fig. 16. Flavanoid content of the leafy vegetables

L1 – Ambasheppu
L2 – Chumalacheera
L3 – Churuli
L4 – Kandariyila
L5 – Kannisoup
L6 - Kozhuppa
L7 - Murikkila
L8 - Ponnankanni
L9 – Thakara
L10 -Valiya kadaladi

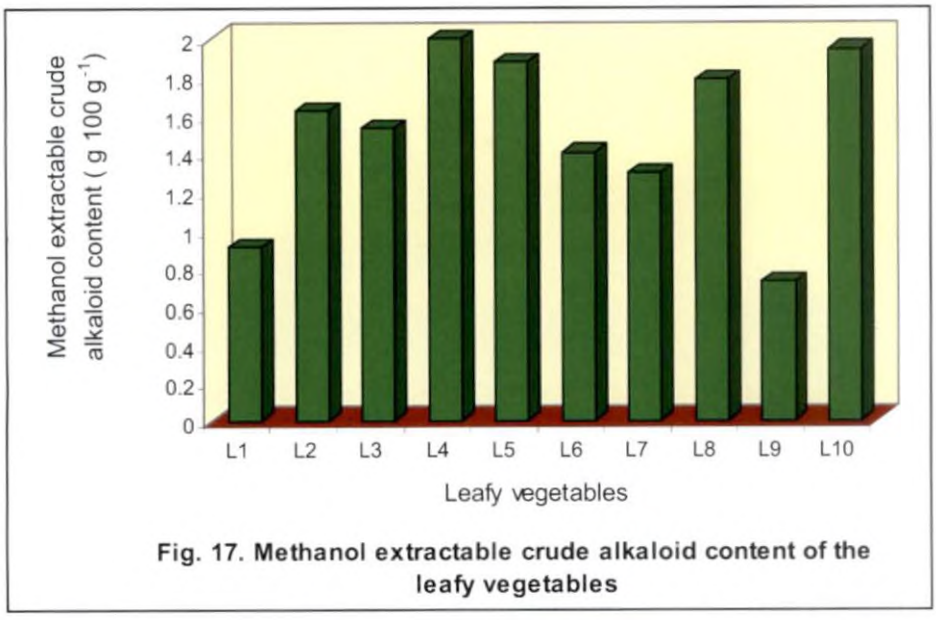

Fig. 17. Methanol extractable crude alkaloid content of the leafy vegetables

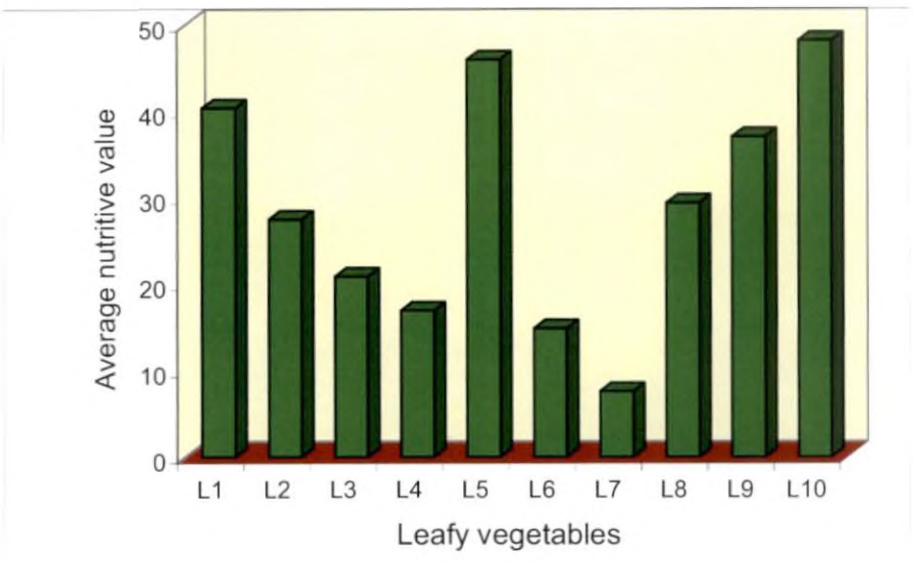

Fig. 18. Average Nutritive Value of the leafy vegetables

L1 – Ambasheppu
L2 – Chumalacheera
L3 – Churuli
L4 – Kandariyila
L5 – Kannisoup
L6 – Kozhuppa
L7 – Murikkila
L8 – Ponnankanni
L9 – Thakara
L10 -Valiya kadaladi

and Valiya kadaladi. The crude alkaloid content of these two leafy vegetables was found to be on par. The crude alkaloid content of the leafy vegetables included in group 'c' and 'cd', 'a' and 'ab', 'cd' and 'de', 'e' and 'de' and 'b' and 'ab' showed no significant difference among themselves with respect to the methanol extractable crude alkaloid content.

4.1.4 Average Nutritive Value

Average nutritive value of the leafy vegetables computed from the protein, fibre, calcium, iron, β carotene and vitamin C contents are presented in Table 4 and Figure 18.

Table 4. Average Nutritive Value of the leafy vegetables

Sl. No.	Leafy vegetable	Average Nutritive Value
1	Ambasheppu	40.34^{c}
2	Chumalacheera	27.44^{e}
3	Churuli	20.82^{f}
4	Kandariyila	16.87^{g}
5	Kannisoup	45.91^{b}
6	Kozhuppa	14.79^{h}
7	Murikkila	7.56^{i}
8	Ponnankanni	29.33^{e}
9	Thakara	37.00^{d}
10	Valiya kadaladi	48.11^{a}

Values having the different superscripts differ significantly at 5% level

The average nutritive value of the leafy vegetables varied from 7.56 to 48.11. The highest value was obtained for Valiya kadaladi and the lowest for Murikkila. Statistical analysis indicated significant variation in the average nutritive value of leafy vegetables except the two leafy vegetables included in group 'e' namely Chumalacherera and Ponnankanni.

4.2 ACCEPTABILITY OF THE LEAFY VEGETABLES

The acceptability of the leafy vegetables was assessed by score card method for five quality attributes namely appearance, colour, flavour, texture and taste after cooking. Each character was scored using five point hedonic scale by a panel of ten judges. The five quality attributes were described as a five point scale and the total score was obtained out of twenty five.

Table. 5. Organoleptic evaluation of cooked leafy vegetables.

Sl. No.	Leafy vegetables	Mean scores					
		Appearance	Colour	Flavour	Texture	Taste	Total
1	Ambasheppu	3.2	3.4	1.6	3.4	1.8	13.4
2	Chumalacheera	3.8	3.6	3.5	3.6	3.7	18.2
3	Churuli	4.9	4.7	3.3	3.8	3.3	20.0
4	Kandariyila	3.9	4.0	4.0	3.2	3.6	18.7
5	Kannisoup	4.0	4.3	2.8	3.6	4.0	18.7
6	Kozhuppa	2.9	2.4	2.9	2.2	2.8	13.2
7	Ponnankanni	4.4	4.1	3.7	3.9	3.8	19.9
8	Murikkila	4.0	3.7	3.5	4.1	3.5	18.8
9	Thakara	3.1	3.3	2.5	2.9	2.5	14.3
10	Valiya kadaladi	4.0	3.7	1.4	3.6	1.9	14.6
	W	0.598**	0.595**	0.594**	0.448**	0.571**	0.695**

** Significant at 1% level

From the table, it can be seen that the scores for appearance was highest in Churuli (4.9) and lowest in Kozhuppa (2.9). The Kendall's coefficient of concordance (W) among the judges on the appearance was found to be 0.598 and it was found to be highly significant.

For the second quality attribute namely colour, the mean score varied from 2.4 to 4.7. The lowest score was assigned to Kozhuppa and highest for Churuli. The degree of agreement among the judges on colour was found to be 0.595 and it was found to be highly significant.

The mean score for flavour ranged from 1.4 to 4.0 with Valiya kadaladi having the lowest and Kandariyila having the highest score. The Kendall's coefficient of concordance (W) among the judges on flavour was found to be 0.594 and was found to be highly significant.

The mean score for texture varied from 2.2 to 4.1. The lowest score was assigned to Kozhuppa and the highest for Murikkila. The Kendall's coefficient of concordance (W) among the judges on texture was found to be 0.448 and was highly significant.

The mean score for taste ranged from 1.8 to 4.0. Ambasheppu was found to have the lowest score and Kannisoup, the highest. The degree of agreement among the judges on taste was found to be 0.571 and was highly significant.

Statistical analysis (Kendall's coefficient of concordance) indicated that all the quality attributes namely appearance, colour, flavour, texture and taste of the cooked leaves were acceptable.

The total mean scores varied from 13.2 to 20.0. Churuli with the highest mean score was found to be highly acceptable and Kozhuppa with total mean score of 13.2 was found to be the least acceptable.

4.3 CLUSTER ANALYSIS OF LEAFY VEGETABLES

Inorder to find out the homogenous groups of leaves, based on the nutrient and anti-nutrient composition of the selected leaves, Non Hierarchial Euclidean Cluster Analysis was worked out. Based on this the leaves were grouped into four clusters (Table 6).

Table 6. Leafy vegetables included in each cluster

Cluster	Members
I	Churuli, Kandariyila and Murikkila
II	Kozhuppa
III	Valiya kadaladi
IV	Ambasheppu, Chumalacheera, Kannisoup, Ponnankanni and Thakara

The average intra and inter cluster distance matrix is shown in Table 7 and represented in Fig.19

Table 7. Average intra and inter cluster distance matrix

Cluster No.	1	2	3	4
1	2.783	–	–	–
2	6.691	0.000	–	–
3	5.821	10.353	0.000	–
4	3.350	6.708	4.79	3.276

On the basis of cluster analysis, Churuli, Kandariyila and Murikkila were grouped in the first cluster. The members of cluster I were found to be high in phosphorus and anti-nutritional factors namely oxalates and nitrates. The mean phosphorus content of the leafy vegetables included in cluster I was found to be 90.10 mg $100g^{-1}$. Within the cluster the phosphorus content of the cluster members varied from 60.30 to 124.61 mg $100g^{-1}$. The mean cluster value for oxalates and nitrates were 0.21g and 0.02 g $100g^{-1}$ respectively. The inter cluster values for oxalates and nitrates varied from 0.103 to 0.300 per cent and 0.018 to 0.031 per cent respectively.

Cluster II and cluster III had only one member each. Kozhuppa was included in cluster II which was found to be high only in moisture (90.42%)with low oxalate(0.02%) and nitrate content (0.01%).

Table 8. Cluster means for nutritional and anti- nutritional composition of the leafy vegetables, per 100g

Cl.	Moisture (g)	Protein (g)	Fat (g)	Crude fibre (g)	Total carbo-hydrate (g)	Calcium (mg)	Phosphorus (mg)	Iron (mg)	Sodium (mg)	Potassium (mg)	βcarotene (µg)	Vitamin C (mg)	Phenol (mg)	Flavanoid (mg)	ME crude alkaloid (g)	Nitrate (g)	Oxalate (g)
1	82.21	4.22	0.70	1.78	3.40	202.67	90.10	15.52	7.63	703.90	1096.54	63.21	21.93	623.25	1.61	0.02	0.21
2	90.42	2.24	0.18	0.48	1.51	214.13	34.51	20.88	2.59	266.00	340.50	37.99	13.02	178.12	1.40	0.01	0.02
3	74.84	5.56	0.73	2.56	3.81	669.67	83.76	70.23	8.67	1170.83	1879.41	34.07	38.06	890.49	1.94	0.02	0.09
4	82.77	4.53	0.43	1.62	3.22	268.90	67.57	53.12	7.35	854.00	1337.58	115.98	38.56	585.54	1.38	0.02	0.14

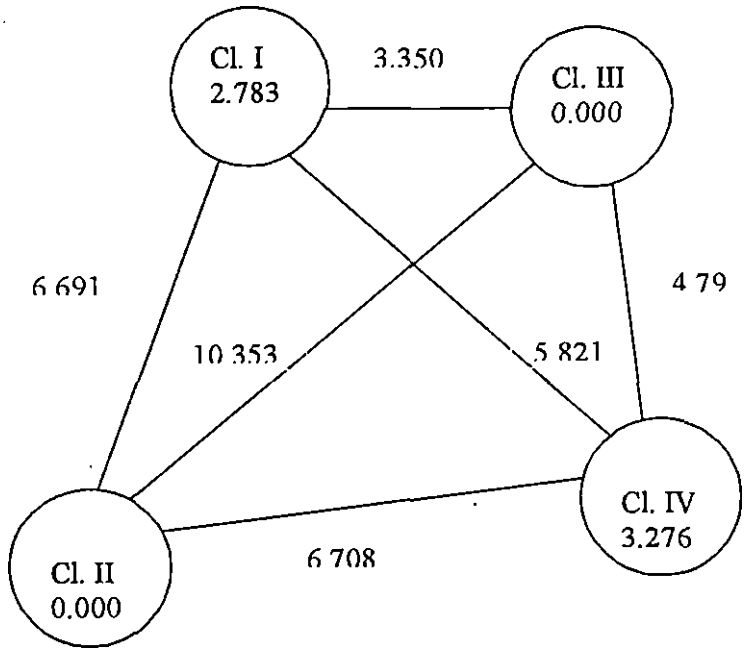

Fig. 19 Cluster analysis of leafy vegetables

Cluster III which had Valiya kadaladi as the sole member was found to be rich in protein (5.56%), fat (0.73%), crude fibre (2.56%) , total carbohydrate (3.81%), calcium (669.67 mg %), iron (70.23 mg %), sodium (8.67 mg %), potassium (1170.83 mg %), β carotene (1879.41 µg %) , flavanoids (890.49 mg %) and methanol extractable crude alkaloid (1.94%). The oxalate and nitrate content of Valiya kadaladi were found to be 0.09 and 0.02 per cent respectively.

Cluster IV which included Ambasheppu, Chumalacheera, Kannisoup, Ponnankanni and Thakara were found to be high in vitamin C and phenols. The mean vitamin C and phenol content of cluster IV are 115.98 mg and 38.56 mg $100g^{-1}$ respectively. The vitamin C and phenol content of the leafy vegetables included in cluster IV varied from 37.07 to 222.22 mg 100 g^{-1} and 33.58 to 49.71 mg 100 g^{-1} respectively.

Discussion

5. DISCUSSION

The study on 'Quality evaluation of selected leafy vegetables consumed by the tribes of Wayanad District' was attempted to assess the nutritional composition, anti-nutritional factors, other chemical constituents and the acceptability of ten leafy vegetables consumed by the tribes of Wayanad district. The ten leafy vegetables under the study includes Ambasheppu, Chumalacheera, Churuli, Kandariyila, Kannisoup, Kozhuppa, Murikkila, Ponnankanni, Thakara and Valiya kadaladi.

The leafy vegetables were analysed for different nutrients like moisture, protein, fat, crude fibre, total carbohydrates, calcium, phosphorus, iron, sodium, potassium, β carotene and vitamin C. Other chemical constituents analysed were phenols, flavanoids and methanol extractable crude alkaloids. The anti-nutritional factors like oxalates and nitrates were also analysed. The acceptability of the leafy vegetables was assessed through organoleptic evaluation using score card based on five point hedonic scale for different parameters like appearance, colour, flavour, texture and taste. The results are discussed under the following heads.

1. Chemical composition of leafy vegetables
2. Acceptability of leafy vegetables
3. Cluster analysis of the leafy vegetables

5.1 CHEMICAL COMPOSITION OF LEAFY VEGETABLES

5.1.1 Nutritional composition of leafy vegetables

The moisture content of the leafy vegetables varied from 74.84 to 90.42 per cent with the highest and the lowest moisture content in Kozhuppa and Valiya kadaladi respectively. Significant variation in the moisture content of the leaves was also observed. Bharathi and Umamaheshwari (2001), Longvah (2000) and Mziray *et al.* (2001) reported almost similar moisture content in the leafy vegetables of Andhra Pradesh, North East India and Tanzania respectively.

However, Edeoga and Gomina (2001) reported a moisture content of about 91 per cent in the leafy vegetables of Nigeria, which was slightly higher than the values observed in the present study.

Significant variation in the protein content of the leafy vegetables was observed with a protein content ranging from 2.24 to 5.65 per cent and a mean protein content of 4.31 per cent. Thakara had the highest and Kozhuppa had the lowest protein content. The protein content of the leaf vegetables included in the present study was found to be similar to the protein content of the leaves consumed by the Paliyar tribal groups of Kodaikanal (Murugesan and Ananthalakshmi, 1991) and tribes of North East India (Longvah, 2000). Chaurasia *et al.* (2000) reported a protein content in the range of 18.3 to 31.7 per cent in the wild leafy vegetables of Ladakh on dry weight basis which will be similar to the present findings when expressed in fresh weight basis . In contrast to these findings, Ijomah *et al.* (2000) and Edeoga and Gomina (2001) reported a lower content of 0.05 to 0.15 per cent in the leafy vegetables of Nigeria. This variation may be due to the varietal variation and differences in the location.

The fat content of the leaves varied from 0.18 to 0.79 per cent with the highest and lowest values in Kandariyila and Kozhuppa respectively. The mean fat content of the leaves was found to be 0.52 per cent. Shingade *et al.* (1995) reported a lipid content in the range of 0.2 to 0.96 per cent in leafy vegetables of Konkan region which is almost similar to the fat content of the leafy vegetables observed in the present study. However, Chaurasia *et al.* (2000) and Bharathi and Umamaheshwari (2001) reported a fat content of 2.85 to 6.52 per cent in the leafy vegetables of Andhra Pradesh and Ladakh respectively.

Significant variation was observed in the fibre content of the leafy vegetables in the present study which varied from 0.48 to 2.56 per cent with Kozhuppa having the lowest and Valiya kadaladi having the highest value. These values were found to be in accordance with the fibre content of the leafy

vegetables consumed by the Paliyar tribal community (Murugesan and Anathalakshmi, 1991) and the leafy vegetables found in the Konkan region (Shingade *et al.*, 1995). Wallace *et al.*(1998) and Chaurasia *et al.* (2000) reported a fibre content of 1.15 to 10.8 per cent on dry weight basis in wild leafy vegetables. Handique (2003) and Murugkar and Subhulakshmi (2003) reported a fibre content of 4.9 to 22.9 per cent on dry weight basis in leafy vegetables of North East India and the unconventional leafy vegetables used by Khasis of Meghalaya respectively which will be similar to the fibre content of the leafy vegetables in the present study when expressed in fresh weight.

The total carbohydrate content of the leafy vegetables varied from1.51 to 5.46 per cent with the highest and lowest value in Kannisoup and Kozhuppa respectively. The mean total carbohydrate content was found to be 3.16 per cent. Edeoga and Gomina (2001) reported a carbohydrate content of 6.6 per cent in the wild leafy vegetables of Nigeria which was slightly higher than the values observed in the present study. Chaurasia *et al.* (2000) and Handique (2003) observed a total carbohydrate content of 6.15 to 38.0 per cent on dry weight basis in the leafy vegetables of various parts of India which will be almost equal to the value observed in the study when it is expressed on fresh weight basis.

The calcium content of the leafy vegetables varied from 142.43 to 669.67 mg 100 g^{-1} with the highest and lowest calcium content in Valiya kadaladi and Churuli respectively with a mean calcium of 281.63 mg 100 g^{-1}. Significant variation was observed in the calcium content of different leafy vegetables. The calcium content observed in the present study was in tune with the values reported by Chandrasekhar and Chitra (1990), Murugesan and Ananthalakshmi (1991), Rozycki *et al.*(1997), Neeliyara (1998) and Chaurasia *et al.*(2000) in different leafy vegetables. However, Longvah (2000) and Mathew (2000) reported lower calcium content of 100 to 267 mg $100g^{-1}$ in the unconventional leafy vegetables of North East India and Kerala. In contrast to the present findings, very high

calcium content (17.4%) in the leafy vegetables of Nigeria was reported by Aletor and Adeogun (1995).

The phosphorus content of the leafy vegetables varied from 22.86 to 124.61 mg 100 g^{-1}. The highest and the lowest values were observed in Kandariyila and Chumalacheera and the mean phosphorus content was 72.64 mg 100 g^{-1}. Significant variation was observed in the phosphorus content of the selected leafy vegetables. Longvah (2000) and Murugesan and Ananthalakshmi (1991) reported a phosphorus content of 20 to 80 mg 100 g^{-1} in the leafy vegetables consumed by the Paliyar tribal group and North East India respectively. The phosphorus content of the selected leafy vegetables evaluated in the present study was in accordance with these findings. Mziray *et al.* (2001) also reported a phosphorus content ranging from 500 to 553 mg 100 g^{-1} on dry weight basis in amaranth from different locations of Tanzania.

The iron content of the selected leafy vegetables varied from 1.59 to 75.81 mg 100 g^{-1} with Kannisoup having the highest and Murikkila having the lowest value. Significant variation was seen in the iron content of selected leafy vegetables. Shadiza (1993) reported an iron content of 0.03 to 0.06 per cent in the non cultivated leafy vegetables of Bihar, Bengal and Orissa. Similar findings were reported by Pathak *et al.* (2000) and Shankaracharya (1998) in various leafy vegetables. However, Murugesan and Ananthalakshmi reported low iron content of 1.8 to 20 mg 100 g^{-1} in the leafy vegetables consumed by the Paliyar tribal group.This may be due to the difference in the varieties selected for the study.

The sodium content of the leafy vegetables varied from 2.59 to 8.95 mg 100 g^{-1} with the highest and lowest sodium content in Kandariyila and Kozhuppa respectively with the mean sodium content of 7.09 mg 100 g^{-1}. Faboya (1983) reported a sodium content of 0.11 to 0.76 mg 100 g^{-1} in wild leafy vegetables of Nigeria which was found to be lower than the sodium content observed in the

present study. But Guerrero *et al.* (1999) reported higher sodium content of 42.1 to 884.7 mg 100 g^{-1} on dry weight basis.

The potassium content of the leafy vegetables varied from 266.00 to 1231.37 mg 100 g^{-1} with Kozhuppa having the lowest value and Kannisoup, the highest and with a mean potassium content of 781.85 mg 100 g^{-1}. Almost similar findings were reported by Guerrero *et al.* (1999) and Kumaran (2003) in the unconventional leafy vegetables which varied from 116.96 to 757.4 mg $100g^{-1}$. Aletor and Adeogun (1995) reported an average potassium content of 3.7 mg $100g^{-1}$ on dry weight basis in leafy vegetables. Faboya (1983) reported low potassium content of 0.36 to 1.55 mg $100g^{-1}$in leafy vegetables.

Highest beta carotene (1879.41 µg 100 g^{-1}) was observed in Valiya kadaladi and lowest (340.5 µg 100 g^{-1}) in Kozhuppa with a mean beta carotene content of 1219.74 µg 100 g^{-1}. Significant variation in the beta carotene content of the leafy vegetables was observed. Bharathi and Umamaheshwari (2001), Rajalakshmi *et al.* (2001) and Kumaran (2003) reported higher beta carotene in the leafy vegetables of Andhra Pradesh, South India and Kerala respectively.

The vitamin C content of the leafy vegetables varied from 31.61 to 222.22 mg $100g^{-1}$ with Chumalacheera having the highest value and Churuli, having the lowest. Significant variation in the vitamin C content was observed with a mean content of 84.15 mg 100 g^{-1}. Achinewhu *et al.* (1995) reported similar ascorbic acid content of 23 to 232 mg 100 g^{-1} in the indigenous leafy vegetables of Nigeria. The vitamin C content of the present study was in accordance with the vitamin C content reported by Chandrasekhar and Chitra (1990), Chandrasekhar *et al.* (1990), Shingade *et al.* (1995) and Bharathi and Umamaheshwari (2001) in the leafy vegetables of different parts of India.

5.1.2 Anti-nutritional factors in leafy vegetables

The oxalate content of the leafy vegetables varied from 0.015 to 0.300 per cent. The highest oxalate content was observed in Kandariyila and lowest in Kozhuppa with a mean content of 0.143 per cent. Thamburaj *et al.* (1994) reported an oxalate content of 0.3 to 1.92 per cent on dry weight basis in different types of leafy vegetables. Guerrero (2001) reported an oxalate content of 0.03 to 0.08 mg 100 g^{-1} in the unconventional leaves of South East Spain . Kumaran (2003) reported an oxalate content ranging from 0.004 to 1.57 per cent in the unconventional leafy vegetables of Kerala, Mziray *et al.* (2001) reported an oxalate content of 3.38 to 4.33 per cent which was found to be higher than the leafy vegetables under study. Shingade *et al.* (1995) reported that the unconventional leafy vegetables in general contained less oxalates as compared to cultivated vegetables. The lower oxalate content of the leafy vegetables may be due to the fact that these leaves are grown under natural habitat.

The nitrate content of the leafy vegetables varied from 0.013 to 0.031 per cent with Kandariyila having the highest value and Kannisoup having the lowest. Significant variation was found in the nitrate content of most of the leafy vegetables with mean nitrate content of 0.022 per cent. The nitrate content of the selected leafy vegetables evaluated in the present study was lower than the nitrate content of leafy vegetables of different parts of India (Devadas,1982; Prakash *et al.*,1993; Goswani *et al.*, 2000 and Kulkarni *et al.*, 2003).Vera *et al.*(1992) reported higher levels of nitrate in leafy vegetables due to excess use of nitrogen containing fertilizer. The variation in the nitrate content is due to differences in the location and fertilizer applications.

5.1.3 *Other chemical constituents in the leafy vegetables*

The phenol content of the leafy vegetables varied from 11.97 (Churuli) to 49.71 mg (Chumalacheera) per 100 g. The mean phenol content was found to be 30.97 mg $100g^{-1}$. Kaur and Kapoor (2002) reported a phenol content ranging from 34 to 400 mg $100g^{-1}$ in some Asian vegetables.

Significant variation was observed in the flavanoid content of most of the leafy vegetables under study, which varied from 178.12 to 962.56 mg 100 g^{-1}. The mean flavanoid content was found to be 586.61 mg 100 g^{-1}.

The methanol extractable crude alkaloid content of the leafy vegetables varied from 0.72 to 1.99 per cent with the lowest in Thakara and the highest value in Kandariyila. Significant variation was observed in the leafy vegetables under study with a mean alkaloid content of 1.51 per cent. The value obtained in the study was found to be lower than the value reported by Gins *et al.* (2001) who reported high alkaloid content of 5.85 per cent in some leaves.

5.2 ACCEPTABILITY OF LEAFY VEGETABLES

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

Significant variation was seen in the quality parameters among the leafy vegetables under study. Colour and appearance were found to be highest for Churuli while for flavour, the highest score was for Kandariyila. Taste and texture were found to be highest in Kannisoup and Murikkila respectively. An overall acceptability score of above 18 out of the total score of 25 was obtained for Chumalacheera, Churuli, Kandariyila, Kannisoup, Murikkila and Ponnankanni while the rest of the leaves namely Ambasheppu, Kozhuppa, Thakara and Valiya

kadaladi had an overall acceptability score in between 13 and 14.6.Among the leafy vegetables, Churuli was found to be the best with respect to the overall acceptability and the least score was obtained for Kozhuppa. The lowest score obtained for the various quality parameters and overall acceptability may be due to the unfamiliarity of these leafy vegetables in our diet.Mathew (2000) also reported similar findings in which the authors observed high acceptability for Amaranthus (21.15) when compared to other eight leafy vegetables in which the score varied from 16.30 to 18.90.

5.3 CLUSTER ANALYSIS OF LEAFY VEGETABLES

Based on the chemical composition, the green leafy vegetables were grouped into four clusters. cluster I comprised of Churuli, Kandariyila and Murukkila, while cluster II and cluster III had only one member each with Kozhuppa and Valiyakadaladi respectively. Ambasheppu, Chumalacheera, Kannisoup, Ponnankanni and Thakara were included in cluster IV.

The cluster means for phosphorus, oxalates and nitrates were 90.10 mg, 0.21 g and 0.02 g 100 g^{-1} respectively in cluster I. Kozhuppa was the only member of cluster II which had a moisture content of 90.42 per cent. The protein (5.56 g), fat (0.73 g), fibre (2.56 g), total carbohydrates (3.81 g), calcium (669.67 mg), iron (70.23 mg), sodium (8.67 mg), potassium (1170.83 mg), β carotene (1879.41μg) and flavanoid (890.49 mg) per 100 g was found to be high in Valiya kadaladi which was included as the sole member of cluster III . The mean oxalate and nitrate content were 0.09 and 0.02 per cent respectively. In cluster IV, the cluster means for vitamin C and phenol were 115.98 mg and 38.56 mg 100 g^{-1} . The mean nitrate content was found to be 0.02 per cent.

The cluster I, III and IV were found to have a similar nitrate content of 0.02 per cent. The oxalate content was found to be high in cluster I (0.21 g $100g^{-1}$)

The intra-cluster distance was found to be maximum for cluster IV (3.276) among the four intra-cluster distances. This may be due to more number of leafy vegetables included in this cluster. As cluster II and III had only one member each, no intra-cluster distance is measurable.

Maximum intercluster distance was found in between cluster II and cluster III. This wide variation is mainly attributed to Valiya kadaladi, whose nutrient contents were higher in comparison with that of the leaves of Kozhuppa. The inter cluster distance between cluster III and cluster IV (4.79) were found to be higher than between III and I (3.35).

Valiya kadaladi which was included as the sole member of cluster III was found to be the best with respect to higher nutrients and lower anti-nutritional factors. Though Valiya kadaladi was having a high content of macro and micro nutrients, the overall acceptability was found to be low when compared to other leafy vegetables under study. The acceptability can be improved by incorporating ingredients to improve the taste and other quality attributes of the recipe according to the taste preference of the consumers.

Since the leafy vegetables included in the present investigation are rich in nutrients, future research should be focused to develop value added products using these leafy vegetables. Moreover the leafy vegetables can be subjected to genetic improvement to further enhance the various quality attributes.

Summary

SUMMARY

The study on 'Quality evaluation of selected leafy vegetables consumed by the tribes of Wayanad District' was undertaken to evaluate the chemical composition and acceptability of ten leafy vegetables. The ten leafy vegetables selected for the study were Ambasheppu, Chumalacheera, Churuli, Kandariyila, Kannisoup, Kozhuppa, Murikkila, Ponnankanni, Thakara and Valiya kadaladi.

The nutrient constituents such as moisture, protein, fat, crude fibre, total carbohydrates, calcium, phosphorus, iron, sodium, potassium, β carotene and vitamin C were analysed. Other constituents like phenols, flavanoids and methanol extractable crude alkaloids were also estimated. The anti-nutritional factors namely oxalates and nitrates were estimated in the leafy vegetables under study. All the values were expressed on fresh weight.

The study revealed that the moisture content of the selected leafy vegetables varied from 74.84 per cent to 90.42 per cent with Kozhuppa having the highest moisture content. The protein content of the leafy vegetables varied from 2.24 to 5.65 per cent, with Thakara having the highest protein content. The fat content was in the range of 0.18 to 0.79 per cent, with the highest fat content in Kandariyila.

The crude fibre content of the ten leafy vegetables varied from 0.48 to 2.56 per cent. Valiya kadaladi was found to have the highest crude fibre content among the ten leafy vegetables analysed. Total carbohydrate content of the leaves was found to be higher in Kannisoup (5.46%) and lowest in Kozhuppa (1.51%).

Among the minerals, the calcium content varied from 142.43 to 669.67 mg 100 g^{-1} in the ten leafy vegetables. The highest calcium content was observed in Valiya kadaladi. The phosphorus content of the leafy vegetables varied from

22.86 to 124.61 mg 100 g^{-1} with Kandariyila having the highest phosphorus content. The iron content of the leafy vegetables varied from 1.59 to 75.81 mg 100 g^{-1}. Kannisoup was found to have the highest iron content among the selected leafy vegetables.

The sodium content was in the range of 2.59 to 8.95 mg 100 g^{-1} in the selected leafy vegetables, with Kandariyila having the highest sodium content. The potassium content of the ten leafy vegetables varied from 266.00 to 1231.37 mg 100 g^{-1} . Kannisoup was found to have the highest potassium content among the ten leafy vegetables analysed.

The β carotene content of the leafy vegetables was in the range of 340.5 to 1879.41 µg 100 g^{-1} with Valiya kadaladi having the highest content. The study revealed that the vitamin C content of the ten leafy vegetables varied from 31.61 to 222.22 mg 100 g^{-1} with Chumalacheera having the highest value.

Considering the anti-nutritional factors in the leafy vegetables, the oxalate content varied from 0.015 to 0.300 per cent with Kandariyila having the highest content and Kozhuppa, the lowest. The nitrate content of the leafy vegetables varied from 0.013 to 0.031 per cent with Kandariyila having the highest and Kannisoup having the lowest nitrate content.

The total phenol content varied from 11.97 to 49.71 mg 100g^{-1} with Chumalacheera having the highest phenol content. The flavanoid content of the leafy vegetables varied from 178.12 to 962.56 mg 100g^{-1} with Kandariyila showing the highest value.

The methanol extractable crude alkaloid content of the leafy vegetables varied from 0.72 to 1.99 per cent. Kandariyila was found to have the highest methanol extractable crude alkaloid content among the ten leafy vegetables under study.

Average nutritive value of the leafy vegetables varied from 7.56 to 48.11 with Valiya kadaladi having the highest value and Murikkila with the lowest value.

The acceptability of the selected leafy vegetables was assessed after cooking using five point hedonic scale by ten judges. The attributes evaluated were appearance, colour, flavour, texture and taste. The total scores ranged from 13.2 to 20.0 for the selected leafy vegetables. Churuli with the highest mean score was found to be highly acceptable. The leafy vegetables were found to be acceptable organoleptically.

On the basis of cluster analysis, the leafy vegetables were grouped into four clusters. Cluster I included Churuli, Kandariyila and Murikkila, which were found to be high in anti-nutritional factors namely oxalates and nitrates. Kozhuppa, which was high in the moisture content was included in cluster II. Valiya kadaladi was included in Cluster III. Cluster IV includes Ambasheppu, Chumalacheera, Kannisoup, Ponnankanni and Thakara which were found to be high in vitamin C and phenol. Valiya kadaladi which was the sole member of cluster III was found to be the best in terms of nutrient contents and lower anti-nutritional factors.

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: 219-224

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

Aletor, V.A. and Adeogun, O.A. 1995. Nutrient and antinutrient components of some tropical leafy vegetables. *Fd Chem.* 53: 3775-3779

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

Aman. 1969. *Medical Secrets of your Food.* Indo American and Dr.M.A.Kline Memorial Hospital Charities Trust. p.307-390

Association of Official Analytical Chemists. 1955. Official and Tentative Methods of Analysis. 8th ed. Association of Official Analytical Chemists, Washington, D.C

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

Association of Official Analytical Chemists. 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: 118-121

Awasthi, C.P. and Tandon, P.K. 1988. Biochemical composition of some unconventional Indian leafy vegetables. *Narendra Deva J. agri. Res.* 3: 161-164

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: 21-28

Babu, L. and Nambisan, B. 1993. Is it cassava or cereals? sweet potato and carrot. *Indian Hort.* 38: 27-28

Barminas, J.T., Charles, M. and Emmanuel, D. 1999. Mineral composition of non-conventional leafy vegetables. *Pl. Fds Hum. Nutr.* 53: 29-36

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

Bharathi, R. and Umamaheshwari, K. 2001. Proximate composition of non traditional leafy vegetables in Nellore and Prakasam Districts of Andhra Pradesh. *J. Fd Sci. Technol.* 38: 534-536

Bharghava, B.S and Raghupati, H.B. 1993. Analysis of plant materials for macro and micro nutrients. *Methods of Analysis of Soil, Plants, Water and Fertilizers* (ed. Tandon, H.L.S) Fertilizer Development and Consultation Organisation, New Delhi, p.82

Bodyfelt, F.W., Tobias, J. and Trout, G.M. 1988. *The Sensory Evaluation of Dairy Products.* AVI publishing Co., New York, p.250

Boora, P., Khetarpaul, N. and Kapoor, A.C. 1998. Glucosinolate content of vegetables grown in Panchkula and Hesai districts of Haryana. *Ann. Boil. Ludhiana* 14: 215-217

Booth, S., Bressani, R. and Johns, T. 1992. Nutrient content of selected indigenous leafy vegetables consumed by the Kekchi people of Alta Verapaz, Guatemala. *J. Fd Comp. Analy.* 5: 25-34

Bravo, L. 1998. Polyphenol: Chemistry, dietary sources, metabolism and nutritional significance. *Nutr. Rev.* 56: 317-333

Brogren, M. and Savage, G.P. 2003. Bioavailability of soluble oxalate from spinach eaten with and without milk products. *Asia Pacif. J. Clin. Nutr.* 12: 219-224

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

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

Chandrasekar, G.K. 2003. Aphrodisiac foods. *Fd Nutr. Wld* 1: 15-17

Chandrasekhar, U. and Chitra, G. 1990. Diet profiles and nutritive value of selected foods eaten by the Kota and Kadar tribes. *Indian J. Nutr. Dietet.* 27: 101-107

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

Chang, C.C., Yang, M.H., Wen, H.M. and Chern, J.C. 2002. Estimation of total flavanoid content in Propolis by two complementary colorimetric methods. *J. Fd Drug Analy.* 10: 178-182

Chaurasia, O.P., Singh, N. and Singh, B. 2000. Potential wild leafy vegetables from Ladakh. *Indian Hort.* 45: 4-5

Cheeke, P.R. and Bronson, J. 1980. Feeding tribals 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 publiushers, Ludhiana, p.110

Cnewya, J.A. 1985. Identification and nutritional importance of indigenous green leafy vegetables in Kenya. *Acta Hort.* 153-199

Davidson, S., Passmore, R. and Brook, J.F. 1973. *Human Nutrition and Dietetics.* Churvhil Livingstone, Edinburgh, p. 230

Devadas, V.S. 1982. Screening for non-bolting type of amaranth suited for year round planting. M.Sc.(Hort.) thesis, Kerala Agricultural University, Thrissur, Kerala, p.82

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

Easwaran, P.P. and Goswani, B. 1989. Nutritive value of selected 15 unconventional plant foods consumed by Khasis of Meghalaya. *Indian J. Nutr. Dietet.* 26: 62-67

Edeoga, H.O. and Gomina, A. 2001. Nutritional values of some non conventional leafy vegetables of Nigeria. *J. Econ. Taxon. Bot.* 25: 439-447

Escudera, N.L., Albarracin, G., Fernandez, S., Arellano, L.M. and Mucciarelli, S. 1999. Nutrient and anti-nutrient composition of *Amaranthus muricatus*. *Pl. Fds Hum Nutr.* 54: 327-336

Etuk, E.U.I., Bassey, M.N., Umoh, U.O. and Inyang, E.G. 1998. Comparitive nutritional studies on three varieties of *Heinsia crinita*. *Pl. varieties seeds* 11: 151-158

Faboya, O.O.P. 1983. The mineral content of some vegetables commonly found in the Western parts of Nigeria. *Fd Chem.* 12: 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

Fathima, A. and Beegum, K. 1998. Dehydration characteristics of microwave dried greens. IFCON'98 4th international Food Convention, November 23-27, Mysore. *Abstracts of poster papers*, p.21

Fathima, A., Beegum, K. and Rajalakshmi, D. 2001. Microwave drying of selected greens and their sensory characteristics. *Pl. Fds Hum. Nutr.* 56: 303-311

Fokou, E. and Domngang, F. 1989. *In vitro* assessment of the nutritive value of proteins in the leaves of *Solanum nigrum* L., *Xanthosoma sp.* and *Gnetum africanum* L. *Indian J. Nutr. Dietet.* 26: 366-369

*Freyre, M.R., Baigorria, C.M., Rozycki, V.R., Bernardi, C.M. and Charpentier, M. 2000. Suitability of wild underexploited vegetables from the Argentine Chaco as a food resource. *Archivos latinoamericanos de Nutrucion* 50: 394-399

*Gins, M.S., Lozovskaya, E.L., Gin, V.K., Kononkov, P.F. and Thacheva, T.V. 2001. The biochemical composition and antioxidant properties of introduced vegetable plants. *Russian Agric. Sci.* 3: 14-15

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. 1982a. Cole crops. *Nutrition.*16: 11

Gopalan, I. 1982b. Nutrient rich drumstick leaves. *Nutrition.*16: 28-30

Goswani, M., Sarkar, C.R. and Das, D. 2000. Nitrate and Nitrite contents in some vegetables. *J. agric. Sci. Soc. N. E. India.* 13: 247-250

Grubben, G.J.H. 1977. *Tropical Vegetables and their Genetic Resources.* International Bureau for Plant genetic Resources, Rome, p.20

Guerrero, J.L. 2001. Nutritional composition of Plantago species (*P. major* L., *P. laceolata* L. and *P. media* L.). *Ecol. Fd Nutr.* 40: 481-495

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

Guerrero, J.L., Madrid, C.P. and Isasa, T.M.E. 1999. Mineral elements determination in wild edible plants. *Ecol. Fd Nutr.* 38: 209-222

Gundimeda, U., Naidu, A.N. and Krishnaswamy, K. 1993. Dietary intake of nitrate in India . *J. Fd Comp. Analy.* 6: 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: 105-116

Gupta, K. and Wagle, P.S. 1988. Nutritional and anti-nutritional factors in green leafy vegetables. *J. agric. Fd Chem.* 36: 472-474

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

Handique, A.K. 2003. Nutritive value of some non conventional leafy vegetables from ethnic sources of North East India. *Crop Res. Hisar* 26: 361-364

Harborne, J.B. 1973. *Phytochemical methods.* Joppan Coperation, Japan, p.320

Hemalatha, G., Sundharaiya, K. and Ponnuswamy, V. 1999. Comparitive analysis of nutritive value in some leafy vegetables. *S. Indian Hort.* 47: 1-6

Herdren, R., Mulokozi, G. and Svanberg, U. 2002. *In vitro* accessibility of carotenes from green leafy vegetables cooked in sunflower oil and palm oil. *Int. J. Fd Sci. Nutr.* 53: 445-453

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

Hesse, P.R. 1971. *A Textbook on Soil Chemical Analysis.* John Mary Publishers Ltd., London, p.528

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

Ijomah, J.U., Igwe, E.C. and Audu, A. 2000. Nutrient composition of five leafy vegetables of Adamawa state, Nigeria . *Global J. Pure Applied Sci.* 6: 547-551

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

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

Jackson, M.L. 1973. *Soil Chemical Analysis.* Prentice Hall of India Pvt Ltd., New Delhi, p.498

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: 53-56

Jellenik, G. 1985. *Sensory Evaluation of Food- Theory and Practice.* Ellis Horwood Ltd. Chichester England and VCH Verlagsgesellschaft mbH, Weinhein, 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. p.89

*Justesen, U., Knuthsen, P., Andersen, N.L. and Leth, T. 2000. Estimation of dietary intake, distribution of flavanols and flavanones in Denmark. *Scavandinarion J.Nutr. Naringsforskning* 44: 158-160

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

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: 71-72

Kaur, C. and Kapoor, H.C. 2002. Antioxidant activity and total phenolic content of some Asian vegetables. *Int. J. Sci. Technol.* 37: 153-161

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

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

Kowsalya, S. and Chandrasekhar, U. 2003. Total carotenoid and beta carotene contents of selected stored plant foods. *Indian. J. Nutr. Dietet.* 40: 122-128

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

Kulkarni, S.G. , Chauhan, A.S. and Ramana, K.V.R. 2003. Nitrate and nitrite content of some important South Indian vegetables. *J. Fd Sci. Technol.* 40: 518

Kumaran, V. 2003. Nutritive profile of selected greens. M.Sc.(Home Science) thesis, Kerala Agricultural University, Thrissur, p.64

Kumari, P. 2001. *Indian Tribal Life*. Sarup and Sons, New Delhi, p.404

*Kundu, B.C., Hossain, M.M.M., Quadir, M.A. and Bhowmik, A. 1998. Yield performance and selected nutritional characteristics of Chinese cabbage genotypes. *Banglaesh J. Botany.* 27: 135-141

Lee, C.V., Shallenberger, R.S., Downing, D.L., Stewsand, G.S. and Peck, N.M. 1971. Nitrate and nitrite in fresh, stored and processed table beet and spinach from different levels of field nitrogen fertilization. *J. Sci. Fd Agric.* 22: 90-98

Longvah, T. 2000. Nutritive value of North East Indian plant foods. *Nutr. News* 21: 1-6

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

Mallika, V.K. 1987. Genome analysis in the genes Amaranthus. Ph.D.thesis, Kerala Agricultural University, Thrissur, p.104

Manay, N.S. and Shadaksharaswamy, M. 1998. *Food: Facts and Principles.* Fourth edition. New Age International Ltd., New Delhi, p.498

Marderosian, A.D., Beutler,J., Pfender, W., Chambers, J., Yoder, R., Weinstriger, 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

Mathew, D. and Sivakumar, K.C. 2002. Documenting under utilized leafy vegetables from Kerala state (India) and *in vitro* regeneration in multivitamin plant (*Sauropus andrgynus* Meeril). International conference on vegetables: Vegetables for sustainable food and nutritional security in the new millenium, November11-14, Prem Nath Agricultural Science Foundation, Bangalore. p.381

Mathew, M. 2000. Quality attributes of selected leafy vegetables. M.Sc (Home Science) thesis. Kerala Agricultural University, Thrissur.p.108

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

Menon, K. 1980. What is great about greens? *Nutrition*. 14: 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: 213-219

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

Mosha, T.C. and Gaga, H.E. 1999. Nutritive value and effect of blanching on the trypsin and chymotrypsin inhibitor activities of selected leafy vegetables. *Pl. Fds Hum. Nutr.* 54: 271-283

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: 235-245

Murcia, M.A.,Vera, A. and Carmona, F.G. 1992. Effect of processing methods on spinach: Proximate composition , fatty acids and soluble protein. *J. Sci. Fd. agric.* 59: 473-476

Murugesan, T.P. and Ananthalakshmi, A. 1991. Dietary practices of Paliyar tribal group and the nutrient content of unconventional foods consumed. *Indian J. Nutr. Dietet.* 28: 297-301

Murugkar, D.A. and Subhulakshmi, G. 2003. Macronutrient and micronutrient profiles of unconventional green leaves consumed by Khasis of Meghalaya. XXXV Annual Meeting. Scientific programmes and abstracts, 12-13 December. National Institute of Nutrition, Hyderabad, *Abstract*

Mwajumwa, L.B.S.M, 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: 275-280

Mziray, R.S., Imungi, J.K. and Karuri, E.G. 2001. Nutrient and antinutrient contents of raw and cooked *Amaranthus hybridus*. *Ecol. Fd Nutr.* 40: 53-65

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

National Institute of Nutrition. 1988. Nutritive value of tribal (Nagaland) foods. *Annual Report, 1987-88,* National Institute of Nutrition, Hyderabad. p.198

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

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

National Institute of Nutrition. 1994a. Dietary fibre in foods, *Annual Report, 1994-95,* National Institute of Nutrition, Hyderabad. p.135-69

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

National Institute of Nutrition. 1999. Nutrient composition of foods. *Annual Report ,1999-2000,* National Institute of Nutrition, Hyderabad. p.11

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

Nayar, N.M. 1992. Root and tuber crops - an overview. *Indian Hort.* 37:21

Ndyanab, W.K. 1974. Oxalate content of some commonly grazed pasture forages of land and Acholi Districts of Uganda. *E. Afr. Agric. For. J.* 39: 215

Neeliyara, A.M. 1998. Nutritive value and acceptability of winged bean genotypes (*Psophocarpus tetragonolobus* L.). M.Sc.(Home Science) thesis. KeralaAgricultural University, Thrissur, p. 71

Nesamvuni, C., Steyn, N.P. and Potgieter, M.J. 2001. Nutritional value of wild, leafy plants consumed in Venda. *S. Afr J. Sci.* 97: 51-54

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, Kautiala in Southern Mali. *Int. J. Fd Sci. Nutr.* 47: 455-468

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

Padma, P.R., Sumathi, S. and Anitha, R. 1999. Effect of heat on the anti oxidants present in selected green leafy vegetables. Scientific programmes and abstracts of XXXII Annual meeting of Nutrition Society of India, 2-4 December, Avinashlingam University,Coimbatore. *Abstract*: 21

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. *Philipp. J. Crop Sci.* 1: 195-205

Pathak, N., Yadav, B.R. and Vasudevan, P. 2000. Curry leaf-An ideal tree for social forestry. *Indian fmg.* 50: 42-44

Pereira, C.,Li, D. and Sinclair, A.J. 2001. The alphalinolenic acid content of green leafy vegetables in Australia. *Int. J. Vitamin Nutr. Res.* 71:223-228

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

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

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

Placida, V. and Meena, V. 1991. Evaluation of new recipies and estimation of vitamin C and protein content of Sauropus plant. *Indian J. Nutr. Dietet.* 28: 245

Prakash. D., Nath, P. and Pal, M. 1993. Analysis of nutritional components in *Amaranthus, chenopodium* and celosia leaves. Golden Jubilee Symposium, Horticultural Society of India, Bangalore, May 24-28. *Abstracts 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. Fd Hum. Nutr.* 47: 221-226

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

Prasak, N., Divakar, S., Kulkarni, A.P., Aradhya, S.M. and Shivamurthy, G.R. 2003. Studies on antioxidant activity of *Ipomoea aquatica* leaf extracts. 5th International Food convention, December 5-8, Mysore. *Abstracts of poster papers*, p.2

Premavalli, K.S., Majumdar, T.K. and Madhura, C.V. 2001. Processing effect on colour and vitamin of green leafy vegetables. *J. Fd Sci.Technol.* 38: 79-81

Raghuramulu, N., Nair, K.M. and Kalyanasundaram, S. 2003. *A Manual of Laboratory Techniques.* National Institute of Nutrition, Hyderabad, p.183

Raghuvanshi, R.S., Chaudhary, V., Singh, R. and Shukla, P. 2000. Formulation and biochemical assessment of lesser known leaves. 14th Indian Convention of Food Scientists and Technologists, 22-24 November, Mysore, p.170

Ragu, S.L. and Kapoor, R. 1997. Nutritional evaluation of some unconventional green leafy vegetables of South India. *Int. J. Trop. Agric.* 15: 143-148

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 Comp. Analy.* 3: 47-53

Raja, T.K., Othiman, O.C. and Bahemukha, T.E. 1997. Levels of crude proteins and inorganic elements in selected green leafy vegetables of Dar es Salaam. *J. Fd Sci. Technol.* 35: 419-422

Rajalakshmi, P., Laxmi, K.V. and Venkatalakshmamma, K. 2001. Effect of boiling on beta carotene of forest green leafy vegetables consumed by the tribals of South India. *J. Fd Sci. Technol.* 38: 56-58

Rajeshwari, M. and Subhulakshmi, G. 2004. Food as medicine. *Fd Nutr. Wld.* 2: 12-18

Ramachandran, C., Peter, K.V. and Gopalakrishnan, P.K. 1980. Chekkurmannis- A multivitamin leafy vegetable. *Indian Hort.* 25: 17-18

Ramaswamy, L. and Sathya, K. 2003. Enrichment of instant food mixes with β carotene through green leafy vegetables. 5th International Food Convention, 5-8 December,CFTRI, Mysore, p.75

Ranganna, S. 1977. *Manual of Analysis of Fruit and Vegetable Product.* Tata Mc.Graw hill publishing company Ltd., New Delhi, p.203

Ranganna, S. 1986. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products.* Second edition. Tata Mc.Graw hill Publishing Company Ltd., New Delhi, p.594

Rao, J.M.L., Ramalakshmi, K.,Borse, B.B. and Raghavan, B. 2003. Antioxidant carbazole alkaloids from the oleoresin of curry leaf (*Murraya koenigii* Spreng.). 5th International Food Convention, 5-8 December, CFTRI, Mysore, p.87

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

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

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

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

*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: 39-52

*Rozycki, V.R., Baigorria, C.M., Freyre, M.R., Bernard, C.M, Zannier, M.S. and Charpentier, M. 1997. Nutrients in wild vegetable products of the Argentine Chaco. *Archivos lactinoamericanos de Nutricion.* 47: 265-270

Sadasivam, S. and Manikam, A. 1992. *Biochemical Methods for Agricultural Sciences.* Wiley Eastern Ltd., New Delhi and Tamil Nadu Agricultural University, Coimbatore, p. 256

Saikia, A. and Shadeque, A. 1994. Ceylon Spinach: A leafy vegetable growing wild in Assam. *Indian Hort.* 39: 10-11

*Saltmarch, M., Crozier, A., Ratcliffe, B. and Goldberg, G. 2003. *Plants: Diet and Health.* The report of a British Nutrition Foundation Task Force, Blackwell Science, U.K, p.120

*Salucci, M. and Stivala, D. 2002. Flavanoids uptake and their effect on cell cycle of human colon adenocarcinoma cells. *Br. J. Cancer* 86: 1645-1651

Santamaria, P., Elia, A., Serio, F. and Todaro, E. 1999.A survey of nitrate and oxalate content in fresh vegetables. *J. Sci. Fd Agric.* 79: 1882-1888

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

*Sayed, E.N.H., Mahmoud, N.H., Soher, E.A., Mohamed, K.H. and Mabry, T.J. 1999. Flavanoids and other constituents from *Diplotaxis acris*(cruciferae). *Revista lactinoamericana-de-Quimicaa.* 27: 1-4

*Shachter, A. and Mirsky, N. 2000. Antioxidants extracted from the saltbush plant. *Czech J. Fd Sci.* 18: 159-161

Shadiza, B. 1993. Mineral content of certain non cultivated leafy vegetables. *Pl. Physiol. Biochem.* 20: 93-95

Shankaracharya, N.B. 1998. Tamarind- chemistry, technology and uses- A critical appraisal. *J. Fd Sci. Technol.* 35: 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: 429-431

Simopoulos, A.P. and Clugston, G. 2002. Omega 3 fatty acids in wild plants, nuts and seeds. *Asia Pacif. J.Clin. Nutr.* 11: 163-173

Singh, G. and Felkar, P. 1998. Cactus-New world foods. *Indian Hort.* 43: 26

Singh, G., Kawatra, A. and Sehgal, S. 2001. Nutritional composition of selected green leafy vegetables, herbs and carrots. *Pl. Fds Hum. Nutr.* 56: 359-364

Singh, S.P. and Govindarajan, D. 2001. Nitrate and nitrite poisoning in domestic animals –causes, diagnosis, treatment and prevention. *Indian Fmr's Digest.* 34: 20-22

Smith, I.F. 1982. Leafy vegetable as a source of minerals in Southern Nigerian diets. *Nutr. Rep. Int.* 26: 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: 245-257

Sreeramulu, N. 1982. Chemical composition of some green leafy vegetables grown in Tanzania. *J. Pl. Fd* 4: 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. Fd* 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. *Fd Chem.* 10: 205-210

Srilakshmi, B. 2001. *Food Science.* New Age International Pvt. Ltd, New Delhi, p.375

Steyn, N.P., Olivier, J., Winter, P., Burger, S. and Nesamvuni, C. 2001. A survey of wild, green, leafy vegetables and their potential in combating micronutrient deficiencies in rural populations. *S. Afr. J. Sci.* 98: 276-278

Su, Q., Rowley, K.G., Itsiopoulos, S.C. and O'Dea, K. 2002. Identification and quantitation of major carotenoids in selected components of Mediterranean diet: green leafy vegetables, figs and olive oil. *European J. Clin. Nutr.* 56: 1149-1154

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, p.150

Suman, K.T. 2000. Effect of amaranth on the health and nutritional profile of adolescents. M.Sc.(Home Science) thesis. Kerala Agricultural University, Thrissur, p.88

Sundriyal, M. and Sundriyal, R.C. 2001. Wild edible plants of the Sikkim Himalaya: Nutritive value of selected species. *Econ. Botany.* 55: 377-390

Svilaas, A., Sakhi, A.K., Anderson, L.F., Svilaas, T., Strom, E.C., Jacobs, D.R., Ose, L. and Blomhoff, R. 2004. Intake of antioxidants in coffee, wine and vegetables are correlated with plasma carotenoids in humans. *Int. J. Nutr.* 134: 562-567

Swaminathan, M. 1974. *Essentials of Food and Nutrition*. Ganesh and Company, Madras, p.498

Swaminathan, M. 1987. *Food Science, Chemistry and Experimental Foods*. Third edition . The Bangalore Printing and Publishing Cooperation Ltd., Bangalore, p.497

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

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

Tewari, D.N. 1992. *Tropical Forestry in India.* International Book Distributors, Dehra Dur, p.340

Thalang, V.N., Trakoonlivakorn, G. and Nakahara, K. 2001. Determination of antioxidant activity of some commonly consumed leafy vegetable in Thailand. *JIRCAS J.* 9: 39-46

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

Thangaraj, T. and Shanmugasundaram, K.A. 2000. New dimensions in coriander breeding. *Spice India.*13: 8-9

Thimmayamma, B.V.S. and Pasricha, S. 1996. *Balanced Diet: Text Book of Human Nutrition.*(Eds. Bamji, M.S., Rao, N.P. and Reddy, V.). Oxford and IBH Publishing Co., New Delhi, p.182

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

*Turan, M., Kordali, S., Zengin, H., Dursun, A. and Sezen,Y. 2003. Macro and micro mineral content of some wild edible leaves consumed in Eastern Anatolia. *Acta Agriculturae Scandinavica* 53: 129-137

Vadera, S., Walia, S. and Soni, G. 2003. Hypocholestrolemic/ hypolipidemic effects of fibre from leafy vegetables. *J. Fd Sci. Technol.* 40: 531-533

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

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

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

Wallace, P.A., Marfo, E.K. and Plahar, W. 1998. Nutritional quality and anti nutritional composition of four unconventional leafy vegetables. *Fd Chem.* 61: 287-291

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

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

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: 239-247

Yadav, S.K. and Sehgal, S. 2002. *In vitro* and *in vivo* availability of iron from Bathua (*Chenopodium album*) and spinach (*Spinacia oleracia*) leaves. *J. Fd Sci. Technol.* 33: 42-46

*Yang,Y., Huang, C.Y., Pang, S.S. and Li, J. 1996. Carotenoid analysis of several dark green leafy vegetables associated with a lower risk of cancers. *Biochem. Environmental Sci.* 9: 386-392

Appendix

APPENDIX 1

SCORE CARD FOR ORGANOLEPTIC EVALUATION
OF COOKED LEAFY VEGETABLES

Name:
Date:

Name of the leafy vegetable:

Character	Score	5	4	3	2	1
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					

QUALITY EVALUATION OF SELECTED LEAFY VEGETABLES CONSUMED BY THE TRIBES OF WAYANAD DISTRICT

By

NEETHA HYDER

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Home Science

(FOOD SCIENCE AND NUTRITION)

Faculty of Agriculture

Kerala Agricultural University

Department of Home Science

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR - 680 656

KERALA, INDIA

2004

ABSTRACT

The study entitled 'Quality evaluation of selected leafy vegetables consumed by the tribes of Wayanad District' was undertaken to estimate the nutrient composition, anti- nutritional factors and organoleptic qualities of the ten leafy vegetables consumed by the tribal communities of Wayanad district.

The leaves were analysed for moisture, protein, fat, crude fibre, total carbohydrates, calcium, phosphorus, iron, sodium, potassium, carotene and vitamin C. The results revealed that among the nutritional constituents, protein content was highest in Thakara than the other nine leafy vegetables. The fat , phosphorus, and sodium were highest in Kandariyila, where as Kannisoup had the highest value for total carbohydrates, iron and potassium. The highest crude fibre, calcium and β carotene were in Valiya kadaladi. Chumalacheera was found to have the highest vitamin C content among the ten leafy vegetables studied.

The anti-nutritional factors namely oxalates and nitrates in the leaves indicated that Kandariyila had the highest oxalate and nitrate content. Oxalate content was found to be low in Kozhuppa, while Kannisoup had the lowest nitrate content.

Other chemical constituents like phenols, flavanoids and methanol extractable crude alkaloids were also estimated. The total phenol content was highest in Chumalacheera whereas, the flavanoid and methanol extractable crude alkaloid contents were found to be highest in Kandariyila.

The average nutritive value computed on the basis of nutrient content of the leafy vegetables revealed that Valiya kadaladi had the highest nutritive value among the leafy vegetables selected for the study.

Organoleptic evaluation of the leafy vegetables indicated Churuli as the most acceptable one.

Based on the nutrient and anti nutrient composition, the leafy vegetables were grouped into four clusters, each cluster containing similar leafy vegetables. Cluster I contained Churuli, Kandariyila and Murikkila. Kozhuppa and Valiya kadaladi were included in Cluster II and III respectively. Ambasheppu, Chumalacheera, Kannisoup, Ponnankanni and Thakara were included in Cluster IV. Valiya kadaladi, which was included as the sole member of Cluster III, was found to be the best with respect to higher nutrients and lower anti-nutritional factors.