NUTRITIONAL PROFILE OF AMARANTHUS AS INFLUENCED BY POST HARVEST HANDLING

BY

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THESIS

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DECLARATION

I hereby declare that this thesis, entitled "Nutritional profile of Amaranthus as influenced by post harvest handling" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis, entitled "Nutritional profile of Amaranthus as influenced by post harvest handling" is a record of research work done independently by Kum.Jijiamma.N.C. 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.

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CONTENTS

	PAGE NO
INTRODUCTION	01
REVIEW OF LITERATURE	04
MATERIALS AND METHODS	47
RESULTS	56
DISCUSSION	170
SUMMARY	184
REFERENCES	i - xiv
APPENDICES	I - XVII
ABSTRACT	

LIST OF TABLES

TABLE NO		PAGE NO
1.	Influence of maturity and season on the protein content of amaranthus leaves (g/100g)	57
2.	Influence of maturity and season on the fiber content of amaranthus leaves (g/ 00g)	59
3.	Influence of maturity and seasons on the calcium content of amaranthus leaves (mg/ 00g)	60
4.	Influence of maturity and seasons on the iron content of amaranthus leaves (mg/ 00g)	62
5.	Influence of maturity and seasons on the ascorbic acid content of amaranthus leaves (mg/ 00g)	63
6.	Influence of different parts and season on the protein content of amaranthus leaves (g/100g)	65
7.	Influence of different parts and seasons on the fiber content of amaranthus leaves (g/ 00g)	66
8.	Influence of different parts and seasons on the calcium content of amaranthus leaves (mg/ 00g)	68
9.	Influence of different parts and seasons on the iron content of amaranthus leaves (mg/ 00g)	69
10.	Influence of different parts and seasons on the ascorbic acid content of amaranthus leaves (mg/ 00g)	71
11.	Moisture content at different storage methods (g/ 00g)	74

TABLE NO		PAGE NO
12.	Effect of varieties (V) post harvest storage periods (P) and storage methods (M) and their interaction on protein content (Rainy Season) (g/100g)	76
13.	Effect of varieties (V) post harvest storage periods (P) and storage methods (M) and their interaction on protein content (Summer season) (g/100g)	77
14.	Effect of varieties (V) post harvest storage periods (P) and storage methods (M) and their interaction on fiber content (Rainy Season) (g/100g)	79
15.	Effect of varieties (V) post harvest storage periods (P) and storage methods (M) and their interaction on fiber content (Summer Season) (g/100g)	80
16.	Effect of varieties(V) post harvest storage periods (P) and storage methods and their interaction on calcium content (Rainy season) (mg/100g)	82
17.	Effect of varieties (V) storage periods (P) and storage methods (M) and their interaction on calcium content (Summer Season) (mg/100g)	83
18	Effect of varieties (V) storage periods (P) and storage methods (M) and their interaction on iron content (Rainy Season) (mg/100g)	85
19.	Effect of varieties (V) storage periods (P) and storage methods (M) and their interaction on iron content (Summer Season) (mg/100g)	86
20.	Effect of varieties (V) storage periods (P) and storage methods (M) and their interaction on ascorbic acid content (Rainy season) (mg/100g)	88

TABLE NO		PAGE NO
21.	Effect of varieties (V) storage periods (P) and storage methods and their interaction on ascorbic acid content (Summer Season) (mg/ oog)	89
22.	Protein content of leaves cooked by different methods (g/100g)	92
23.	Fiber content of leaves cooked by different methods (g/ oog)	94
24.	Calcium content of leaves cooked by different methods (mg/ oog)	96
25	Iron content of leaves cooked by different methods (mg/ oog)	98
26	Ascorbic acid content of leaves cooked by different methods (mg/ oog)	100
27.	Effect of varieties (V) cooking methods (M) and cooking vessels (C) and their interaction on the protein content (Rainy Season) (g/100g)	103
28.	Effect of varieties (V) cooking methods (M) and cooking vessels (C) and their interaction on the protein content (Summer season) (g/100g)	104
29	Effect of varieties (V) cooking methods (M) and cooking vessels (C) and their interaction on the fiber content (Rainy Season) (g/100g)	106
30.	Effect of varieties (V) cooking methods (M) and cooking vessels (C) and their interaction on the fiber content (Summer Season)(g/ oog)	107
31.	Effect of varieties (V) cooking methods (M) cooking vessels (C) and their interaction on the calcium content (Rainy Season) (mg/100g)	109

TABLE NO		PAGE NO
32.	Effect of varieties (V) cooking methods (M) cooking vessels (C) and their interaction on the calcium content (Summer Season) (mg/100g)	110
33	Effect of varieties (V) cooking methods (M) cooking vessels (C) and their interaction on iron content (Rainy Season) (mg/100g)	112
34.	Effect of varieties (V) cooking methods (M) cooking vessels (C) and their interaction on iron content (Summer Season) (mg/100g)	113
35.	Effect of varieties (V) cooking methods (M) cooking vessels (C) and their interaction on the ascorbic acid content (Rainy Season) (mg/100g)	115
36	Effect of varieties (V) cooking methods (M) cooking vessels (C) and their interaction on the ascorbic acid content (Summer Season) (mg/100g)	116
37.	Influence of seasons on the organoleptic qualities of two varieties of amaranthus leaves	119
38	Influence of seasons and position of leaf on the amaranthus plant in terms of the quality parameter - Colour	121
39	Influence of seasons and position of leaf on the amaranthus plant in terms of the quality parameter - Doneness	123
40.	Influence of seasons and position of leaf on the amaranthus plant in terms of the quality parameter - Tenderness	124
41	Influence of seasons and position of leaf on the amaranthus plant in terms of the quality parameter - Odour	125

TABLE NO		PAGE NO
42.	Influence of seasons and position of leaf on the amaranthus plant in terms of the quality parameter - Taste	126
43.	Influence of varieties, seasons, storage periods and storage methods on the quality parameter of the amaranthus leaves - Colour	128
44.	Influence of seasons and storage periods on the quality parameter of the leaves of two varieties of amaranthus - Colour	130
45.	Influence of periods on the quality parameter of amaranthus leaves grown during different seasons - Colour	131
46	Influence of varieties, seasons, storage periods and storage methods on the quality parameter of the amaranthus leaves - Doneness	133
47	Influence of seasons and storage periods on the quality parameter of the leaves of two varieties of amaranthus - Doneness	135
48	Influence of storage periods on the quality parameter of amaranthus leaves grown during different seasons - Doneness	136
49.	Influence of varieties, seasons, storage periods and storage methods on the quality parameter of the amaranthus leaves - Tenderness	137
50.	Influence of seasons and storage periods on the quality parameter of the leaves of two varieties of amaranthus - Tenderness	139

TABLE NO		PAGE NO
51	Influence of storage periods on the quality parameter of amaranthus leaves grown during different seasons - Tenderness	140
52	Influence of varieties, seasons, storage periods and storage methods on the quality parameter of the amaranthus leaves - Odour	141
53	Influence of seasons and storage periods on the quality parameter of the leaves of two varieties of amaranthus leaves - Odour	143
54.	Influence of storage periods on the quality parameter of amaranthus leaves grown during different seasons - Odour	144
55.	Influence of varieties, seasons, storage periods and storage methods on the quality parameter of the amaranthus leaves - Taste	145
56	Influence of seasons and storage periods on the quality parameter of two varieties of amaranthus - Taste	147
57.	Influence of storage periods on the quality parameter of amaranthus leaves grown during different seasons - Taste	148
58	Influence of two varieties grown during the two seasons, in terms of quality parameter - Colour	149
59	Influence of different methods of cooking on the amaranthus leaves of two varieties grown during the two seasons, in terms of quality parameter - Doneness	150

TABLE NO		PAGE NO
60	Influence of different methods of cooking on the amaranthus leaves of two varieties grown during the two seasons, in terms of quality parameter - Tenderness	151
61.	Influence of different methods of cooking on the odour of two varieties grown during the two seasons in terms of quality parameter - Odour	152
62.	Influence of different metnods of cooking on the leaves of two varieties grown during the two seasons, in terms of quality parameter - Taste	153
63	Influence of seasons, varieties, cooking methods and cooking vessels on the quality parameter of amaranthus leaves - Colour	155
64	Influence of seasons and cooking methods on the quality parameter of the two varieties of amaranthus - Colour	157
65	Influence of seasons, varieties, cooking methods and cooking vessels on the quality parameter of amaranthus leaves - Doneness	158
66.	Influence of seasons and cooking methods on the quality parameter of the two varieties of amaranthus leaves - Doneness	159
67	Influence of seasons, varieties, cooking methods and cooking vessels on the quality parameter of amaranthus leaves - Tenderness	161
68	Influence of seasons and cooking methods on the quality parameter of two varieties of amaranthus - Tenderness	163

TABLE NO PAGE NO

69. Influence of seasons, varieties, cooking methods and cooking vessels on the quality parameter of amaranthus leaves - Odour 164

70. Influence of seasons and cooking methods on the quality parameter of two varieties of amaranthus - Odour 166

71. Influence of season, varieties, cooking methods and cooking vessels on the quality parameter of amaranthus leaves - Taste 167

72. Influence of seasons and cooking methods on the quality parameter of two varieties of amaranthus - Taste 169

LIST OF APPENDICES

I. Evaluation card for triangle test

II Score card for the organoleptic evaluation of cooked amaranth under different conditions

III Effect of maturity levels on the nutritional composition of two varieties of amaranthus during rainy season

IV. Effect of maturity levels on the nutritional composition of two varieties of amaranthus during summer season

V. Effect of location of leaves on the nutritional composition of the two varieties of amaranthus during rainy season

VI. Effect of location of leaves on the nutritional composition of the two varieties of amaranthus during summer season

VII Effect of storage periods and storage methods on the nutritional composition of the two varieties of amaranthus leaves during rainy season

VIII. Effect of storage periods and storage methods on the nutritional composition of the two varieties of amaranthus leaves during summer season

IX. Effect of different methods of cooking on the nutritional composition of the two varieties of amaranthus during rainy season

X. Effect of different methods of cooking on the nutritional composition of the two varieties of amaranthus during summer season

XI. Effect of different types of cooking vessels on the nutritional composition of the two varieties of amaranthus during rainy season

XII. Effect of different types of cooking vessels on the nutritional composition of the two varieties of amaranthus during summer season

XIII. Effect of location of leaves on the organoleptic qualities of the two varieties of amaranthus during rainy season

XIV. Effect of location of leaves on the organoleptic qualities of the two varieties of amaranthus during summer season

XV. Effect of storage periods and storage methods on the organoleptic qualities of the two varieties of amaranthus during rainy and summer season

XVI. Effect of different methods of cooking on the organoleptic qualities of the two varieties of amaranthus during rainy and summer season

XVII. Effect of different types of cooking vessels on the organoleptic qualities of the two varieties of amaranthus during rainy and summer season

IST OF I I ATES

1 *Amaranthus tricolor* (red variety) at harvest (10 DAT)

2 *Amaranthus tricolor* (green variety) at harvest (10 DAT)

3. *Amaranthus tricolor* (red variety) at harvest (20 DAT)

4 *Amaranthus tricolor* (green variety) at harvest (20 DAT)

5 *Amaranthus tricolor* (red variety) at harvest (30 DAT)

6 *Amaranthus tricolor* (green variety) at harvest (30 DAT)

LIST OF ILLUSTRATIONS

FIGURE NO	TITLE
1.	Effect of maturity on the protein and fibre content of red and green varieties of Amaranthus.
2.	Effect of maturity on the Calcium, Iron and Ascorbic acid content of red and green varieties of Amaranthus
3.	Effect of different methods of cooking on the Ascorbic acid content of red and green varieties of Amaranthus.

LIST OF ABBREVIATIONS

cm	-	centimetre
m	-	metre
g	-	gram
ha	-	hectare
kg	-	kilogram
°C	-	degree celsius
µg	-	microgram
mg	-	milligram
ml	-	milli litre
β	-	Beta
DAT	-	Days After Transplanting
KAU	-	Kerala Agricultural University
ICMR	-	Indian Council of Medical Research
TNAU	-	Tamil Nadu Agricultural University
I.U	-	International Unit
CVS	-	cultivars
Var	-	Variety
spp.	-	species
ns	-	not significant
EAA	-	Essential Amino Acid
hrs	-	hours
kcal	-	kilo calories

INTRODUCTION

INTRODUCTION

Leafy vegetables are inexpensive food items and are consumed by people all over our country. Palak, amaranth, Gogu, methi leaves, mint and drumstick leaves are some of the most commonly used leafy vegetables. Use of such leafy vegetables are more popular in states like West Bengal, Orissa and Tamil Nadu. Out of the common leafy vegetables, the amaranthus is consumed by most people all over India.

The family Amaranthaceae includes about 600 genera and 800 species comprising mostly of herbaceous annual plants. According to Mallika (1987) the most common cultivated species of amaranthus are *Amaranthus tricolor* and *Amaranthus dubius*. Amaranthus is a high yielding, nutritious tropical leafy vegetable widely grown in Asia, West Africa and Caribbean region. It is a hardy plant with high tolerance to arid conditions and poor soils. Vegetable types of amaranthus from India are reported to be introduced to the western world by the names Chinese spinach, Malabar spinach or Tampala.

Green leafy vegetables play a vital role in human nutrition and are considered to be the cheapest source of minerals and vitamins and hence these food articles are classified under "protective foods". Among leafy vegetables, amaranthus is rich in protein, iron, calcium, vitamin.A and C and is a rare example of a vegetable where all these essential dietary components are combined in one. Earlier studies had indicated that amaranthus leaf protein could be a good supplementary source for rice or wheat protein. The balanced diet recommended by the ICMR suggests the inclusion of 100 g of leafy vegetables daily. However, average daily consumption of green leafy vegetables in India is reported to be around 16 g. The consumption of green leafy vegetables is recommended for the people whose diet is predominently composed of cereals.

The amaranthus plants are normally pulled out at 20 to 30 days after sowing for use as tender greens. Consumption of plants in still tender stage within 15 to 20 days as well as at a later mature stage of 40 to 45 days are also common. However, information on the composition of nutrients such as minerals, Vitamins and protein at different stages of growth and at different post harvest handling methods is scanty and such type of studies would be useful to upgrade the present diets by inclusion of greens.

With this in view, the present studywas undertaken in Amaranthus tricolor (Red and green variety) with the following objectives.

1) To study the nutritional composition of amaranthus at various seasons and at different maturity levels and at different storage periods
2) To study the effect of various post harvest handling and cooking practices on the nutritional composition, and organoleptic qualities
3) To study the effect of various types of cooking vessels on the nutritional composition and organoleptic qualities

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Nutritional importance of green leafy vegetables

Green leaves of palak, Amaranthus, Fenugreek, drumstick, mint etc. are consumed all over the country as leafy vegetables, and most of them are reported to be rich source of major nutrients (ICMR, 1987). As reported by ICMR (1987) green leaves are the inexpensive source of many nutrients essential for growth and maintenance of normal health According to Schelstrute and Kennedy (1980) nutrient densities of leaves/100 kcal compared with Recommended Dietary Allowances (RDA) were greater than one for all constituents Peter (1979) has reported that drumstick leaves are more nutritious than most of the vegetables commonly used. According to Ramachandran et al (1980) Chekkurmanis, one of the popular green leafy vegetable in South India is commonly known as a multi-vitamin and multi-mineral packed leafy vegetable. The authors further reported that the nutritive value of this vegetable in general is very high as compared to the annual leafy vegetables such as amaranthus, ceylone spinach, water leaf spinach and palak.

Minerals are reported to be abundantly present in green leafy vegetables (Indira Gopalan, 1982). The mineral content of curry leaves is reported to be 4.2 per cent (Philip _et al_ 1981).

Green leafy vegetables are found to be very rich in moisture content since they are reported to contain 73.1 to 91.1 per cent moisture. As reported by Philip _et al_ (1981) the moisture content of curry leaves is 66.3 per cent. Wills _et al_ (1984) had reported the water content of popular Chinese green leafy vegetables on the range of 89.5 - 96.8 per cent. The author had studied the nutrient composition of Australian foods and found that the green leafy vegetables had moisture 86.8 to 92.9g/100g. Islam _et al_ (1987) determined the proximate composition of _Atriplex triangularis_ leaves, spinach and mustard greens and reported that average moisture contents of _Atriplex triangularis_ leaves spinach and mustard greens were 88.1 per cent, 90.6 per cent and 92.5 per cent respectively.

Ifon and Bassir (1980) studied the nutritive value of some Nigerian green leafy vegetables and reported that the ash content ranges from 9.7 to 18.6 per cent.

As reported by Faboya, (1983) the green leafy vegetables examined had an average of 20 per cent total ash Studies were conducted by Awasthi and Abidi (1985) to assess the biochemical and nutritive characteristics of nine green leafy vegetables commonly grown in Eastern Uttar Pradesh The variation for total ash was found to be 12.66 - 25.82 per cent. Bawa and Yadav (1986) determined the protein and mineral contents of green leafy vegetables consumed by Sokoto population and found that ash content ranges from 7.0 - 18.o per cent.

Menon (1980) had reported that green leafy vegetables are rich in mineral nutrient 'iron' (Fe) which is needed for blood formation in the body, especially during pregnancy and lactation According to Choudhari and Rajendran (1980) the iron content of palak, Beta vulgaris variety Bengalensis is 36 03 mg Ramachandran et al (1980) has reported the Fe content of Chekkurmanis leaves, on an average was 28 mg Faboya (1983) analysed twelve locally grown green leafy vegetables for their mineral contents and the concentration ranges for Fe were found to be 0.35 - 0.56 (in mg g-1 dry weight). According to Cnweya (1985) the Fe content in Solanum nigrum and Gynandropsis gynandra and Amaranthus hybridus leaves, popular green leafy vegetables in Kenya, is about 10 mg/100g Schelstrute and Kennedy (1980) have reported that miners lettuce (Montia perfoliata) contains 10 per cent of Fe Smith (1982) reported that leafy vegetables contains 1.4 to 12.3 mg of Fe. According to Wills et al (1984) non-brassica leafy vegetables, popular in China contained 2.4 - 3.9 mg/Fe/100g, while Brassica spp. contained only 0.3 - 1.7 mg of Fe per 100g of edible portion. Mohideen et al (1985) reported that Co-3 culture amaranthus contains 0.84 per cent Fe on dry weight basis. According to Islam et al (1987) Atriplex triangularis leaves are low in Fe content. Bawa and Yadav (1986) determined the mineral contents of green leafy vegetables consumed by Sokoto population and found that among the green leafy vegetables popular, Lalo (Corchorus sp.) have the highest content of Fe (0.31 per cent) According to Castanedac et al (1986) spinach has a high Fe content. Similarly Erandankeera is reported to contain more Fe than amaranthus white with coloured stem and reddish green Keera (KAU 1984).

Among the various green leafy vegetables drumstick leaves are reported to contain the highest amount of calcium (Ca) (Peter, 1979 and Nautiyal et al 1987).

Sundara Raj *et al* (1970) reported that amaranthus contain seven times more Ca than milk. Chekkurmanis leaves are reported to contain 441 mg of Ca per 100g of leaves (Ramachandran *et al* 1980). According to Choudhary and Rajendran (1980), Palak, *Beta vulgaris* var. *Bengalensis* contains 293.2g of Ca. Menon (1980) has reported that green leafy vegetables contain good amounts of calcium which is necessary for the proper growth of bones. Smith (1982) reported that the Ca content of green leafy vegetables, are in the range of 70 to 280 mg/100g. Cnweya (1985) has reported that the Ca content in the leaves of the 3 species popular in Kenya are 291, 251 and 480 mg/100g respectively. Amaranthus is reported to be rich in minerals (Vijayakumar and Shunmugavelu, 1985) Particularly Amaranthus is reported to be rich in Calcium (Castanedac *et al* 1986).

Mohideen *et al* (1985) reported that Co-3 culture amaranthus contains 2.48 per cent Ca. According to Islam *et al* (1987) *Atriplex triangularis* leaves are low in Ca.

Studies were conducted by Awasthi and Abidi (1985) to assess the biochemical and nutritive characteristics of nine green leafy vegetables commonly grown in Eastern Utter Pradesh The variation for phosphorous (P) content in these green leafy vegetables was found to be 0.34 - 1.43 per cent Faboya (1983) analysed twelve locally grown green leafy vegetables in Nigeria for their mineral content and the concentration ranges for P were found to be 0.18 - 0.39. Bawa and Yadav (1986) determined the mineral content of green leafy vegetables consumed by Sokoto population and found that among the green leafy vegetables Lalo (*Corchorus sp.*) had the highest content of P (0.48 per cent). There were significant positive correlation between P and Magnesium (Mg.) Mohideen *et al* (1985) reported that Co-3 culture amaranthus contain 0.47 per cent P on dry weight basis.

Besides Ca and P, other minerals abundantly present in the green leafy vegetables were Magnesium (Mg) Sulphur (S) Zinc (Zn) Manganese (Mn) Flourine (F) Sodium (Na) and Potassium (K). Of the eight minerals determined in the green leafy vegetables by Faboya (1983) Mg was the most abundant ranging from 0.66 mg/g-1 in *Celosia argentea* to 1.76 mg/g-1 in *Corchorus olitorius*.

It is however, noteworthy that the red stalked varieties of both *Amaranthus caudatus* and *Celosia argentea* contained slightly higher Mg content. Ramachandran *et al* (1980) has reported that chekkurmanis leaves contains 6 1 mg of Mg Bawa and Yadav (1986) found that Lalo (*Corchorus sp*) popular among Sokoto population had the highest content of Mg (0.47 per cent). Mohideen *et al* (1985) reported that Co-3 culture amaranthus contains 1.35 per cent on dry weight basis. According to Awasthi and Abidi (1985) the Sulphur content of nine green leafy vegetables commonly grown in Eastern Utter Pradesh was in the range of 0.13 - 0.98 per cent Faboya (1983) analysed 12 locally grown green leafy vegetables in Nigeria for their mineral contents and the concentration ranges for manganese were found to be 0.03 - 0.12 (mg g-1 dry weight).

Smith (1982) reported that leafy vegetables contains Zn, which ranges from 0.3 to 1.9 mg/100g. According to Islam *et al* (1987) *Atriplex triangularis* leaves are low in Zn content. As reported by Faboya (1983) the Zn content of green leafy vegetables, grown in Nigeria ranges from 0.04 - 0.12 (in mg g^{-1} dry weight).

The flouride contents of common Nigerian vegetables were studied by Sanni (1982) and he had reported that ten vegetables contained flouride 16 to 91, average being 32μg/g. He had further reported that these vegetables might provide a valuable source of flourine in Nigeria where the incidence of dental caries is increasing rapidly.

Choudhary and Rajendran (1980) has reported the Na content of Palak, Beta vulgaris variety Bengalensis as 20.24 mg per 100g As reported by Faboya (1983) the Na and K content of twelve locally grown green leafy vegetables in Nigeria were found to be 0.11 - 0.76 and 0.36 - 1.07 (in mg g^{-1} dry weight) respectively Mohideen et al (1985) had reported that Co-3 culture amaranthus contained 3.21 per cent K on dry weight basis. Studies conducted by Islam et al (1985) had indicated that Atriplex triangularis leaves contained 17 times more Na than spinach. However, the K content of Atriplex triangularis leaves are low compared to other leafy vegetables.

Green leafy vegetables are generally found to be rich in vitamins Among vitamins, Vitamin C, Vitamin A, Carotene and Vitamin B complex are found in abundance in green leafy vegetables The drumstick leaves are reported to be richer in ascorbic acid than tomato, radish, carrot and pea. (Peter, 1979 and Nautiyal et al 1987) Ramachandran et al (1980) has reported the vitamin C content of chekkurmanis as 247 mg. Choudhary and Rajendran (1980) has reported the vitamin C content of palak, Beta vulgaris variety Bengalensis as 23.58 mg. Philip et al (1981) has reported that the ascorbic acid content of curry leaves is 4 mg per 100 g. Leaves from Solanum nigrum and Gynandropsis gynandra which are the indigenous green leafy vegetables popular in Kenya may have ascorbic acid contents as high as 144 and 131 mg/ 100 g respectively (Cnweya 1985) Schelstruete and Kennedy (1980) reported the composition of miners lettuce (Montia perfoliata) which contained 33 per cent of the adult recommended dietary allowance for ascorbic acid. Wills et al (1984) studied the nutrient composition of Chinese vegetables and reported that water cress and Brassica Juncea contained approximately 100 mg ascorbic acid per 100 g edible portion, hardy melon contained 70 mg per 100 g and remaining vegetables contained 12-55 mg per 100 g and can be considered useful sources of vitamin C. Mohideen et al (1985) reported that

Co-3 amaranthus culture contains 35.9 mg of ascorbic acid in 100 g of fresh matter. According to Islam *et al* (1987) ascorbic acid level of *Atriplex triangularis* leaves is comparable to that of mustard green and much higher than that of spinach. Rao *et al* (1980) studied the vitamin B-Complex content of various uncommon leafy vegetables of India and found that *Trianthema portulacastrum* was rich in the nutrients studied. According to Philip *et al* (1981) the nicotinic acid content of curry leaf is 2.3 mg/100 g.

Indira Gopalan (1982) has reported that drumstick leaves contain the highest carotene, among green leaf vegetables. Peter *et al* (1979) has reported that drumstick leaves contain an equal amount of vitamin A (11,300IU/100g) as carrot roots. Chekkurmanis leaves, grown in abundance in South India are found to contain 9510 I U of vitamin A in 100 g of fresh leaves (Ramachandran *et al* (1980) According to Choudhary and Rajendran (1980) Palak, *Beta vulgaris* variety *Bengalensis* contained 3750 Mg of carotene while the carotene content of curry leaf is reported to be 12,600 I.U/100 g (Philip *et al* 1981)

Menon (1980) has reported that green leafy vegetables in general are rich sources of carotene Schelstruete and Kennedy (1980) reported the composition of miners lettuce (Monita perfoliata) which contained 22 per cent of the adult recommended dietary allowances for Vitamin A. Wills et al (1984) studied the nutrient composition of Chinese vegetables and reported that the vegetables, except B chinensis and B.pekinensis contained > 1000 μg β-carotene/100 g and are therefore good vitamin A sources. According to Cnweya (1985) the carotene content of indigenous green leafy vegetables in Kenya may exceed 7000μg/100g. Joseph and Peter (1985) reported the high vitamin A content of curry leaves, (Murruya koenigii) amongst other valuable components. Erandankeera contained more vitamin A than Amaranthus white (KAU 1984). According to Islam et al (1987) Vitamin A content of Atriplex triangularis leaves is relatively low

Green leafy vegetables are reported to be good sources of carotene Begum and Pereira (1977) studied the β-carotene content in 32 types of edible green leaves The study reveals that out of 32 varieties, twelve contained carotene with a range of 4630 to 7305 μg per 100 g in the edible portion and eight types had small amounts of carotene in the range of 1180 to 2280 μg per 100 g. Bressani *et al* (1986) found, green leafy vegetables are rich source of carotene. Speek *et al* (1988) reported that leafy vegetables contains considerably more carotenoids than tuburous vegetables and fruits, and is mainly deposited in the leaves, which in general, have a higher relative β-carotene content than the stalks Bushway (1986) found that in lettuce β carotene was the most prevalent carotenoid and also reported that the outer layer was the greenest and contained the most vitamin A. activity than the inner layer. According to Aiyasamy and Aruchami (1988) amaranthus leaves contained appreciably more carotene than paw paw fruits. Mohideen *et al* (1985) reported that Co.3 culture amaranthus contains 11.04 mg of carotene in 100 g of fresh matter. Besides vitamin C, vitamin A and carotenes, the green leaves are reported to contain tocopherols also (Indira Gopalan 1980)

According to Bressani *et al* (1986) green leafy vegetables are good sources of water soluble vitamins and essential minerals. Vijayakumar and Shunmugavelu (1985) pointed out that amaranthus is rich in vitamins.

Among the green leafy vegetables, few green leafy vegetables are found to be protein sources also. Rao *et al* (1980) studied the protein/N content of various uncommon leafy vegetables of India and found that *Trianthema portulacastrum* was rich in the nutrient studied. Chekkurmanis leaves are reported to contain 6.8 g of protein (Ramachandran *et al*(1980) while Peter (1979) reports that drumstick leaves contain 6.7 of protein equivalent to peas. Ifon and Bassir (1980) studied the nutritive value of some Nigerian green leafy vegetables and reported that the protein content ranges from 17.2 to 28.4 on dry weight basis According to Philip *et al* (1981) curry leaves contain 6.1 g per cent of protein. Cnweya (1985) reported that protein content in the leaves of the identical plants in Kenya range from about 28 per cent to 36 per cent. According to Sreeramulu (1984) *Cassia tora*, *Gynandropsis gynandra*, *solanum nigrum* and *Moringa oleifera* grow in Tanzania contained highest protein followed by *Basella argentea*. He further reports that since these species had low fibre value, extraction of leaf proteins would be aided by this high protein fibre ratio Wills _et al_ (1984) has reported the protein content of popular Chinese green leafy vegetables as 0.3 - 0.33 per cent Among the nine green leafy vegetables grown in Eastern Utter Pradesh abundantly, _Chinopodium album_, _Cicer arietinum_ _Brassica campestis_ and _spinacia oleracea_ leaves were found to be qualitatively potential source of protein and other biochemical constituents over the rest studied and would serve as prominent supplementary tool for nutritionally inferior diets of economically backward class, resulting in acute malnutrition and related syndroms. (Awasthi and Abidi, 1985) According to the author, the protein content in these green leafy vegetables ranges from 22.92 - 31.50 per cent. Amaranthus is reported to be rich in protein (Vijayakumar and Shunmugavelu 1985). Wills _et al_ (1984) had studied the nutrient composition of Australian foods and found that protein was highest in broccoli 4.7, Brussels sprouts 3.8 and Kohlrabi 3.7g/100g. According to KAU (1984) Erandankeera contains more protein than amaranthus green. Mohideen _et al_. (1985) reported that on a dry weight basis Co-3 culture amaranthus contains 12.5 per cent protein.

Bawa and Yadav (1986) determined the protein content of green leafy vegetables consumed by Sokoto population and found that protein was 13.1 - 29.2 per cent. Castanedac *et al* (1986) reported that the protein content of amaranthus is similar to that of spinach. Islam *et al*. (1987) determined the proximate composition of *Atriplex triangularis* leaves, spinach and mustard green and the protein content of *Atriplex triangularis* leaves is found to be 2.9 per cent compared to 3.1 per cent of spinach and 2.1 per cent of mustard green. Bressani *et al*. (1988) reported the chemical composition of amaranthus, spinach and chipilin leaves on a fresh weight basis. With respect to protein chipilin contained higher amounts (7.6) than amaranth (4.4) and spinach (2.8). On a dry weight basis, protein content was 32.5, 27.4 and 48.9 per cent for amaranth, spinach and chipilin respectively. Gupta *et al*. (1989) reported that protein content in Amaranth, drumstick, Fenugreek and pumpkin varied from 25.1 to 28.5 per cent while in colocasia (18.00 per cent) and Neem (15.7 per cent), it was in lower range.

Vijayakumar and Shunmugavelu (1985) reported that amaranthus is found to be rich in certain EAA, which are constituents of proteins. Studies were conducted by Awasthi and Abidi (1985) among nine green leafy vegetables commonly grown in Eastern Utter Pradesh and found that certain amino acids like methionine and tryptophan present in these green leafy vegetables were in the range of 0.054 - 0.11g/16 gN and 0.119 - 0.835g/16 gN. Bressani _et al_. (1986) studied that all the green leaves are good sources of lysine.

A major component reported to be abundantly present in green leafy vegetables is fibre. Among the various types of green leafy vegetables, chekkurmanis leaves are found to contain 2.5 gm per cent of fibre (Ramachandran _et al_. 1980). Ifon and Bassir (1980) has reported the fiber content of some Nigerian green leafy vegetables as 8.5 to 20.9. Curry leaves which are used in Indian cookery for flavouring food preparation, the fiber content is 6.4g per cent (Philip _et al_. 1980). According to Sreeramulu (1984) fiber was highest in _Amaranthus viridis_ (21.3g/100g) and lowest in _Moringa oleifera_ (5.7g) grown in Tanzania. Wills _et al_ (1984) has reported the fiber content of popular Chinese green leafy vegetables as 1.1 to 4.5 per cent. According to a study by Wills _et al_. (1984) among green leafy vegetables grown in Australia dietary fiber was from

1.7 to 4.5g/100g with highest values in Brussels sprouts and Broccoli. Vijayakumar and Shunmugavelu (1985) reported that Amaranthus hypochondriacum and Amaranthus edulis were found to have a high content of fibre, thus making them less palatable. They further reported that Co-1(Amaranthus dubius)and Co.2(Amaranthus gangeticus) types presented a low crude fiber content and both are found to be highly palatable. According to Mohideen et al (1985) Co.3 culture amaranthus contains 17.4 per cent crude fiber on a dry weight basis. Dietary fiber and its components as well as starch, have been determined in those vegetables (including Amaranthus tricolor) that are extensively grown and consumed in South East Asia by John et al. (1987) and they had found that the richest sources of total dietary fiber among the 24 vegetables were Pithecellobium jiringa, Hibiscus esculentus and Pisum sativum variety Marcrocarpus Bressani et al. (1988) reported the fiber content of amaranth (1.3) spinach (0.7) and chipilin leaves (1.8) on a dry weight basis and the results indicate that chipilin leaves contained more fiber than amaranthus and spinach

Green leafy vegetables are not considered suitable food articles to meet the carbohydrate content.

However a few studied on these lines present an entirely different picture. Ifon and Bassir (1980) has reported the carbohydrate content of some Nigerian green leafy vegetables as 51.0 to 66.1 per cent. Rao *et al*. (1980) studied the carbohydrate content of various uncommon leafy vegetables of India and found that *Trianthema portulacastrum* was rich in the nutrient studied. According to Ramachandran *et al*. (1980) carbohydrate content of chekkurmanis leaves was 11.6g per cent and curry leaves are found to contain 16g per cent of carbohydrate (Philip *et al* 1981). Sreeramulu (1984) has reported that many of the green leafy vegetables grown in Tanzania were good sources of carbohydrates.

As in the case of carbohydrate green leafy vegetables are reported to be in general poor sources of fat. The range of fat content in the green leafy vegetables commonly used in our country are 0.3 to 3g Ifon and Bassir (1980) has reported the fat content of some Nigerian green leafy vegetables ranges from 2.7 to 8.1 per cent. According to Philip *et al* (1981) the fat content of curry leaves is 1.0 per cent. The lipid composition of eight varieties of amaranthus was determined by Lorenz and Hwang (1985) and found that free lipids range from 5.69 to 7.23 per cent and found lipids from 0.42 to 0 91 per cent.

2 Effect of maturity on the nutritional composition of green leafy vegetables

Maturity of a plant is an important factor which may influence the nutritional composition of a plant. According to Waheed et al (1986) the proximate analysis of vegetables and green leafy vegetables at different maturity stages had indicated that the nutrient composition of vegetables were species specific and maturity dependent.

Mohideen and Muthukrishnan (1981) had reported that the optimum harvest time for amaranthus (*Amaranthus gangeticus*) was 25 days after sowing Orimoyegum and Kebeba (1983) reported that foliage nutrient composition of Obeche did not vary approximately with tree age. Bassir and Fafunso (1976) had reported that the composition of leafy vegetables (*Amaranthus hybridus*, *Corchorus olitrius*, *Solanum africana*) varied with species and stage of growth (age).

Protein is a major nutrient influenced by maturity in green leafy vegetables According to Ramanathan (1983) crude protein (19.3 per cent) was highest in amaranthus at 27 days after sowing while Waheed et al (1986) has reported that protein contents of leafy vegetables were high (25 to 46 per cent) at immature stage Lexander et al (1970) reported that plants of Amaranthus caudatus harvested at 10-12 weeks after sowing produced 240 to 250 g protein in an area of one square metre. Imbamba (1973) found that the protein content was 28.1 per cent in dried amaranth leaves at 36 days after sowing, but this decreased to 19.0 per cent in 67 days old plants. Stafford et al (1976) recorded 5.85 and 5.17 per cent of protein in Amaranthus hybridus, sub sp. hybridus, harvested at 35th and 45th day after sowing. He recorded the maximum content of protein at 42nd day and in later stages it gradually decreased. Stafford et al. (1976) studied the protein content of Amaranthus hybridus diminished with increasing maturity. Subbiah (1979) found that the crude protein content in Co.1 and Co.2 culture amaranthus harvested on 27th and 42nd day was on par and higher than the 36th day. Vijayakumar (1980) reported that the types A.145, A.111 recorded the highest protein content of 18.04 per cent at 30th day and 40th day respectively Singhal and Sen (1984) reported that the protein content in the leaves of several amaranthus spp. vary with the age of the plants.

They attained their highest content at the seedling stage and this decreased gradually as the plants give to the vegetative and flowering stages. The maximum amount of protein was detected in _A.tricolor_ (22.6 per cent) when compared to other species. Jan Bai Giri _et al_ (1984) had studied the nutritive value of chekkurmanis leaves at different stages of growth and they found that the lateral leaves of chekkurmanis of one year plant were richer in protein when compared to terminal leaves and leaves of less than one year plants. Ravindran and Ravindran (1988) had reported that the crude protein content of cassava leaves decreased with maturity. Vijayakumar and Shunmugavelu (1985) reported that the amino acid content in ten fresh amaranthus leaves varied with respect to harvest stages. High lysine content was found in A.33, A.42, A.53, A.90 and A.102 on the 25th day, and analysis on the 40th day revealed that lysine was highest in A.9 and A.117 types.

Among vitamins, vitamin C (ascorbic acid) and carotene are the two nutrients, generally influenced by the maturity level of the plant. Devadas _et al_. (1965) reported that the ascorbic acid content of leaves and stem reached a maximum value of 155 mg/100g and 32 mg/100g respectively when the plant is 29 days and almost stationary between 29 and 38 days of growth and slowly decreased afterwards.

Pushpamma and Joshi (1970) studied the ascorbic acid content of spinach at different ages, was found to differ, with a maximum of 32.64 mg occuring when the plant was 50 days old and minimum of 12.57 mg when the plant was 70 days old. It was observed that there was a gradual increase in the ascorbic acid level followed by a gradual decline. According to Abrams (1975) distribution of ascorbic acid within the Brussel sprouts are influenced, since the meristem had the highest concentration which decreased through the inner light green leaves to the outer dark green leaves Stafford _et al_ (1976) observed that the ascorbic acid content of _Amaranthus hybridus_ sub sp. _hybridus_, at 35th and 45th day of harvest were 153 and 135 mg in 100g of fresh matter Abe and Imbamba (1977) reported highest levels of ascorbic acid at 50 days after planting in _Amaranthus lividus_ Ramachandran (1977) reported that amaranth at tender stage contained 99 mg of ascorbic acid Subbiah (1979) found that the ascorbic acid was high on 27th day and it was low in subsequent stages of harvest. Vijayakumar (1980) reported that the optimum stage of harvest in most of the types of amaranthus would be fixed around 25-30 days after sowing to get highest yield of nutritious and palatable greens. In respect of ascorbic acid content Amaranthus hypochondriacus recorded high values uniformly at all stages, while the type Amaranthus gangeticus L had the highest ascorbic acid content on 30th day. Ramanathan (1983) reported that ascorbic acid (162.6 mg/100g) was highest in amaranthus at 27 days after sowing. Janbaigiri et al (1984) studied the nutritive value of chekkurmanis leaves at different stages of growth and they found that the lateral leaves of chekkurmanis of one year plant were richer in vitamin C when compared to terminal leaves and leaves of less than one year plants.

Abe and Imbamba (1977) reported that the highest levels of carotene could be obtained between 55-65 days after planting in Amaranthus lividus Begum and Pereira (1977) reported that the carotene content was higher in mature than in the tender leaves of leafy vegetables. Subbiah (1979) reported higher carotene content at 27th day and 36th day in Co.1 and Co.2 variety amaranthus after sowing. Vijayakumar (1980) reported that the Amaranthus types A.153, A.102 and Co.1 amaranthus recorded, greater levels of carotene on 40th day. Ramanathan (1983) reported that carotene (11.5 mg/100g) and chlorophyll (1.17 mg/g) were highest in amaranth at 36 and 41 days after sowing. Janbaigiri et al (1984) reported that the β-carotene content of chekkurmanis leaves at different stages of growth were higher in lateral leaves of chekkurmanis of one year plant, when compared to terminal leaves and leaves of less than one year plants. The riboflavin and thiamin content of chekkurmanis leaves increased with stages of growth and the maturity of the leaves (Janbaigiri et al 1984).

Major minerals influenced by maturity of the plant are Ca, P, Fe, Na, K, Mg, Mn, Zn and Cu Janbaigiri et al. (1984) had reported that ash content was higher in the lateral leaves. It was also reported that ash content of the leaves increased with stages of growth and the maturity of the leaves.

The Ca content of amaranthus plants decreased as the plants matured. (Subbiah, 1979). Vijayakumar (1980) reported that the type Co.1 amaranthus recorded the highest amount of Ca on 20th day. Omueti (1982) reported that in the four Celosia argentea CVS., leaf Ca decreased with age, being highest between 5 and 7 weeks after sowing Janbaigiri et al.(1984) reported that Ca content of chekkurmanis leaves increased with stages of growth and the maturity of the leaves.

Omueti (1982) reported that the phosphorous content of four Celosia argentea CVS L. decreased with age, being highest between 5 and 7 weeks after sowing. Taylor et al (1983) reported that with increasing age the phosphorous content of the vegetables increased significantly. Janbaigiri et al (1984) reported that the phosphorous content of chekkurmanis leaves were higher in one year plant and was at the lateral leaves of chekkurmanis than the terminal leaves.

Stafford et al (1976) recorded 7.2 and 11.4 mg of iron in 100 g in Amaranthus hybridus harvested at 35th and 45th day after sowing respectively The iron content of Amaranthus hybridus rose steeply when harvest was delayed until the 63rd day after planting (Stafford et al (1976). Subbiah (1979) found that higher iron content in Co.1 and Co.2 amaranthus plants harvested at 27th day Vijayakumar (1980) reported that the Amaranthus types A 83, A.104 and A.33 had greater amount of iron on 25th day than the other types. Omueti (1982) reported that the two red anthocyanin pigmented CVS. of Celosia argentea contained more Fe than the green CVS According to Taylor et al (1983) iron content of all the vegetables decreased as age advanced.

Omueti (1982) reported that the two red anthocyanin pigmented CVS contained more Na than the green CVS. Taylor et al (1983) reported that with increasing age the Na content of the vegetables increased significantly. Janbaigiri et al (1984) reported that the lateral leaves of chekkurmanis of one year plant were richer in Na when compared to terminal leaves and leaves of less than one year plants. It was also reported that Na content increased with stages of growth and maturity. According to Waheed et al (1986) leafy vegetables accumulated more Na as compared with the rest of the vegetables.

Omueti (1982) reported that in the four Celosia argentia CVS, K content of the leaves decreased with age, being highest between 5 and 7 weeks after sowing. Taylor et al (1983) reported that the K content of Amaranthus caudatus, Cucurbita pepo and Solanum aethiopicum decreased as age advanced. Janbaigiri et al (1984) reported that the terminal leaves of chekkurmanis of one year plant contains more 'K' and decreased with stages of growth and maturity of the leaves. According to Waheed et al (1986) leafy vegetables accumulated more K as compared with the rest of the vegetables.

According to Subbiah (1979) the Mg content of amaranthus plants decreased as the plants matured. Omueti (1982) studied that in the four Celosia argentea CVS, the Mg content of the leaves increased upto 15 weeks. Janbaigiri et al (1984) reported that the Mg content of chekkurmanis leaves increased with stages of growth and the maturity of the leaves.

Omueti (1982) reported that Mn content of four Celosia argentia CVS increased upto 15 weeks after sowing. Taylor et al. (1983) reported that with increasing age the Mn content of the vegetables increased significantly. According to Janbaigiri et al. (1984) the Mn content was higher in lateral leaves of chekkurmanis of one year plant when compared to terminal leaves and leaves of less than one year plants.

Taylor et al (1983) reported that with increasing age the Zn content of the vegetables increased significantly. Janbaigiri et al (1984) studied the nutritive value of chekkurmanis leaves at different stages of growth and they found that Zn content was higher in the terminal leaves of one year plant and decreased with stages of growth and maturity of the leaves.

According to Taylor *et al* (1983) the copper content of all the vegetables decreased as age advances According to Janbaigiri *et al* (1984) the Cu content of chekkurmanis leaves increased with stages of growth and the maturity of the leaves. It was also observed that Cu content was higher in lateral leaves of one year plant than terminal leaves of less than one year plants.

Carbohydrates is a major nutrient, the concentration of which is influenced by the stage of growth and maturity of the plant. Janbaigiri *et al* (1984) reported that the carbohydrate content of chekkurmanis leaves increased with stages of growth and the maturity of the leaves. Singhal and Sen (1984) reported that the carbohydrate contents in the leaves of several amaranthus spp. vary with the age of the plant. They attained their highest content at the seedling stage, and this decreased gradually as the plants grow to the vegetative and flowering stage. The maximum amount of carbohydrate recorded was detected in *Amaranthus spinosus* (46.5 mg/g-1) According to Janbaigiri *et al* (1984) the carbohydrate was higher in lateral leaves of chekkurmanis of one year plant when compared to terminal leaves and leaves of less than one year plants. Ravindran and Ravindran (1988) reported that the carbohydrate content of cassava leaves decreased with maturity.

According to Janbaigiri et al (1984) the fat content of green leaves increased with stages of growth and the maturity of the leaves According to the author the fat content was higher in lateral leaves of one year plants than terminal leaves and leaves of less than one year plant. Moisture content in the leaves was found to be higher in the terminal leaves of one year plant and decreased with stages of growth and maturity of the leaves (Janbaigiri et al 1984). Unlike moisture the fibre content of green leaves increased with maturity (Ravindran and Ravindran (1988))

Effect of different seasons on the nutritional composition

Season is an important factor which may influence the nutritional composition of green leafy vegetables. Bassir and Fafunso (1975) reported the nutritional composition of some leafy vegetables including *Amaranthus hybridus* has hardly affected by season Mohideen and Muthukrishnan (1981) carried out trials with 75 types of *Amaranthus gangeticus* harvested in the summer and monsoon season at 20, 25, 30 or 35 days after sowing It was found that yield and vegetable quality were better in the summer season. The types A.51, A.54 and A.88 performed best in both seasons. Mohideen and Muthukrishnan (1982) has further reported in *Amaranthus tricolor* L. the range, mean and co-efficient of variation for different characters showed a decrease in monsoon as compared to summer season. The genotypic and phenotypic variances were generally low in monsoon season as compared to summer season.

Begum and Pereira (1977) found that values for β carotene in green leafy vegetable varied seasonally and were higher in mature than in tender leaves.

Devadas *et al* (1969) studied the variation in the nutrient content of *Amaranthus flavus* over the 3 seasons, namely, the South West Monsoon, North East Monsoon and Cold Weather and found that significant variation in the ascorbic acid content between the two monsoon seasons from 87 mg/100g during South West Monsoon to 107 mg in the North East Monsoon and 105 mg in the Cold weather.

According to Devadas et al. (1969) there was no significant difference in the protein content of *Amaranthus flavus* during different seasons.

It was found that a significant reduction in the moisture content during cold weather from 88.99g in the North East Monsoon to 73.1g/100g (Devadas et al. 1969).

There was no significant difference in the Ca, Fe and P content of amaranthus leaves during three seasons (Devadas et al 1969).

Effect of various post harvest handling on the nutritional composition

Post harvest handling plays an important role in influencing the nutritional composition of green leafy vegetables. Bhobe and Pai (1986) reported that the quality of frozen vegetables remained constant during the entire period of storage for 3½ months Waheed et al (1986) studied the post harvest losses in vegetables. Maximum quantitative loss was recorded in spinach (52 per cent) of which 25 per cent was at retailers shops.

According to Devadas et al (1965) the average losses of ascorbic acid in amaranthus stored under market conditions in open air for 4 and 8 hour were 22.8 per cent and 37.4 per cent respectively. The average losses of ascorbic acid in the whole plant stored under different home conditions were, refrigerator 8.0 per cent, mud pot cooler (Janatha cooler) 16.1 per cent moist cloth 22.9 per cent and polythene basket 40 per cent. Pushpamma and Joshi (1970) studied the ascorbic acid losses during storage and found that the maximum loss of ascorbic acid was observed in open storage at room temperature and minimum storage in freezing. As reported by the author, the percentage loss of ascorbic acid in 24 hours for freezing and open storage was found to be 5 per cent and 97 per cent respectively. The losses in samples stored at room temperature and in refrigerator were minimised by storing in wet cloth and polythene bags respectively. Shukla and Bindu (1975) reported losses of ascorbic acid in green vegetables stored $\leq$72 hours at 29-30.5C, uncovered or covered with wet muslin cloth or in a refrigerator at 10 C, from 12 to 25 per cent of ascorbic acid was lost during 24 hours at room temperature without cover, with greatest losses in coriander leaves, spinach and radish leaves and rising to 65.7, 46.4 and 56.7 per cent after 48 hours and smallest losses in radish leaves covering with wet muslin reduced loss of ascorbic acid in spinach after 24, 48 and 72 hours from 21.3, 32.8 and 46.6 to 17.3, 23.6 and 38.9 per cent. Refrigerator storage caused 1.15 per cent losses of ascorbic acid during 24 hours. Varghese and Umapathi (1977) studied about the effect of some household methods of storage on the ascorbic acid content of kilkeerai greens and found that refrigeration is the best method of storage for leafy vegetables. The study further revealed that plastic bucket, unsuitable for storing greens since it resulted in highest losses of ascorbic acid Phadnis and Annapurna (1980) studied the effect of different household and market methods of vegetable storage on the retention of ascorbic acid and the results indicated that janatha refrigerator was the best method of storage for green leafy vegetables under household conditions for the retention of ascorbic acid. Among the other methods tried in this study, polythene bag, dipping the roots in water, wet cloth, in the order of preference could be recommended. Plastic bucket, cane basket and storing the cut vegetables in closed vessel and the most popular methods were found to be unsuitable for storing greens, since it resulted in high losses of ascorbic acid. Phadnis and Annapoorna (1980) evaluated the different methods of storage under market conditions and found that the highest retention of ascorbic acid was observed in green leafy vegetables stored by covering with wet cloth. The least retention was found in green leafy vegetables kept open in cane basket. It was also found that as the period of storage increased, the retention of ascorbic acid decreased.

Ranganath and Dubash (1981) reported that dehydration at higher temperature of 85 to 90 C led to greater destruction of ascorbic acid than the corresponding losses encountered by dehydration at lower temperatures. Ranganath and Dubash (1981) further studied that the ascorbic acid of dehydrated spinach is only about 22 per cent of that of the fresh samples after storage at 24°C for four months. Sreeramulu et al. (1983) reported that the ascorbic acid content in the leafy vegetables stored open (uncovered) in the laboratory (25-35°C) for 24 hours decreased, the lost varying from 28.0 to 48.3 per cent. Contrary to this, the loss of ascorbic acid during storage in the leaves covered with a wet cloth was much less ranging from 1.6 to 10.4 per cent.

Fawusi (1983) studied that storage of Corchorus olitorius at room temperature (25-28°C) resulted in 93 per cent loss in ascorbic acid content within four days. Under refrigerated storage (4 C) loss of ascorbic acid over a four week period were 77 per cent. Russel et al. (1983) studied the vitamin C content of fresh spinach and found that storage of field grown spinach under conditions simulating commercial marketing resulted in vitamin C losses upto 90 per cent of field level. According to Fawusi (1983) holding of leaves at 25-28°C for 4 days resulted in a rapid deterioration in quality, especially with regard to ascorbic acid. However, when leaves were stored at between +4 C and -6°C most of the quality factors determined were preserved throughout the 4 week duration of the storage treatments. Lazen et al (1987) studied the water stress and quality decline during storage of Amaranthus caudatus and Brassica juncea and found that unwrapped leaves lost vitamin C wrapping in plastic film restricted ascorbic acid, particularly at the lower temperature regime and leaves retained their turgidity Gyang and Mbachu (1987) reported that 97 per cent loss of ascorbic acid during market sale, when the leaves remained exposed in the sun for several hours Onayemi and Badifu (1987) studied the effect of blanching and drying methods on the nutritional and sensory quality of leafy vegetables and found that blanching and drying treatments caused a significant reduction in the levels of ascorbic acid The study further revealed that water blanching and sundrying caused greater reduction in the levels of ascorbic acid than steam blanching and cabinet drying Bushway _et al_. (1985) reported that the water soluble vitamin content of fiddle head greens decreased with processing. Waheed _et al_ (1986) had reported that the vitamin contents of all vegetables indicated significant losses during storage.

According to Varghese and Umapathi (1977) for retaining moisture in the leaves, refrigeration is the best method of storage for leafy vegetables. Plastic bucket was found to be unsuitable for storing greens since it resulted in highest losses of moisture Phadnis and Annapoorna (1980) reported that plastic bucket, cane basket and storing the cut vegetables in closed vessel and the most popular methods were found to be unsuitable for storing greens since it resulted in high losses of moisture. They further reported that the highest retention of moisture was observed in green leafy vegetables stored by covering in wet cloth According to Lazen _et al_ (1987) unwrapped leaves lost water rapidly during storage, particularly at the higher temperature regime, resulting in rapid wilting

Kaur and Manjurekar (1975) reported that storage of green leafy vegetables for 2-8 months decreased the chlorophyll content but the β carotene content did not change much. Ranganath and Dubash (1981) reported that dehydration at higher temperature of 85-90 C led to greater destruction of carotenoid than the corresponding losses encountered by dehydration at lower temperature. According to Onayemi and Badifu (1987) blanching and drying treatments caused a significant reduction in the levels of carotene.

According to Fawusi (1983) the Ca content of *Corchorus olitorius* stored at room temperature increases slightly as the storage period lengthened probably due to dehydration.

Hebrero *et al* (1988) found that in frozen spinach, stored in a display freezer and subjected to temperature fluctuations an increase was observed in vitamin B content In spinach originally frozen but stored at room temperature, the vitamin B content decreased after showing an initial increase It was also reported that in fresh spinach stored both at room temperature and under refrigeration, the content in this vitamin decreased throughout the study.

According to Bushway _et al_ (1985) the protein content of fiddle head greens decreased with processing. Lazen _et al_ (1987) reported that the protein content of unwrapped leaves decreased during storage, particularly at the higher temperature regime.

According to Bushway _et al_. (1985) the ash content of fiddle head greens decreased with processing Onayemi and Badifu (1987) had reported that blanching and drying treatments of leafy vegetables caused a significant reduction in the levels of ash.

Fawusi (1983) studied that the 'P' content of _Corchorus olitorius_ stored at room temperature, increased slightly as the storage period lengthened probably due to dehydration

<u>Effect of different cooking methods and cooking vessels on the nutritional composition of leafy vegetables</u>

The nutrients which are much affected by application of heat as well by contact with different types of metals at a higher temperature are vitamin C, carotene and proteins.

A study conducted by Rajeswari *et al* (1966) proved that among the different methods of cooking on the ascorbic acid content of fenugreek leaves, boiling in water resulted in maximum loss. Pushpamma and Joshi (1970) studied that cooking losses of ascorbic acid in spinach ranged from 40 per cent in pressure cooking for two minutes to 100 per cent in samples cooked with dhal for 15 minutes. In other methods of cooking the losses ranged from 39-64 per cent. It was also observed that the losses could be minimised if the cooking time was reduced or when pH was decreased by addition of tamarind Kamalanathan *et al* (1974) studied that pressure cooking was found to be better than the other methods because it lead to maximum retention of ascorbic acid. According to stafford *et al* (1976) steaming or boiling the amaranthus leaves for only 10 minutes produced the least loss of nutrients.

Ajayi *et al* (1980) reported values for total vitamin C in fresh vegetables before and after boiling were *Amaranthus hybridus* 560 and 228, *Celosia argentea* 553 and 237 *Corchorus olitorius* 588 and 140 mg/100g Mudambi *et al* (1981) reported that the ascorbic acid losses due to cooking of certain vegetables which are rich sources ranged from 54 per cent in Fenugreek leaves and brinjal to 82 per cent in drumstick. Bhat and Malik (1981) reported that loss of ascorbic acid during cooking varied from 29.4 in radish to 50.0 per cent in beetroot, carrot and knolkhol leaves. Padma *et al* (1982) studied that the ascorbic acid content of all the six vegetables was reduced significantly when boiled, steamed or pressure cooked. Steaming proved to be the best method of cooking. The loss of ascorbic acid was significant when the vegetables were over cooked beyond the tender stage It was also reported that the loss of ascorbic acid was more in green leafy vegetables when compared to other groups of vegetables. According to Sreeramulu (1983) boiling the leaves with excess or little water results in loss of vitamin C (0 to 99, mean 71 per cent and 0 to 97, mean 55 per cent respectively). The vitamin C content of common edible leaves decreased after cooking (Keshinro and Ketiku 1979, Fafunso and Bassir, 1977, Abrams, 1975, Bhobe ahd Pai 1986). Gyang and Mbachu (1987) reported that cooking of leafy vegetables led to significant loss of ascorbic acid. The study further indicated that cooking for 15 minutes resulted in 60 to 90 per cent loss of ascorbic acid.

Renquist et al. (1978) found that no β-carotene was lost during boiling, stewing or frying in fat at moderate temperature in tropical leafy vegetables, but drying in ultra-violet light destroyed β-carotene Bhat and Malik (1981) reported that loss of carotene due to cooking varied from 9.00 in beetroot leaves and turnip leaves to 9.02 per cent in knol-khol and radish leaves. Faboya (1985) studied the chlorophyll changes in some green leafy vegetables during cooking and found that atleast 56 per cent of the total chlorophyll was lost, (100°C) the rate of loss decreased with the initial total chlorophyll content. Aiyasamy and Aruchami (1986) reported 25 per cent loss of β-carotene in amaranthus during cooking Dikshit and Udipi (1988) studied that β-carotene losses occured in almost all cooked preparations and were greater when these vegetables were either cooked for a prolonged period or were highly macerated or were deep fried in oil. Nagra and Khan (1988) studied the vitamin A content of 17 varieties of local vegetables before and after cooking for 60 minutes and found that loss of vitamin A in cooking ranged from 10-59 per cent of different vegetables.

Fafunso and Bassir (1977 and 1979) analysed leaf protein in raw and cooked leaves of Amaranthus hybridus and found that the nutritive value of leaf protein concentrate were significantly reduced by heat. Fafunso and Bassir (1979) further studied that heating lowering the nutritional qualities of the vegetables. Their PER values were most adversely affected. Thus the decrease in the overall content of the EAA brought about by the leaching of the soluble proteins into the processing water coupled with the depressed availability of lysine and methionine, were most probably responsible for the decreased nutritional quality of the cooked leafy vegetables. Bhat and Malik (1981) reported that on dry matter basis, protein content of raw and cooked greens varied from 20.81 and 20.03 in carrot to 29.18 and 28.74 per cent in raddish leaves respectively Abobaker et al (1986) studied that cooking had the effect of lowering the levels of nitrate in all types of fresh vegetables, no nitrate was formed during cooking.

Kamalanathan et al (1972) studied about the Ca and Fe content of 3 vegetables cooked by three methods and found that Ca and Fe did not vary due to the different methods of cooking. It was also observed that thiamin losses varied significantly with different methods of cooking.

The iron content and organoleptic acceptability of amaranth leaves cooked in iron, aluminium and brass vessels were studied by Devadas et al. (1965) and found that the iron content of amaranth cooked in aluminium, or tin coated brass vessels, with or without tamarind juice were 11.4/13.4 mg and 11.3/12.7mg/100g respectively. It was also observed that the increase in the iron content was very high in amaranth cooked in cast iron pan, (110.7mg/100g). The author further observed that cooking with tamarind extract caused a further increase (164.3mg/100g).

MATERIALS AND METHODS

MATERIALS AND METHODS

The study on nutritional profile of Amaranthus as influenced by post harvest handling was assessed based on

(i) the variation in nutrients and organoleptic qualities of leaves at different stages of maturity at various seasons and at different storage periods.

(ii) the effect of various post harvest handling and cooking practices on the nutritional composition and organoleptic qualities

(iii) the effect of various types of cooking vessels on the nutritional composition and organoleptic qualities

A. Details of experiment

Field culture

The crop was raised in the Instructional Farm of the College of Agriculture, Vellayani as per the package of practices recommendations (KAU,1987).

Cultivation of Amaranthus

The land was prepared by digging followed by levelling and shallow trenches of width 30 cm were made at 30 cm apart Well rotten Farm Yard Manure at 50 tonnes/ha was mixed with the soil in the trenches Transplanting of 20 days old seedling was done in the shallow trenches at a distance of 20 cm apart. During the rainy season planting was done on raised beds.

The varieties selected for the study were red and green *Amaranthus tricolor* The crop was raised during the rainy and summer seasons in the year 1988-89.

Leaves were collected at random from eighty plants in the morning between 7 and 8 am during when they are turgid and frozen The leaves were collected from the tip, middle and basal portion of the plant for chemical analysis and for studies on storage methods, cooking methods and effect of cooking vessels. Leaves were also collected 10, 20 and 30 days after transplanting, to study the effect of different maturity levels on the nutrient composition Analysis was done immediately after collection of leaves. The chemical analysis of leaves from different parts of the plant, storage methods, cooking methods and cooking vessels were done with 20 days old leaves alone. All the estimations were done on samples from plants raised during both rainy and summer seasons.

Chemical analysis

Fresh leaf samples were analysed for protein, ascorbic acid, calcium, iron and crude fiber by the following methods.

Protein content in the leaves were estimated by following the standard Macrokjeldhal method of Hawk-Oser (1965)

Ascorbic acid in leaves was estimated according to the method of A.O A.C (1955) using 2,6 dichlorophenol indophenoldye.

Estimation of calcium and iron in leaves was done in diacid extract of fresh leaves using an Atomic Absorption Spectrophotometer (Perkin-Elmer 1982).

Crude fiber was estimated by acid-alkali digestion methods as suggested by Chopra and Kanwar (1978).

Effect of maturity levels of plants on nutritional composition

The nutritional composition of leaves of two varieties of amaranthus at different maturity levels were done using the leaves collected from plants harvested at 10th, 20th and 30th day after transplanting.

Effect of location of leaves in plants on nutritional composition

For estimating the nutritional composition of leaves at different parts of the plant, leaves were harvested separately from the tip, middle and base portion of the plant.

Effect of different methods of storage on nutritional composition

The effect of different methods of storage on the nutrient composition was determined on leaves stored in refrigerator, polythene bag, by wrapping in wet cloth and by dipping the roots in water and kept it open under room temperature. The leaves were packed in polythene cover and then placed in the refrigerator Prior to storing in polythene bags, the leaves were sprinkled with water. Influence of storage periods viz., 24 hrs, 48 hrs and 72 hrs using the above four methods were also studied.

PLATE (i)

Amaranthus tricolor (red variety) at harvest (10 DAT)

PLATE (ii)

Amaranthus tricolor (green variety) at harvest (10 DAT)

PLATE (i)

PLATE (ii)

PLATE (iii)

Amar nthus tricolor (red variety) at harvest (20 DAT)

PLATE (iv)

Amaranthus tricolor (green variety) at harvest (20 DAT)

PLATE (iii)

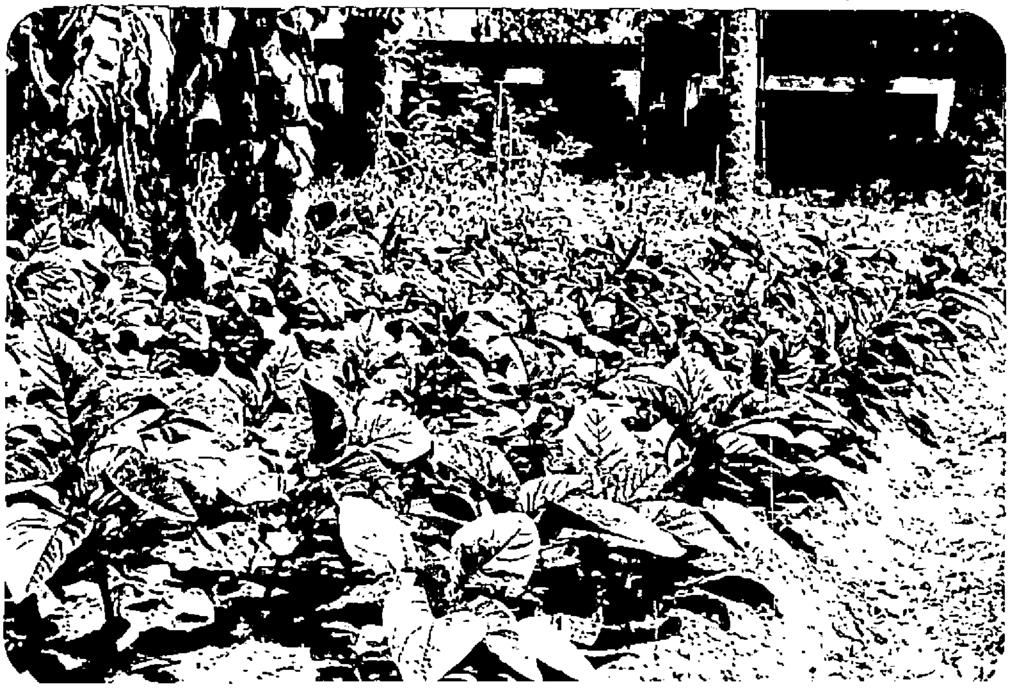


PLATE (iv)

PL T (v)

Am ranthus tri^olor (red v riety) at harvest (30 DAT)

PLATE (vi)

Amaranthus tricolor (green variety) at harvest (30 D T)

PLATE (v)

PLATE (vi)

Effec of dıfferent metnods of cookın; on nutrıtıonal composıtıon

Varıatıon in the presence of nutrıents when d ffe e methods of cookıng applıed on leaves were assessed Common cookıng methods such as boılıng in water, shal ow fryıng, bakıng and steamıng were the methods selected for the study. All these methods of cookıng were done usıng glass vessels The cooked samples of the leaves were weighed and used for analysing of varıous nutrıents

Effect of dıfferent types of cook ng vessels on nutr tıona composıtion

The ınfluence of dıfferent types of cookın vesse on the nutrıent composıtıon of leaves were studıed by cookıng the leaves of the two varıetıes of amaran hus ın aluminıum, alloy ıron copper, steel and mudpo Popular methods of cookıng such as boılıng and shallow fryıng were u ed ın thıs respect Known quantitie of cooked samples each were analyse for varıous nu r en s

B Organolepti qualıtıes and acceptabılıty

Acceptabılıty trıals of the leaves of two va ıetie of amaranthus were planned at the labo atory level

A s r es o ac ptability tria were carr d ou a e laboratory with a selec ed panel of judges The pane members we e selected from a group of 10 heal ny wo en in the age group of 28 to 45. Simple triangle te t was employed to s le t the panel members (Jellinek 1985) The evaluation card used fo the triangle te t is presented in Append x I From the 10 women who participated in the triangle test, six women were se ec e as judges for the presen acceptability t ial

The organoleptic q alities and acceptability trials on panel members were done using the scoring method A score card developed for the s dy is pre ented in Appendix II The major quality attr bu es in uded n the score we e colour doneness tendernes , odo r a e and overall acceptability on a ive point hedon a Each of the above me ioned quality is asse sed by a five point rating scale

The judg were reques ed to tas e one sampl a d score it Th y were reques ed to ta te the e on sam le after wa hin the r mou h Each quality wa asse ed b n pa el m mber after t s n g the s me samp se a time if needed T panel mber wer permi ted to ta t e own e a d to judge the samples leis ely

The testing was conducted in the afternoon between 3 p.m and 4 p.m. Since this time is considered as the ideal time for conducting the acceptability studies (Swaminathan, 1974) The acceptability tests among the panel members were conducted on different days.

preparation of the sample

The leaves were washed throughly in water to remove the adhering dirt and cut into small pieces using a stainless steel knife. 125g of the chopped material were added to 50 ml of boiling water and then 1g of salt was added. The mixture was cooked for 10 minutes.

The acceptability tests were conducted in rainy and summer seasons with the same panel members.

Influence of seasons on the organoleptic qualities of two varieties of Amaranthus leaves

The organoleptic qualities and acceptability of two varieties of amaranthus at different seasons were evaluated, on leaves collected from plants harvested at 20th day after transplanting.

Effect of location of leaves in plants on organoleptic qualities

The organoleptic qualities and acceptability of leaves at different parts of the plants were evaluated by harvesting the leaves separately from the tip, middle and base portion of the plant.

Effect of different methods of storage on the organoleptic qualities

The effect of different methods of storage on the organoleptic qualities were determined on leaves stored in refrigerator, polythene bag by wrapping in wet cloth and by dipping the roots in water and keeping it open under room temperature. Influence of storage periods viz , 24 hrs, 48 hrs and 72 hrs using the above four methods were also evaluated.

Effect of different methods of cooking on organoleptic qualities

The effect of different methods of cooking on the organoleptic qualities of leaves were determined by using common cooking methods such as boiling in water shallow frying, baking and steaming.

Effect of different types of cooking vessels

The organoleptic qualities and acceptability of the leaves of two varieties of amaranthus when cooking in different types of cooking vessels such as aluminium, alloy, copper, iron, steel and mudpot were evaluated by the panel members Popular methods of cooking such as boiling and shallow frying were used in this respect.

Statistical analysis

The data collected were subjected to statistical analysis as per methods suggested by Panse and Sukhatme (1957).

RESULTS

RESULTS

The results pertaining to the study entitled "Nutritional profile of amaranthus as influenced by post harvest handling", are presented under the following headings

a. Nutritional composition of amaranthus leaves

b. Organoleptic qualities of the amaranthus leaves

a. Nutritional composition of amaranthus leaves

1. Effect of maturity on the nutrition composition of amaranthus leaves

The nutritional composition of amaranthus was determined at different maturity levels, such as 10, 20 and 30 days after transplanting. Major nutrients analysed were protein, ascorbic acid, calcium, iron and fiber

Table 1 presents the influence of maturity and season on the protein content in the leaves of the two varieties of amaranthus.

Table 1 Influence of maturity and season on the protein content of amaranthus leaves (g/100g)

Varieties	Maturity levels	Rainy season	Summer season
Red	10 days	3.40	3.50
	20 "	4 00	4.10
	30 "	4.50	4.60
Green	10 days	3.60	3.70
	20 "	4.20	4.30
	30 "	4.70	4.80
$F_{1,6}$ (Variety)		3.00^{ns}	2.40^{ns}
$F_{2,6}$ (maturity)		30.33**	24.27**
CD -(Maturity) at 5%		0.3460	0 3869

As revealed in the Table, the protein content was found to increase with the age of the plant Concentration of protein in the plant is found to be directly proportional to the maturity of the plant. It was higher in 30 days old plants compared to 10 and 20 days in both the seasons. The protein content in two varieties of the plant had no much variation during both the seasons.

As shown in the table, there was no significant varietal variation during rainy and summer season. But significant difference in the protein content was observed, at both season, in the two types of amaranthus at all levels of maturity. The protein content was significantly low in 10 days old leaves when compared to 20 and 30 days old plants.

When comparing the effect of seasons, it was found that seasonal variation had no effect on the protein of two varieties. However, the protein content of the two varieties of amaranthus during summer season and during the 30th day maturity were found to be higher and this was more evident in the green variety.

Table 2 presents the influence of maturity and seasons on the fiber content of the amaranthus leaves.

As revealed in table 2, the fiber content was higher in green amaranthus when compared to red amaranthus at both the seasons. In both the varieties, fiber content increased with the maturity of the plant.

Table 2 Influence of maturity and season on the fiber content of amaranthus leaves (g/100g)

Variety		Maturity levels	Rainy Season	Summer Season
		10 days	0.70	0.50
Red		20 "	1.03	0.54
		30 "	1.20	1.05
		10 days	0.90	0.80
Green		20 "	1.20	1.10
		30 "	1.35	1.25
$F_{1,6}$	(Variety)		6.42*	5.33*
$F_{2,6}$	(Maturity)		6.95*	7.58*
$F_{2,6}$	(V x M)		0.52^{ns}	0.08^{ns}
CD - (Variety) at 5%			0.2156	0.2826
CD - (Maturity) at 5%			0.2641	0.3461

Statistical analysis showed that the fiber content of both varieties were lower in tender leaves harvested on 10th day But no significant difference in the fiber content were observed at 20 and 30 days old leaves at both seasons. From the statistical analysis, it was observed that there was no significant interaction between the two seasons. But significant difference in the fiber content was observed in the two varieties at both seasons

Major minerals analysed were calcium and iron. Table 3 presents the influence of maturity and seasons on the calcium content of amaranthus leaves

Table 3 Influence of maturity and seasons on the calcium content of amaranthus leaves (mg/100g)

Variety	Maturity levels	Rainy season	Summer season
Red	10 days	322.50	333.04
	20 "	367.00	372.02
	30 "	360 40	365.00
Green	10 days	340.50	352.00
	20 "	379.05	386 04
	30 "	371.00	378.01
$F_{1,6}$ (Variety)		112.06**	34.12**
$F_{2,6}$ (Maturity)		381.27**	71.91**
$F_{2,6}$ (V xM)		2.87^{ns}	$0\ 50^{ns}$
CD - (Variety) at 5%		3.1591	6.4231
CD - (Maturity) at 5%		3.8690	7 8670

As shown in the table, Ca content varied with seasons and also at different maturity levels in both the varieties. Calcium content of red and green amaranthus decreased with increasing age of the plant at both the seasons. It was found that Ca content was higher in 20 days old leaves and decreased in plants harvested after 30 days. It was also indicated in the table, that season had great influence on the calcium content of the leaves. Calcium content was significantly higher during summer season in both red and green varieties compared to rainy season.

As revealed in the table, there was significant difference in the calcium content between the two types of amaranthus at both seasons and was found to be higher in green amaranthus. Similarly, it was also revealed that the calcium content was significantly low at 10 days old leaves during both the seasons and had no signinificant difference in calcium content at 20 and 30 days old leaves.

Table 4 presents the influence of maturity and seasons on the iron content of leaves

Table 4 Influence of maturity and seasons on the iron content of amaranthus leaves (mg/100g)

Variety	Maturity levels	Rainy season	Summer season
Red	10 days	14.10	15.20
	20 "	22.16	23.38
	30 "	20.70	21.90
Green	10 days	17.04	18.90
	20 "	25.85	27.29
	30 "	23.40	25.20
$F_{1,6}$ (Vafiety)		17.47**	79.20**
$F_{2,6}$ (Maturity)		47.87**	152.50**
$F_{2,6}$ (V x M)		0.16^{ns}	1.87^{ns}
CD - (Variety) at 5%		1.8150	0.3159
CD - (Maturity) at 5%		2 2230	0.3869

It was observed that, both red and green amaranthus were found to be a better source of iron at both the seasons, especially during summer season. The iron content of the leaves were found to increase as age advanced in both the varieties during the two seasons. However, the increase in iron content in the plants were high in both varieties at 20 days, when compared to 30 days of maturity

From the statistical analysis it was revealed that season does not influence the iron content of amaranthus leaves. It was also found that there was no significant difference in iron content at 20 and 30 days of maturity, but significantly low at 10 days old leaves. Similarly, it was also revealed that there was significant varietal difference at different levels of maturity at both seasons.

Table 5 presents the influence of maturity and seasons on the ascorbic acid in the leaves of two varieties of amaranthus.

Table 5 Influence of maturity and seasons on the ascorbic acid content of amaranthus leaves (mg/100g)

Variety	Maturity levels	Rainy season	Summer season
Red	10 days	49.50	40.00
	20 "	98.00	72.00
	30 "	98.00	72.00
Green	10 days	56.00	44.00
	20 "	96.00	68.00
	30 "	96.00	68.00
$F_{1,6}$ (Variety)		2.57^{ns}	0.142^{ns}
$F_{2,6}$ (Maturity)		22.50**	28.00**
$F_{2,6}$ (V xM)		19.5**	0.571^{ns}
CD - (Maturity) at 5%		1.8689	10.5723
CD - (Va Ma) at 5%		2.643	..

FIG 1 EFFECT OF MATURITY ON THE PROTEIN AND FIBER CONTENT OF RED AND GREEN VARIETIES OF AMARANTHUS

SCALE - 3 cm = 1 g

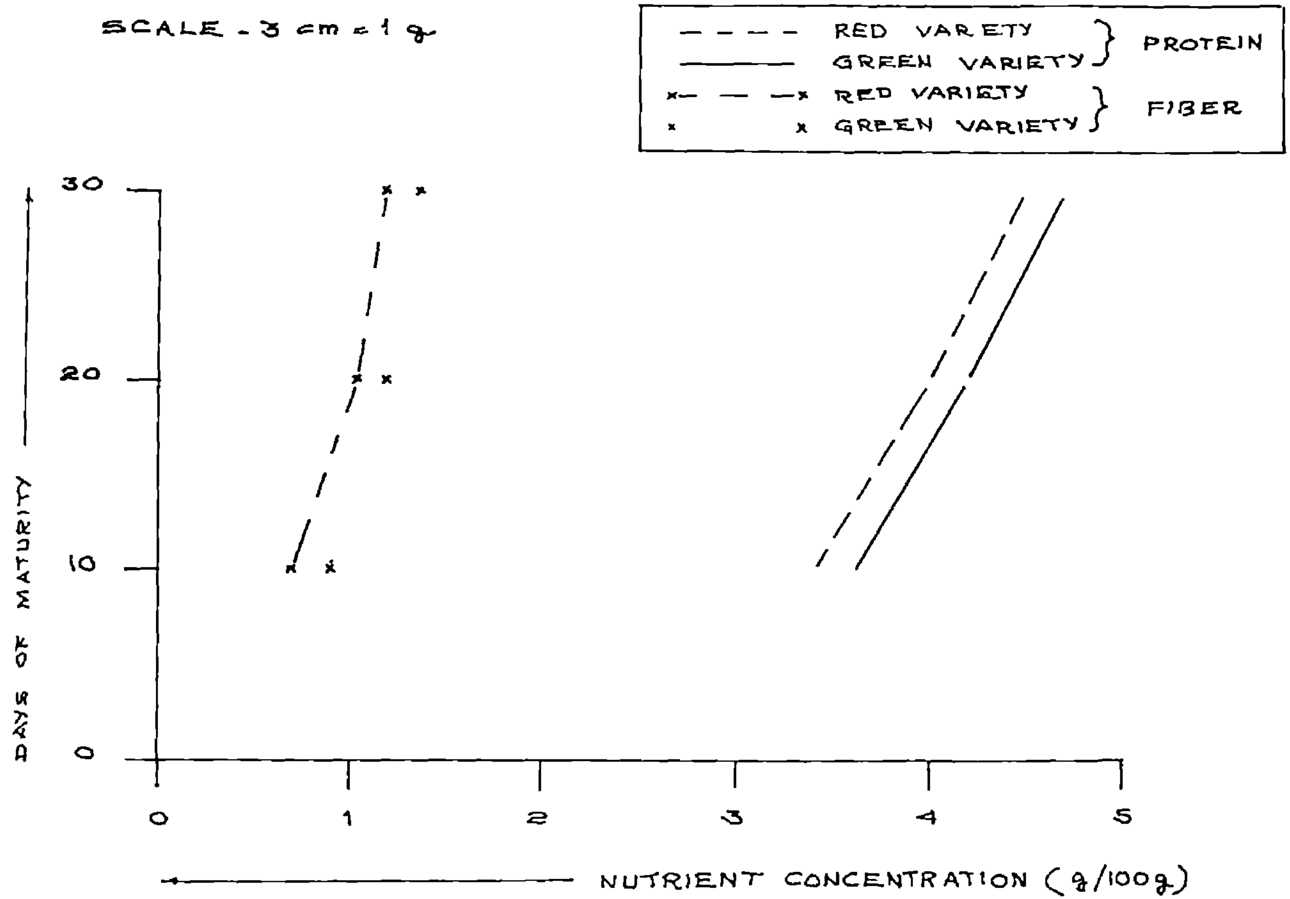
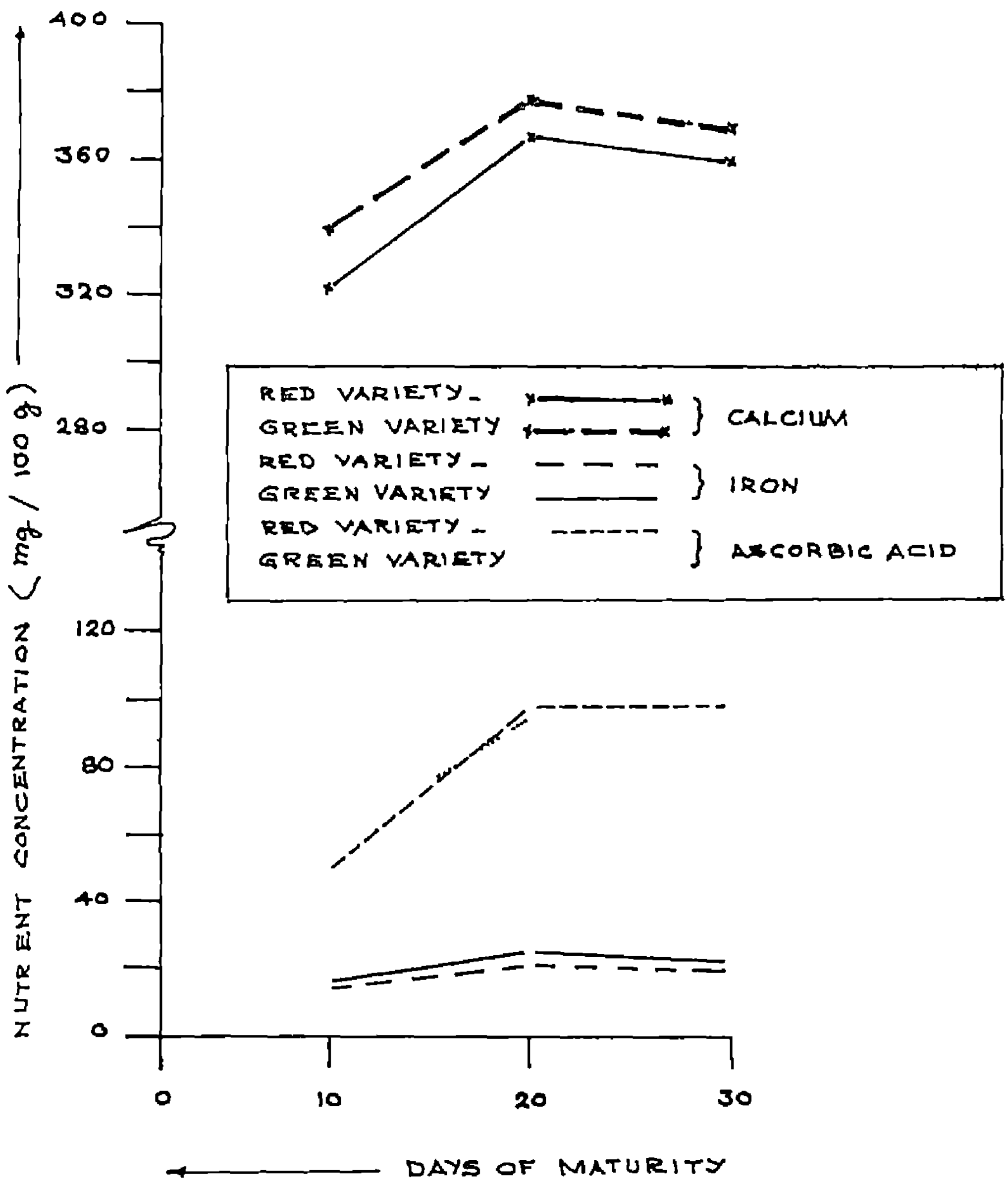


FIG 2 EFFECT OF MATURITY ON THE CALCIUM IRON AND ASCORBIC ACID CONTENT OF RED AND GREEN VARIETIES OF AMARANTHUS

SCALE 1 cm - 20 mg.



As shown in the table, it was found that there was not much difference in the ascorbic acid content of two varieties of amaranthus at both seasons But ascorbic acid was higher during rainy season when compared to summer season in both varieties.

From the statistical analysis, it was observed that ascorbic acid was significantly higher at 20 days old leaves and were no change after 30 days of maturity, but significantly low at 10 days old leaves. It was also found that there was no significant interaction between the two seasons and varieties.

Abstract of ANOVA related to the effect of maturity levels on the nutritional composition of two varieties of amaranthus during rainy and summer season are presented in Appendix III and IV.

2. The nutritional composition of amaranthus leaves collected from different parts of the plant

The nutritional composition of amaranthus leaves collected from different parts of the plant such as the tip, middle and base portion were analysed for protein, fibre, calcium, iron and ascorbic acid contents.

Table 6 presents the protein content of the leaves collected from different parts of the plant.

Variety	Different parts	Rainy season	Summer season
Red	Tip	4.20	4.30
	Middle	4.45	4.50
	Base	4.02	4.10
Green	Tip	4.30	4.35
	Middle	4.60	4.65
	Base	4.10	4.20
$F_{1,6}$	(Variety)	0.60^{ns}	0.88^{ns}
$F_{2,6}$	(Different parts)	5.07^{ns}	3.38^{ns}

As given in table 6, protein content was higher in leaves collected from the middle portion of the plant in both the varieties at both the seasons. Unlike red variety of amaranthus in comparison to rainy season, the protein content of the green variety of amaranthus was higher during summer season Protein content of the leaves collected from the base portion was lowest in both the varieties at both the seasons. It was also observed that protein was higher in green variety at both the seasons. Leaves collected from the 'base' had less amount of protein compared to the middle and tip.

Season has little influence on the protein content of the leaves.

From the statistical analysis, it was found that, there was no significant varietal variation during rainy and summer season. Similarly significant variation was not observed at different parts during rainy and summer season. Similarly, season had no influence on the protein content of the leaves.

Table 7 presents the fiber content of the leaves from different parts of the plant, during rainy and summer season.

Table 7 Influence of different parts and seasons on the fiber content of amaranthus leaves (g/100g)

Variety	Different parts	Rainy season	Summer season
	Tip	1.04	0.97
Red	Middle	1.23	1.05
	Base	1.11	1.04
	Tip	1.06	1.00
Green	Middle	1.16	1.20
	Base	1.08	1.11
$F_{1,6}$ (Variety)		0.22^{ns}	14.16**
$F_{2,6}$ (Parts)		3.43^{ns}	10.72**
CD - (Variety) at 5%			0.0975
CD - (Different parts) at 5%			0.1195

Fiber content was found to be higher in leaves, collected from the middle part of the plant in red as well as in green varieties. Seasonal variation had no influence on the fiber content of the plant. Similarly there was no much difference in the fiber content between red and green varieties. However an increase was noted in the leaves collected from the middle part of green variety when compared to red variety in both the seasons.

Statistical analysis showed that there was no varietal difference during rainy season, but significant difference was observed during summer season. Regarding the effect of different parts on the fiber content was not significantly varying at the tip, middle and base portion. However, significant difference was observed at the middle portion during summer season.

Calcium and iron were the two minerals analysed. Table 8 presents the details of Ca content of the leaves collected from different parts of the plant of two varieties of amaranthus.

Table 8 Influence of different parts and seasons on the calcium content of amaranthus leaves (mg/100g)

Variety	Different parts	Rainy season	Summer season
Red	Tip	288 02	318.20
	Middle	335.50	351.04
	Base	315.00	341.08
Green	Tip	308.62	325.00
	Middle	350.00	364.00
	Base	334.20	352.00
$F_{1,6}$ (Variety)		194.40**	42.85**
$F_{2,6}$ (Different parts)		399.80**	195.85**
$F_{2,6}$ (V x P)		2.60^{ns}	1.28^{ns}
CD - (Variety) at 5%		3.1591	3.7379
CD - (Different parts) at 5%		3.8690	4.5779

As shown in the table, calcium content was higher in leaves collected from the middle when compared to the tip and the base of the plants of the two varieties grown in both the seasons. It was also found that calcium content was higher in green amaranthus During summer season, the calcium content of the leaves collected from the middle and basal portion of the plants of the two varieties were found to be higher, when compared to rainy season Leaves collected from the tip portion in both the varieties and during the two seasons gave lowest value for calcium content.

From the statistical analysis, it was concluded that there was significant varietal difference at both the seasons. Similarly, significant difference in the calcium content was observed at the three parts of the plant during the two seasons.

Table 9 presents the iron content of the leaves collected from the different parts of the plant during rainy and summer season

Table 9 Influence of different parts and seasons on the iron content of amaranthus leaves (mg/100g)

Variety	Different parts	Rainy season	Summer season
Red	Tip	10.30	11.70
	Middle	20.58	21.30
	Base	18.50	18.80
Green	Tip	12.20	13.89
	Middle	21.18	22.36
	Base	19.10	19.60
F1,6 (Variety)		26.69**	117.60**
F2,6 (Different parts)		858.53**	1716.60**
F2,6 (V xP)		4 691*	10.40**
CD - (Variety) at 5%		0.4894	0 3159
CD - (Different parts) at 5%		0 5994	0.3869
CD - (V x P) at 5%		0.8477	0.5472

As indicated in the table, leaves collected from the middle portion of the plant of the two varieties were found to be rich in iron content when compared to the leaves collected from the tip and basal portions at both seasons. The iron content of the leaves collected from the tip portion of the plants of the two varieties were least than the other two parts in both the seasons. Regarding the varietal variation, it was found that iron content was very high in the green variety at both the seasons.

Statistical analysis showed that there was no interaction between the two seasons but has significant varietal difference. It was also found that, at both the seasons, there was no significant difference in the iron content between the middle and base portion but significantly low at the tip.

Ascorbic acid content of the leaves collected from the different parts of the plant are presented in table 10.

Table 10 Influence of different parts and seasons on the ascorbic acid content of amaranthus leaves (mg/100g)

Variety	Different parts	Rainy season	Summer season
Red	Tip	56.00	34.00
	Middle	68 00	49.00
	Base	64.00	34.00
Green	Tip	48.00	32.00
	Middle	68.00	47.50
	Base	60.00	40.00
$F_{1,6}$ (Variety)		3.00^{ns}	1.92^{ns}
$F_{2,6}$ (Different parts)		16.33**	230.84**
CD - (Different parts) at 5%		6.9210	1.8010

As revealed in the table, there was no difference between the two varieties of amaranthus with respect to ascorbic acid at both the seasons. It was also observed that season has a slight influence on the ascorbic acid content of the two varieties. Ascorbic acid was higher during rainy season. From the table, it was also found that, compared to the tip and base portion, ascorbic acid was higher in the leaves collected from the middle portion of the plant

From the statistical analysis it was concluded that there was no varietal variation at both the seasons. however, significant difference in ascorbic acid was observed at the tip, middle and base portion during rainy and summer season.

Abstract of ANOVA related to the effect of location of leaves on the nutritional composition of the two varieties of amaranthus during rainy and summer season are presented in Appendix V and VI

3. Effect of post harvest storage on the nutritional composition of the leaves using different storage methods

The methods of Post harvest storage selected for this study were refrigeration, keeping in polythene bag, wrapping in wet cloth, dipping the roots in water and keeping it open under room temperature. The leaves collected from 20 days old green and red varieties of the amaranthus stored by these methods for different periods and the influence of storage period on the nutritional composition was assessed Besides loss of moisture the protein, fiber, calcium, iron and ascorbic acid content was determined.

The effect of storing amaranthus leaves for 24, 48 and 72 hours by different methods on the moisture content are presented in table 11.

As revealed in the table, among the different methods of storage tried, leaves packed in polythene cover and stored in refrigerator were found to conserve more moisture than the other methods. This method was followed by the method in which the leaves were stored in polythene bags and the leaves stored in water and by wrapping in wet cloth in conserving moisture. The rate of moisture loss was found to be directly proportional to the duration of storage. Between the two varieties, red amaranthus leaves were conserving more moisture than the green variety The same trend was shown in all methods of storage.

Table 11   Moisture content at different storage methods (g/100g)

Variety	Storage period	Refrigerator		Wet cloth		Dipping the roots in water		Polythene bag	
		Moisture content	Percentage loss	Moisture content	Percentage loss	Moisture content	Percentage loss	Moisture content	Percentage loss
Red Amaranthus	24 hours	87.80	0.45	86.90	1.47	87.00	1.36	87.60	0 68
	48 "	87 50	0.70	86.20	2.27	86.80	1559	87.40	0.91
	72 "	87.30	1.02	86.00	2.49	86.60	1.80	86 90	1.47
Green Amaranthus	24 hours	87.60	0.45	86.20	2.05	86.70	1.48	87.40	0.68
	48 "	87.30	0.80	86.00	2.27	86 50	1.70	87.00	1 14
	72 "	87 20	0.90	85.80	2.50	86.20	2.05	86 70	1.48

Percentage difference was worked out on the basis of the moisture content of fresh leaves

Moisture content in fresh leaves   Red amaranthus 88.2

Green amaranthus 88.0

The effect of varieties (V) storage periods and storage methods (M) and their interaction on the protein content was assessed during rainy and summer season and the results are presented in tables 12 and 13

Table 12 Effect of varieties (V) Post harvest storage periods (P) and storage methods (M) and their interaction on protein content (Rainy season) (g/100g)

Varieties	24 hours (P_1)	48 hours (P_2)	72 hours (P_3)	Refri-gerator (M_1)	Wet cloth (M_2)	Dipping the roots in water (M_3)	Poly-thene bag (M_4)	Mean (Variety)
Red Amaranthus (V_1)	3.97	4.03	4.06	4.07	3.96	4.03	4.03	4.02
Green Amaranthus (V_2)	4 16	4.21	4.23	4.18	4.22	4.19	4.20	4.20
Mean-period/ method	4.07	4.12	4.15	4.13	4.13	4.11	4.12	
Refrigerator	4.10	4.13	4.16					
Wet cloth	4.01	4.11	4.16					
Dipping the roots in water	4.09	4.11	4.14					
Polythene bag	4.08	4.13	4.13					

Table 13 Effect of varieties (V) Post harvest storage periods (P) and storage methods (M) and their interaction on protein content (Summer Season) (g/100g)

Varieties	24 hours (P_1)	48 hours (P_2)	72 hours (P_3)	Refrigerator (M_1)	Wet cloth (M_2)	Dipping the roots in water (M_3)	Polythene bag (M_4)	Mean (Variety)
Red Amaranthus (V_1)	4.10	4.12	4.15	4.15	4.11	4.12	4.12	4.13
Green Amaranthus (V_2)	4.31	4.34	4.36	4.31	4.35	4.33	4.34	4.34
Mean-period/method	4.21	4.23	4.26	4.23	4.23	4.23	4.23	
Refrigerator	4.22	4 23	4.26					
Wet cloth	4.21	4.22	4.25					
Dipping the roots in water	4.20	4.24	4.25					
Polythene bag	4.20	4.23	4.26					

As revealed in the table, in all the treatments, there was no change in the protein content of the two varieties at both the seasons.

From the statistical analysis, it was found that there was no significant difference in protein content between the two types of amaranthus at different storage methods. Similarly duration of storage has no significant influence on the protein content of the leaves of the two varieties at both the seasons. Similar trend were shown during the two seasons when the effect of different storage methods on the protein content of the leaves were compared.

The effect of varieties (V) Post harvest storage period (P) and storage methods (M) and their interaction on the fiber content of the amaranthus leaves during rainy and summer season were assessed and the results are presented in tables 14 and 15.

Table 14 Effect of varieties (V) storage period (P) and storage methods (M) and their interaction on fiber content (Rainy Season) (g/100g)

Varieties	24 hours (P_1)	48 hours (P_2)	72 hours (P_3)	Refrigerator (M_1)	Wet cloth (M_2)	Dipping the roots in water (M_3)	Polythene bag (M_4)	Mean (Variety)
Red amaranthus (V_1)	1.01	1.02	1.02	1.02	1.01	1.02	1.02	1.02
Green amaranthus (V_2)	1.20	1.22	1.24	1.23	1.21	1.21	1.22	1 22
Mean-period/ storage method	1.11	1 12	1 13	1.13	1.11	1.12	1.12	
Refrigerator	1.12	1.12	1.14					
Wet cloth	1.10	1.12	1.11					
Dipping the roots in water	1.10	1.12	1.13					
Polythene bag	1.10	1.12	1.14					

CD - (Variety) at 5% 0.1216

Table 15 Effect of varieties (V) storage period (P) and storage methods (M) and their interaction on fiber content (Summer Season) (g/100g)

Varieties	24 hours (P_1)	48 hours (P_2)	72 hours (P_3)	Refrigerator (M_1)	Wet cloth (M_2)	Dipping the roots in water (M_3)	Polythene bag (M_4)	Mean (Variety)
Red amaranthus (V_1)	0.80	0.82	0.85	0.80	0.83	0.85	0.83	0.83
Green amaranthus (V_2)	1.11	1.14	1.18	1.12	1.18	1.12	1.15	1.14
Mean-period/ storage method	0.96	0.98	1.02	0.96	1.01	0.99	0.99	
Refrigerator	0.94	0.96	0.99					
Wet cloth	0.98	0.99	1.01					
Dipping the roots in water	0.95	1.00	1.01					
Polythene bag	0.96	1.00	1.02					

CD - Variety at 5% 0.2813

As shown in the table, the fiber content of the leaves were not affected by storing in different media at different durations.

Statistical analysis showed that during summer and rainy season, among the two types of amaranthus, green amaranthus leaves had higher fiber content than that of red amaranthus and the difference was statistically significant. When comparing the seasons, the fiber content of the leaves of two varieties of the amaranthus was higher when stored during rainy season However the storage periods had no significant influence on the fiber content of the leaves of the two varieties at both the seasons.

The influence of different storage periods on the fiber content of the leaves of the two varieties indicated that there was no significant variation in the fiber content of the leaves, when stored under different methods during the two seasons.

The effect of varieties (V) storage periods (P) and storage methods (M) and their interaction on the calcium content of amaranthus leaves during rainy and summer season were assessed and are discussed in tables 16 and 17.

Table 16 Effect of varieties (V) storage periods (P) and storage methods (M) and their interaction on calcium content (Rainy Season) (mg/100g)

Varieties	24 hours (P_1)	48 hours (P_2)	72 hours (P_3)	Refrigerator (M_1)	Wet cloth (M_2)	Dipping the roots in water (M_3)	Polythene bag (M_4)	Mean (Variety)
Red amaranthus (V_1)	367.50	368.20	368.90	367.70	368.80	368.30	368.10	368.20
Green amaranthus (V_2)	379.40	380.10	380.90	379.60	381.10	380.10	379.80	380.20
Mean-periods/ method	373.50	374.20	374.90	373.70	375.00	374 20	374.00	
Refrigerator	373.10	373.70	374.30					
Wet cloth	374.00	375.00	376.00					
Dipping the roots in water	373.00	374.20	374.80					
Polythene bag	373.40	374.00	374.00					

CD - (Variety) at 5% 0.0965

Table 17 Effect of varieties (V) storage periods (P) and storage methods (M) and their interaction on calcium content (Summer Season) (mg/100g)

Varieties	24 hours (P_1)	48 hours (P_2)	72 hours (P_3)	Refrigerator (M_1)	Wet cloth (M_2)	Dipping the roots in water (M_3)	Polythene bag (M_4)	Mean (Variety)
Red amarantnus (V_1)	372.70	374.10	375.70	373.50	375.00	374.00	373.70	374.20
Green amaranthus (V_2)	386.30	387.20	388.30	386.50	387.90	387.40	387.20	387.30
Mean-periods/ method	379.50	380.70	382.00	380.00	381.50	381.00	380.50	
Refrigerator	379.00	380.00	381.00					
Wet cloth	379.90	381.50	383.00					
Dipping the roots in water	379.70	380.90	382.50					
Polythene bag	379.50	380.30	381.50					

CD - (Variety) at 5% 2.0563

As revealed in the table, the calcium content of stored greens was slightly higher as compared to the fresh leaves, mainly due to the moisture loss from the leaves during storage.

The calcium content of amaranthus varieties were significantly varying during both the seasons. Between the two varieties, the calcium content was found to be more in green amaranthus. Among different storage methods, leaves stored in wet cloth were found to give a higher value for calcium, than other media during both the seasons, and but it was not statistically significant. Similarly, no significant difference in the calcium content of both the varieties at different periods of storage were noticed.

The effect of varieties (V) storage periods (P) and storage methods (M) on the iron content of amaranthus leaves during rainy and summer season were assessed and are discussed in tables 18 and 19.

Table 18 Effect of varieties (V) storage periods (P) and storage methods (M) and their interaction on iron content (Rainy Season) (mg/100g)

Varieties	24 hours (P_1)	48 hours (P_2)	72 hours (P_3)	Refrigerator M_1)	Wet cloth (M_2)	Dipping the roots in water (M_3)	Polythehe bag (M_4)	Mean (Variety)
Red amaranthus (V_1)	22.38	22.47	22.57	22.31	22.63	22.40	22.55	22.47
Green amaranthus (V_2)	26.02	26.16	26.30	25.92	26.48	26.02	26.22	26.16
Mean-period/ method	24.20	24.32	24.44	24.12	24.56	24.21	24.39	
Refrigerator	24.05	24.12	24.18					
Wet cloth	24.44	24.54	24.68					
Dipping the roots in water	24.13	24.19	24.32					
Polethene bag	24.20	24.41	24.56					

CD (Variety) at 5% 0.0799

Table 19 Effect of varieties (V) storage periods (P) and storage methods (M) and their interaction on iron content (Summer Season) (mg/100g)

Varieties	24 hours (P_1)	48 hours (P_2)	72 hours (P_3)	Refrigerator (M_1)	Wet cloth (M_2)	Dipping the roots in water (M_3)	Polythene bag (M_4)	Mean Variety
Red amaranthus (V_1)	23.47	23.62	23.54	23.49	23.60	23.53	23.54	23.54
Red amaranthus (V_2)	27.37	27.52	27.45	27.39	27.52	27.42	27.46	27.44
Mean-period/method	25.42	25.57	25.50	25.44	25.57	25.48	25.50	
Refrigerator	25.37	25.51	25.44					
Wet cloth	25.48	25.56	25.06					
Dipping the roots in water	25.41	25.47	25.55					
Polythene bag	25.44	25.50	25.57					

CD-(Variety) at 5% 0.0156

As revealed in the table, the iron content of stored greens were found to be slightly higher during the two seasons when compared to the fresh leaves mainly due to the moisture loss from the leaves during storage.

Statistical analysis showed significant varietal difference in both the seasons. Between the varieties iron content was found to be more in green amaranthus in both the seasons, as in the normal fresh leaves. With respect to the storage periods, the leaves stored for 72 hours were giving higher values than 24 and 48 hours of storage. Among different storage methods, leaves stored by wrapping in wet cloth was giving higher values for iron than other methods at both the seasons, but it was not found to have any statistical significance.

The effect of varieties (V) storage period (P) and storage methods (M) and their interaction on the ascorbic acid content was assessed during rainy and summer season and the results are presented in tables 20 and 21.

Table 20 Effect of varieties (V) storage periods (P) and storage methods (M) and their interaction on ascorbic acid content (Rainy Season) (mg/100g)

Varieties	24 hours (P_1)	48 hours (P_2)	72 hours (P_3)	Refrigerator (M_1)	Wet cloth (M_2)	Dipping the roots in water (M_3)	Polythene bag (M_4)	Mean (Variety)
Red amaranthus (V_1)	87.50	77.00	64.80	89.70	62.00	73.30	80.70	76.40
Green amaranthus (V_2)	84.50	72.50	59.50	86.00	60.00	65.30	75.30	72.20
Mean-period/method	86.00	74.80	62.20	87.90	61.00	69.30	78.00	
Refrigerator	93.00	88.00	82.50					
Wet cloth	79.00	61.00	43.00					
Dipping the roots in water	84.00	71.00	56.00					
Polythene bag	88.00	79.00	67.00					

CD - (Variety) at 5% 3.393
CD (Periods) at 5% 4.156
CD - (Methods) at 5% 4.799
CD - (P x M) at 5% 6.134

Table 21 Effect of varieties (V) storage periods (P) and storage methods (M) and their interaction on ascorbic acid content (Summer Season) (mg/100g)

Varieties	24 hours (P_1)	48 hours (P_2)	72 hours (P_3)	Refrigerator (M_1)	Wet cloth (M_2)	Dipping the roots in water (M_3)	Polythene bag (M_4)	Mean Variety
Red amaranthus (V_1)	61.50	50.50	40.50	62.00	42.70	48.00	50.70	50.80
Green amaranthus (V_2)	57.50	46.00	37.50	58.00	39.30	43.30	47.30	47.00
Mean-period/method	59.50	48.30	39.00	60.00	41.00	45.70	49.00	
Refrigerator	66.00	60.00	54.00					
Wet cloth	54.00	38.00	31.00					
Dipping the roots in water	58.00	45.00	34.00					
Polythene bag	60.00	50.00	37.00					

CD - (Variety) 3 685
CD - (Storage methods) 5.212
CD - (Periods) 4.513

As indicated in the table, in all the methods, the ascorbic acid content of the two varieties of amaranthus during the two seasons, were found to be decreased after 24, 48 and 72 hours of storage Among the methods keeping at low temperature in refrigerator was found to be better in conserving the nutrient at different durations of storage. This was followed by storing in polythene bags and by dipping the roots in water Least response was noticed by storing in wet cloth.

Statistical analysis showed that, in both the seasons, varietal variation was found to be significant and the rate of loss of ascorbic acid from green amaranthus was more than that of red amaranthus Similarly, significant difference among the methods showed that refrigerator was the best method for storing greens and wet cloth was found to be the least and it was also noticed that the loss of the nutrient increased as the storage period lengthened

Abstract of ANOVA related to the effect of storage periods and storage methods on the nutritional composition of the two varieties of amaranthus leaves during rainy and summer season are presented in Appendix VII and VIII

4 Different cooking methods

Cooking methods selected for the study were boiling in water, frying, baking and steaming.

The effect of different cooking methods viz , boiling in water, frying, baking and steaming on the protein content of the amaranthus leaves are presented in table 22.

Table 22 Protein content of leaves cooked by different methods (g/100g)

Variety (Va)	Cooking methods (Me)	Rainy season	Summer season
Red Amaranthus	Boiling	3.75	3.90
	Frying	3.85	4.00
	Baking	3.97	4.04
	Steaming	3.98	4.08
Green Amaranthus	Boiling	3.80	4.10
	Frying	3.90	4.00
	Baking	4.00	4.20
	Steaming	4.10	4.25
$F_{1,8}$	Va	0.07^{ns}	3.66^{ns}
$F_{3,8}$	Me	1.40^{ns}	1.88^{ns}
$F_{3,8}$	Va Me	0.07^{ns}	0.43^{ns}

As revealed in the table, protein content of the leaves were slightly affected by different cooking methods

Statistical analysis showed no significant difference in the protein content of the two varieties at both the seasons under different methods of cooking Among the different cooking methods steaming were found to be comparatively better but was not statistically significant. Similarly seasonal variation was also absent.

The fiber content of the leaves cooked by boiling, frying, baking and steaming are presented in the table 23.

Table 23 Fiber content of leaves cooked by different methods (g/100g)

Variety (Va)	Cooking methods (Me)	Rainy season (S)	Summer season (S_2)
Red Amaranthus	Boiling	0.90	0.70
	Frying	1.00	0.80
	Baking	0.90	0./0
	Steaming	1.00	0.80
Green Amaranthus	Boiling	1.00	1.00
	Frying	1.10	1.15
	Baking	1.10	1.00
	Steaming	1.20	1.10
$F_{1,8}$	Va	4.00^{ns}	13.86**
$F_{3,8}$	Me	0.74^{ns}	0.61^{ns}
$F_{3,8}$	Va,Me	0.148	0.02^{ns}

CD - (Variety) at 5% (S_2) 0.1933

As revealed in the table, the crude fiber content of the amaranthus leaves were not affected by the different cooking methods.

As shown in the table, the different cooking methods had no significant influence on the fiber content of the leaves of the two varieties of amaranthus at both the seasons. However during summer season, varietal variation was found to be significant while during rainy season, there was no significant difference between the two varieties

The effect of different cooking methods on the calcium content of amaranthus leaves of the two varieties grown during rainy and summer season were determined and the results are presented in table 24.

Table 24 Calcium content of leaves cooked by different methods (mg/100g)

Variety (Va)	Cooking methods (Me)	Rainy season	Summer season
Red Amaranthus	Boiling	282 00	283.00
	Frying	277.00	277.00
	Baking	292.00	297.00
	Steaming	298 00	303 00
Green Amaranthus	Boiling	295.00	298.00
	Frying	288.00	296.00
	Baking	300.00	306.00
	Steaming	314.00	317.00
$F_{1,8}$	Va	11.50**	135.38**
$F_{3,8}$	Me	82.20**	75.93**
$F_{3,8}$	Va x Me	2.26^{ns}	2.81^{ns}
CD - (Variety) at 5%		2.5782	2.8243
CD - (Methods) at 5%		3.6461	3.9941

As presented in the table, after cooking the calcium content of the leaves in general were found to decrease at both the seasons Among the different cooking methods applied steaming and baking were the two methods in which the calcium conserved in comparison with boiling and frying. Between the two varieties, rate of loss of calcium in red amaranthus was more but no difference between the two seasons.

Statistical analysis showed, significant varietal difference at both the seasons. Similarly, the effect of different cooking methods were also found to be statistically significant and the retention of calcium in steam cooked leaves were more when compared to other methods of cooking at both the seasons

The influence of different cooking methods on the iron content of amaranthus leaves of the two varieties were assessed at two seasons and the results obtained are given in table 25.

Table 25 Iron content of leaves cooked by different methods (mg/100g)

Variety (Va)	Cooking methods (Me)	Rainy season	Summer season
Red Amaranthus	Boiling	14.40	14.90
	Frying	15.90	16.90
	Baking	16.30	17.20
	Steaming	18.40	19.10
Green Amaranthus	Boiling	17.40	17.80
	Frying	19.60	19.20
	Baking	20.20	20.40
	Steaming	21.90	22.50
$F_{1,8}$	Va	994.05**	847.05**
$F_{3,8}$	Me	244.18**	323 22**
$F_{3,8}$	Va Me	2 98^{ns}	3.60^{ns}
CD - (Variety) at 5%		0.2578	0.2377
CD - (Methods) at 5%		0.3646	0.3362

As presented in the table, cooking results in the loss of iron from both the varieties of amaranthus at both the seasons Among the cooking methods, steaming was found to be better in conserving the iron content of the leaves at both the seasons With respect to the varieties, the rate of iron was found to be uniform at both the seasons

Statistical analysis showed, significant varietal difference at both the seasons. Similarly, the effect of different methods were also found to be statistically significant and steaming method was considered to be better in conserving this nutrient and the retention was least in 'boiling method'.

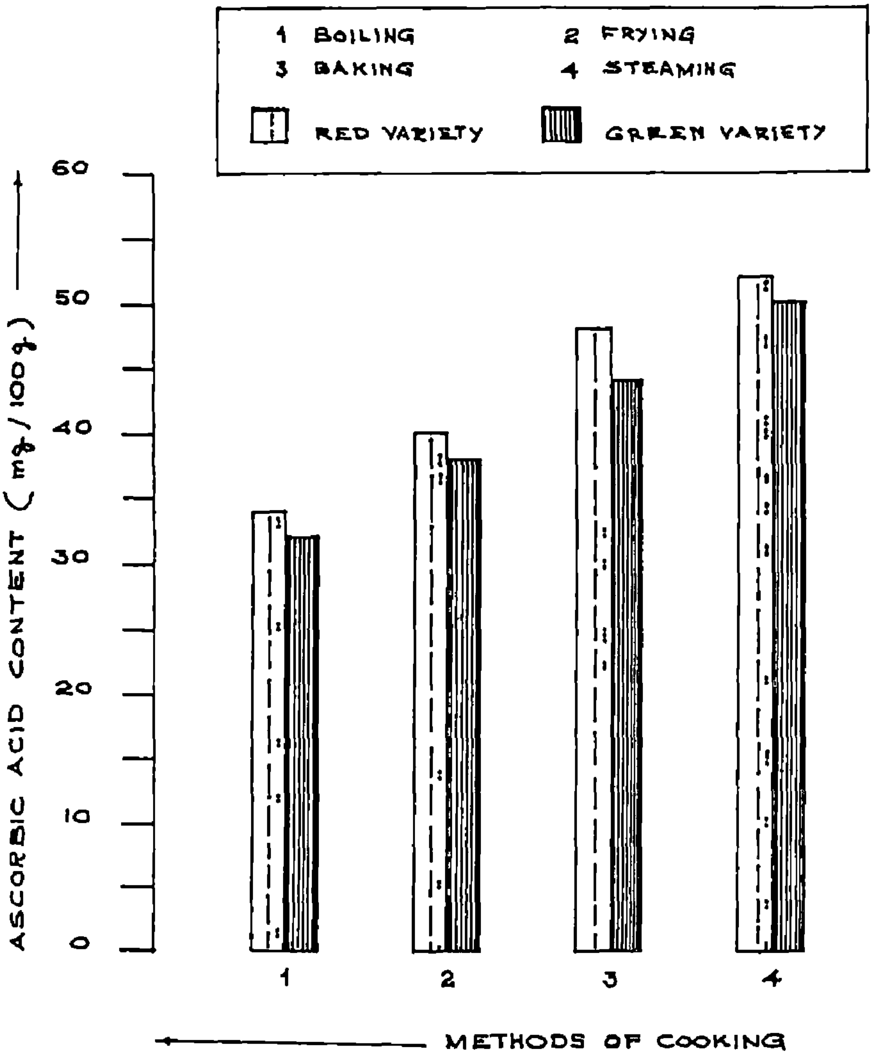
Effect of different cooking methods on the ascorbic acid content of amaranthus leaves were assessed and the results are presented in table 26.

Table 26 Ascorbic acid content of leaves cooked by different methods (mg/100g)

Variety (Va)	Cooking methods (Me)	Rainy season	Summer season
Red Amaranthus	Boiling	34.00	24.00
	Frying	40.00	32.00
	Baking	48.00	36.00
	Steaming	52.00	40.00
Green Amaranthus	Boiling	32.00	22.00
	Frying	38 00	30.00
	Baking	44.00	34.00
	Steaming	50.00	38.00
$F_{1,8}$ Va		3.71^{ns}	3.58^{ns}
$F_{3,8}$ Me		39.24**	29 61**
$F_{3,8}$ Va x Me		0.19^{ns}	0.18^{ns}
CD - (Methods) at 5%		4.3141	4.3405

FIG 3 EFFECT OF DIFFERENT METHODS OF COOKING ON THE ASCORBIC ACID CONTENT OF RED AND GREEN VARIETIES OF AMARANTHUS

SCALE - 1 Cm = 5 mg



As presented in the table, the loss of ascorbic acid was found to be high when cooking the greens by different methods. Among the cooking methods, boiling in water results in higher losses when compared to other methods of cooking and ascorbic acid was better in steam cooked leaves in both the seasons. Similarly the rate of loss of ascorbic acid from the two varieties, when different cooking methods applied, were found to be uniform.

From the statistical analysis it was revealed that "steaming" was better in cooking greens and was statistically significant to other methods of cooking. However, varietal variation was found to be absent in both the seasons.

Abstract of ANOVA related to the effect of different methods of cooking on the nutritional composition of the two varieties of amaranthus during rainy and summer season are presented in Appendix IX and X.

5. Different cooking vessels

The effect of cooking in different types of vessels, such as aluminium, steel, alloy, iron, copper and mudpot on the protein content of amaranthus leaves were assessed and the results are presented in tables 27 and 28.

Table 27 Effect of varieties (V) cooking methods (M) and cooking vessels (C) and their interaction on the protein content (Rainy Season) (g/100g)

	Boiling (M_1)	Frying (M_2)	Aluminium (C_1)	Steel (C_2)	Alloy (C_3)	Iron (C_4)	Copper (C_5)	Mud pot (C_6)	Mean (Variety)
Red Amaranthus (V_1)	4.00	4.04	4.06	4.02	4.03	4.00	4.03	4.00	4.02
Green Amarantnus (V_2)	4.14	4.15	4.14	4.13	4.11	4.15	4.18	4.20	4 15
Mean-Methods/ vessels	4.07	4.10	4 10	4.08	4.07	4.08	4.11	4.10	.
Aluminium (C_1)	4.10	4.08							
Steel (C_2)	4 06	4.09							
Alloy (C_3)	4.05	4.09							
Iron (C_4)	4.08	4.07							
Copper (C_5)	4.08	4.13							
Mudpot (C_6)	4 08	4.13							

Table 28 Effect of varieties (V) cooking methods (M) and cooking vessels (C) and their interaction on the protein content (Summer Season) (g/100g)

	Boiling (M_1)	Frying (M_2)	Aluminium (C_1)	Steel (C_2)	Alloy (C_3)	Iron (C_4)	Copper (C_5)	Mudpot (C_6)	Mean (Variety)
Red Amaranthus (V_1)	4 13	4.12	4.09	4 11	4.13	4 17	4 14	4 13	4 13
Green Amaranthus (V_2)	4.32	4 33	4 26	4 33	4 34	4 33	4 36	4 34	4 33
Mean-Methods/ Vessels	4.23	4 23	4 18	4.22	4.24	4.25	4 25	4 24	
Aluminium (C_1)	4.19	4.16							
Steel (C_2)	4.20	4.24							
Alloy (C_3)	4 20	4 27							
Iron (C_4)	4.27	4 23							
Copper (C_5)	4.26	4.24							
Mudpot (C_6)	4.25	4 22							

As shown in the table, the protein content of the two varieties of amaranthus had no change when cooking in different types of vessels. Similar results were obtained in both the varieties grown during rainy as well as summer season.

On analysis of the data it was found that no significant difference between the varieties grown during two seasons could be observed when cooked by different methods with respect to the protein content. Similarly while cooking, different types of vessels were found to have no significant influence on the protein content of the two varieties of amaranthus grown during two seasons.

The effect of varieties (V) cooking methods (M) and cooking vessels and their interaction on the fiber content of the two varieties of amaranthus grown during rainy and summer season were assessed and the results are presented in tables 29 and 30.

Table 29 Effect of varieties (V) cooking methods (M) and cooking vessels (C) and their interaction on the fiber content (Rainy Season) (g/100g)

	Boiling (M_1)	Frying (M_2)	Aluminium (C_1)	Steel (C_2)	Alloy (C_3)	Iron (C_4)	Copper (C_5)	Mudpot (C_6)	Mean (Variety)
Red Amaranthus (V_1)	1.02	1.03	1.03	1.02	1.03	1.01	1.02	1.03	1.03
Green Amaranthus (V_2)	1.15	1.14	1.15	1.15	1.17	1 16	1 12	1.14	1.15
Mean-Methods/ Vessels	1.09	1.09	1.09	1.09	1.10	1.09	1 07	1.09	
Aluminium (C_1)	1.10	1.08							
Steel (C_2)	1.08	1.09							
Alloy (C_3)	1.10	1.09							
Iron (C_4)	1.09	1.07							
Copper (C_5)	1.05	1.08							
Mudpot (C_6)	1.09	1.08							

CD (Variety) at 5% 0.01119

Table 30 Effect of varieties (V) cooking methods (M) and cooking vessels (C) and their interaction on the fiber content (Summer season) (g/100g)

	Boiling (M_1)	Frying (M_2)	Aluminium (C_1)	Steel (C_2)	Alloy (C_3)	Iron (C_4)	Copper (C_5)	Mud pot (C_6)	Mean (Variety)
Red Amaranthus (V_1)	0.82	0.83	0.86	0.80	0.80	0 79	0.84	0.85	0.83
Green Amaranthus (V_2)	1.09	1.10	1.11	1.14	1 09	1.08	1 06	1.11	1.10
Mean-Methods/ Vessels	0.96	0.97	0.99	0.97	0.95	0.94	0.95	0.98	
Aluminium (C_1)	1.00	0.97							
Steel (C_2)	0.97	0.97							
Alloy(C_3)	0.94	0.95							
Iron (C_4)	0.93	0.94							
Copper (C_5)	0 94	0.96							
Mudpot (C_6)	0.97	0.99							

CD - (Variety) at 5% 0.1209

From the tables, it can be seen that the different types of vessels had no influence on the fiber content of the amaranthus leaves when cooked by frying and boiling.

With respect to the two cooking methods the fiber content in the two varieties of amaranthus leaves did not differ significantly during the two seasons. Similarly the types of vessels used for cooking had no significant influence on the fiber content of the amaranthus leaves grown during rainy and summer seasons.

The effect of varieties (V) cooking methods (M) and cooking vessels (V) and their interaction on the calcium content of amaranthus leaves grown during rainy and summer season were assessed and the results are presented in tables 31 and 32.

Table 31 Effect of varieties (V) cooking methods (M) cooking vessels (C) and their interaction on the calcium content (Rainy Season) (mg/100g)

	Boiling (M_1)	Frying (M_2)	Aluminium (C_1)	Steel (C_2)	Alloy (C_3)	Iron (C_4)	Copper (C_5)	Mud-pot (C_6)	Mean (Variety)
Red Amaranthus (V_1)	292.00	289.00	307.80	298.90	289.20	286.00	282.20	278.90	290.50
Green Amaranthus (V_2)	311.00	302.70	317.00	310.30	308.00	306.20	300.70	298.00	306.90
Mean-Methods/ Vessels	301.50	295.90	312.40	304.60	298.60	296.10	291.50	288.80	.
Aluminium (C_1)	313.10	311.70							
Steel (C_2)	306.70	302.50							
Alloy (C_3)	299.40	297.80							
Iron (C_4)	297.50	294.70							
Copper (C_5)	298.20	284.80							
Mudpot (C_6)	294.00	283.50							
CD - Variety at 5%	12.2695								

Table 32 Effect of varieties (V) cooking methods (M) cooking vessels (C) and their interaction on the calcium content (Summer Season) (mg/100g)

	Boiling (M_1)	Frying (M_2)	Aluminium (C_1)	Steel (C_2)	Alloy (C_3)	Iron (C_4)	Copper (C_5)	Mud pot (C_6)	Mean (Variety)
Red Amaranthus (V_1)	298.00	290.40	307.00	300.50	292.50	294.80	289 30	283.00	294 50
Green Amaranthus (V_2)	303.40	300.90	311.30	310.00	300.50	302.00	290.00	299.30	302.20
Mean-Methods/ Vessels	301.00	295.70	309.20	305.30	296.50	298.40	289.70	291.20	
Aluminium (C_1)	307.30	311.00							
Steel (C_2)	306.30	304.30							
Alloy (C_3)	302.50	290.50							
Iron (C_4)	303.30	293.50							
Copper (C_5)	291.30	288.00							
Mudpot (C_6)	295.50	286.80							

CD - (Variety) at 5% 4 0528

As indicated in the tables, different types of vessels had no specific effect on the calcium content of the amaranthus leaves, eventhough there was considerable loss during cooking.

As shown in tables different types of cooking vessels during cooking had no significant influence on the calcium content of the two varieties of amaranthus leaves, grown during two seasons.

Effect of varieties (V) cooking methods (M) and cooking vessels (C) on the iron content of amaranthus leaves grown during rainy and summer season were assessed and the results are presented in tables 33 and 34.

Table 33 Effeect of varieties (V) cooking methods (M) and cooking vessels (C) and their interation on iron content (Rainy Season) (mg/100g)

	Boiling (M_1)	Frying (M_2)	Aluminium (C_1)	Steel (C_2)	Alloy (C_3)	Iron (C_4)	Copper (C_5)	Mud pot (C_6)	Mean (Variety)
Red Amaranthus (V_1)	17.59	18.58	14.82	14.72	15.61	33 97	15 52	14.78	18.09
Green Amaranthus (V_2)	20.31	22.12	18 98	18.55	18.25	35 70	17 93	17.90	21.22
Mean-Method/ Vessels	18.95	20.35	16.90	16.64	16.93	34.84	16.73	16 34	.
Aluminium (C_1)	16.49	17.30							
Steel (C_2)	16 38	16.90							
Alloy (C_3)	16 25	17.61							
Iron (C_4)	33 17	36.50							
Copper (C_5)	15.52	17.03							
Mudpot(C_6)	16.92	16 75							
CD - (Variety) at 5%	0.6450								
CD -(Vessels) at 5%	1.1172								

Table 34 Effect of varieties (V) cooking methods (M) cooking vessels (C) and their interaction on iron content (Summer Season) (mg/100g)

	Boiling (M_1)	Frying (M_2)	Aluminium (C_1)	Steel (C_2)	Alloy (C_3)	Iron (C_4)	Copper (C_5)	Mud pot (C_6)	Mean (Variety)
Red Amaranthus (V_1)	17.59	18.58	14.82	14.72	15.61	33.97	15.52	14.78	18.09
Green Amaranthus (V_2)	20.31	22.12	18.98	18.55	18.25	35.70	17.93	17.90	21.22
Mean-Method/ Vessels	18.95	20.35	16.90	16.64	16.93	34.84	16.73	16.34	..
Aluminium (C_1)	16.49	17.30							
Steel (C_2)	16 38	16.90							
Alloy (C_3)	16.25	17.61							
Iron (C_4)	33.17	36.50							
Copper (C_5)	15.52	17.03							
Mudpot (C_6)	16.92	16.75							

CD - (Variety) at 5% 0.6635

CD - (Vessels) at 5% 1.1493

As presented in the table the iron content of the leaves cooked in iron vessel were found to be very high when compared to other types of vessels.

Among the cooking vessels, the iron vessel was found to influence significantly the iron content of the amaranthus leaves at both the seasons. The iron content of the leaves cooked in all the vessels, except iron vessel were found to be the same. However when cooked in iron vessel, the iron content of the two varieties were found to be very high during the two seasons.

The effect of varieties (V) cooking methods (M) and cooking vessels (C) and their interaction on the ascorbic acid content of amaranthus leaves were assessed in two seasons and the results are presented in tables 35 and 36.

Table 35 Effect of varieties (V) cooking methods (M) cooking vessels (C) and their interaction on the ascorbic acid content (Rainy Season) (mg/100g)

	Boiling (M_1)	Frying (M_2)	Aluminium (C_1)	Steel (C_2)	Alloy (C_3)	Iron (C_4)	Copper (C_5)	Mud pot (C_6)	Mean (Variety)
Red Amaranthus (V_1)	38.30	36.00	46.00	43.00	43.00	28.00	19.00	44.00	37 21
Green Amaranthus (V_2)	33.00	32.00	41.00	38.00	39.00	23.00	16.00	38.00	32.50
Mean-Method/ Vessels	35 65	34.00	43.50	40.50	41.00	25.50	17.50	41.00	.
Aluminium (C_1)	45.00	42.00							
Steel (C_2)	41.00	40.00							
Alloy (C_3)	44.00	38.00							
Iron (C_4)	25.00	26.00							
Copper (C_5)	16.00	19.00							
Mudpot (C_6)	43.00	39.00							

CD - (C) at 5% 4.128

Table 36 Effect of varieties (V) cooking methods (M) cooking vessels (C) and their interation on the ascorbic acid content (Summer Season) (mg/100g)

	Boiling (M_1)	Frying (M_2)	Aluminium (C_1)	Steel (C_2)	Alloy (C_3)	Iron (C_4)	Copper (C_5)	Mud pot (C_6)	Mean (Variety)
Red Amaranthus (V_1)	30.00	29.00	35.00	33.00	35.00	23.00	14.00	37.00	29.50
Green Amaranthus (V_2)	26.70	24.70	21.00	29.00	32.00	20.00	10.00	32.00	25.70
Mean-Methods/ Vessels	28.40	26.90	33.00	31.00	33.50	21 50	12 00	34.50	..
Aluminium (C_1)	34.00	32.00							
Steel (C_2)	32.00	30.00							
Alloy (C_3)	33.00	34.00							
Iron (C_4)	25.00	18.00							
Copper (C_5)	10.00	14.00							
Mudpot (C_6)	36.00	33.00							

CD (C) at 5% 10.870.

As shown in the table, it can be noticed that loss of ascorbic acid was found to be very high when cooked in copper and iron vessels as compared to other types of vessels.

On statistical analysis of the data, it was found that no varietal variation during the two seasons could be noticed when the samples were cooked in different vessels. Similarly no significant difference was observed among different cooking methods. However, the influence of cooking vessels, especially copper and iron vessels were found to be significant at both the seasons in the two varieties of amaranthus.

Abstract of ANOVA related to the effect of different types of cooking vessels on the nutritional composition of the two varieties of amaranthus during rainy and summer season are presented in Appendix XI and XII.

b <u>Organoleptic qualities and acceptability</u>

1. <u>Organoleptic qualities of the leaves of different varieties of amaranthus</u>

Organoleptic qualities of the two varieties of amaranthus leaves collected at 20 days of maturity during the two seasons are presented in table 37.

Table 37 presents the mean scores obtained for the organoleptic qualities of the two varieties of amaranthus collected at 20 days of maturity during two distinct seasons

Table 37 Influence of seasons on the organoleptic qualities of two varieties of amaranthus leaves

Varieties	Colour		Doneness		Tenderness		Odour		Taste	
	Rainy season	Summer season	Rainy season	Summer season	Rainy season	Summer season	Rainy season	Summer season	Rainy season	Summer season
Red Amaranthus (V_1)	5.00	5.00	4.70	4.70	5.00	5.00	5.00	4.80	4.70	4.70
Green Amaranthus (V_2)	4.80	4.80	4.50	4.50	4.80	4.80	4.80	4.80	4.70	4.70
Mean	4.90	4.90	4.60	4.60	4.90	4.90	4.90	4.80	4.70	4.70

From the table, it can be seen that there was no significant difference in the mean scores obtained for the plants grown during the two seasons with respect to all the qualities. Between the varieties, red amaranthus was found to obtain higher scores for all the qualities, but was not statistically significant

2. Organoleptic qualities of the leaves collected from different parts of the plant

Table 38 presents the mean scores obtained for colour for the leaves collected from tip, middle and base part of red and green amaranthus grown during the two seasons.

Table 38 Influence of seasons and position of leaf on the amaranthus plant in terms of quality parameter - colour

Varieties	Rainy Season				Summer Season			
	Location of leaves in the plant				Location of leaves in the plant			
	Tip	Middle	Base	Mean	Tip	Middle	Base	Mean
Red Amaranthus	4.83	4.83	4.33	4.67	5.00	5.00	4.83	4.94
Green Amaranthus	4.67	4.33	4.17	4.39	5.00	4.83	4.50	4.78
Mean	4.75	4.58	4.25	..	5.00	4.92	4.67	.

CD - for different parts at 5% 0.443

CD - for different parts at 5% 0.271

From the data, it can be observed that, there was significant difference in the mean scores obtained for the colour of the leaves collected from the tip of the plant, compared to the leaves collected from the base portion during the two seasons. In this context, varietal variation was found to be not significant However, the mean scores obtained for red amaranthus in all respects were higher than those for green amaranthus.

The mean scores obtained for doneness of the leaves collected from different parts of the amaranthus plants of two varieties during rainy and summer season are given in table 39.

Table 39 Influence of seasons and position of leaf on the amaranthus plant in terms of quality parameter - doneness

Varieties	Rainy Season				Summer Season			
	Tip	Middle	Base	Mean (Varieties)	Tip	Middle	Base	Mean (Varieties)
Red Amaranthus	4.67	4.50	4.00	4.39	4.83	5.00	4.83	4.89
Green Amaranthus	4 83	4.33	4.17	4 44	4.83	5.00	4.50	4 78
Mean	4.75	4.42	4.08	.	4.83	5.00	4.67	..

CD - for different parts at 5% 0.304

Significant difference in the mean score was obtained for doneness for the leaves collected from middle and base portion of the two varieties of amaranthus grown during summer season Varietal variation was found to be not significant during the two seasons.

The mean score obtained for tenderness of the leaves collected from different parts of the two varieties of amaranthus during the two seasons are presented in table 40.

Table 40 Influence of seasons and position of leaf on the amaranthus plant in terms of quality parameter-Tenderness

Varieties	Rainy Season				Summer Season			
	Tip	Middle	Base	Mean (Varieties)	Tip	Middle	Base	Mean (Varieties)
Red Amaranthus	3.50	4.00	3.83	3.78	4.83	4.83	4.50	4.72
Green Amaranthus	3.67	4.00	3 83	3.83	4.67	4.67	4.67	4.67
Mean	3 58	4.00	3 83	.	4.75	4.75	4 58	

As indicated in the table, mean scores obtained for tenderness for the leaves of the two varieties of amaranthus grown during the two seasons had no significant variation. Similarly the varietal variation in this context was also found to be not significant.

The mean scores obtained for odour of the leaves collected from different parts of the two varieties of amaranthus grown during the two seasons are presented in table 41.

Table 41 Influence of seasons and position of leaf on the amaranthus plant in terms of quality parameter - Odour

Varieties	Rainy Season				Summer Season			
	Tip	Middle	Base	Mean (Varieties)	Tip	Middle	Base	Mean (Varieties
Red Amaranthus	4 50	4.50	4.33	4.44	5.00	5.00	4.83	4.94
Green Amaranthus	4.83	4.50	4.00	4.44	5.00	4 83	5 00	4.94
Mean	4.67	4 50	4.17	.	5.00	4.92	4.92	..

As shown in the table, there was no significant variation in the mean scores obtained for odour for the leaves collected from different parts of the plant of the two varieties during the two seasons Similarly, varietal variation was also found to be not significant during rainy and summer season.

The mean scores obtained for taste of the leaf samples collected from different parts of the two varieties of amaranthus grown during two distinct seasons are presented in table 42

Table 42 Influence of seasons and position of leaf on the amaranthus plant in terms of quality parameter - Taste

Varieties	Rainy Season				Summer Season			
	Tip	Middle	Base	Mean (Varieties)	Tip	Middle	Base	Mean (Varieties)
Red Amaranthus	4.33	4 17	4 00	4 17	4 83	5 00	4 50	4.78
Green Amaranthus	4 33	3 67	3 83	3 94	4 67	5 00	4.17	4 61
Mean	4.33	3 92	3.92		4.75	5.00	4.33	

CD - for different parts at 5% 0 323

As revealed in the table, there was significant difference in the mean scores obtained for taste of the leaves collected from the middle of the plant in comparison to the base portion during summer season

However, during rainy season, the leaves collected from the different parts of the plants of the two varieties did not show any significant variation in the mean scores obtained for taste Between the two varieties, higher scores were obtained for red amaranthus, but when statistically analysed the variation was not significant

Abstract of ANOVA related to the effect of location of leaves on the organoleptic qualities of the two varieties are presented in Appendix XIII and XIV.

3. Organoleptic qualities of the two varieties of amaranthus stored by different methods for different durations

The mean scores obtained for colour of the leaves of two different varieties of amaranthus grown during the distinct seasons and stored by different methods for different periods such as 24 hours, 48 hours and 72 hours are presented in table 43

Table 43 Influence of varieties, seasons, storage periods and storage methods on the quality parameter of the amaranthus leaves - Colour

Storage methods	Seasons		Varieties		Periods			Mean (Storage methods)
	Rainy season	Summer season	Red amaranthus	Green amaranthus	24 hous	48 hours	72 hours	
Refrigerator	4.14	4.69	4.58	4.25	4.75	4.46	4.04	4.42
Wet cloth	4.25	4.47	4.42	4.31	4.75	4.29	4.04	4 36
Dipping the roots in water	3 92	4.25	4.28	3.89	4 54	4.17	3 54	4.08
Polythene bag	4.06	4 36	4.37	4.11	4.71	4.25	3 o7	4.21
Mean	4.09	4.45	4.40	4.14	4.69	4 29	3.82	..
	CD - Season at 5% 0.144		CD - for varieties at 5% 0.144		CD - for periods 0.176		CD - for storage methods at 5% 0 204	

As revealed in the table, there was significant difference in the scores obtained for the colour of the leaves of the two varieties when stored for different durations by different methods, during the two seasons. The leaves harvested during summer season had higher scores for colour compared to those grown during rainy season Between the two varieties, the colour of the red variety appeared to be better It was also found that the leaves stored for 72 hours gave minimum scores and leaves stored for 24 hours had maximum scores. Similarly, among the different storage methods tried, leaves stored in refrigerator gave the highest score for colour while the lowest score was recorded in leaf samples stored by "dipping the roots in water' The decreasing colour imparted on the samples was observed to be in the order refrigerator, wet cloth, polythene bag and dipping the roots in water.

The table 44 presents the variation in the mean scores obtained for colour of the leaves of the two different varieties of amaranthus when stored for different periods during the two seasons.

Table 44 Influence of seasons and storage periods on the quality parameter of the leaves of two varieties of amaranthus - Colour

Varieties	Season		Storage periods			Mean (Varieties)
	Rainy season	Summer season	24 hours	48 hours	72 hours	
Red Amaranthus	4.22	4.57	4.81	4.46	3.92	4.40
Green Amaranthus	3.96	4.32	4.56	4.13	3.73	4.14
Mean	4.09	4.45	4.69	4.29	3.82	..

From the data presented in the table, there was no significant interaction in the mean scores obtained for colour of the leaves of the two varieties of amaranthus during the two seasons and when stored for different periods.

Table 45 presents details about the variation in the mean scores obtained during the two seasons at different storage periods

Table 45 Influence of storage period on the quality parameter of amaranthus leaves grown during different seasons - Colour

Seasons	Storage periods			Mean (seasons)
	24 hours	48 hours	72 hours	
Rainy season	4.50	4.15	3.03	4 09
Summer season	4.88	4.44	4.02	4.45
Mean (Storage periods)	4.09	4 29	3.82	.

As revealed in the table, the interaction between seasons and storage periods was found to be statistically not significant.

Table 46 presents the mean scores obtained for doneness when the two varieties of amaranthus leaves grown during different seasons were stored by different methods for different storage periods.

Table 46 Influence of varieties, seasons, storage periods and storage methods on the quality parameter of the amaranthus leaves - Doneness

Storage methods	Seasons		Varieties		Storage periods			
	Rainy season	Summer season	Red amaranthus	Green amaranthus	24 hours	48 hours	72 hours	Mean (Storage methods)
Refrigerator	4.25	4.36	4.44	4.17	4 63	4.25	4 04	4.31
Wet cloth	4 03	4.42	4.36	4.08	4.54	4.33	3.79	4 22
Dipping the roots in water	3.78	4.31	4.14	3.94	4.42	4 04	3.67	4.04
Polythene bag	3.75	4.25	4.17	3.83	4.46	4.00	3 54	4.00
Mean	3.95	4.33	4.28	4 01	4.51	4 16	3.76	..
	CD-for seasons at 5% 0.182		CD-for varieties at 5% 0.182		CD-for periods at 5% 0.223			

From the data presented in the table, it was clear that there was significant difference in the mean scores obtained for doneness for the leaves of the two varieties, grown during the two seasons and under sifferent storage periods.

As shown in the table, the leaves grown and harvested and stored during the summer season had significantly higher scores for doneness over those grown in the rainy season Between the varieties, red amaranthus gave higher scores for doneness than that of green amaranthus. Among the storage periods, leaves stored for 72 hours gave significantly less score for doneness when compared to the leaves stored for 24 hours. The different storage methods had no significant influence on doneness of the two varieties of amaranthus.

The table 47 presents the interaction of the two varieties of amaranthus between the seasons and storage periods.

Table 47   Influence of seasons and storage periods on the quality parameter of the leaves of two varieties of amaranthus - Doneness

Varieties	Season		Storage periods			Mean (Varieties)
	Rainy season	Summer season	24 hours	48 hours	72 hours	
Red Amaranthus	4.11	4.44	4.65	4.29	3.90	4.28
Green Amaranthus	3.79	4.22	4.38	4.02	3.63	4.01
Mean	3.95	4.33	4.51	4.16	3.76	

As shown in the table, the interaction between the varieties and seasons and different storage periods were found to be not significant when statistically analysed

The table 48 presents the interaction between the seasons and storage periods

Table 48 Influence of storage periods on the quality parameter of amaranthus leaves grown during different seasons - Doneness

Seasons	Storage periods			Mean (seasons)
	24 hours	48 hours	72 hours	
Rainy season	4.31	4.00	3.54	3.95
Summer season	4 71	4.31	3.98	4.33
Mean (Storage periods)	4.51	4.16	3.76	

From the data obtained, it was found that, there was no significant interaction between the seasons and storage periods.

Table 49 presents the mean scores obtained for tenderness when the two varieties of amaranthus leaves grown during different seasons were stored by different methods for different storage periods.

Table 49 Influence of varieties, seasons, storage periods and storage methods on the quality parameter of the amaranthus leaves - Tenderness

Storage methods	Seasons		Varieties		Storage periods			Mean (Storage methods)
	Rainy season	Summer season	Red amaranthus	Green amaranthus	24 hours	48 hours	72 hours	
Refrigerator	3.89	4.28	4.19	3 97	4.50	4.08	3 67	4.08
Wet cloth	3.94	3 97	4.14	3.78	4.25	4.04	3.58	3.96
Dipping the roots in water	3.75	3.83	3.83	3.75	4.21	3.75	3.42	3.79
Polythene bag	3.44	3 81	3 75	3 50	4.21	3.71	2.96	3 63
Mean	3 76	3.97	3.98	3 75	4.29	3.90	3 41	..

CD-for seasons at 5% 0.188

CD-for varieties at 5% 0.188

CD-for periods at 5% 0.229

CD-for storage methods at 5% 0 266

As presented in the table, there was significant difference in the mean scores obtained for tenderness of the two varieties of amaranthus leaves grown during the two seasons and stored by different storage methods for varying storage periods Different storage methods had significant influence on the mean score obtained for tenderness of the amaranthus leaves. The samples stored in refrigerator recorded higher scores and in polythene bag, minimum scores. Similarly, the mean scores obtained for tenderness of the leaves was found to be significantly affected when stored for longer durations of 72 hours.

Between the varieties, red amaranthus recorded higher scores for tenderness Between the two seasons, higher scores were recorded for the leaves grown during summer season.

Table 50 presents data on the interaction among the varieties, seasons and storage periods.

Table 50 Influence of seasons and storage periods on the quality parameter of the leaves of two varieties of amaranthus - Tenderness

Varieties	Season		Storage periods			Mean (Varieties)
	Rainy season	Summer season	24 hours	48 hours	72 hours	
Red Amaranthus	3.88	4.08	4.40	4.06	3.48	3.98
Green Amaranthus	3.64	3 86	4.19	3.73	3.33	3.75
Mean	3.76	3.97	4.29	3.90	3 41	

As recorded in the table, it can be seen that, the seasons and storage periods had no significant interaction on the two varieties of amaranthus.

Table 51 presents data on the interaction between seasons and storage periods.

Table 51 Influence of storage periods on the quality parameter of amaranthus leaves grown during different seasons - Tenderness

Seasons	Storage periods			Mean (seasons)
	24 hours	48 hours	72 hours	
Rainy season	4.31	3.77	3.19	3.76
Summer season	4.27	4.02	3.03	3.97
Mean	4.29	3.90	3.41	.

From the table, it can be noticed that there was no significant interaction between seasons and storage periods.

Table 52 presents the mean scores obtained for odour of the two varieties of amaranthus leaves grown during two seasons and stored by different methods for different periods.

Table 52 Influence of varieties, seasons, storage periods and storage methods on the quality parameter of the amaranthus leaves - Odour

Storage methods	Seasons		Varieties		Storage periods			Mean (Storage methods)
	Rainy season	Summer season	Red amaranthus	Green amaranthus	24 hours	48 hours	72 hours	
Refrigerator	3.78	4.39	4.19	3.97	4.50	4.21	3.54	4.08
Wet cloth	3.50	4.22	3.94	3.78	4.42	4.00	3.17	3.86
Dipping the roots in water	3.47	4.08	3.92	3.64	4.08	4.04	3.21	3.78
Polythene bag	3.67	4.31	4.08	3.89	4.46	4.00	3.50	3.99
Mean	3.60	4.25	4.03	3.82	4.36	4.06	3.35	

CD-for seasons at 5% 0.201 CD-for varieties at 5% 0.201 CD-for periods at 5% 0.246

As revealed in the table, odour of the two varieties of amaranthus leaves were significantly influenced by seasons and storage periods

Different methods of storage had no significant influence on the mean scores obtained for odour of the leaves. Minimum scores were obtained when the leaves were stored by dipping the roots in water and maximum scores when stored in refrigerator A significant influence was observed when the leaves were stored for longer durations of 72 hours. Mean score obtained for leaves when stored for 72 hours were found to be significantly low Scores obtained for odour, in the two varieties was better during summer season Among the two varieties, red amaranthus obtained higher scores during the two seasons.

Table 53 presents data on the interaction between varieties, seasons and storage periods.

Table 53 Influence of seasons and storage periods on the quality parameter of the leaves of two varieties of amaranthus leaves - Odour

Varieties	Seasons		Storage periods			Mean (Varieties)
	Rainy season	Summer season	24 hours	48 hours	72 hours	
Red Amaranthus	3.69	4.38	4.46	4.15	3.50	4.03
Green Amaranthus	3.51	4.13	4.27	3.98	3.21	3.82
Mean	3.60	4.25	4.36	4.06	3.35	

As shown in the table, there was no significant interaction among the seasons, periods and varieties.

Table 54 presents data on interaction between seasons and storage periods.

Table 54 Influence of storage periods on the quality parameter of amaranthus leaves grown during different seasons - Odour

Seasons (S)	Storage periods (P)			Mean (Seasons)
	24 hours	48 hours	72 hours	
Rainy season	4.46	4.15	3.50	3.00
Summer season	4.27	3.98	3.21	4.25
Mean-periods	4.36	4.36	4.06	.

CD - for (S x P) 0.062

As revealed in the table, there was significant interaction between the seasons and storage periods in the case of doneness.

Table 55 presents mean scores obtained for taste of the two varieties of amaranthus leaves grown during two seasons and stored by different methods for different periods.

Table 55 Influence of varieties, seasons, storage periods and storage methods on the quality parameter of the amaranthus leaves - Taste

Storage methods	Seasons		Varieties		Storage periods			Mean (Storage methods)
	Rainy season	Summer season	Red amaranthus	Green amaranthus	24 hours	48 hours	72 hours	
Refrigerator	3.04	4.08	3.94	3.78	4.29	3.92	3.38	3.86
Wet cloth	3.50	3.89	3.75	3 64	4.33	3.03	3 13	3.69
Dipping the roots in water	3.42	3 86	3.78	3.50	4.08	3.67	3 17	3.04
Polythene bag	3.42	3 89	3 89	3.42	4.04	3.54	3.38	3 65
Mean	3 49	3.93	3.84	3 58	4.19	3 69	3 26	

CD-for seasons at 5% 0 187

CD-for varieties at 5% 0 187

CD-for periods at 5% 0 229

As revealed in the table, there was significant difference in the mean scores obtained for taste of the leaf samples of the two varieties of amaranthus grown during the two seasons and stored by different methods for varying periods.

Leaves grown during summer season had better taste over rainy season. Similarly, between the varieties, the leaves of red amaranthus appeared to have higher score for taste. Among the storage periods, the leaves stored only for 24 hours had secured higher scores than the leaves stored for 48 and 72 hours. Mean scores obtained by the leaves stored by different methods of storage indicated that the quality taste was uniformely affected by all the methods.

Table 56 presents the mean scores for taste on the interaction among the varieties, seasons and storage periods.

As shown in the table, there was no significant interaction among the seasons, varieties and storage periods.

Table 56 Influence of seasons and storage periods on the quality parameter of the leaves of two varieties of amaranthus - Taste

Varieties	Seasons		Storage periods			Mean (Varieties)
	Rainy season	Summer season	24 hours	48 hours	72 hours	
Red Amaranthus	3.61	4.07	4.31	3.81	3.40	3.84
Green Amaranthus	3.38	3.79	4.06	3 56	3 13	3 58
Mean	3.49	3 93	4.19	3.69	3.26	.

Table 57 presents data on the interaction between seasons and storage periods.

Table 57 Influence of storage periods on the quality parameters of amaranthus leaves grown during different seasons - Taste

Seasons	Storage periods			Mean (Seasons)
	24 hours	48 hours	72 hours	
Rainy season	4.10	3.48	2.90	3.49
Summer season	4.27	3.90	3.64	3.93
Mean (Periods)	4.19	3.69	3.26	

As revealed in the table, there was no significant interaction between the seasons and storage periods

Abstract of ANOVA related to the effecet of storage periods and storage methods on the organoleptic qualities of the two varieties of amaranthus during rainy and summer season are presented in Appendix XV

4 Organoleptic qualities of the two varieties of amaranthus cooked by different methods

Table 58 presents the mean scores obtained for colour for the leaf samples of the two varieties of amaranthus, grown during the two seasons, were cooked by different methods.

Table 58 Influence of differenct methods of cooking on the leaves of two varieties grown during the two seasons, in terms of quality parameter-Colour

Varieties	Cooking methods				Mean (Varieties)
	Boiling	Frying	Baking	Steaming	
Red Amaranthus(V_1)	4.83	4.25	3 83	4.17	4.27
Green Amaranthus(V_2)	4.50	4.25	2.33	3.50	3.65
Mean (Cooking methods)	4.67	4.25	3.08	3 83	3.96

CD - for cooking methods at 5% 1.22

As revealed in the table, there was significant variation in the mean scores obtained for colour of the two varieties of amaranthus when cooked by different methods

Among the cooking methods tried, leaves cooked by boiling recorded higher scores when compared to other types of cooking The minimum scores were recorded for the samples cooked by baking However, a comparison of colour between the varieties and between seasons indicated no significant variation

Table 59 presents data on the mean scores obtained for doneness for the leaf samples of the two varieties of amaranthus cooked by different methods

Table 59 Influence of different methods of cooking on the amaranthus leaves of two varieties grown during the two seasons in terms of quality parameter - Doneness

Varieties	Cooking methods				Mean (Varieties)
	Boiling	Frying	Baking	Steaming	
Red amaranthus	3 83	3 75	4 33	4 00	4.23
Green amaranthus	4 67	4.00	3 75	3 75	4 04
Mean(cooking methods)	4 75	3.88	4 04	3 88	4 14

From the table, it can be seen that, the different cooking methods and seasons had no significant influence on the doneness of the two varieties of amaranthus Similarly in this context, there was no significant difference between the two varieties

Table 60 presents data on the influence of different methods of cooking on the tenderness of the leaves of the two varieties of amaranthus during rainy and summer season

Table 60 Influence of different methods of cooking on the amaranthus leaves of two varieties grown during the two seasons, in terms of quality parameter - Tenderness

Varieties	Cooking methods				Mean (Varieties)
	Boiling	Frying	Baking	Steaming	
Red amaranthus	4.42	4.00	3 67	3.17	3 81
Green amaranthus	4.25	3.25	3 17	2 92	3.40
Mean(cooking methods)	4.33	3 63	3 42	3 04	3 61

As revealed in the table, it was observed that, the influence of different methods of cooking on the tenderness of the leaves of the two varieties of amaranthus were found to be not significant Similarly plants grown during different seasons were not showing significant variation

Table 61 presents the mean scores obtained for the odour of the two varieties of amaranthus when cooked by different methods during the two seasons.

Table 61 Influence of different methods of cooking on the odour of two varieties grown during the two seasons in terms of quality parameter - Odour

Varieties	Cooking methods				Mean (Varieties)
	Boiling	Frying	Baking	Steaming	
Red amaranthus	4.67	4 17	4 17	3 42	4.10
Green amaranthus	4 33	3 83	3 42	2 92	3 63
Mean(cooking methods)	4 50	4 00	3.79	3.17	3 87

As revealed in the table, the different types of cooking methods and seasons had no influence on the odour of the two varieties Similarly, the two varieties did not differ significantly when the mean scores obtained for odour were compared

Table 62 presents data on the mean scores obtained for the taste of the two varieties of amaranthus when cooked by different methods during rainy and summer season.

Table 62 Influence of different methods of cooking on the leaves of two varieties grown during the two seasons, in terms of quality parameter - Taste

Varieties	Cooking methods				Mean (Varieties)
	Boiling	Frying	Baking	Steaming	
Red amaranthus	4 42	3.75	4 00	3.50	3.92
Green amaranthus	4.08	3.58	3.17	3 58	3.60
Mean(cooking methods)	4.25	3.67	3.58	3.54	3 76

As revealed in the table, it was clear that, the different methods of cooking had no significant influence on the taste of the leaves, during the two seasons Similarly mean scores obtained for taste of the two varieties also showed no significant variation

Abstract of ANOVA related to the effect of different methods of cooking on the organoleptic qualities of the two varieties of amaranthus during rainy and summer season are presented in Appendix XVI

5 Effect of different cooking vessels on the organoleptic qualities of the two varieties of amaranthus leaves

Table 63 presents the mean scores obtained for colour of the leaves of two different varieties of amaranthus grown during the two distinct seasons and cooked in different types of vessels

Table 63 Influence of seasons, varieties, cooking methods and cooking vessels on the quality parameter of amaranthus leaves - Odour

Cooking vessels	Season		Varieties (v)		Cooking methods		Mean (vessels)
	Rainy season	Summer season	Red amaranthus	Green amaranthus	Boiling	Shallow frying	
Aluminium	4.38	4.58	4 67	4 29	4.46	4.50	4.48
Steel	4.50	4 67	4 75	4.42	4 58	4 58	4.58
Alloy	4 54	4 38	4 71	4.21	4 54	4 38	4 46
Iron	4 08	4 25	4 25	4 08	4 21	4.13	4.17
Copper	4 21	4 29	4 42	4 08	4 54	3 96	4.25
Mudpot	4 20	4 46	4 38	4 29	4 42	4.25	4.33
Mean	4 32	4 44	4 53	4 23	4 46	4 30	4.38

CD-(V) 5% 0.156

CD-for cooking methods 5% 0 156

From the data presented in the table it was clear that there was significant difference in the mean score obtained for colour of the two varieties when cooked by boiling and frying method.

From the data, it was also clear that, between seasons, the leaves grown and harvested during summer season had better colour over those grown in the rainy season, but this variation was not statistically significant. Between the two varieties, red and green, the red variety appeared to have better scores for colour as indicated by the significantly higher mean scores obtained Between the two cooking methods tried, boiling method imparted better colour to the members as indicated by the higher mean scores obtained. Among the vessels tried, the leaves cooked in steel vessel gave the highest score for colour, while the lowest score was recorded in iron vessel but this was also not found to differ significantly

Table 64 presents data on the mean scores obtained for the interaction between varieties, seasons and cooking methods.

Table 64 Influence of seasons and cooking methods on the quality parameters of the two varieties of amaranthus - Colour

Varieties	Season		Cooking methods		Mean (Varieties)
	Rainy season	Summer season	Boiling	Shallow frying	
Red amaranthus	4 47	4.58	4.54	4.51	4 53
Green amaranthus	4.17	4.29	4.38	4.08	4.23
Mean	4.32	4.44	4 46	4.30	4 38

As shown in the table, there was no significant interaction between the seasons, cooking methods and varieties

Table 65 presents data on the mean value of scores obtained for doneness when leaf samples of two different varieties were cooked in different types of cooking vessels and during two seasons.

Table 65 Influence of seasons, varieties, cooking methods and cooking vessels on the quality parameter of amaranthus leaves - Doneness

Cooking vessels	Seasons		Varieties		Cooking methods		Mean (Vessels)
	Rainy season	Summer season	Red amaranthus	Green amaranthus	Boiling	Shallow frying	
Aluminium	4.42	4.50	4.54	4.36	4.54	4 38	4.46
Steel	4 50	4.50	4.54	4.46	4.58	4.42	4.50
Alloy	3.88	4.29	4.13	4.04	4 25	3 92	4.08
Iron	4 21	4 42	4 46	4.17	4.38	4.25	4 31
Copper	4.00	4.21	4.21	4.00	4.25	3 96	4.10
Mudpot	3.96	4.58	4 38	4.17	4.42	4.13	4.27
Mean	4 6	4 42	4 38	4 20	4 40	4 7	4 29

CD - for seasons at 5% level 0.167   CD-for varieties at 5% 0.167   CD-for cooking methods at 5% 0.167

From the data presented in the table, it was clear that, there was significant difference in the mean scores obtained for doneness when the varieties, seasons and cooking methods were compared.

It was clear from the table that, between seasons, the leaves grown and harvested during the summer season had a significant influence on the doneness of the two varieties. Similarly, it was also found that, the different types of vessels had no influence on the doneness of the leaves.

Table 66 presents data on the interaction between the seasons, varieties and cooking methods.

Table 66 Influence of seasons and cooking methods, on the quality parameter of the two varieties of amaranthus leaves - Doneness

Varieties	Rainy season	Summer season	Boiling	Shallow frying	Mean (Varieties)
Red amaranthus	4.29	4 46	4 49	4.26	4.38
Green amaranthus	4 03	4 38	4.32	4 08	4 20
Mean	4 16	4.42	4.40	4.17	4.29

As shown in the table, the interaction of varieties, seasons and cooking methods were found to be not significant statistically

Table 67 presents data on the mean value of scores obtained for tenderness when the two varieties of amaranthus were cooked in different types of vessels during two seasons.

Table 67 Influence of seasons, varieties, cooking methods and cooking vessels on the quality parameter of amaranthus leaves - Tenderness

Cooking vessels	Seasons		Varieties		Cooking methods		Mean (vessels)
	Rainy season	Summer season	Red amaranthus	Green amaranthus	Boiling	Shallow frying	
Aluminium	4.00	4.00	4.25	3.75	4.04	3.96	4.00
Steel	3.71	4 33	4.13	3 92	4.13	3.92	4.02
Alloy	3.50	3.88	3.63	3.75	3.96	3.42	3.69
Iron	3 96	4.25	4.33	3.86	4.21	4.00	4.10
Copper	3.58	4.25	3.96	3.86	3 83	4.00	3.92
Mudpot	3 75	4.13	3.96	3.92	4.17	3.71	3.94
Mean	3 75	4 4	4 04	3 85	4 06	3 83	3 95

CD-for seasons 5% level 0 182

CD-for varieties 5% level 0.182

CD-for cooking methods at 5% 0.182

From the data, it is clear that, there was significant difference in the mean scores obtained for tenderness when the two varieties of amaranthus grown during the two seasons were cooked by boiling and frying in different types of vessels Between seasons, the leaves grown during summer season had obtained better scores for tenderness and was more in red amaranthus when compared to green variety Between the two cooking methods tried, the samples cooked by boiling gave significantly higher mean scores than that of shallow frying method Among the different cooking vessels tried, it was observed that, the cooking vessels had no significant influence on the tenderness of the two varieties of amaranthus during the two seasons.

Table 68 presents the mean scores obtained for the interaction between the varieties, seasons and cooking methods on the tenderness of the amaranthus leaves.

Table 68 Influence of seasons and cooking methods on the quality parameter of two varieties of amaranthus - Tenderness

Varieties	Seasons		Cooking methods		Mean (Varie-ties)
	Rainy season	Summer season	Boi-ling	Shallow frying	
Red amaranthus	3 85	4.24	4.15	3 93	4.04
Green amaranthus	3.65	4.04	3.96	3 74	3.85
Mean	3.75	4.14	4.06	3.83	3.95

As revealed in the table, there was no significant interaction between the varieties, seasons and cooking methods.

Table 69 presents data on the mean scores obtained for odour when the leaves of the two varieties of amaranthus were cooked in different types of vessels, during rainy and summer seasons.

Table 69 Influence of seasons, varieties, cooking methods and cooking vessels on the quality parameter of amaranthus leaves - Odour

Cooking vessels	Seasons		Varieties		Cooking methods		Mean (vessels)
	Rainy season	Summer season	Red amaranthus	Green amaranthus	Boiling	Shallow frying	
Aluminium	4.08	4.21	4.29	4.00	4.25	4.04	4.15
Steel	4.25	4.21	4.33	4.13	4.33	4.13	4.23
Alloy	3.92	3.63	3.75	3.79	4.08	3.48	3.77
Iron	4.00	4.13	4.17	3.96	4.08	4.04	4.06
Copper	3.88	4.38	4.21	4.04	4.42	3.83	4.13
Mudpot	3.46	4.08	4.08	3.48	4.04	3.50	3.77
Mean	3.93	4.10	4.14	3.90	4.20	3.83	4.02

CD-for varieties (5%) 0.198

CD-for cooking methods (5%) 0.198

From the data, presented in the table, it was clear that, leaves grown and harvested during summer season had higher scores for odour than the leaves grown during rainy season, but statistically it was non significant

Between the varieties, better scores were obtained for red amaranthus Between the two cooking methods tried, boiling method imparted better odour as indicated by the higher mean scores obtained It was also revealed from the table that cooking vessels had no significant influence on the odour of the cooked amaranthus leaves.

Table 70 presents data on the mean scores obtained for the interaction between seasons, cooking methods and varieties

Table 70 Influence of seasons and cooking methods on the quality parameter of two varieties of amaranthus - Odour

Varieties	Seasons		Cooking methods		Mean (varieties)
	Rainy season	Summer season	Boiling	Shallow frying	
Red amaranthus	4.11	4.17	4.35	3 93	4.14
Green amaranthus	3.75	4.04	4 06	3 74	3.90
Mean	3.93	4.10	4 20	3 83	4 02

As indicated in the table, the interaction between seasons, varieties and cooking methods were found to be statistically non significant

Table 71 presents data on the mean value of scores obtained for taste when cooked samples of the two different varieties in different types of containers and during two distinct seasons, were presented.

Table 71 Influence of seasons, varieties, cooking methods and cooking vessels on the quality parameter of amaranthus leaves - Taste

Cooking vessels	Seasons		Varieties		Cooking methods		Mean (vessels)
	Rainy season	Summer season	Red amaranthus	Green amaranthus	Boiling	Shallow frying	
Aluminium	4.00	4.29	4.29	4.00	4.17	4 13	4.15
Steel	3.88	4.08	4.13	3.83	4.08	3 88	3.98
Alloy	3.58	3.79	3.07	3.71	3.79	3 58	3 69
Iron	3.79	4 08	3.88	4.00	4.13	3.75	3 94
Copper	3 67	4 04	4.00	3.71	3.92	3 79	3 85
Mudpot	3.38	3.95	3.67	3.67	3 54	3.79	3 64
Mean	3.72	4.04	3 94	3.82	3.94	3 82	•

CD-for seasons at 5% 0.176

From the data presented in the table, it was clear that there is significant difference in the taste of the two varieties in the two seasons It is clear from the table that between seasons, the leaves grown and harvested during the summer season had a better or preferred taste over that grown in the rainy season. However, the taste of the two varieties were on par. They did not differ significantly. The two cooking methods used were found not to have significant effect on the taste of the two varieties Among the cooking vessels tried the leaves cooked in aluminium vessels gave the highest score for taste while the lowest was recorded for that cooked in mudpot but that has no significant influence on the taste of the samples

Table 72 presents mean scores obtained for the interaction of varieties, seasons and cooking methods on the taste of the amaranthus leaves.

Table 72 Influence of seasons and cooking methods on the quality parameter of two varieties of amaranthus - Taste

Varieties	Seasons		Cooking methods		Mean (varieties)
	Rainy season	Summer season	Boiling	Shallow frying	
Red amaranthus	3.74	4.14	3.94	3.93	3.94
Green amaranthus	3.69	3.94	3 93	3.71	3.82
Mean	3.72	4.04	3 94	3 82	

As shown in the table, the interaction of season, cooking methods and varieties on the taste of the amaranthus leaves were found to be statistically not significant.

Abstract of ANOVA related to the effect of different types of cooking vessels on the organoleptic qualities of the two varieties of amaranthus during rainy and summer season are presented in Appendix XVII

DISCUSSION

DISCUSSION

The study on "Nutritional profile of amaranthus as influenced by post harvest handling" was an assessment of the nutritional composition and organoleptic qualities of red and green varieties of A. tricolor grown during rainy and summer season.

Findings related to these quality parameters are discussed in relation to, maturity levels of the plant different location of the plant, different storage methods and storage periods, different cooking methods and different types of cooking vessels.

The different maturity levels selected for the study were 10 days, 20 days and 30 days Major nutrients analysed were protein, fiber, calcium, iron and ascorbic acid.

The protein content of the amaranthus leaves of the two varieties showed an ascending trend throughout the growing stages from 10th day to 30th day during rainy and summer season Similar results were observed by Vijayakumar (1980) when A 145 at 30th and A.111 at 40th days were analysed Stafford et al (1976) had also reported similar findings on 42nd day in Amaranthus hybridus sp hybridus.

The crude fiber is one of the most important components in green leafy vegetables and this component increased with age, in both the varieties grown during the two seasons. This finding lends support to the results of studies on green leafy vegetables conducted by Ravindran and Ravindran (1988) and Sniffen and Jacobson (1975).

Unlike protein and crude fiber calcium content in the two varieties increased upto 20th day and thereafter these components in the leaves declined This is in corroboration with the reports of Omueti (1982) in *Celosia argentea* cvs Subbiah (1979) in amaranthus and Djamei (1973) in lucerne In the present study, the two varieties recorded the highest calcium content on 20th day.

Similar trend in the concentration of iron was observed, since the iron content in general was at its peak on 20th day and with increase in age it tended to fall down in red and green amaranthus at both the seasons. This is in agreement with the findings of Taylor *et al* (1983) and Subbiah (1979).

The ascorbic acid content of the two varieties of amaranthus was also found to increase from the initial stage to 20th day and after that there was no change upto 30th day in the two seasons However, Subbiah (1979) reported high ascorbic acid content on 27th day in Co.1 and Co.2 amaranthus, whereas Abe and Imbamba (1977) observed similar findings on 50th day in A lividus The findings of the present study are in line with the result of Vijayakumar (1980) and Subbiah and Ramanathan (1983) in amaranthus. It can be concluded that the leaves of the two varieties of amaranthus are nutritionally richer on 20th day of its maturity A comparison of the two varieties of amaranthus had indicated that protein, fiber, calcium and iron were higher in green amaranthus when compared to red amaranthus during the two seasons and a comparison of the seasons indicated that, in general, the quality of the leaves were better during summer season. This was in agreement with the result of Mohideen and Muthukrishnan in several types of amaranthus (1982, 1981).

However in the present study, ascorbic acid and fiber were higher during rainy season in both the varieties The findings are supported by earlier studies conducted by Devadas et al (1969) in A. flavus

Leaves located at different parts of the plant are generally used for consumption and compared to the leaves from the base and middle part of the plant, leaves at the tip are preferred.

An analysis of the leaves collected from different parts of the plant indicated that there was no significant difference in protein among the leaves collected from different parts of the plant in the two varieties of amaranthus grown during rainy and summer seasons.

The same trend was observed in the concentration of the fiber content in the two varieties at rainy season However, during summer season, significant difference was observed among the different parts in green amaranthus. The concentration of protein and fiber was higher in the leaves collected from the middle portion of the plant.

An analysis of the leaves collected from different parts of the plant, for Ca, Fe and ascorbic acid indicate significant difference in the concentration of these nutrients Leaves from the middle portion of the two varieties of amaranthus gave higher values for calcium, iron and ascorbic acid, during the two seasons.

It was also noticed that the leaves collected from the tip portion of the plant gave considerably less value for all the nutrients when compared to the leaves collected from the base and middle portions. It can be concluded that, the leaves collected from the middle portion of the red and green amaranthus leaves at both the seasons are nutritionally richer than the leaves found at the other parts of the plant.

The amaranthus leaves when purchased in bulk are generally stored in refrigerator, polythene bag, wet cloth or by dipping the roots in water Generally the leaves after harvest are stored for 1 to 3 days before consumption The leaves when stored by these methods for longer duration are expected to lose their nutritive value.

The effect of storage on the nutritional composition of the leaves of the two varieties of amaranthus stored in a refrigerator, polythene bag, wet cloth and by dipping the roots in water were assessed in two seasons for different duration.

Leaves generally when stored, were found to lose moisture considerably and this loss was directly proportional to the duration of storage Among the different methods of storage, the leaves stored in the refrigerator were found to lose less moisture compared to other methods. Leaves stored in polythene bag was found to be ranked as second in this context and rate of loss of moisture from the leaves stored by dipping the roots in water was ranked next and lastly the leaves stored in wet cloth storage These findings are in agreement with the results of Lazen et al (1987) Phadnis and Annapoorna (1980) and Varghese and Umapathi (1977).

Analysis of the nutrients such as protein, fiber, calcium, iron and ascorbic acid present in the leaves stored by these methods for different durations revealed that protein and fiber content of the leaves of the two varieties of amaranthus was not affected by storage by these methods for different durations. However the calcium content of the two varieties of amaranthus was slightly affected during storage for different durations in refrigerator, polythene bag, dipping the roots in water and in wet cloth This finding is in agreement with the results of Fawusi (1983) in C olitorius.

However, the iron content of the two varieties of amaranthus leaves grown during the two seasons was found to be not affected significantly during storage for different durations.

Unlike minerals, the ascorbic acid content of stored amaranthus leaves, was found to decrease as the storage period increased Among the different methods evaluated, highest loss of ascorbic acid was observed in the leaves stored in wet cloth, while these losses were found to be least in the leaves stored in the refrigerator. The loss of ascorbic acid from the leaves stored in polythene bag, open storage in water and wet cloth was found to be significantly higher than that in refrigerator.

From the results, it can be concluded that, among the various methods of storage tried, keeping in refrigerator was found to be most ideal for storing greens. This finding is supported by the earlier studies of Phadnis and Annapoorna (1980), Varghese and Umapathi (1977) and Shukla and Bindu (1975).

However, even in refrigerated storage, it was found that the variation in nutrients increased as the storage period increased and the loss of nutrients was higher in leaves when stored for 72 hours in all these storage methods.

The effect of cooking methods on the nutritional composition of amaranthus leaves were assessed. Various cooking methods tried were boiling in water, frying, baking and steaming.

From the results, it could be seen that slight loss of protein occured during cooking in the two varieties of amaranthus. This finding is supported by the earlier findings of Abobaker et al (1986) Bushway (1985) and Fafunso and Bassir (1979, 1977) In the present study, among the various methods of cooking tried, steaming was found to be the best Swaminathan (1987) had reported the adverse effects of severe heat processing such as baking, frying and roasting on the protein content of food articles.

However, the fiber content of the leaves of the two varieties of amaranthus grown during the two seasons was found to be not affected by different methods of cooking tried.

Unlike the fiber content, the calcium and iron content of the amaranthus leaves were found to be decreased after cooking. In boiling methods, the loss might be due to the extraction of calcium and iron from the leaves to the cooking medium This finding is in agreement with the earlier reports of Swaminathan (1987), Lachance (1977), Anon (1956) and Krehl and Winters (1950) Among the various cooking methods tried, steaming was found to be the ideal one to conserve the water soluble minerals present in the leaves compared to baking, frying and boiling methods.

As already reported by several workers, the loss of ascorbic acid during cooking was found to be significant at both the season in the two varieties of the leaves. The loss of ascorbic acid was more in leaves boiled in water and least in steaming method. This finding was supported by the results of Gyang and Mbachu (1987), Sreeramulu (1983), Padma et al (1982), Stafford et al (1976), and Rajeswari et al (1966).

On the basis of the cooking trials conducted on the two varieties of amaranthus leaves, it can be concluded that, among the different cooking methods, "steaming" was found to be the ideal one in conserving the nutrients to a greater extent.

For cooking green leaves, generally vessels made of aluminium, alloy, steel, iron, copper and mudpot are used and in the present study the influence of different cooking vessels on the nutritional composition of amaranthus leaves grown during rainy as well as summer season were ascertained, and results are discussed. Among the different types of vessels tried, it was found that aluminium, steel, alloy, iron, copper and mudpot had no influence on the protein content of the two varieties during cooking at two seasons

The same trend was observed in the fiber and calcium content of amaranthus leaves during the two seasons. This implies that the different types of vessels had no influence on the protein, fiber and calcium content of the amaranthus leaves grown during rainy and summer season.

However, a significant influence on the iron content of amaranthus leaves were observed during the two seasons when cooked in iron vessel In this study, when amaranthus leaves were cooked in iron pan, a considerable increase in iron content was observed in the two varieties, indicating the possible action on the acidity of the amaranth on the surface of the vessel This finding is in agreement with the reports of Swaminathan (1987) and Devadas et al (1965).

However, the other types of vessels had no influence on the iron content of amaranthus leaves.

When considering the effect of different types of cooking vessels on the ascorbic acid content of the two varieties of amaranthus revealed that copper and iron vessel had a significant influence on the ascorbic acid content of amaranthus leaves during the two seasons This may be due to the interaction of copper and iron with the ascorbic acid This finding is supported by the earlier reports of Swaminathan (1987) and Borenstein (1977).

Organoleptic qualities

The acceptability of the two varieties of amaranthus grown during rainy and summer season was evaluated in 20 days old leaves using score card method.

Acceptability related to seasons revealed that, leaves of the two varieties of amaranthus grown during rainy as well as summer season were equally acceptable. Major qualities studied were colour, doneness, tenderness, odour and taste.

The acceptability of the leaves collected from different parts of the plant, during the two seasons, revealed that the quality attribute, colour in leaf samples collected from the tip portion of the plant had obtained significantly higher scores But for doneness and taste the leaf samples in the middle portion of the plant obtained significantly higher scores during summer season. While for tenderness and odour, leaf samples from the different parts of the amaranthus varieties during the two seasons, obtained more or less similar scores.

A comparison of the two varieties indicated that scores obtained for all the quality parameters were found to be higher in red amaranthus eventhough significant variation did not exist. The poor acceptability of the green amaranthus was found to be due to the sliminess and the slight unpleasant taste of the leaves

During storage the acceptability of the leaves are adversely affected The storage methods tried were refrigeration, wrapping in wet cloth, dipping the roots in water, and keeping in polythene bags.

Among the various methods of storage, mean scores obtained for various quality attributes of the leaves stored for different durations, revealed that, the leaves stored in the refrigerator were more acceptable than any other method of storage and was significantly better in retaining the various quality attributes like colour and tenderness.

Leaves stored by dipping the roots in water was found to be the least acceptable for qualities like colour, odour and taste Among the different periods of storage, the scores obtained for all the qualities for the leaf samples of the two varieties stored for 24 hours obtained higher scores in all the methods during the two seasons. For all the quality parameters, the stored leaf samples grown during summer season got higher scores Compared to green amaranthus, red amaranthus was better in retaining these qualities.

In addition to the loss of quality during storage, the leaves stored by open storage in water were having an objectionable odour This odour was found to be increasing in its intensity as the duration of storage increased Compared to red amaranthus, green amaranthus was most easily affected.

Application of heat during cooking affects the quality of amaranthus. The different cooking methods tried in this study were, boiling in water, shallow frying, baking and steaming. Mean scores obtained for the leaves of the two varieties of amaranthus cooked by different methods revealed that boiling was the best method to preserve the qualities There was no variation between the two varieties grown during summer and rainy season. However, among cooking methods, steaming was found to conserve more nutrients, compared to shallow frying, baking and boiling.

For cooking, aluminium, alloy, steel, iron, copper and mudpot vessels are commonly used. The influence of different types of cooking vessels on the general acceptability as well as the different qualities of the two varieties of amaranthus grown during the two seasons revealed that, the different types of vessels had no significant influence on the various quality attributes tested.

SUMMARY

SUMMARY

The study on 'Nutritional profile of amaranthus as influenced by post harvest handling' was an assessment of the influence of season, maturity, location of leaves in the plant and the effect of storage and cooking methods on the nutritional composition and acceptability

Major nutrients estimated were protein, calcium, iron, ascorbic acid and fibre Protein and fibre content of the leaves were found to increase with age of the plant irrespective of varieties and seasons. Between the varieties, fiber content was more in green amaranthus.

Minerals such as calcium and iron and vitamin C increased upto 20 days of maturity and after that the mineral content gradually declined but vitamin C stabilised Calcium and iron were found to be higher in green amaranthus when compared to red amaranthus. Location of leaves in the plant is another factor, found to influence the nutritional composition The protein content of the amaranthus leaves were not influenced by location of leaves in the plant irrespective of varieties and seasons But, the concentration of fiber content was found to be varying in different parts of the plant during summer season

However, with regard to the mineral content and ascorbic acid, significant difference in the concen tration of these constituents were observed among the different parts of the plant. Calcium, iron and ascorbic acid were found to be in higher concentration in the middle portion of the plant in both the varieties compared to the tip and base portion, during the two seasons

Among the different storage methods tried for storing amaranthus leaves during the two seasons, refrigeration was found to be the best method compared to other methods of storage such as keeping in polythene bag, dipping the roots in water and wet cloth storage for different duration Storage for different duration had no effect on protein, fiber, calcium and iron content of the leaves of the two varieties. However, significant variation in ascorbic acid content was observed in storage during the two seasons Loss of ascorbic acid was significantly low in refrigerated samples when compared to leaf samples stored by other methods.

Among the different cooking methods tried, steamed samples were found to conserve more nutrients such as calcium, iron and ascorbic acid compared to other methods like boiling, frying and baking However, protein and fiber content of the two varieties of the amaranthus were not affected by cooking while calcium, iron and ascorbic acid content of the leaves of the two varieties at two seasons significantly reduced during cooking

Protein, fiber and calcium content of the leaves were found to be not affected by the types of vessels used for cooking There was significant variation on the iron and ascorbic acid content of the leaves cooked in different vessels, in the two seasons The iron content of the leaves cooked in iron vessels was found to be high when compared to other cooking vessels Loss of ascorbic acid was very high in the leaves cooked in copper and iron vessels compared to other vessels

The acceptability tests conducted on the two varieties of amaranthus at various treatments recorded higher score for red amaranthus during the two seasons A comparison of seasons indicated better acceptance of the plants grown during summer season.

Leaves at the tip and middle part of the two varieties of amaranthus were more acceptable than those from the basal portion Among the different storage methods tried, during the two seasons, the acceptability was more for samples stored in refrigerator However, the acceptability of the leaves stored for longer duration were found to be decreasing

Among different cooking methods, leaves cooked by boiling, were the most acceptable one, followed by shallow frying, baking and steaming with reference to quality attributes such as tenderness, odour and taste, however, colour was much affected during baking and doneness during frying

Among the different cooking vessels selected for the study, no vessels had significant influence on the acceptability of the two varieties of amaranthus when leaf samples grown during the two seasons were tested However, higher scores for various quality parameters were obtained for the leaves cooked in steel and aluminium vessels

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* Original not seen

APPENDICES

APPENDIX I

Evaluation card for triangle test

Name of the product   Sugar solution

Note   Two of the three samples are identical
       Identify the odd sample

Serial No	Code no.of sample	Code no.of identical samples	Code no.of odd sample

APPENDIX II

Score card for the organoleptic evaluation of cooked Amaranth under different conditions

Quality attributes	Subdivisions of attributes	Score for each sub-division attributes	Score for samples Code No			
			1	2	3	4
Appearance colour	Natural colour well preserved	5				
	Colour fairly preserved	4				
	Moderately preserved	3				
	Slightly discoloured	2				
	Highly discoloured	1				
Doneness	Well cooked	5				
	Fairly cooked	4				
	Just cooked	3				
	Slightly under cooked	2				
	Slightly over cooked	1				
Tenderness	Very soft	5				
	Soft	4				
	Fairly soft	3				
	Fibrous	2				
	Very fibrous	1				
Odour	Odour of well cooked	5				
	No odour	4				
	Odour of uncooked greens	3				
	Slightly foreign odour	2				
	Very unpleasant odour	1				
Taste	Very good	5				
	Good	4				
	Bland	3				
	Bad	2				
	Very bad	1				

APPENDIX III

Effect of maturity levels on the nutritional composition of two varieties of amaranthus during rainy season

Abstract of ANOVA

Source	Mean squares					
	D F	Protein	Fiber	Calcium	Iron	Ascorbic acid
Varieties (V)	1	0 120	0.213*	560 3**	28 830 *	3 000
Maturity levels (M)	2	1.213**	0 303*	1906 35**	79 000**	2025 582 *
V x M	2	0 0001	0 003	14 350	0 280	2[illegible] 75[illegible]**
Error	6	0 04	0.04	5 000	1 650	1 167

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX IV

Effect of maturity levels on the nutritional composition of two varieties of amaranthus during summer season

Abstract of ANOVA

Source	Mean squares					
	D.F	Protein	Fiber	Calcium	Iron	Ascorbic acid
Varieties (V)	1	0.120	0.827*	705.300**	39 603**	5.336
Maturity (M)	2	1.213**	0.480*	1486 350**	76 253**	1045 334**
V x M	2	0 0001	0 061	10.350	0 0930	21.332
Error	6	0 05	0 078	20 67	0.05	37.333

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX V

Effect of location of leaves on the nutritional composition of the two varieties of amaranthus during rainy season

Abstract of ANOVA

Source	Mean squares					
	D.F	Protein	Fiber	Calcium	Iron	Ascorbic acid
Varieties (V)	1	0.03	0 001	972.000**	3 203**	2 082
Different parts (P)	2	0.253	0.022	1999 00**	103.023**	250.083**
V x P	2	0.0001	0 002	13.000	0.563*	20 084**
Error	6	0 05	0 006	5 000	0.120	1.083

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX VI

Effect of location of leaves on the nutritional composition of the two varieties of amaranthus during summer season

Abstract of ANOVA

Source	Mean squares					
	D F	Protein	Fiber	Calcium	Iron	Ascorbic acid
Varieties (V)	1	0.053	0 068**	300.000**	5 88**	48.00
Different parts (P)	2	0 203	0.051**	1371.000**	85.813**	261.334**
V x P	2	0.003	0.038*	9.000	0.520**	16.000
Error	6	0 06	0.005	7 000	0.05	16.000

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX VII

Effect of storage periods and storage methods on the nutritional composition of the two varieties of amaranthus leaves during rainy season

Abstract of ANOVA

Source		Mean squares				
	D F	Protein	Fibre	Calcium	Iron	Ascorbic acid
Varieties (V)	1	0.424	0.364**	168.673**	164.650**	216.70**
Storage periods (P)	2	0.006	0.002	0.811	0.277	2282.540**
Storage methods (M)	3	0.004	0.002	0.272	0.484	1557.860**
V x P	2	0.004	0.001	0.059	0.029	5.250
V x M	3	0.011	0.002	0.031	0.037	9.640
P x M	6	0.007	0.003	0.375	0.026	177.695**
V x P x M	6	0.005	0.005	0.008	0.020	0.805
Error	24	0.331	0.023	0.143	0.970	17.667

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX VIII

Effect of storage periods and storage methods on the nutritional composition of the two varieties of amaranthus leaves during summer season

Abstract of ANOVA

Source	Mean squares					
	D.F.	Protein	Fibre	Calcium	Iron	Ascorbic acid
Varieties (V)	1	0.492	1.268*	1627 510**	182 910**	200 08**
Storage periods (P)	2	0.0007	0.002	14.775	0.009	1614 085**
Storage methods (M)	3	0.003	0.006	37 057	0 004	739.190**
V x P	2	0.0009	0 0005	1.622	0 0002	0.085
V x M	3	0 003	0.007	19 841	0 0003	4.530
P x M	6	0.003	0.003	17 079	0 0001	44 528
V x P x M	6	0 0003	0 003	27 621	0.0001	1 193
Error	24	0 266	0.223	119.115	0.004	20 83

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX IX

Effect of different methods of cooking on the nutritional composition of the varieties of amaranthus during rainy season

Abstract of ANOVA

Source		Mean squares				
	D F	Protein	Fibre	Calcium	Iron	Ascorbic acid
Varieties (V)	1	0 053	0.04	57 5**	49 703**	26.00
Cooking methods (M)	3	0 051	0 017	411 00**	12 209**	274 67**
V x M	3	0.007	0 003	11.33	0 149	1.33
Error	8	0 012	0 023	5 00	0.05	7.00

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX X

Effect of different methods of cooking on the nutritional composition of the two varieties of amaranthus during summer season

Abstract of ANOVA

Source	D F	Mean squares				
		Protein	Fibre	Calcium	Iron	Ascorbic acid
Varieties (V)	1	0 076	0.391**	812 300**	30.00**	26 02
Cooking methods (M)	3	0 039	0 017	455 600**	13 737**	214.667**
V x M	3	0 009	0.001	16 900	0.153	1 337
Error	8	0.021	0.028	6.000	0.043	7 25

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX XI

Effect of different types of cooking vessels on the nutritional composition of the two varieties of amaranthus during rainy season

Abstract of ANOVA

Source	Mean squares					
	D.F	Protein	Fibre	Calcium	Iron	Ascorbic acid
Varieties (V)	1	0.213	6.310**	9603 350**	6 109**	2.613
Cooking methods (M)	1	0.0001	0 074	289 590	1.628	3.333
Cooking vessels (V)	5	0 006	0 039	303.33	404 705**	91.333**
V x M	1	0.008	0.132	230.125	0.504	5.299
V x C	5	0 004	0 032	205 172	0 733	2.133
M x C	5	0 003	0 028	274 772	6 547**	22 133
V x M x C	5	0 007	0 030	449 98	0 441	0 541
Error	24	0 193	0 189	424 660	0 638	6 083

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX XII

Effect of different types of cooking vessels on the nutritional compo
of the two varieties of amaranthus during summer season

Abstract of ANOVA

Source	Mean squares				
	D.F	Protein	Fiber	Calcium	Iron
Varieties (V)	1	0.241	1.005**	1687 50*	11 781**
Cooking methods (M)	1	0.030	0.003	468 750	2 329
Cooking vessels (V)	5	0 031	0.007	442 050	443 202**
V x M	1	0.021	0 0002	61.500	2 633
V xC	5	0.014	0 003	247.350	1 506
M x C	5	0 018	0 0003	186 750	2 082
V x M x C	5	0 031	0 0007	90 700	0 203
Error	24	1 032	0.022	251.950	0.675

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX XIII

Effect of location of leaves on the organoleptic qualites of th
varieties of amaranthus during rainy season

Abstract of ANOVA

Source	Mean squares				
	D F	Colour	Doneness	Tenderness	Odour
Varieties (V)	1	0 694	0 027	0.028	0 0001
Different parts (P)	2	0 778	1.333	0 528	0 778
V x P	2	0.111	0.111	0 028	0 333
Error	30	0 283	0 061	0 817	1.156

APPENDIX XIV

Effect of location of leaves on the organoleptic qualities of the two varieties of amaranthus during summer season

Abstract of ANOVA

Source	Mean squares					
	D.F	Colour	Doneness	Tenderness	Odour	Taste
Varieties (V)	1	0.250	0.111	0.028	0.0001	0.250
Different parts (P)	2	0.361	0.333	0.111	0.028	1.361
V x P	2	0.083	0.111	0.111	0.083	0.083
Error	30	0.106	0.133	0.239	0.056	0.150

APPENDIX XV

Effect of storage periods and storage methods on the organoleptic qualities of the two varieties of amaranthus during rainy and summer season

Abstract of ANOVA

Source	Mean squares					
	D.F	Colour	Doneness	Tenderness	Odour	Taste
Seasons (A)	1	9 031**	10.503**	3 337*	30 013**	13 781**
Varieties (B)	1	4 753**	5 281**	3 781*	3 337*	4 753*
Storage periods (C)	2	17 983**	13 514**	18 886**	26 823**	10 670**
Storage methods (D)	3	1 042*	1 522	2 865*	1 309	0 753
A x B	1	0 003	0 169	0 003	0 086	0 031
B x C	2	0 128	0 001	0 219	0 107	0.003
A x C	2	0 073	0 097	1 399	3 510*	1 906
A x D	3	0 365	0 652	0 624	0 049	0 022
B x D	3	0 291	0 059	0 235	0 040	0 457
C x D	6	0.274	0 199	0 455	0 351	0 406
A x B x C	2	0 483	0 431	0 149	0 045	0 281
A x B x D	3	0 522	0 077	0 235	0 105	0 439
A x C x D	6	0 115	0.773	0 756	0 056	0 355
B x C x D	6	0 068	0 111	0 186	0 117	0 054
A x B x C x D	6	0 154	0 199	0 089	0.313	0 230
Error	240	0 388	0 019	0 660	0 756	0 656

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX XVI

Effect of different methods of cooking on the organoleptic qualities of the two varieties of amaranthus during rainy and summer season

Abstract of ANOVA

Source		Mean squares				
	D F	Colour	Doneness	Tenderness	Odour	Taste
Seasons	1	0.006	0.766	0 840	0.766	0.141
Varieties (A)	1	1 563	0 141	0 094	0 918	0 391
Cooking methods (B)	3	1 824	0.096	1.178	1 219	0.437
A x B	3	0 4 4	0 117	0.069	0 003	0.149
Error	80	0 746	1 081	0 813	0.894	0.006

APPENDIX XVII

Effect of different types of cooking vessels on the organoleptic qualities of the two varieties of amaranthus during rainy and summer season

Abstract of ANOVA

Source	Mean squares					
	D.F	Colour	Doneness	Tender-ness	Odour	Taste
Seasons (A)	1	1 003	4.754**	10.889**	2 169	7 070**
Varieties (B)	1	6.420**	2.170*	2 723*	4 253*	1 003
Cooking methods (C)	1	1.837*	3 781**	3.556*	9.753**	1 003
Cooking vessels(D)	5	1.170	1.445	0.972	1.886	1 604
A x B	1	0.003	0.586	0.0004	1.003	0 419
B x C	1	1.252	0.003	0.0004	0 169	0 781
A x C	1	0.587	0 586	0 222	2 531	2 169
A x D	5	0.270	0.028	0.705	1 387	0.237
B x D	5	0.270	0.078	0 722	0 570	0.453
C x D	5	0 604	0.089	0 789	0 720	0 537
A x B x C	1	0 781	0.003	0.056	0.170	0 170
A x B x D	5	0 137	0.179	1.001	0 036	0 454
A x C x D	5	0.537	0.612	0.889	0.448	0 420
B x C x D	5	0.820	0 529	0.217	0 154	0.115
A x B x C x D	5	0.365	0 045	0.205	0.203	0.319
Error	240	0 456	0.522	0 619	0.733	0 578

* Significant at 5 per cent level

** Significant at 1 per cent level

NUTRITIONAL PROFILE OF AMARANTHUS AS INFLUENCED BY POST HARVEST HANDLING

BY

JIJIAMMA, N C.

ABSTRACT OF A THESIS
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ABSTRACT

A study was undertaken to estimate the nutritional composition and organoleptic qualities of red and green varieties of *Amaranthus tricolor*, during rainy and summer season, with respect to the post harvest handling methods and maturity levels of the plant

The leaves were analysed for protein, fiber, calcium, iron and ascorbic acid contents The results showed that, concentration of the nutrients was highest in the two varieties of amaranthus when harvested around 20 days after transplanting Of the two varieties studied, the green variety was ranked higher in the concentration of various nutrients during the two seasons Quality of the amaranthus leaves grown during summer season was better except for ascorbic acid

Leaves collected from the middle portion of the plant of both the varieties had higher nutrient concentration than the leaves from tip and base portions

Storage of leaves for different duration was found not to affect the nutrient content except ascorbic acid Among the different methods of storage, refrigerator was found to be better when compared to other methods

Loss of nutrients during cooking was found to be lesser during 'steaming', while it was higher in the leaves cooked by boiling in respect of ascorbic acid Different types of vessels had no influence in altering the nutrient content of the leaves from two varieties of amaranthus during the two seasons However, the iron content of the two varieties of amaranthus was found to be increased when cooked in cast iron pan Loss of ascorbic acid was found to be significantly higher when cooked in copper and iron vessels

Results of the acceptability tests indicated that red amaranthus was found to be more acceptable than green amaranthus The acceptability was more in the leaves grown during summer season

Leaves collected from the middle and tip portion of the plant were found to be more acceptable than leaves from the base portion

Among the different storage methods tried during the two seasons, leaves stored in refrigerator were found to have a better acceptability The acceptability of the leaves decreased as the storage period increased

An analysis of the acceptability of the leaves cooked under different methods indicated that boiling in water was the most acceptable and aluminium and steel vessels were found more suitable for retaining the qualities of the leaves.