QUALITY EVALUATION OF SELECTED VEGETABLES UNDER RAIN SHELTER AND OPEN FIELD CULTIVATION

By

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THESIS

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DECLARATION

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

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ABBREVIATIONS

A.A.U.	-	Assam Agricultural University
A.O.A.C	-	Association of Official Analytical Chemists
CD	-	Critical Difference
EDTA	-	Ethelene Diamine Tetra Acetic acid
g	-	Gram
K.A.U.	-	Kerala Agricultural University
kg	-	kilogram
μg	-	Micro gram
mg	-	Milli gram
ml	-	Milli liter
%	-	Per cent
O	-	Open field
ppm	-	Parts per million
R	-	Rain shelter

Introduction

INTRODUCTION

Vegetables are important source of protective nutrients such as vitamins and minerals. Vegetables supply many nutrients besides providing variety to the diet. They make the food attractive by their color, texture and flavour (Srilakshmi, 2003). Apart from nutritive value of vegetables, constituents such as antioxidants, bioflavanoids, flavour compounds and dietary fibres play a vital role in disease prevention. Vegetables as a group, supply high amounts of water and the mineral elements present in them, contribute the alkaline substances in the body. This enables to maintain the acid base balance of the body.

Vegetable production and productivity must be increased to meet the present inadequate supply and to keep pace with the rising population for nutritional security. In the present scenario of high demand of vegetables and shrinking land holding, protected cultivation is the best alternative approach for using land and other resources efficiently.

Commercial cultivation of flowers and vegetables is still the mainstay of Indian Horticulture. The protected cultivation of these crops opened up new avenues for producing good quality flowers and vegetables for domestic markets and export purposes. Protected cultivation has been found beneficial to produce hybrid seeds, vegetable seedlings, and also for off-season cultivation of vegetables. Environmental stimulation in the form of protected structures like green house, poly house, tunnels, trenches etc. under good management agricultural practices can increase crop yield by 3-4 times compared to open cultivation (Rathore *et al.*, 2005). The major fraction of cost is that of the structure which accounts to 70 per cent of the cost of production of vegetables. Therefore to make it a profitable and sustainable farm activity, cost effective structures are to be developed, which will enhance protected cultivation in large areas. Hence, right sizing of the green house technology is the need of the day. Corrected efforts are required to bring down the cost of the structure by utilizing locally available materials like wooden or bamboo poles whenever possible. Protected cultivation needs to be standardized for different locations based on temperature, humidity, rainfall, wind velocity and other related parameters.

Hi-tech structures, which are fully climate controlled, cannot be recommended for the farmers of Kerala, whose resource bases are very low. Hence low cost structures, which protect crop from heavy rain fall and which provide ample natural ventilation named, as 'Rain shelter' will be much useful in this context. They are structures with only roof cladding and open sides. Cladding is provided with U.V.stabilized polyethylene film. Sides are kept open or protected by wire nets. These rain shelters are also used during summer month using shade nets of lower shade percentage for desired modification of microclimate. Growing vegetables in rain shelter provide ample scope for enhancement of vegetable production in Kerala by facilitating off-season cultivation. Systematic study on the nutritive value and acceptability of vegetables grown under protected cultivation has not been evaluated in our state. Hence, the study on quality evaluation of vegetables under rain shelter and open field cultivation is proposed with the following objectives.

1. To determine the nutritional and anti nutritional composition of selected vegetables, and
2. To estimate the acceptability of these vegetables.

Review of Literature

2: REVIEW OF LITERATURE

The literature relevant to the study entitled "Quality evaluation of selected vegetables under rain shelter and open field cultivation" is reviewed under the following sections.

2.1. Significance of vegetables in our diet.
2.2. Composition of vegetables.
2.3. Anti nutritional factors in vegetables.
2.4. Importance of protected cultivation in vegetables.
2.5. Organoleptic evaluation.

2.1. SIGNIFICANCE OF VEGETABLES IN OUR DIET.

Vegetables are plants or parts of plants that are used as foods. The term vegetables has through usage come to apply in more narrow sense to those plants or parts of plants that are served raw or cooked, as part of the main course of the meal (Srilaksmi, 2003).

The main purpose of vegetables in human diet is that they embellish the existing diet with nutrients, enrich the staple food, make it more palatable and improve the digestion and some times they have a curative action (Indira and Peter, 1988). According to Jayaraman *et al.* (1991), vegetables form an important component of the Indian dietary in which they are normally prepared and consumed in the form of different types of curries as traditionally formulated in various regions of the country. Vegetables play an important role in our health security, which is endangered by the low intake of protective foods. Among protective foods, vegetables are excellent sources of roughages, carbohydrates, proteins, vitamins and minerals like calcium and iron (Dutt, 1996 and Ramesh *et al.*, 1997). Manay and Shadaksharaswamy (1998), opined that the intake of vegetables has been too low in our daily diet because we are not able to appreciate the vast potential of vegetables in our diet and therefore continue to depend too much on cereals. Vegetables among protective foods are rich sources of essential elements besides having medicinal and therapeutic properties and able to provide nutritional security to a predominantly vegetarian country like India (Verma, 2001).

According to Passmore and Eastwood (1986), the large bulk of vegetables help to promote satiety and this, with their low energy value makes them useful in the prevention and treatment of obesity. Vegetarianism not only reduce the food cost but also lower blood cholesterol, non insulin dependent diabetes mellitus and has lower risk of developing some of the serious scourges of mankind like atherosclerosis, diverticular disturbances of colon, haemorrhoids, gall stones and even constipation and obesity (Kanwar *et al.*, 1997). Epidemiological studies have shown that diets rich in plant foods significantly reduce the incidence and mortality rates of degenerative diseases caused by oxidative stress (Tibble, 1998). Padma *et al.* (1999) indicated that the maximum levels of antioxidants can be derived from the consumption of raw vegetables and fruits rather than cooked ones.

Vegetables also play a key role in neutralizing the acids produced during digestion of protein and fatty foods and also provide roughage in the form of dietary fibre, which helps in digestion and bowel movement (Chakrabarthi, 2001). Increasing intake of dietary antioxidants from vegetables may help to maintain an adequate antioxidant status and therefore the normal physiological functions of a living system (Kaur and Kapoor, 2001). Vadera *et al.* (2003) reported hypocholesterolemic and hypolipidemic effect of fibre from mustard and curry leaves with a potential anti-atherogenic property. Consumption of fruits and vegetables has been reported to reduce the incidence of major diseases like cancer, cardiovascular diseases, diabetes, cataracts and inflammatory diseases (Svilaas *et al.*, 2004).

2.2. COMPOSITION OF VEGETABLES.

Fruits and vegetables provide substantial amounts of nutrients important for human health. They are particularly important sources of micronutrients such as provitamin A, vitamin E, vitamin C, vitamin B6 folic acid, iron and magnesium (Singh and Kalloo, 2001). Vegetables are primary dietary sources of essential nutrients viz vitamin C, β carotene, folic acid and minerals. Further more vegetable provides many nutritionally less defined yet important for our diet like fibers and antioxidants (De, 2001).

The main micronutrients present in vegetables showing strong anticarcinogenic effect include provitamin A, vitamin C, vitamin E and selenium (Ames *et al.*, 1993 and Bertram, 1996). Until recently most attention has been paid to vitamins such as vitamin C, provitamin A and dietary fibre in vegetables but in recent years it has been shown that plant tissue contain a whole variety of potentially anticarcinogenic secondary metabolites (Savery *et al.*, 1999).

2.2.1. Green Leafy vegetables.

The bulk of green leafy vegetables available in India are comprised of water within the range of 73.1 to 91.1 per cent (Jijiamma, 1989). The moisture content of green leafy vegetables from North East India was found to be 85 per cent (Longvah, 2000). Study conducted by Mathew (2000) indicated moisture content of 78.92 to 92.78 percent in unconventional leaves of Kerala. Mziray *et al.* (2001) reported moisture content of about 85.3 to 86.5 per cent in *Amaranthus hybridus*, which were collected from different areas of Tanzania. Kumaran (2003) observed 72.33 to 85.78 per cent moisture in green leafy vegetables.

Amaranthus species are known to contain high levels of protein (Mugerva and Bwabye, 1974). Reddish green keera is reported to contain more protein than amaranthus green (KAU, 1984). On dry weight basis CO-3 culture amaranthus contain 12.5 per cent protein (Mohidcen *et al.*, 1985). The green leafy vegetables are reported to be good sources of protein and the dry matter of leaves contain as much as protein as legumes (Reddy, 1999).

The crude protein content of amaranthus sp. were reported to be 4 $g100g^{-1}$ (Hemalatha *et al.*, 1999). Suman (2000) observed 3.35 per cent of crude protein in fresh amaranth.

Amaranthus hybridus grown in different locations of Tanzania exhibited a protein content of 28.2 to 31.6 per cent (Mziray *et al.*, 2001). Punia *et al* (2004) reported that the protein content of amaranth in fresh weight basis were 5.44 g $100g^{-1}$.

Leafy vegetables like amaranth, gogu and fenugreek provide an average of 0.34 per cent of fat and these leaves contain high amount of alpha linolenic acid NIN (1994).

Tanzanian vegetables provided a crude fat in the range of 2.57 to 4.34 percent, the lowest being in amaranthus and highest in cow pea leaves (Mosha *et al.*, 1995).

Shingade *et al.* (1995) estimated the fat concentration of ten unconventional leafy vegetables and found that these were poor sources of fat, which ranged between 0.2 and 0.96 per cent. The authors also observed a maximum crude fat content of 0.96 per cent in drumstick leaves, 0.6 per cent in *Amaranthus tricolor* and 0.7 per cent in kawala while the rest of the vegetables contained 0.4 per cent of crude fat.

Mathew (2000) studied the fat content of nine leafy vegetables and reported a variation of 0.16 per cent to 0.65 per cent with *Amamranthus tristis* having the highest value.

Pereira *et al.* (2001) reported high concentration of PUFA in mint leaves with a value of 195 mg $100g^{-1}$.

The fibre content of most leafy vegetables fell within the narrow range of 1 to 4 per cent (Jones *et al.*, 1990).

Total fibre content of green leafy vegetables viz. amaranth, gogu and bacchali varied from 1.6 to 2.6 per cent (NIN, 1994).

Mosha *et al.* (1995) and Lucas (1988) indicated that crude fibre content of amaranth on dry weight basis varied from 9.1 to 21.25 per cent.

The most commonly consumed green leafy vegetables were analyzed for their dietary fibre fractions by Rao and Ramulu (1998) and indicated that majority of them contained 2.5 to 6.6 per cent Total Dietary Fibre (TDF), 1.6 to 5.1 per cent Insoluble Dietary Fibre (IDF) and 0.9 to 1.5 per cent of Soluble Dietary Fibre (SDF). Escudera *et al.* (1999) reported a total dietary fibre content of 53.81 g $100g^{-1}$ in *Amaranthus muricatus* on dry weight basis.

Suman (2000) reported 1.72 per cent of fibre in fresh amaranth. Handique (2003) analysed some non-conventional leafy vegetables in North East India like *Amaranthus viridis, Boerhavia diffusa, Alternanthera sessilis, Polygonum chinese* and *Ipomea aquatica* and the fibre content of leaves varied from 4.9 to 14.2 per cent.

Punia *et al.* (2004) reported that the crude fibre content of amaranth leaves were 1.56 g $100g^{-1}$ on fresh weight basis.

Wills *et al.* (1984) analyzed the nutritional composition of Chinese vegetables and found that *Amaranthus tricolor* had a starch content of 0.2 g $100g^{-1}$ of the edible portion.

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

Kumaran (2003) observed a starch content ranging from 0.04 to 0.31 per cent in green leafy vegetables with highest in coriander leaves. Handique (2003) analysed five unconventional vegetables from ethnic sources of North East India and reported a carbohydrate content of 6.16 to 17.00 per cent.

Devadas and Saroja (1979) revealed that amaranthus sp. are excellent source of iron and β carotene and daily inclusion of amaranth in the diet of children could help to alleviate iron and vitamin A deficiencies.

Amaranthus sp. is known to contain high levels of calcium (Castendac *et al.*, 1986). According to Gopalan *et al.* (1989), iron and calcium contents of *Amaranthus gangeticus* are 25.5 mg and 397 mg respectively, while *Amaranthus tricolor* are 3.49 mg and 397 mg $100g^{-1}$ respectively.

Beegum and Pereria (1990) reported that the daily inclusion of 50-80 g of amaranth in our diet would considerably help to meet the RDA of vitamins and minerals. Among the leafy vegetables amaranth is best to improve the iron nutritional status of adolescents (Devadas *et al.*, 1992).

According to Hemalatha *et al.* (1999), amaranthus sp. contained 340 mg of calcium per 100 g, which is greater when compared to kanni keerai (196.0 mg $100g^{-1}$). Suman (2000) reported 197.39 mg and 20.52 mg of calcium and iron respectively in amaranthus. Mziray *et al.* (2001) analyzed fresh amaranth from four cities of Dar es Salaam and reported that the level of calcium, iron and phosphorous varied 2062 to 2263 mg $100g^{-1}$, 108 to 128 mg $100g^{-1}$ and 500 to 553 mg $100g^{-1}$ respectively on dry weight basis. Bharathi and Umamaheshwari (2001) analyzed ten traditional leafy vegetables of Andhra Pradesh and showed that they are good sources of moisture, protein, crude fibre, β carotene and ascorbic acid, more over the leaves contained less fat and moderate oxalic acid.

The iron content of Bathua (*Chenopodium album*) and spinach (*Spinacia oleracia*) were reported to be 20.63 mg and 26.54 mg respectively (Yadav and Sehgal, 2002).

Nordeide *et al.* (1996) reported that leaves of *Amaranthus viridis*, a cultivated leafy vegetable in Southern Mali, are rich in β carotene (3290 μg $100g^{-1}$). The β carotene content of 12 genotypes of Chinese cabbage varied from 0.88 to 1.62 mg $100g^{-1}$ (Kundu *et al.*, 1998). Suman (2000) reported a β carotene content of 15064 μg $100g^{-1}$ in amaranthus. Sue *et al.* (2002) reported β carotene content of sow thistle and amaranth as 3.3 mg and 4 mg $100g^{-1}$ respectively.

Some green leafy vegetables like spinach, amaranth, fenugreek, mustard, drumstick, mint and coriander are good sources of vitamin C (Thimmayamma and Pasricha, 1996). The vitamin C content of *Amaranthus gangeticus* was found to be 72.1 $mg100g^{-1}$ (Premavalli *et al.*, 2001).

According to Punia *et al.* (2004) calcium, iron, vitamin C and β carotene content of fresh amaranth leaves were 611.95, 1.75, 32.36 mg $100g^{-1}$ and 2744.0 μg $100g^{-1}$ fresh weight basis respectively.

2.2.2. Other vegetables.

Neeliyara (1998) analyzed the moisture content of five winged bean genotype available in Kerala and found that it varied from 70.32 to 74.6 per cent. Kathi (2002) reported that moisture content in hyacinth bean genotypes varied from 84.32 to 86.9 per cent. A 100 g of edible part of bitter gourd contains 92.4 per cent moisture (Kumar and Sagar, 2003). According to Mousa *et al.* (2004) the moisture content of fresh brinjal fruits were 91.44 per cent.

Leguminous vegetables are important sources of dietary protein (Nowacki, 1980). According to Neeliyara (1998) the protein content of five winged bean genotypes available in Kerala varied from 2.7 to 3 per cent. Edible portion of bitter gourd contain 1.6 g100g^{-1} of protein (Kumar and Sagar, 2003). Soy proteins have number of health benefits such as cancer prevention, cholesterol reduction and combating osteoporosis (Jayachandran *et al.*, 2005).

Neeliyara (1998) analysed five varieties of winged bean genotypes grown in Kerala and found that the fat content varied from 0.5 to 0.7 g 100g^{-1}. Pumpkin seeds are rich in fats (Manay and Sadaksharaswamy, 1998). Thampi (1998) analysed 20 varieties of thamaravenda genotype and found that the fat content varies between 12.52 to 14.83 g 100g^{-1}. According to Kumar and Sagar (2003) an edible portion of bitter gourd contains 0.2 g of fat per 100 g.

According to Neeliyara (1998) the fibre content of five winged bean genotypes available in Kerala varied from 16.2 to 18.2 per cent. Thampi (1998) analysed 20 varieties of thamaravenda genotypes and found that the fibre content ranged from 9.28 per cent to 15.17 per cent. George (2000) observed that fresh amla contained 3.2 g 100g^{-1} of fibre. Fibre content in hyacinth bean genotypes varied from 0.5 to 0.7 g 100g^{-1} (Kathi, 2002). A 100g edible portion of bitter gourd contains 0.8 g of crude fibre (Kumar and Sagar, 2003).

Neeliyara (1998) analysed five varieties of winged bean genotypes commonly growing in Kerala and found that starch content varied from 23.6 to 27.5 per cent.

The starch content of five high yielding varieties of hyacinth bean genotypes ranged between 28 to 34.4 mg 100g^{-1} (Kathi, 2002). According to Kumar and Sagar (2003) bitter gourd have a carbohydrate content of 4.2 g 100g^{-1}.

Neeliyara (1998) reported that the iron content in five varieties of winged bean genotypes ranged from 0.56 to 1.41 mg $100g^{-1}$ and calcium content between 209.6 to 299.9 mg $100g^{-1}$ respectively. Kathi (2002) studied five high yielding varieties of hyacinth bean genotypes and reported that ascorbic acid content ranged between 8 to 9.6 mg $100g^{-1}$. Bitter gourd is rich in all the essential vitamins and minerals especially β carotene, B, C and iron. A100g edible portion of bitter gourd contain 20 mg of calcium, 70 mg of phosphorous and 1.8 mg of iron (Kumar and Sagar, 2003).

Among Indian varieties of tomato 'Indoprocess III' (Sethi and Anand, 1986), 'Pusa Ruby' (Rao and Yadav, 1988) and 'MTH-5' (Thakur and Lalkaushal, 1995) are some of promising varieties in terms of lycopene content. Tomato fruits cultivated in Hungary showed variation of 1to 3 fold in lycopene content (Abushita *et al.*, 1997). The lycopene content of different Spanish tomato varieties ranged from 1.9 to 6.5 mg $100g^{-1}$ (Martinez *et al.*, 2002). Raffo *et al.* (2002) observed relatively high levels of carotenoids in cherry tomato (cv. Naomi F_1).

2.2.3. Roots and tubers.

The potatoes contain an average of 80 per cent water (Kumar and Singh, 2003). According to Bhupinder and Gursharan (2003) the moisture content of carrot was 88.2 percent. An analysis of white radish showed that it consisted of 94.4 per cent moisture (Bakhru, 2003). Fresh potatoes have a moisture content ranging from 6-8 kg water per kg (Neema and Datta, 2004). Potato tubers contain about 80 per cent of water (Singh *et al.*, 2004). According to Kumar *et al.* (2004) onion slices have moisture content of 86.5 per cent. Sagar *et al.* (2004) studied four varieties of carrot and found that the moisture content ranged from 88.83 in Sel-14 to 91.15 per cent in Pusa Kesar.

An analysis of white radish shows that it consists of 0.7 per cent protein (Bakhru, 2003). According to Swamy (2004) colocasia tubers contained about 3.0 g of protein per 100 g.

Pathak *et al.* (2000) observed that the fat content of radish, carrot and cauliflower were 0.3 per cent, 0.2 and 0.4 per cent respectively.

An analysis of white radish shows that it contains about 0.1 per cent of fat (Bakhru, 2003). Swamy (2004) observed that the colocasia tubers contained 0.1 g of fat per 100g.

According to Bakhru (2003) white radish contained 0.8 per cent of fibre.

Yam constituted a staple carbohydrate food of the people in tropics (Rasper and Coursey, 1976). Sweet potato consisted of 88 per cent of carbohydrates of which a major portion is starch (Collins and Hutseil, 1987).

Some of the important root vegetables, which are commonly consumed in our country, are tapioca; potato, sweet potato, carrots, yam and colocasia. They are all rich in carbohydrates and can form an important source of energy (NIN, 1994). Tapioca consumed in Kerala as carbohydrate source helps to meet a short supply in cereals during drought conditions (NIN, 1994).

Potato tubers contained 16-18 per cent starch, besides very small quantities of reducing sugar and sucrose (Kumar and Singh, 2003).

Tapioca and yams are rich in calcium (NIN, 1994). Carrots and yellow varieties of yams are rich in carotenes and potato is a significant source of vitamin C (NIN, 1994).

Among vegetables carrot have the highest amounts of carotene, 1222 µg

$100g^{-1}$ while the other vegetables such as beans, tomato and pumpkin contained 737, 283 and 444 μg of carotenoids respectively. Beetroot, cauliflower and yam had the lowest amounts 13. 25 and 29.4 μg $100g^{-1}$ respectively (Seema *et al.*, 1998).

The radish is one of the richest sources of iron, calcium and sodium among common vegetables. An analysis of radish showed that it consisted of 0.6 per cent of minerals such as calcium 35 mg $100g^{-1}$ and phosphorous 22 mg $100g^{-1}$ (Bakhru, 2003).

Sagar *et al.* (2004) studied four varieties of carrot and observed that β carotene content in fresh carrot of Sel-14 was 42.97 mg $100g^{-1}$ on moisture free basis and less in *Pusa meghali* that is about 37.6 mg $100g^{-1}$.

Epidemiological studies have shown that the phenolic compounds which are naturally occuring antioxidants found in foods such as fruits, vegetables, cereals, nuts, tea, coffee and wine have a protective effect against coronary heart diseases (Shahidi and Naczk, 1995).

Sies and Stahl (1995) reported that the lycopene present in tomato fruits exhibits the highest antioxidant activity, which may contribute to a reduction in disease risk. In cell culture studies the activity of lycopene in inhibiting breast cancer has been well demonstrated (Levy *et al.*, 1995).

Giovannuccui *et al.* (1995) reported that the dietary intake of lycopene is epidemiologically correlated with diminished risk of cancer.

More recently lycopene was found to protect against carcinogen induced oxidative damage by stimulating GSH dependent hepatic detoxification systems (Velmurugan *et al.*, 2001). According to Kaur *et al.* (2004) the antioxidant activity of lycopene is associated with lowering DNA damage, malignant transformation and reducing biological oxidative damage of proteins, lipids and other cell component *in vitro.*

In vitro antioxidant activity of hot chilli pepper was found to be 3.49 mM (Gunduc and El, 2003).

Cherry tomato variety 818 cherry had the highest antioxidant content (ascorbic acid, phenols and beta carotene) and antioxidant activity (2.3 mM) among the 12 tomato varieties screened (George *et al.*, 2004).

2.3. ANTI NUTRITONAL FACTORS IN VEGETABLES.

Anti nutritional factors are the substances, particularly of plant origin, which interfere with the assimilation if nutrients present in them (NIN, 1994).

Oxalic acid, a dicarboxylic acid or its salts are a widely distributed anti nutrient in plant foods (Gopalan, *et al.*, 1989). Oxalate levels in foods are of concern, because, free radicals bind essential dietary divalent minerals, primarily calcium and make them nutritionally unavailable. The absolute amounts of minerals are therefore of little value, unless considered in relation to oxalic acid content. The calcium oxalate formed may accumulate resulting in oxalurea or kidney stone (Gopalan *et al., 1989*).

Despite the high levels of nutrients, the main constraint to the nutritive value of green leafy vegetables is the presence of some anti nutritional factors like oxalates and nitrates (Singh and Saxena, 1972., Cheek and Bromson, 1980. and Gupta and Wagle, 1988). Marderosian *et al.* (1979) and Mallika (1987) observed that the oxalate of amaranth increased with maturity. Mallika (1987) reported that oxalic acid levels in amaranth green become high when grown under dry conditions. Charley (1982) *reported that the calcium in spinach and* other plants of this family become unavailable because the oxalic acid present, binds the calcium to an insoluble form. Aletor and Adeogun (1995) analysed the anti nutritional factors of seven vegetables found in Nigeria and observed that the dry vegetables generally had higher oxalate than fresh ones.

Arka Suguna is a new multicult amaranth released by IIHR, Bangalore and has 1.49 per cent of oxalic acid (Varalakshmi *et al.*, 1998). According to Reddy (1999) certain leafy vegetables such as spinach, amaranth and gogu are rich in oxalic acid and hence the individual prone to renal calculi should avoid such foods. Mathew (2000) reported that the bengal keera had highest oxalate content and *Amaranthus tricolor* had highest nitrate content among nine leafy vegetables analyzed. Anti nutritional composition of *Amaranthus hybridus* from four locations of Dar es Salaam were studied by Mziray *et al.* (2001) and reported an oxalate content of 3383 to 4333 mg $100g^{-1}$.

The usual human dietary intake of nitrate is about 100 mg $100g^{-1}$ (White, 1975).

Kurien *et al.* (1976) and Singh *et al.* (1985) observed a direct influence of nitrogen fertilization on the nitrate content of foods. Palis and Bustrillos (1976) reported that nitrate accumulated significantly in the edible portion with increased fertilizer levels. The nitrate may get converted to nitrite and nitrosamins in the body (Tannenbaum *et al.*, 1978). According to Vera *et al.* (1992) lower rates of fertilizer should be recommended commercially to reduce the nitrate concentration in green leafy vegetables such as spinach. Chan (1996) reported that excessive intake of nitrate and nitrite in the diet may cause toxic effects due to the formation of methmoglobin by oxidation of haemoglobin by nitrite.

Zhou *et al.* (2000) reported accumulation of high levels of nitrate and nitrite by the application of nitrogenous fertilizers in vegetables grown in China. Nitrate present in the soil and water accumulates in the plants in toxic concentration, which is ingested by animals and gets converted into nitrites in the digestive tract (Singh and Govindarajan, 2001).

Schmidt *et al.* (1971) reported an average nitrate content of 0.67 per cent in *Amamaranthus cruentus.* Devadas (1982) studied the nitrate content of 25 genotypes of amaranth and reported that the content varied from 0.25 to 0.75 percent on dry weight basis. The author also reported that among eight species, the lowest nitrate content was in *Amaranthus dubicus.* In Andhra Pradesh, the nitrate content of the leafy vegetables contributed to 1.38 per cent of the total nitrate intake (Gundimeda *et al.*, 1993). Prakash *et al.* (1993) found a nitrate content of 0.31 to 0.92 per cent in *Amaranthus hypochondriacus.*

Santamaria *et al.* (1999) reported high levels of nitrate in green leafy vegetables than bulb, root, shoot, inflorescence and tuber vegetables. Mathew (2000) analysed eight leafy vegetables and reported a variation of 0.11 to 0.35 per cent in the nitrate content with highest in *Amaranthus tricolor* and lowest in basella leaves. Anti nutritional composition of *Amaranthus hybridus* from four locations of Dar es Salaam was studied by Mziray *et al* (2001) and reported a nitrate content of 501 to 560 mg $100g^{-1}$. Cabbage tends to accumulate nitrate if grown in nitrate rich soil (Singh and Govindarajan, 2001). Kulkarni *et al.* (2003) analyzed nine leafy vegetables and reported that nitrate content of leaves ranged from 52.8 to 312.4 mg on fresh weight basis.

Anti nutritional factors such as trypsin and chymotrypsin inhibitors, phytates and phenol present in the dry seeds of moth bean could be destroyed to a great extent by processing, such as roasting, sprouting, boiling etc (Khokhar and Chauhan, 1986). Henderson *et al.* (1986) reported trypsin inhibitors, lectins, phytates and oligosaccharides in defatted and decorticated cucurbita seed meals. Kantha *et al.* (1986) reported that tannin content in different varieties of winged bean; the range was 0.02 to 0.07 per cent. Singh *et al.* (1987) reported the specific haemagglutinating activity, trypsin inhibitors and saponin content of winged bean seeds as 3.92 Hua g^{-1} sample, 1317.20 mg g^{-1} and 92.91 mg g^{-1} respectively.

Mohan and Janardhanan (1995) reported the presence of anti nutritional factors like total free phenols and tannins in the green plasm seeds of the tree legume *Arbus precatorius* and *Cassia of obtusifolia.*

Presence of a variety of anti nutrients such as enzymes, protease inhibitors, haemagglutinates, phytates, oligosaccharides, saponins, sterols, alcohols, goitrogens and phenolic compounds have been reported in soybeans (Naik, 1997). According to Kowsalya and Mohandas (1999) the raw leaves of cauliflower has anti nutrients like phytates, tannins and oxalates within the range reported for leafy vegetables. It was noticed that cooking reduced the anti nutrient content to one third for oxalates, but was less for phytates and marginal for tannins.

Lancaster *et al.* (1982) studied the ill effects of cyanogenic glycosides of cassava, which released cyanide on hydrolysis. Delange *et al.* (1982) had also found that antithyroid action of cassava was due to the release of thiocyanate from the cyanide (hydro cyanic acid) produced by the hydrolysis of linamarin. Radhakrishnan (1987) analyzed six varieties of cassava and found an average of 19.29 per cent of hydro cyanic acid in cassava.

Cyanide content in the range of 10 to 20 mg $100g^{-1}$ of pulses were considered to be safe (Srilakshmi, 2003). Cooking of colocasia thoroughly is essential to remove the toxic effects of oxalic acid crystals in the outer layers of colocasia tubers (Swamy, 2004). Tannins form complex with protein, starch and digestive enzymes to cause reduction in the nutritional value of foods (Jayachandran *et al.*, 2005).

2.4. IMPORTANCE OF PROTECTED CULTIVATION IN VEGETABLES.

In the present scenario of perpetual demand of fruits and vegetables and shrinking land holding drastically, protected cultivation is the best alternative and drudgery less approach for using land and other resources more efficiently. In protected environment, the natural environment is modified to suitable conditions for optimum plant growth, which ultimately provide quality fruits and vegetables (Sirohi and Behera, 2000).

Under protected cultivation we can get high quality products along with higher yield by providing or altering specific environmental conditions and cultural practices (Vezhavendan, 2001).

Protective cultivation is actually an invention attempting to achieve higher water and nutrient use efficiency and reducing transpiration (Prabhakar and Hebbar, 2002).

2.4.1. Light

Light affects the composition of leafy vegetables and fruits especially their ascorbic acid content. Somers and Kelly (1957) observed that turnip plants grown in full sunlight contained more ascorbic acid than those grown in shade.

Light, acids and other factors were reported to cause isomerisation of lycopene in tomato fruits (Nguyen and Schwartz, 1998 and Shi *et al.*, 1999).

Ajithkumar (1999) reported that bright sunshine of 5.2 to 10 hours is required for optimum growth of tomato under Vellanikkara conditions.

According to Lara *et al.* (1999) *Capsicum pubescence* plants were grown under four shade levels (90, 70, 50 and 30 per cent) while controls were grown without any shading. The highest shade level caused excessive stem elongation. Overall, the best vegetative and reproductive development occurred under 30-70 per cent shade levels.

When tomato fruits were exposed to light, there were greater capacity for storing starch (higher fruit weight). High light intensity is closely associated with high vitamin C content, on the other hand too light intensity or strong direct radiation on fruit reduces fruit quality (Vezhavendan, 2001).

Low light intensity reduces pigment synthesis resulting in uneven fruit colouring and leads to the formation of swollen or hollow fruit or fruit with a mealy taste. Under very low light intensities the fruit set is reduced due to lack of photo assimilates. One per cent reduction in light level in winter time is translated into a weight loss of 0.6 per cent in young plants and one per cent in older plants, while loss in fruit yield is approximately one per cent (Dorais and Papadapouloss, 2001).

2.4.2. Temperature

Ascorbic acid content is increased in vegetables when the temperature maintained at 24^0C for turnips, chive - 21-24^0C, chicory -24^0 C' spinach beet - 12^0C, broad bean - >12^0C and cress - >12^0C (Rosenfed, 1979).

Rajendar (1985) reported that temperature plays an important role in the growth and development of plants. Temperature influenced the rate of photosynthesis, respiration and other metabolic processes, which then, influenced the yield, quality of the product and timing of crops maturity.

It is reported that increasing ambient temperature by 1^0C increases fruit dry matter content by 0.07 per cent. High temperature accelerates fruit development and reduces the time required for ripening, but also decreases their size and therefore their quality. They also favour an increase in the number of misshapen fruit and soft fruit (Dekoning, 1992).

Tomato fruits grown in green house either in summer or in winter are lower in lycopene content than fruits produced out door during summer. Fruits picked in green, and ripened in storage are lower in lycopene than vine ripened fruits (Gould, 1992).

Bakker (1993) reported that high temperature level does not seem favorable for firmness, shelf life and flavor of sweet pepper fruits. Low temperature, however gives rise to small, oblate fruits with elongated styles more cracked fruits and more rotten fruits during post harvest stage.

Growth and development of satsuma fruits are highly dependent on temperature, particularly during early fruit development and that growers should strive to maximize the temperature. They achieve this for instance by planting on the warmer sites available and maintaining a shelter and possibly development takes place during early summer when temperature is higher (Richardson and Marsh, 1993).

Relatively high temperature (38^0C) was found to inhibit lycopene production while low temperatures inhibited both lycopene production and fruit ripening in tomatoes (Lurie *et al.*, 1996).

2.4.3. Humidity

Kobryn (1998) reported that high air humidity had no effect on the contents of dry matter, vitamin C and nitrates in Chinese cabbages. High humidity conditions cause a decrease of nutrient uptake (Ca), an increase in root pressure, and generally favour fruit cracking (Dorais and Papadapouloss, 2001). Fruits produced under low relative humidity are firmer, juicier, less mealy and have less physiological disorders such as cracking and gold specks than fruits produced under low relative humidity (Vezhavendan, 2001).

2.4.4. Carbon dioxide enrichment.

According to Islam *et al* (1995), the carbon dioxide enriched fruits had significantly lower concentrations of citric, malic and oxalic acid but significantly higher reducing sugar contents and acid invertase activities at harvest and during storage. Elevated carbon dioxide resulted in a deeper red colour during storage.

In strawberry high carbon dioxide tended to improve fruit quality. Rising of carbon dioxide concentration accelerated dry matter increment and total sugar accumulation in fruits, especially for sucrose and decreased titrable acid content, resulting in higher sugar / acid ratios of fruits (Kai *et al.*, 1997).

Good quality fruits with low rates of infected and malformed fruits were produced in the presence of carbon dioxide at 100 ppm. The highest marketable yields were also obtained with 1000 ppm and 1500ppm (Yongseub *et al.*, 1998).

2.4.5. Cultural practices

Adams and Winsor (1976) reported that plants grown in nutrient film technique system (NFT) yield fruits higher in dry matter content, soluble sugars and titrable acids compared to solid substrates.

Fertigation, the application of nutrients through the irrigation system is a popular method in green house vegetable cultivation. Fertilizer formulations and fertigation schedules for various soil less tomato and cucumber production system have been standardized (Papadapouloss *et al.*, 1997). Currently computer controlled fertigation systems, which take into account of crop and environmental conditions are becoming popular in various European and North American green houses (Papadapouloss and Pararasingham, 1998).

Off-season cropping pattern under low cost plastic green house cum rain shelter is more suitable for tomato crop (A.A.U., 1997). The yield of tomato inside the shelter was higher (5 kg m^{-1}) than under open field conditions (1.3 kg m^{-1}) (KAU, 1999).

The productivity of capsicum hybrids under low cost green house was not significantly higher (71.3 t/ha) but the produce had excellent quality as compared to open field cultivations (Khan *et al.*, 2000).

Capsicum grown under naturally ventilated poly house showed four times more yield compared to those grown in the field (Nagalakshmi *et al.*, 2001). Hydroponics culture is the most intensive method of crop production in today's agricultural industry, and generally permits the production of higher quality fruit than in soil (Dorais and Papadapouloss, 2001).

Anbarasan (2003) reported that realized yield of tomato gave a B/C ratio of 0.22 under poly house and 0.46 under open field cultivation. On computing the potential / expected yield, B/C ratio obtained was 1.14 and 1.58 for crops under open field and poly house conditions respectively.

2.5. ORGANOLEPTIC EVALUATION

According to Amerin *et al.* (1965) foods are submitted to sensory examination to provide information that can lead to product improvement, quality maintenance or other development of new products or analysis of the market. Quality is the ultimate criteria of the desirability of any food product to the consumer. Overall quality depends on quantity, nutritional and other hidden attributes and sensory quality (Ranganna, 1977). According to Bodyfelt *et al.* (1988), measuring the sensory attributes like color, appearance, feel, aroma, taste and texture are the deciding factors in food acceptance (Pal *et al.*, 1995). Quality refers to many aspects like hygienic and sanitary quality, color, size, shape, nutrient content, shelf life, suitability for processing and conversion into value added products. Numerous genetic, climatic and cultural factors were found to influence the organoleptic and nutritional properties of fruits and vegetables (Vezhavendan, 2001).

Adams (1990) reported that restriction in water supply improved the organoleptic qualities in tomato fruits. Reduction in fruit water content as well as an increase in fruit soluble solids, sucrose, hexoses, citric acid and potassium have been reported in tomato plants growing under water stress conditions. Tomato fruit color depends on fruit carotenoids. Their concentration in fruits depends on the cultivars and growing conditions (Fraser *et al.*, 1994). Yuxin *et al.* (1997) reported that the flavour of the tomato fruit from the top and middle layers of the plants were better than the tomato from the bottom layer, which was similar to that of the soil control. According to Sams (1999) texture is an important constituent of tomato fruit quality and acceptability. Texture is composed of several properties such as mechanical and chemical characteristics. These factors vary not only among cultivars but also as a function of growing conditions.

Jijiamma and Prema (1993) observed better acceptability for red amaranthus grown during summer. Alleman *et al.* (1996) evaluated six amaranthus genotypes in South Africa, for taste and acceptability as a source of nutrition. Acceptability of the leaf material for human consumption was tested for both taste and texture. According to the authors *A. tricolor* and *A. hypochondriacus* had the best taste, significantly better than that of *A. cruentus.* Kala *et al.* (1998) compared the sensory attributes of microwave cooked and conventionally cooked green leafy vegetables viz amaranth, kilkeerai, shepu and spinach. Results showed that only the color of cooked greens preferred to conventionally cooked greens. Mathew (2000) studied the acceptability of different leafy vegetables during summer and rainy season and reported that the leafy vegetables are more acceptable during summer and also observed that better acceptability for red and green amaranth during summer and rainy season.

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

Cayuela *et al.* (1997) studied the quality of straw berries cultivated ecologically and compared with that of conventionally cultivated straw berries. The result showed that ecologically grown fruits had a superior quality to the conventionally grown fruits, the former showing a more intense colour, higher sugar and better organoleptic properties. Fruit colour, fresh quality and sweetness were better as planting density decreased. Sugar content was influenced by planting density in watermelon (Soongi *et al.*, 1997). Organoleptic evaluation of fruit of pumpkin revealed that in general the sensory attributes like colour, flavour, texture and overall appearance was influenced neither by the maturity stage nor the source of nutrition in varieties CO-1 and suvarna (Veena, 2001).

Thampi (1998) studied the acceptability of 20 varieties of thamaravenda genotypes and reported that the highest score was obtained for the genotype AM-2 and the lowest score for AM-27.

Kathi (2002) studied the acceptability of five high yielding varieties of hyacinth bean genotypes and found that the genotype DL-50 had the highest score followed by DL-40 while the lowest for the genotype DL-6-1.

Materials and Methods

3. MATERIALS AND METHODS

The methods used for the study "Quality evaluation of selected vegetables under rain shelter and open field cultivation" are given under the following heads.

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

3 .1. SELECTION OF VEGETABLES

Two varieties of tomato, amaranth and capsicum cultivated in rain shelter and open field in the ongoing NATP in the department of Olericulture were used for the study. The varieties are

1.Amaranth

a). Arun

b). Mohini

2.Capsicum

a). California Wonder

b). Pusa Deepthi

3.Tomato

a). Shakthi

b). Anagha

Plate 1. Rain shelter with roof ventilation

Plate 2. Rain shelter without roof ventilation

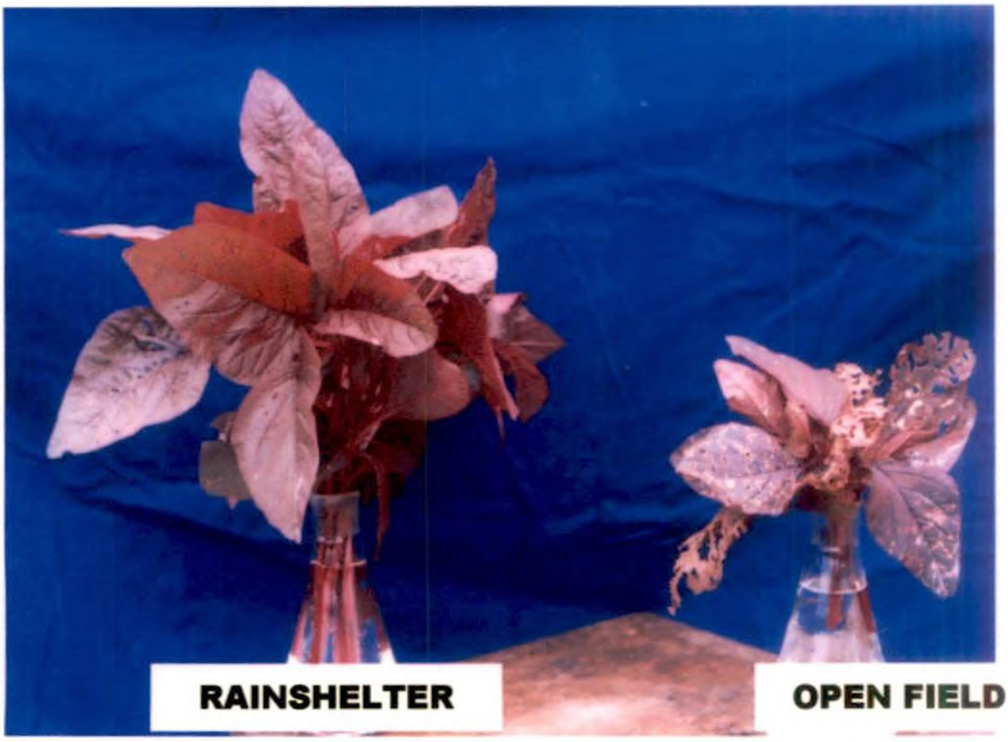

Plate 3. Amaranth (Arun)

Plate 4. Amaranth (Mohini)

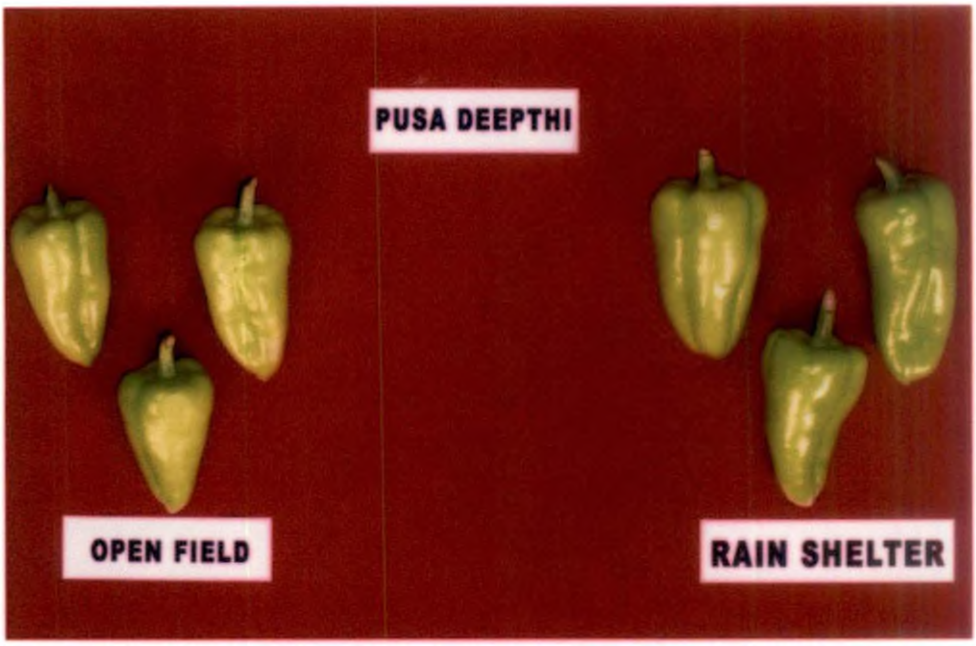

Plate.5. Capsicum (Pusa Deepthi)

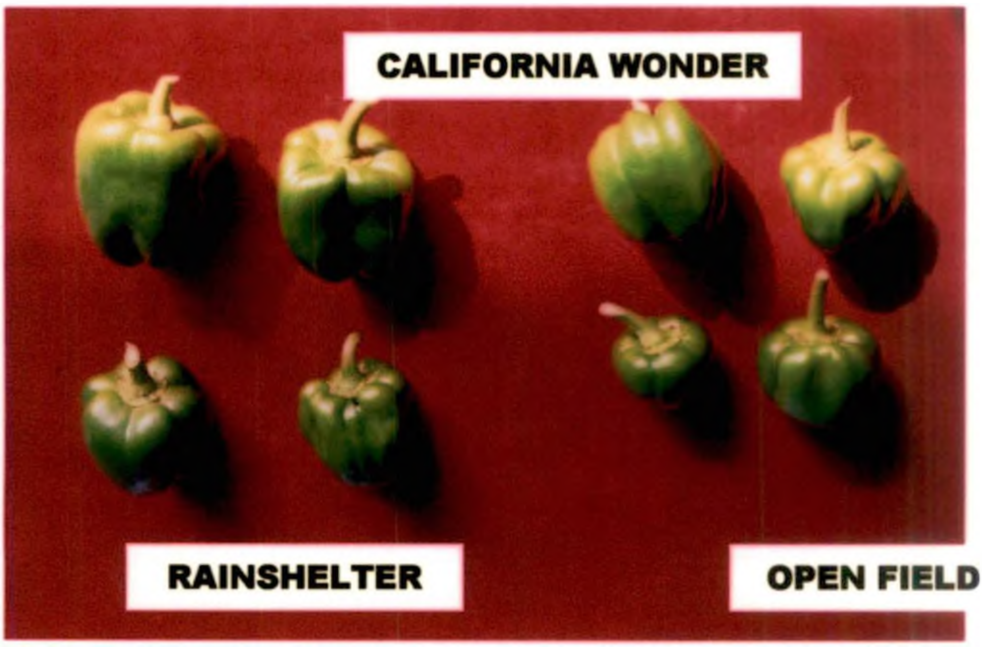

Plate. 6.Capsicum (California Wonder)

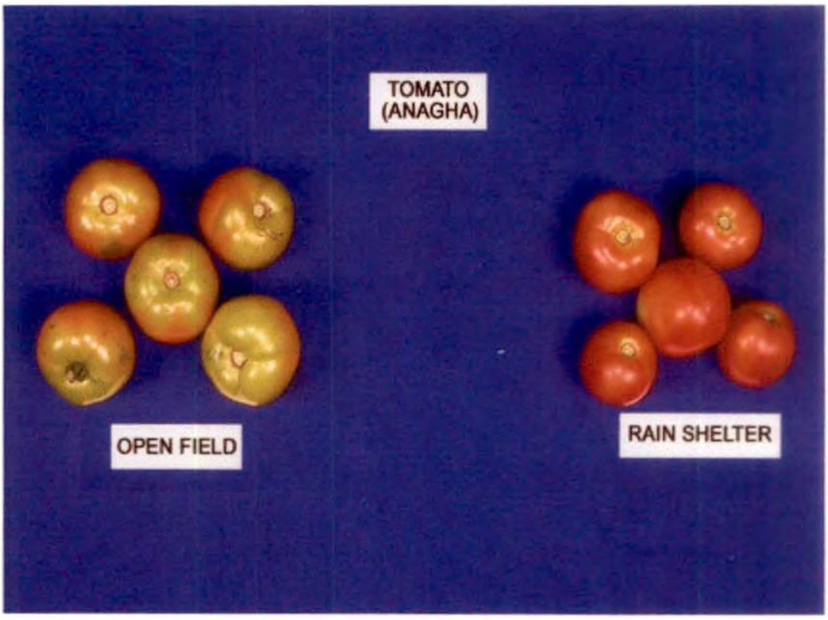

Plate. 6.Tomato (Anagha)

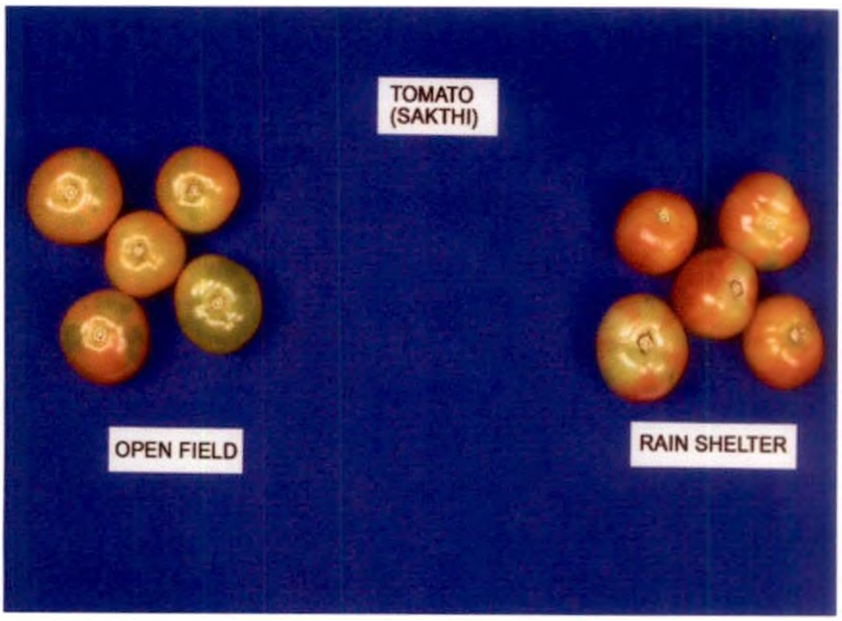

Plate. 7.Tomato (Shakthi)

3.2. COLLECTION OF SAMPLES

Vegetables cultivated under rain shelter and open field in rainy season were collected for the study. From each variety of vegetables seven samples were randomly collected for analysis in the following stages.

Tomato-red ripe stage.
Amaranth -edible stage.
Capsicum - before ripening.

3.3. NUTRIENT ANALYSIS OF VEGETABLES.

The selected vegetables were analyzed for the following nutrients.

1) Moisture
2) Fibre
3) Protein
4) Starch
5) Calcium
6) Iron
7) Phosphorus
8) Potassium
9) Sodium
10) Vitamin C
11) β carotene and
12) Lycopene (tomato only).

3.3.1. Moisture

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

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

3.3.2. Fibre

The fibre content was estimated by acid-alkali digestion method as suggested by Chopra and Kanwar (1978).

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

3.3.3. Protein

The protein content was estimated using the method suggested by Fischer (1973).

In one litre of distilled water, dissolved 0.382 g of NH_4Cl and from that 100 ppm, 120 ppm, 140 ppm, 160 ppm, 180 ppm and 200 ppm were read colourimetrically for the preparation of standard graph. Weighed 0.5 g of sample and was digested in conc. sulphuric acid for 10 minutes and added 2-3 ml of hydrogen peroxide drop wise till the solution became colourless. The solution was made up to 100 ml. From the working solution, 5 ml was taken and 1 ml of 10 per cent sodium silicate followed by 2 ml of 10 per cent sodium hydroxide were added and made up to 50 ml. To this 1.6 ml of Nessler's reagent was added and the red colour developed was read at 410 nm. Standard graph was prepared and estimated the protein content.

3.3.4. Starch.

Starch content was estimated colourimetrically using anthrone reagent, as suggested by Sadasivam and Manikkam (1992).

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

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

3.3.5. Calcium

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

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

3.3.6. Iron

The iron content was analyzed colourimetrically using ferric iron, which gives a blood red colour with potassium thiocyanate (NIN, 2003).

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

3.3.7. Phosphorus

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

One gram of dried and powdered plant sample was pre digested with 12 ml of 9:4 diacid and volume made up to 100 ml. Five ml of the aliquot was pipetted into a 25 ml volumetric flask, and five ml of nitric acid - vanadate molybdate reagent and made up to 25 ml. After 10 minutes the intensity of yellow colour was read at 470 nm in a spectrophotometer. A standard graph was prepared using serial dilutions of standard phosphorus solution. From the standard graph the phosphorus content of the sample was estimated and converted to fresh weight basis.

3.3.8. Potassium

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

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

3.3.9. Sodium

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

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

3.3.10. Vitamin C

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

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

3.3.11. β carotene

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

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

3.3.12. Lycopene.

Lycopene content in tomato was estimated based on the measurement of absorption of the petroleum ether extract of the total carotenoids (Ranganna, 1977).

About 2g of tomato pulp was weighed and extracted repeatedly with acetone in a pestle and mortar until the residue was colourless. The acetone extract was transferred to a separating funnel containing 10-15ml of petroleum ether and 20 ml of 5 per cent sodium sulphate. The lower phase was transferred to a conical flask and the petroleum ether extract containing carotenoids to an amber coloured bottle containing about 10g of anhydrous sodium sulphate. An aliquot was diluted to 50ml with petroleum ether and the intensity was measured in spectrophotometer at 530 nm by using petroleum ether as blank. The lycopene content of the tomato was calculated from the reading.

3.4. ANALYSIS OF ANTI NUTRITIONAL FACTORS.

The anti nutritional factors like oxalates and nitrates in amaranth growing under rain shelter and open field were analyzed.

3.4.1. Oxalate

The oxalate content in the sample was analysed colourimetrically as suggested by Marderosian *et al.* (1979).

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

3.4.2. Nitrate

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

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

3.5. ORGANOLEPTIC EVALUATION.

Organoleptic evaluation of the selected vegetables growing under rain shelter and open field cultivation was conducted at the laboratory level.

3.5.1. Selection of judges

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

3.5.2. Preparation of the sample for acceptability studies

Fresh vegetables of each variety at maturity levels were collected and used for acceptability studies.

For amaranth, the fresh leaves (50 g) were washed thoroughly in water to remove the adhering dirt and cut into small pieces using a stainless steel knife. The leaves were sprinkled with water (20 ml) and cooked under low flame in a beaker with lid.

3.5.3. Sensory evaluation

The sensory evaluation was carried out using a score card (Swaminathan, 1974) by the selected ten judges. Five quality attributes like appearance, colour, flavour, texture and taste (only for amaranth) were evaluated using the score cards. Each of the above mentioned quality attribute was assessed by a five point hedonic scale. The score card used for sensory evaluation is given in Appendix I, II, III and IV.

3.6. STATISTICAL ANALYSIS

Analysis of data was carried out by using statistical analysis such as analysis of variance and Mann Whitney's Test.

Results

4. RESULTS

The results pertaining to the study entitled "Quality evaluation of selected vegetables under rain shelter and open field conditions "are presented under the following headings.

1. Duration of maturity.
2.Nutritional composition of vegetables.
3.Antinutritional factors in amaranth.
4.Organoleptic qualities of vegetables.

4.1. DURATION OF MATURITY

Duration of maturity was calculated from the number of days taken from sowing to harvest and the observations are presented in table 1.

The duration of maturity of amaranth was calculated from sowing to harvest that is at tender edible stage. This was varied from 55 to 59 days. The duration of maturity was maximum for the variety 'Arun' cultivated under open field condition (59 days) and it was 57 days for rain shelter crop. In 'Mohini' the duration of maturity was highest in open field crop (58 days) than rain shelter crop (55 days). The duration of maturity of amaranth was high for open field crops than rain shelter crops.

The duration of maturity of capsicum was calculated from sowing to harvest that is before ripening stage. This was varied from 103 to 110 days. The duration of maturity was maximum for the variety 'California Wonder' grown in open field (110 days) than in rain shelter (106 days). In 'Pusa Deepthi' the duration of maturity was maximum for open field crops (107 days) than rain shelter crops (103 days). The duration of maturity of capsicum was high for open field crops than rain shelter crops.

The duration of maturity of tomato was calculated from sowing to harvest that is at red ripe stage. This was ranged from 94 to 100 days. The duration of maturity was maximum for the variety Shakthi cultivated under rain shelter (100 days) than open field crop (96 days). In Anagha the duration of maturity was highest in rain shelter crop (98 days) than in open field crop (94 days). The duration of maturity of tomato was more for rain shelter crops than open field crops.

Table.1. Duration of maturity of vegetables.

Vegetables		Duration of maturity (days)	
Varieties		Rain shelter	Open field
Amaranth	Arun	57	59
	Mohini	55	58
Capsicum	Pusa Deepthi	103	107
	California Wonder	106	110
Tomato	Anagha	98	94
	Shakthi	100	96

4.2. NUTRITIONAL COMPOSITION OF VEGETABLES

Two varieties of amaranth (Mohini, Arun), capsicum (California Wonder, Pusa Deepthi) and tomato (Sakthi, Anagha) cultivated under rain shelter and open field in rainy season were analysed for twelve constituents i.e., moisture, fibre, protein, starch, calcium, iron, phosphorous, potassium, sodium, vitamin C, β carotene and lycopene (tomato only).

4.2.1. AMARANTH

The results of nutrient composition of amaranth cultivated under rain shelter and open field are presented in table 2 and depicted in figure 1.

4.2.1.1. Moisture.

The moisture content of amaranth varied from 80.5 to 85.01 per cent. Maximum moisture content was in the variety 'Arun' cultivated under rain shelter and minimum in the same variety under open field (80.5 %). Moisture content in 'Mohini' was 84.68 per cent in rain shelter crop and 80.6 per cent in open field crop. In both the varieties moisture content was significantly high in amaranth grown in rain shelter.

4.2.1.2 Fibre.

The fibre content of amaranth varied from 1.04g to 1.7g. The fibre content was maximum for the variety 'Mohini' cultivated under rain shelter (1.7g $100g^{-1}$) and minimum for the variety 'Arun' cultivated under open field (1.04g$100g^{-1}$). In both the varieties fibre content was less in amaranth cultivated in open field but the difference observed was not significant.

4.2.1.3 Protein

The protein content of amaranth ranged from 5.07 to 6.3 g $100g^{-1}$. The protein content was maximum for the variety 'Arun' cultivated under rain shelter (6.3g $100g^{-1}$) and minimum for the variety 'Mohini' cultivated under open field (5.07g $100g^{-1}$). In both the varieties protein content was high for the rain shelter crops and the variations observed in the protein content between rain shelter and open field crops were significant.

Table.2. Nutritional composition of amaranth varieties (Fresh weight basis)

Nutrients	Mohini			Arun		
	R	O	CD	R	O	CD
Moisture (g $100g^{-1}$)	84.68	80.6	2.05*	85.01	80.5	2.05*
Fibre (g $100g^{-1}$)	1.7	1.21	0.42*	1.33	1.04	0.42
Protein (g 100 g^{-1})	6.21	5.07	0.037*	6.3	5.28	0.037*
Starch (g $100g^{-1}$)	0.17	0.15	0.0075*	0.16	0.14	0.0075*
Calcium (mg $100g^{-1}$)	363.35	342.28	38.7	305.42	275.14	38.7
Iron (mg $100g^{-1}$)	29.27	26.02	2.31*	27.36	24.2	2.31*
Phosphorous (mg $100g^{-1}$)	68.05	64.86	2.38*	72.70	59.44	2.38*
Potassium (mg $100g^{-1}$)	841.5	834.2	31.95	832.27	817.7	31.95
Sodium (mg $100g^{-1}$)	9.61	7.98	1.12*	14.34	14.27	1.12
Vitamin C (mg $100g^{-1}$)	53.56	51.7	7.72	39.98	33.2	7.72
β carotene (μg $100g^{-1}$)	1153.55	1361.13	90.7*	1252.04	1262.60	90.7

$P<0.05$

R-rain shelter CD – Critical Difference

O-open field * - Significant at 5 per cent level

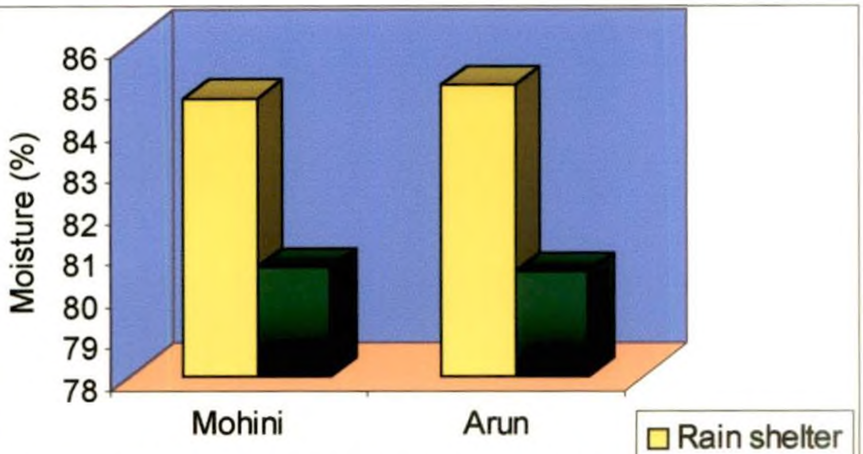

Fig.1.(a) Moisture content of amaranth

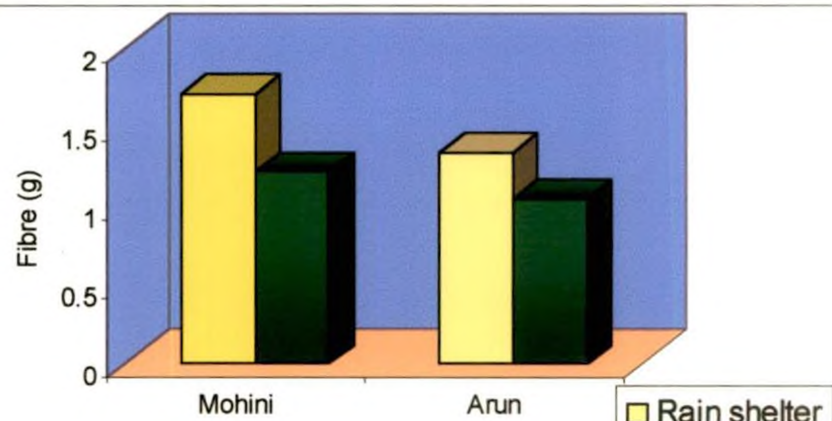

Fig.1.(b) Fibre content of amaranth

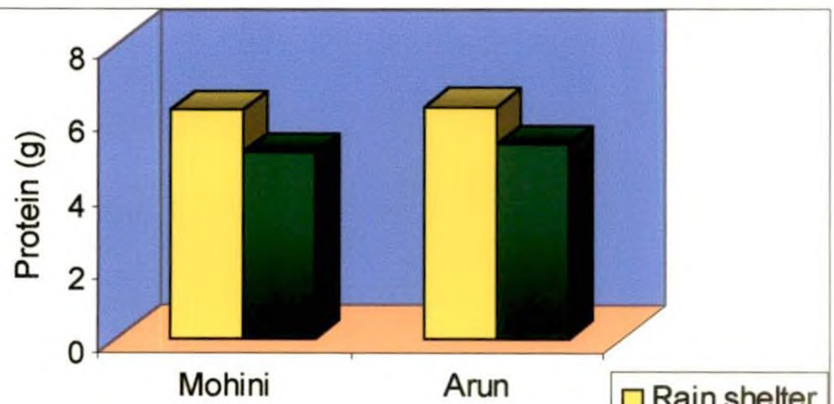

Fig.1. (c) Protein content of amaranth

4.2.1.4 Starch.

The starch content of amaranth varied from 0.14 to 0.17 per cent. The starch content was maximum for the variety 'Mohini' cultivated under rain shelter (0.17 %) and minimum for the variety 'Arun' cultivated under open field (0.14 %). Starch content was less for 'Mohini' (0.15 %) and 'Arun' (0.14 %) cultivated in open field when compared to the rain shelter crops. Starch content was significantly high for rain shelter crops in both the varieties.

4.2.1.5. Calcium

The calcium content of amaranth ranged from 275.14 to 363.35 mg100g^{-1}. The calcium content of amaranth was maximum for the variety 'Mohini' cultivated under rain shelter (363.35 mg 100g^{-1}) and minimum for the variety 'Arun' cultivated under open field (275.14 mg100g^{-1}). The calcium content of 'Mohini' (342.28 mg 100g^{-1}) and 'Arun' (275.14 mg 100g^{-1}) was less in open field cultivation but the difference in calcium content observed was not significant when compared to the rain shelter crops.

4.2.1.6.Iron

The iron content of amaranth ranged from 24.20 to 29.27mg100g^{-1}. The iron content of amaranth was maximum for the variety 'Mohini' cultivated under rain shelter (29.27 mg100g^{-1}) and it was significantly low (26.02 mg 100g^{-1}) in open field cultivation. In 'Arun' also iron was significantly high (27.36 mg100g^{-1}) in rain shelter crop than in open field crop (24.20 mg 100g^{-1}).

4.2.1.7.Phosphorous

The phosphorous content of amaranth ranged from 59.44 to 72.70 mg 100g^{-1}. The phosphorous content of amaranth was maximum for the variety 'Arun'

Figure 1. continued

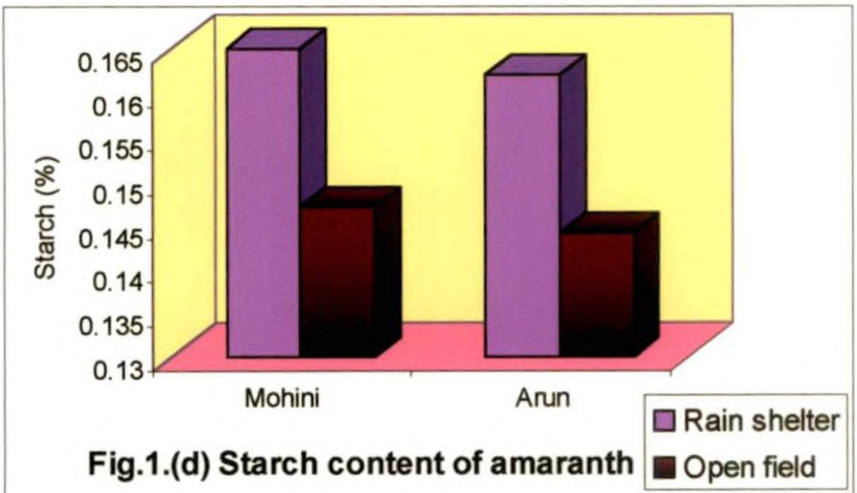

Fig.1.(d) Starch content of amaranth

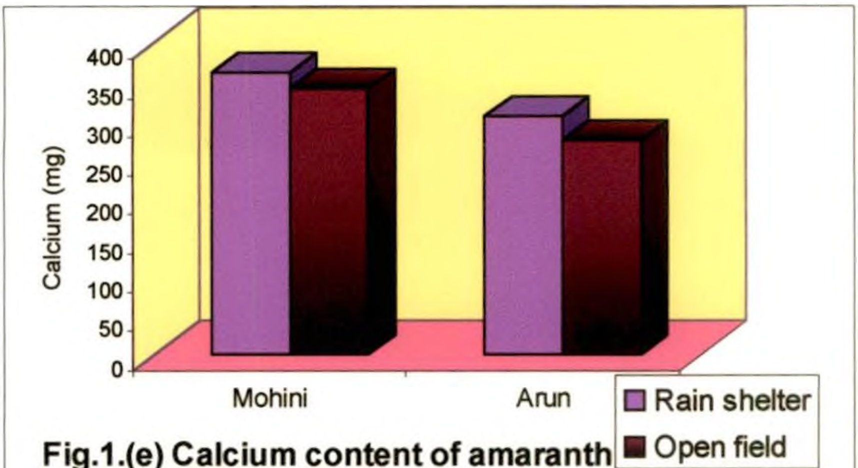

Fig.1.(e) Calcium content of amaranth

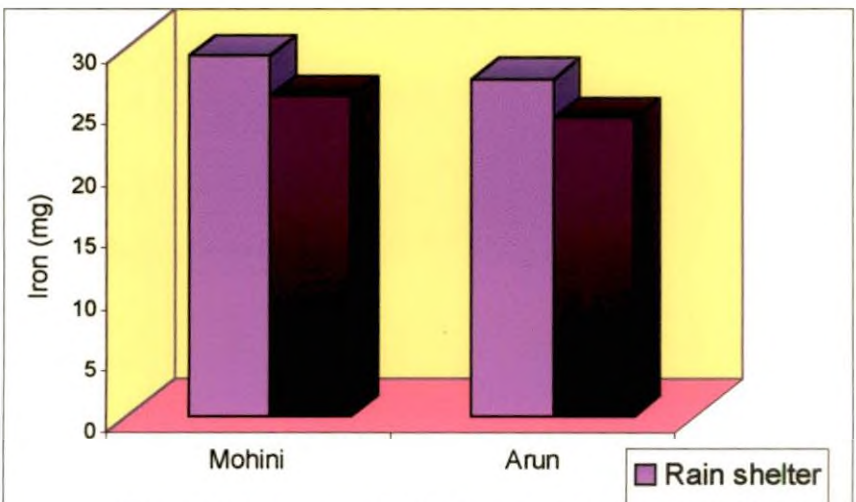

Fig.1.(f) Iron content of amaranth

cultivated under rain shelter (72.7 mg $100g^{-1}$), which was significantly high when compared to open field crop (59.44 mg $100g^{-1}$). In 'Mohini' also phosphorous was significantly high in rain shelter (68.05 mg) crop than in open field (64.86 mg)crop.

4.2.1.8.Potassium

The potassium content of amaranth was maximum for the variety 'Mohini' cultivated under rain shelter (841.5 mg $100g^{-1}$) and minimum for the variety 'Arun' cultivated under open field (817.70 mg $100g^{-1}$). There was no significant variation with respect to potassium content of both the varieties of amaranth in rain shelter and open field. In both the varieties potassium value was less in open field crops (Mohini- 834.2 mg $100g^{-1}$ and Arun 817.7 mg $100g^{-1}$) but the difference was not significant.

4.2.1.9.Sodium

The sodium content of amaranth was maximum for the variety 'Arun' cultivated under rain shelter (14.34 mg $100g^{-1}$) and minimum for the variety 'Mohini' cultivated under open field (7.98 mg $100g^{-1}$). Sodium content was more in the variety 'Arun' under rain shelter (14.34 mg $100g^{-1}$) and open field (14.27 mg $100g^{-1}$) when compared to 'Mohini, which was 9.61mg $100g^{-1}$ for rain shelter and 7.98 mg $100g^{-1}$ for open field crop. There was significant variation with respect to sodium content of amaranth variety 'Mohini' under rain shelter and open field conditions.

4.2.1.10. Vitamin C

The vitamin C content of amaranth ranged from 33.20 to 53.56 mg$100g^{-1}$. The vitamin C content of amaranth was maximum for the variety 'Mohini' cultivated under rain shelter (53.56 mg $100g^{-1}$) whereas it was 51.70 mg $100g^{-1}$ in

Figure 1. continued

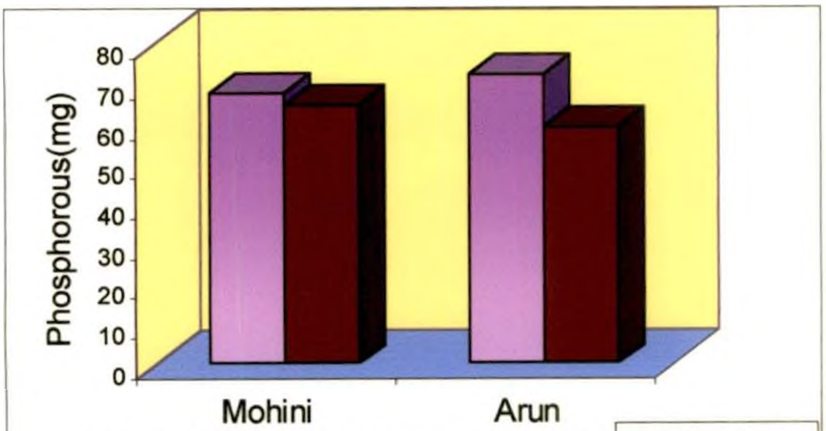

Fig.1.(g) Phosphorous content of amaranth

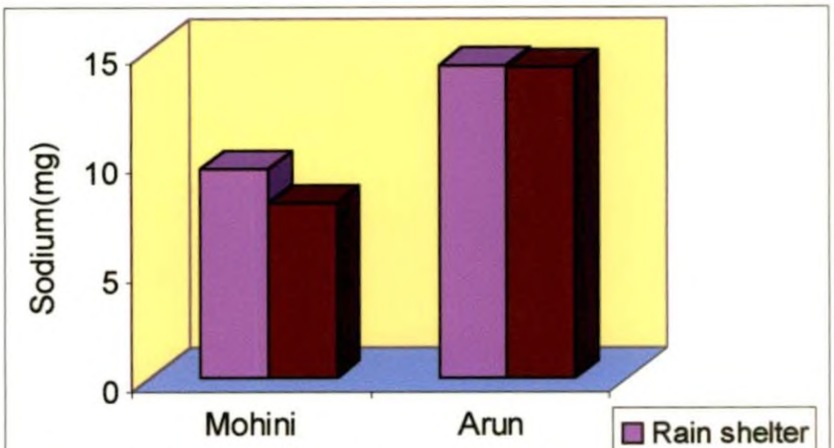

Fig.1.(h) Sodium content of amaranth

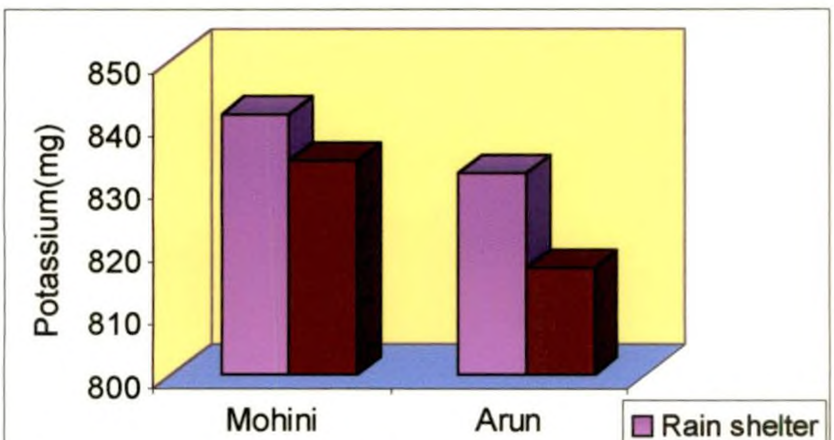

Fig.1.(i) Potassium content of amranth

Figure1. continued

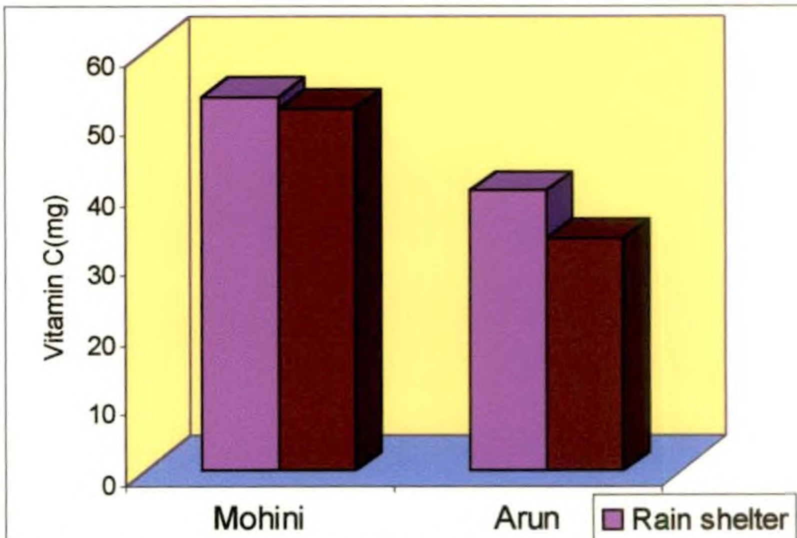

Fig.1.(j)Vitamin C content of amaranth

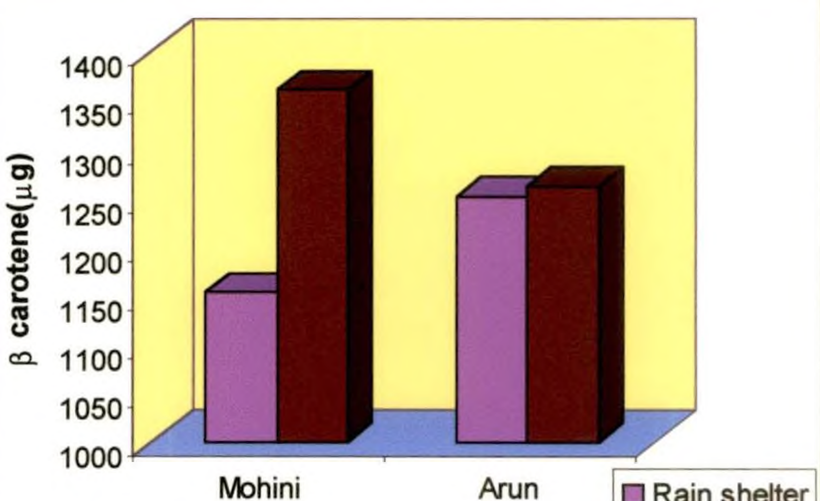

Fig.1.β (k) carotene content of amaranth

open field cultivation. In 'Arun' also rain shelter crop showed high vitamin C (39.98 mg $100g^{-1}$) when compared to open field cultivated crop but the variation observed in the vitamin C content of crops grown under rain shelter and open field was not significant.

4.2.1.11.β carotene

The β carotene content of amaranth varied from 1153.55 μg to 1361.13 μg $100g^{-1}$. The β carotene content of amaranth was maximum for the variety 'Mohini' cultivated in open field (1361.13 μg $100g^{-1}$) but it was 1153.55 μg $100g^{-1}$ in rain shelter cultivated crop. In 'Arun' also β carotene was more in open field crop (1262.6 μg $100g^{-1}$) when compared to rain shelter crop (1252.04 μg $100g^{-1}$). There was no significant variation with respect to β carotene content of 'Arun' cultivated in rain shelter and open filed but there was significant difference with respect to β carotene content for the variety 'Mohini'.

4.2.2. CAPSICUM

The results of nutritional composition of capsicum cultivated under rain shelter and open field conditions are presented in table 3 and depicted in figure 2.

4.2.2.1. Moisture.

The moisture content of capsicum ranged from 91.24 to 93.91 per cent. The moisture content was maximum for the variety 'Pusa Deepthi' cultivated under rain shelter (93.91 %), which was significantly high when compared to the open field cultivated crop (91.24 %). In 'California Wonder' rain shelter cultivated crop showed higher moisture value (92.48 %) when compared to the open field crop (92.24 %) but the difference was not significant.

Table.3. Nutritional composition of capsicum. (Fresh weight basis)

Nutrients	Pusa Deepthi			California Wonder		
	R	O	CD	R	O	CD
Moisture (g $100g^{-1}$)	93.91	91.24	1.56*	92.48	92.24	1.56
Fibre (g 100 g^{-1})	6.35	6.22	0.43	6.36	6.21	0.43
Protein (g $100g^{-1}$)	2.53	2.37	0.14*	2.60	2.26	0.14*
Starch (g $100g^{-1}$)	0.126	0.114	0.003*	0.126	0.115	0.003*
Calcium (mg $100g^{-1}$)	31.71	30.0	3.29	30.0	29.4	3.29
Iron (mg $100g^{-1}$)	4.27	3.27	0.32*	4.95	4.40	0.32*
Phosphorous (mg $100g^{-1}$)	91.6	89.8	7.8	89.07	82.63	7.8
Potassium (mg $100g^{-1}$)	347.65	347.42	14.7	423.21	365.20	14.7*
Sodium (mg $100g^{-1}$)	3.7	3.15	0.453*	4.91	3.35	0.453*
Vitamin C (mg $100g^{-1}$)	107.08	93.64	9.17*	104.32	96.41	9.17
β carotene (μg $100g^{-1}$)	283.26	444.68	43.6*	786.14	962.3	43.6*

$P<0.05$

R-Rain shelter CD – Critical Difference

O -Open field * - Significant at 5 per cent level

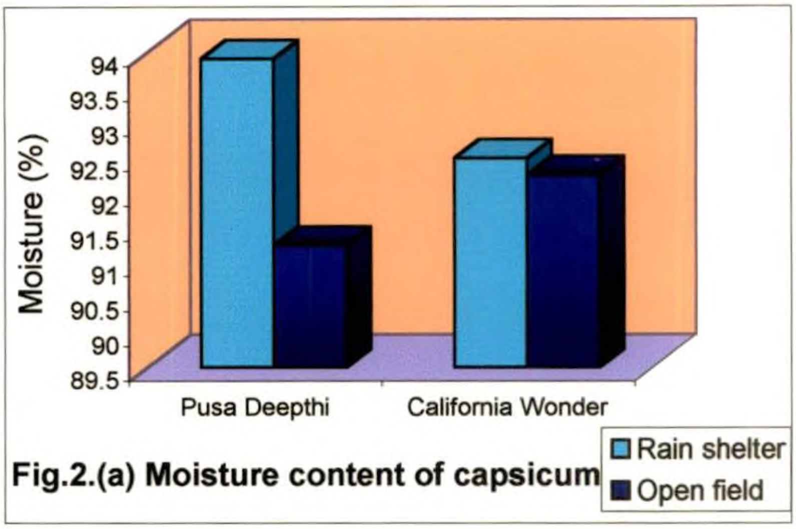

Fig.2.(a) Moisture content of capsicum

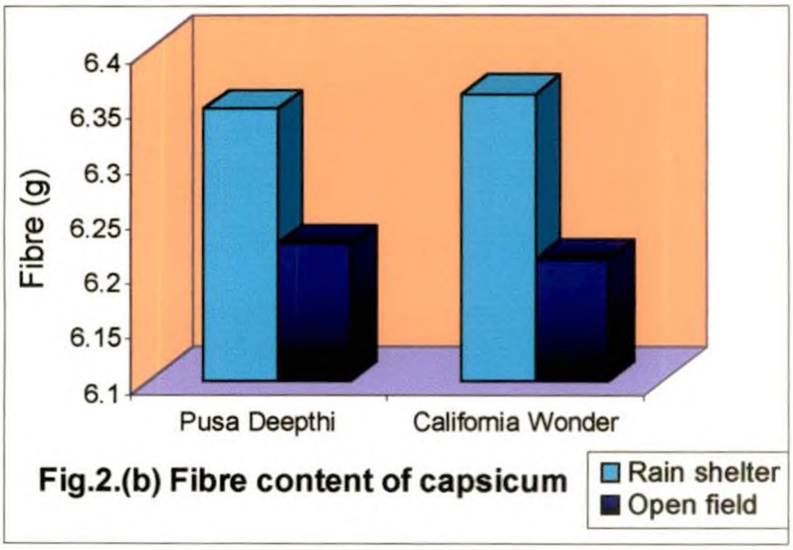

Fig.2.(b) Fibre content of capsicum

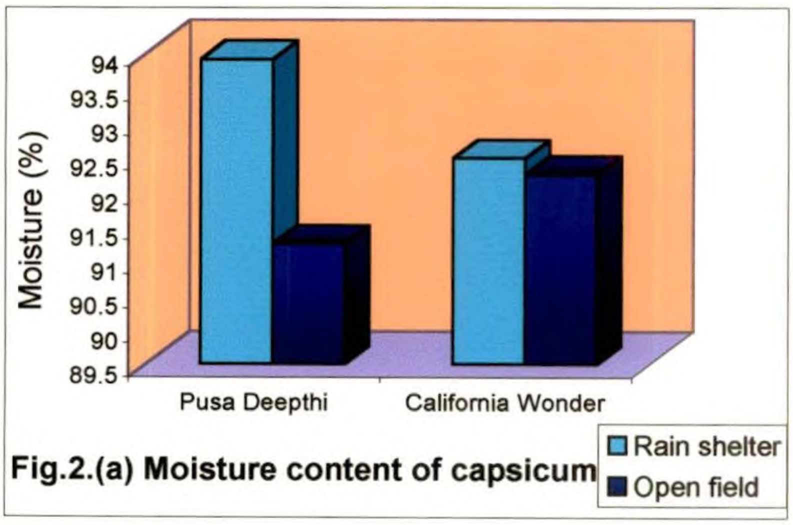

Fig.2.(a) Moisture content of capsicum

4.2.2.2. Fibre

The fibre content of capsicum varied from 6.21 to 6.36 g $100g^{-1}$. The fibre content was maximum for the variety 'California Wonder' cultivated under rain shelter (6.36 g $100g^{-1}$), which showed no significant difference with that of open field crop (6.21 g $100g^{-1}$). In 'Pusa Deepthi' also there was no significant difference in the fibre content of rain shelter crop (6.35 g $100g^{-1}$) and open field (6.22 g $100g^{-1}$) crop.

4.2.2.3.Protein

The protein content of capsicum ranged from 2.26 to 2.60 g $100g^{-1}$. The protein content was maximum for the variety 'California Wonder' cultivated under rain shelter (2.60 g $100g^{-1}$), which was significantly high when compared to the open field cultivated crop (2.26 g $100g^{-1}$). Protein content for 'Pusa Deepthi' was 2.53 g $100g^{-1}$ for rain shelter crop and 2.37 g $100g^{-1}$ for open field crop and the difference was significant.

4.2.2.4.Starch

The starch content of capsicum ranged from 0.114 to 0.126 per cent. The starch content was maximum for 'Pusa Deepthi' and 'California Wonder' cultivated under rain shelter (0.126 %) and minimum for 'Pusa Deepthi' (0.114%) cultivated under open field condition and 0.115 per cent in 'California Wonder.' There was significant variation in the starch content of capsicum cultivated under rain shelter and open field condition.

4.2.2.5.Calcium

The calcium content of capsicum varied from 29.40 to 31.71mg $100g^{-1}$. The calcium content was maximum for 'Pusa Deepthi' under rain shelter

(31.71mg 100g^{-1}) and it was 30 mg 100g^{-1} for open field crop. In 'California Wonder' also calcium content was higher (30.0 mg 100g^{-1}) in rain shelter crop than open field crop (29.4 mg 100g^{-1}). But the difference in calcium content of both the varieties was not significant with respect to the rain shelter and open field crops.

4.2.2.6.Iron

The iron content of capsicum varied from 3.27 to 4.95 mg 100g^{-1}. The iron content of capsicum was maximum for 'California Wonder' cultivated under rain shelter (4.95 mg 100g^{-1}), which was significantly higher than the open field crop (4.40 mg 100g^{-1}). In 'Pusa Deepthi' also rain shelter crop showed significantly higher iron content (4.27 mg 100g^{-1}) than open field crop (3.27 mg 100g^{-1}).

4.2.2.7.Phosphorus

The phosphorous content of capsicum varied from 82.63 to 91.60 mg 100g^{-1}. The phosphorous content was maximum for 'Pusa Deepthi' under rain shelter (91.60 mg 100g^{-1}), which showed no significant difference with that of open field crop (89.8 mg100g^{-1}). In 'California Wonder' also there was no significant variation in phosphorous content of the crops cultivated under rain shelter (89.07 mg100g^{-1}) and open field (82.63 mg100g^{-1}).

4.2.2.8.Potassium

The potassium content of capsicum varied from 347.42 to 423.21 mg 100g^{-1}. The potassium content of capsicum was maximum for 'California Wonder' under rain shelter (423.21 mg 100g^{-1}), which was significantly higher than the open field crop (365.2 mg 100g^{-1}). 'Pusa Deepthi' cultivated under rain

Figure 2 continued

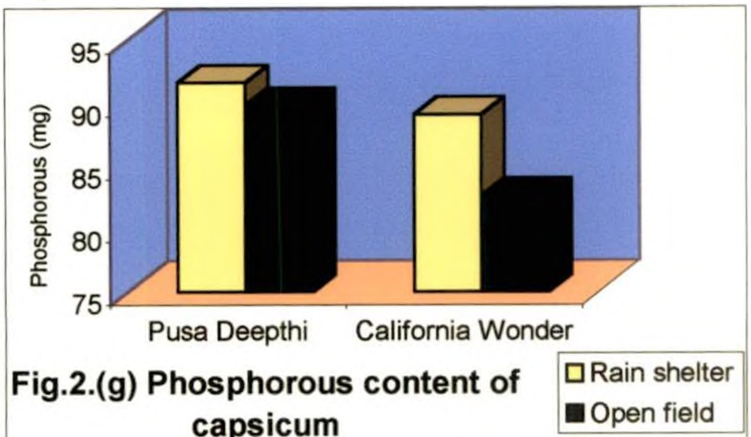

Fig.2.(g) Phosphorous content of capsicum

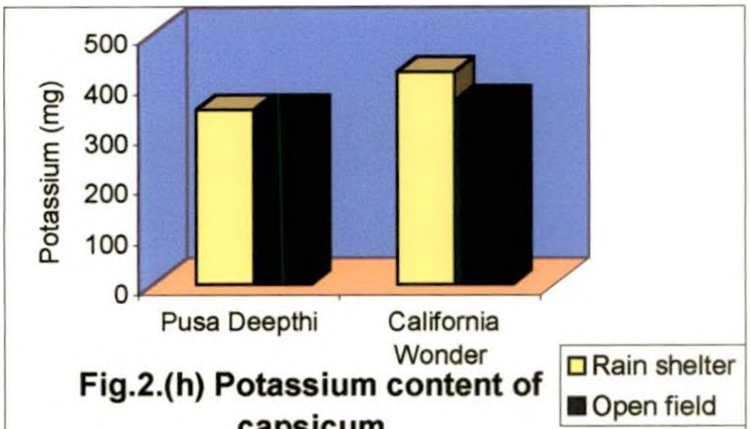

Fig.2.(h) Potassium content of capsicum

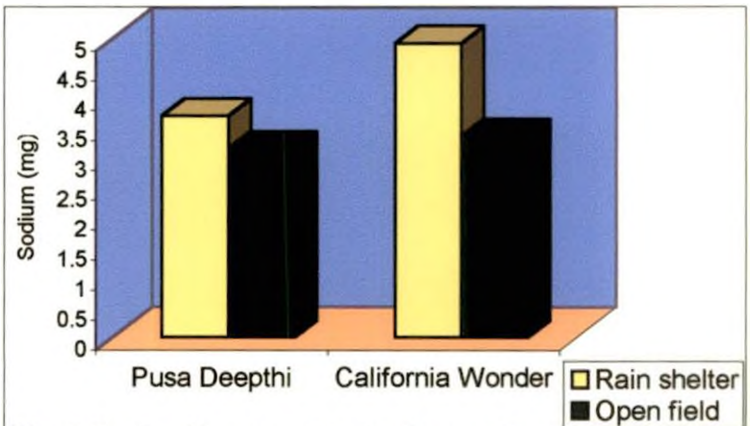

Fig.2(i). Sodium content of capsicum

shelter (347.65 mg $100g^{-1}$) and open field (347.42 mg $100g^{-1}$) showed no significant variation with respect to potassium content.

4.2.2.9.Sodium

The sodium content of capsicum varied from 3.15 to 4.91mg$100g^{-1}$. The potassium content of capsicum was maximum for 'California Wonder' under rain shelter (4.91mg $100g^{-1}$), which was significantly higher than the open field crop (3.35 mg $100g^{-1}$). For 'Pusa Deepthi' also significantly higher sodium content was observed in rain shelter crop (3.7 mg$100g^{-1}$) than open field crop (3.15 mg$100g^{-1}$).

4.2.2.10. Vitamin C

The vitamin C content of capsicum varied from 93.64 to 107.08 mg $100g^{-1}$. The vitamin C content was maximum for 'Pusa Deepthi' under rain shelter (107.08 mg $100g^{-1}$), which was significantly higher than the open field crop (93.64 mg $100g^{-1}$). In 'California Wonder' rain shelter crop showed higher vitaminC (104.32 mg $100g^{-1}$) than open field crop (96.41 mg $100g^{-1}$) but the variation observed was not significant.

4.2.2.11.β carotene

The β carotene content of capsicum varied from 283.26 to 962.30 μg $100g^{-1}$. The β carotene content was maximum for 'California Wonder' under open field (962.30 μg $100g^{-1}$), which was significantly higher than the rain shelter crop (786.14 μg $100g^{-1}$). In 'Pusa Deepthi' also significantly higher β carotene was observed in open field crop (444.68 μg $100g^{-1}$) than rain shelter crop (283.26 μg $100g^{-1}$).

Figure 2. continued

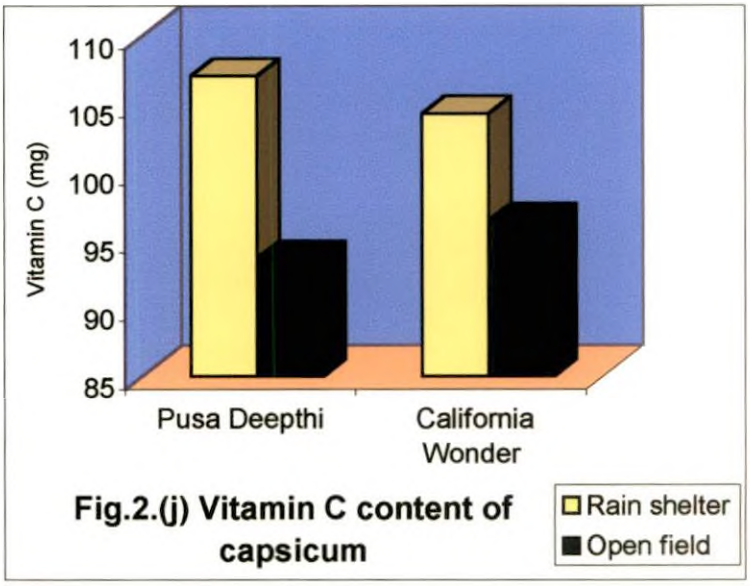

Fig.2.(j) Vitamin C content of capsicum

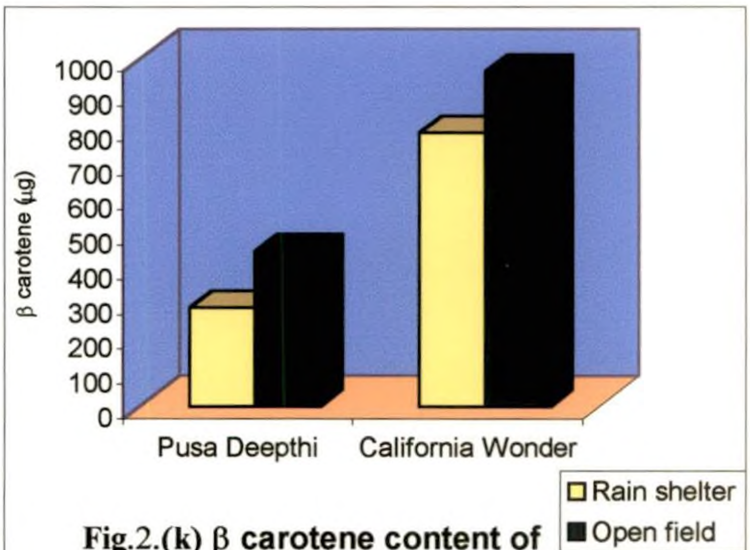

Fig.2.(k) β carotene content of capsicum

4.2.3. TOMATO

The results of nutritional composition of tomato cultivated under rain shelter and open field conditions are presented in table 4 and depicted in figure 3.

4.2.3.1.Moisture

The moisture content of tomato ranged from 94.48 to 95.43 per cent. The moisture content was maximum for the variety 'Shakthi' cultivated under rain shelter (95.43 %) and for open field crop it was 94.7 per cent. In 'Anagha' cultivated under rain shelter, moisture was 95.24 per cent and for open field cultivated crop, it was 94.48 per cent. There was no significant difference in the moisture content of tomato cultivated under rain shelter and open field conditions.

4.2.3.2.Fibre

The fibre content of tomato ranged from 0.693 to 0.907 $g100g^{-1}$. The fibre content of tomato was maximum for the variety 'Shakthi' cultivated under rain shelter (0.907 $g100g^{-1}$) and it was 0.693 $g100g^{-1}$ for open field cultivated crop. In 'Anagha' also high fibre content was observed in rain shelter crop (0.889 $g100g^{-1}$) than in open field crop (0.693 $g100g^{-1}$). Both the varieties showed no significant variation in the fibre content of rain shelter and open field crops.

4.2.3.3.Protein

The protein content of tomato varied from 0.90 to 0.997g $100g^{-1}$. The protein content was maximum for the variety 'Anagha' cultivated under rain shelter (0.997 g $100g^{-1}$), which was higher than the open field cultivated crop (0.917 g $100g^{-1}$). The variety 'Shakthi' cultivated under rain shelter also showed higher protein content in rain shelter crop (0.967 g $100g^{-1}$) than the open field

Table.4. Nutritional composition of tomato.(Fresh weight basis)

Nutrients	Anagha			Shakthi		
	R	O	CD	R	O	CD
Moisture ($g\ 100g^{-1}$)	95.24	94.48	2.06	95.43	94.7	2.06
Fibre ($g\ 100g^{-1}$)	0.889	0.693	0.41	0.907	0.693	0.41
Protein ($g\ 100g^{-1}$)	0.997	0.917	0.16	0.967	0.900	0.16
Starch ($g\ 100g^{-1}$)	0.119	0.113	0.0075	0.118	0.114	0.0075
Calcium ($mg\ 100g^{-1}$)	48.3	45.8	2.65	47.75	43.1	2.65*
Iron ($mg\ 100g^{-1}$)	0.67	0.62	0.03*	0.65	0.59	0.03*
Phosphorous ($mg\ 100g^{-1}$)	23.34	20.48	1.12*	23.11	21.56	1.12*
Potassium ($mg\ 100g^{-1}$)	233.48	222.85	15.2	403.5	352.78	15.2*
Sodium ($mg\ 100g^{-1}$)	5.14	4.12	6.42	5.26	4.35	6.42
Vitamin C ($mg\ 100g^{-1}$)	32.03	30.47	0.36*	31.81	30.62	0.36*
β carotene ($\mu g\ 100g^{-1}$)	406.28	368.75	85.01	384.31	346.73	85.01
Lycopene ($mg\ 100g^{-1}$)	3.33	2.49	0.415*	3.02	2.18	0.415*

$P<0.05$

R-Rain shelter CD – Critical Difference

O-Open field * - Significant at 5 per cent level

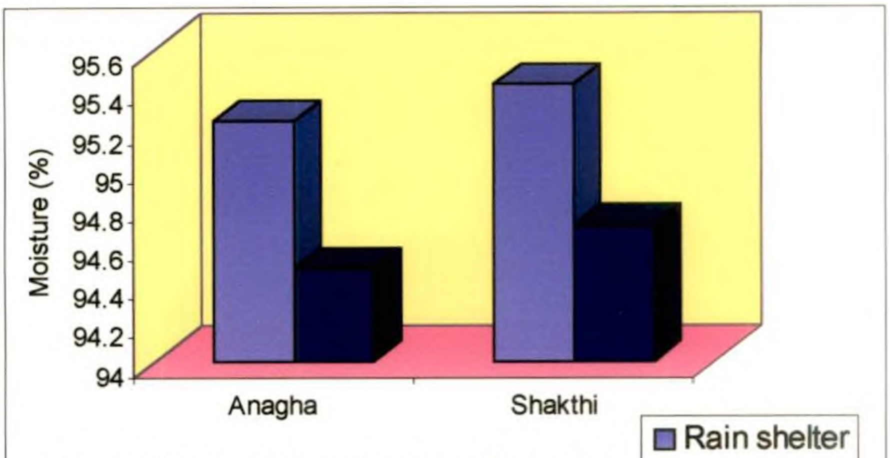

Fig.3. (a) Moisture content of tomato

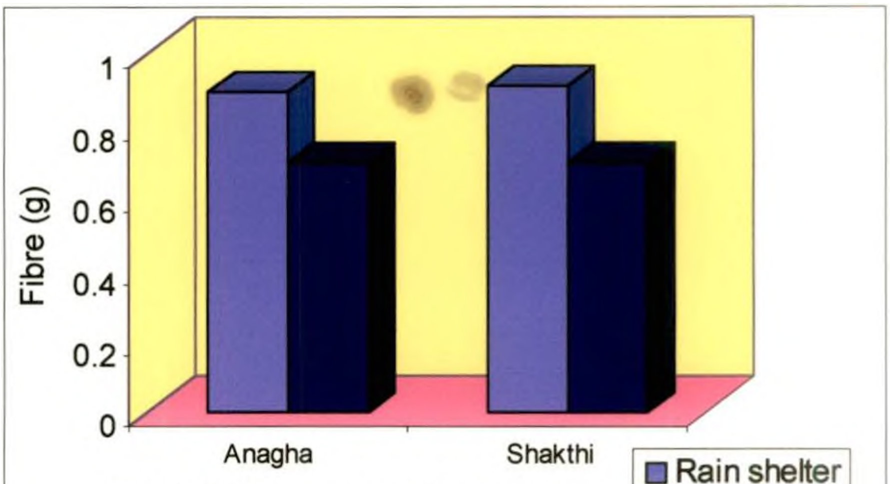

Fig.3.(b) Fibre content of tomato

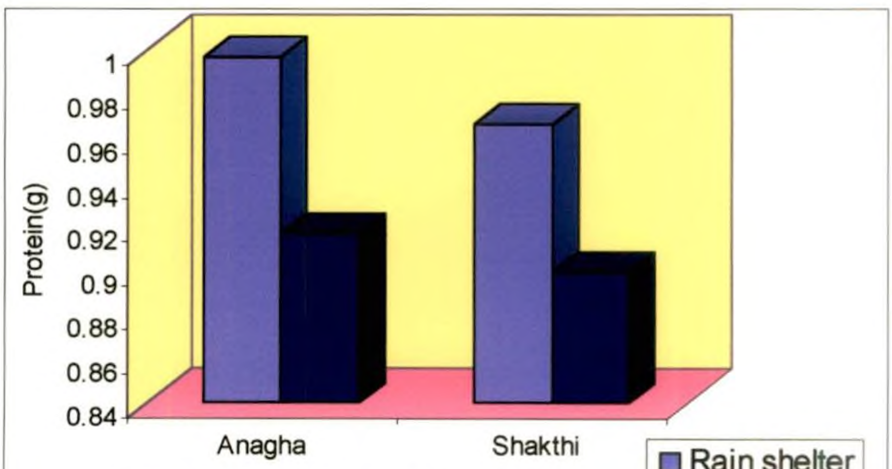

Fig.3.(c) Protein content of tomato

cultivated crop (0.90 g $100g^{-1}$). Both the varieties showed no significant variation in the protein content of rain shelter and open field crops.

4.2.3.4.Starch

The starch content of tomato varied from 0.113 to 0.119 per cent. The starch content of tomato was maximum for the variety 'Anagha' cultivated under rain shelter (0.119 %), which was not significantly different from the open field crop (0.113 %). In 'Shakthi' also starch content of rain shelter crop (0.118 %) showed no significant variation with the open field crop (0.114 %).

4.2.3.5. Calcium

The calcium content of tomato varied from 43.1mg to 48.3 mg $100g^{-1}$. The calcium content was maximum for the variety 'Anagha' cultivated under rain shelter (48.3 mg $100g^{-1}$), which was not significantly higher than the open field crop (45.8 mg $100g^{-1}$). However the variety 'Shakthi' showed significantly higher calcium content in rain shelter crop (47.75 mg $100g^{-1}$) than in the open field crop (43.1 mg $100g^{-1}$).

4.2.3.6. Iron

The iron content of tomato varied from 0.59 to 0.67 mg$100g^{-1}$. The iron content was maximum for 'Anagha' under rain shelter (0.67 mg $100g^{-1}$) and for open field cultivation it was 0.62 mg $100g^{-1}$. In 'Shakthi' iron content was 0.65 mg$100g^{-1}$ for rain shelter crop and 0.59 mg$100g^{-1}$ for open field crop. There was significant variation with respect to iron content of tomato for 'Anagha' under rain shelter and open field conditions. The variety 'Shakthi' also showed significantly higher iron content in rain shelter crop than open field crop.

Figure.3. continued

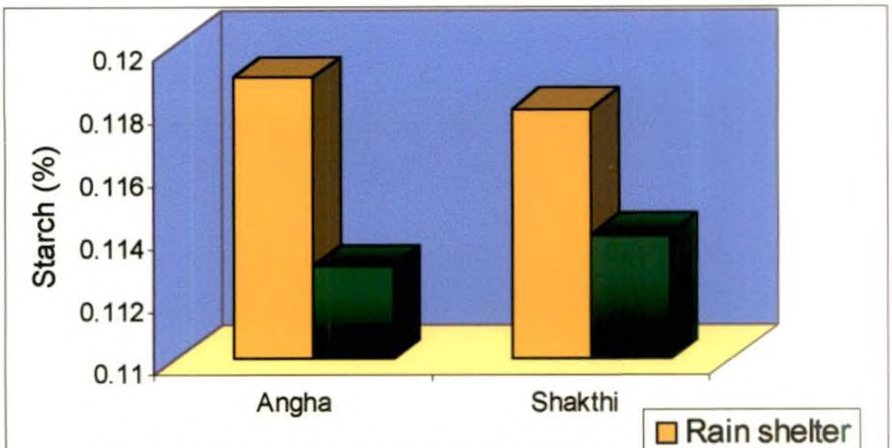

Fig.3.(d) Starch content of tomato

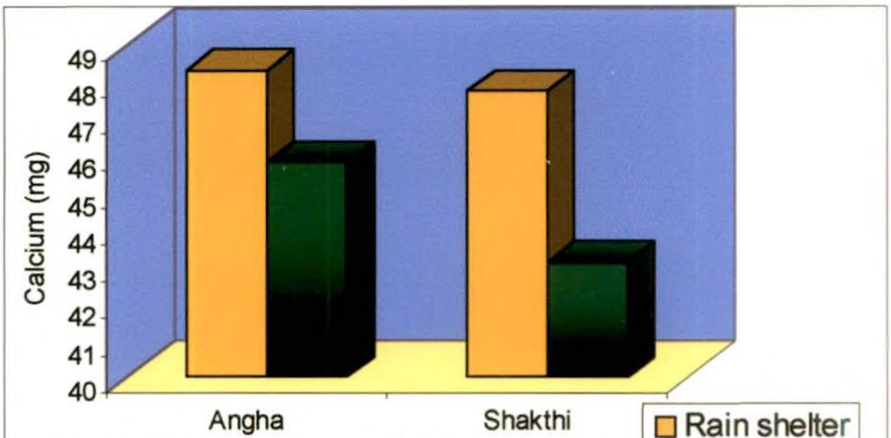

Fig.3. (e) Calcium content of tomato

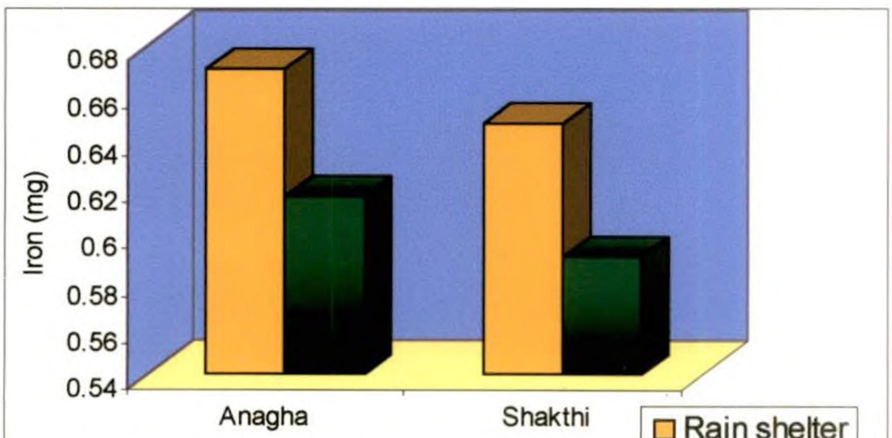

Fig.3.(f) Iron content of tomato

4.2.3.7. Phosphorous

The phosphorous content of tomato varied from 20.48 to 23.34 mg $100g^{-1}$. The phosphorous content was maximum for 'Anagha' under rain shelter (23.34 mg $100g^{-1}$), which was significantly higher than the open field crop (20.48 mg$100g^{-1}$). 'Shakthi' also showed significantly higher phosphorous content in rain shelter crop (23.11 mg $100g^{-1}$) than in open field crop (21.56 mg $100g^{-1}$).

4.2.3.8. Potassium

The potassium content of tomato varied from 222.85 to 403.50 mg $100g^{-1}$. The potassium content of tomato was found to be maximum for 'Shakthi' under rain shelter (403.50 mg $100g^{-1}$) where as in open field cultivation it was 352.78 mg $100g^{-1}$. In 'Anagha' the potassium content was 233.48 mg $100g^{-1}$ for rain shelter crop and 222.85 mg $100g^{-1}$ for open field crop. There was no significant difference with respect to potassium content of tomato for 'Anagha' under rain shelter and open field conditions but there was significant difference with respect to potassium content of tomato for 'Shakthi' under rain shelter and open field conditions.

4.2.3.9. Sodium

The sodium content of tomato varied from 4.12 to 5.26 mg $100g^{-1}$. The sodium content was found to be maximum for the variety 'Shakthi' under rain shelter (5.26 mg $100g^{-1}$) and it was 4.35 mg $100g^{-1}$ for open field cultivated crop. In 'Anagha' also cultivated under rain shelter had more sodium content (5.14 mg $100g^{-1}$) than open field crop (4.12 mg $100g^{-1}$). There was no significant difference in the sodium content of both varieties of tomato cultivated under two different conditions.

Figure.3. continued

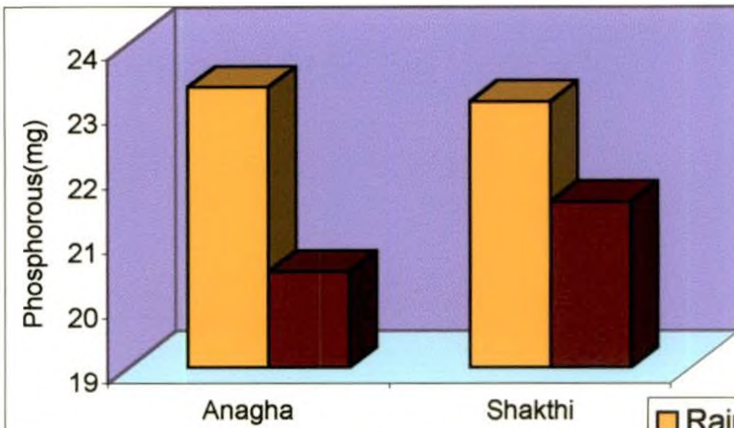

Fig.3. (g)Phosphorous content of tomato

Rain shelter
Open field

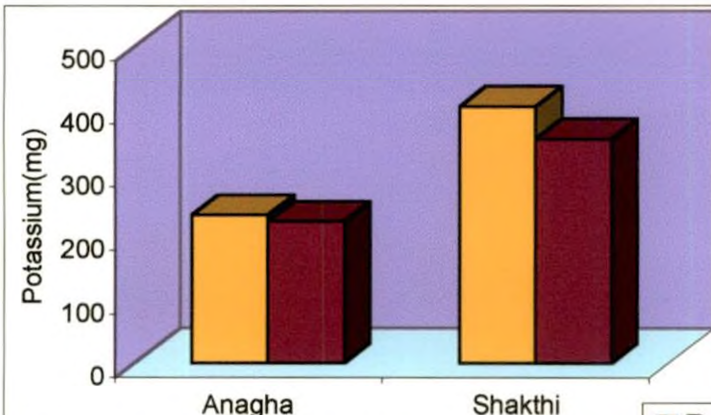

Fig.3.(h) Potassium content of tomato

Rain shelter
Open field

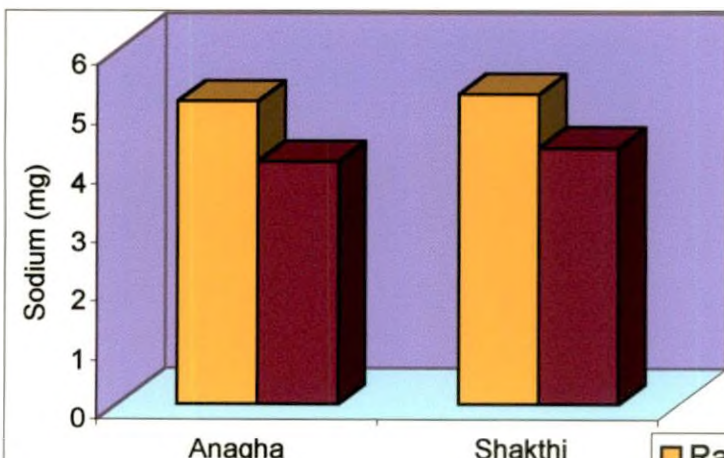

Fig.3.(i) Sodium content of tomato

Rain shelter
Open field

4.2.3.10. Vitamin C

The vitamin C content of tomato varied from 30.62 to 32.03 mg $100g^{-1}$. The vitamin C content of tomato was found to be maximum for 'Anagha' under rain shelter (32.03 mg $100g^{-1}$), which was significantly higher than the open field crop (30.47 mg $100g^{-1}$).'Shakthi'under rain shelter (31.81 mg $100g^{-1}$) also revealed significantly high vitamin C content than open field crop (30.62 mg $100g^{-1}$)

4.2.3.11. β carotene

The β carotene content of tomato varied from 346.73 to 406.28 μg$100g^{-1}$. The β carotene content of tomato was found to be maximum for 'Anagha' under rain shelter (406.28 μg $100g^{-1}$) and for open field crop it was 368.75 μg $100g^{-1}$. In 'Shakthi' also high β carotene content was observed in rain shelter crop (384.31 μg $100g^{-1}$) than open field crop (346.73 μg $100g^{-1}$). There was no significant difference with respect to β carotene content of both varieties of tomato cultivated under rain shelter and open field conditions.

4.2.3.12. Lycopene.

The lycopene content of tomato varied from 2.18 to 3.33 mg$100g^{-1}$. The lycopene content of tomato was maximum for 'Anagha' under rain shelter (3.33 mg 100 g^{-1}), which was significantly higher than the open field crop (2.49 mg$100g^{-1}$). In 'Shakthi' also significant difference was observed in lycopene content of rain shelter crop (3.02 mg$100g^{-1}$) and open field crop (2.18 mg$100g^{-1}$).

Figure.3. continued

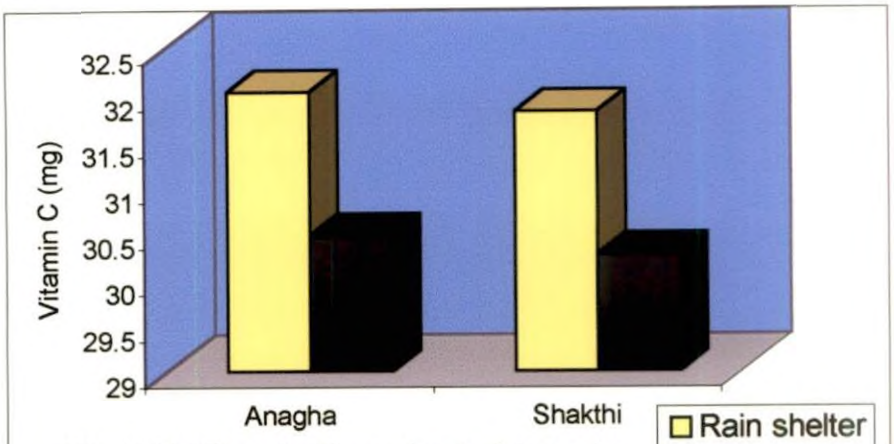

Fig.3.(j) Vitamin C content of tomato

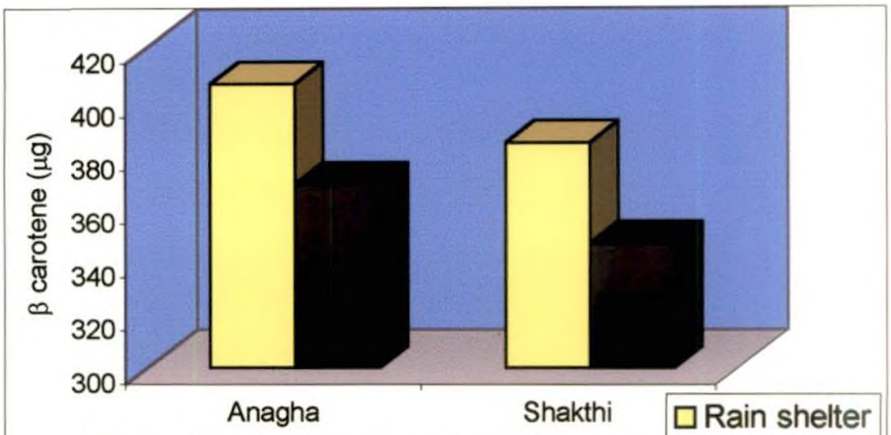

Fig.3.(k) β carotene content of tomato

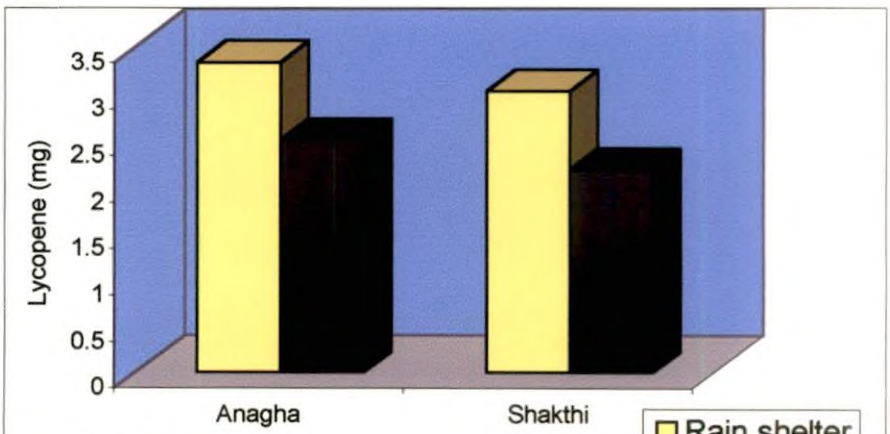

Fig.3.(l) Lycopene content of tomao

4.3. ANTI NUTRITIONAL FACTORS IN AMARATNH.

The anti nutritional factors namely oxalates and nitrates in amaranth was analysed and the results are furnished in table 5 and depicted in figure 4.

Table.5. Anti nutritional factors in amaranth. (Fresh weight basis)

Anti nutrients	Mohini			Arun		
	R	O	CD	R	O	CD
Oxalates ($g\ 100g^{-1}$)	0.407	0.514	0.197^{NS}	0.381	0.486	0.197^{NS}
Nitrates ($g\ 100g^{-1}$)	0.793	0.864	0.219^{NS}	0.957	1.16	0.219^{NS}

R-Rain shelter. NS- Non significant

O-Open field.

4.3.1. Oxalates

The oxalate content of amaranth was found to be maximum for the variety 'Mohini'cultivated under open field (0.514 g $100g^{-1}$) and for rain shelter it was 0.407 g $100g^{-1}$. In 'Arun' under open field, oxalate content was 0.486 g $100g^{-1}$ and in rain shelter it was 0.381 g $100g^{-1}$. There was no significant difference with respect to oxalate content of amaranth cultivated under rain shelter and open field conditions.

4.3.2. Nitrates

Maximum nitrate content was observed in 'Arun' under open field condition (1.16 g $100g^{-1}$) and in rain shelter crop it was 0.957 g $100g^{-1}$. In 'Mohini' also open field crop showed higher nitrate content (0.864 g $100g^{-1}$) than rain shelter crop (0.793 g $100g^{-1}$) but the difference observed was not significant in both the varieties with respect to cultivation conditions.

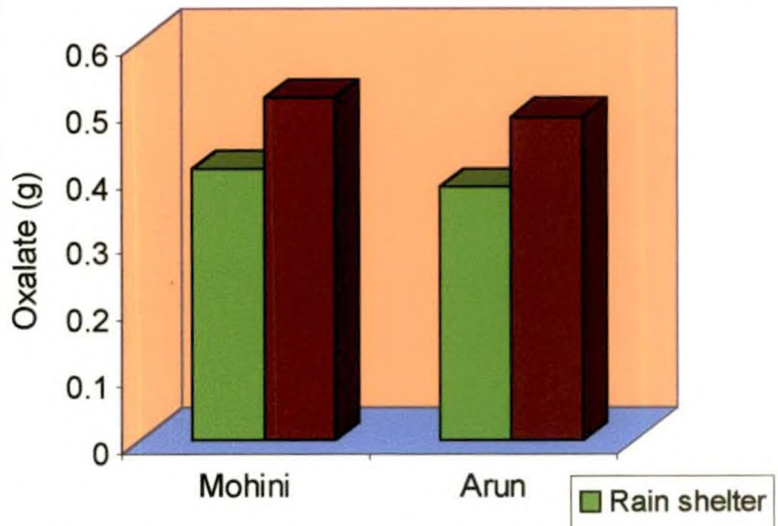

Fig.4.a. Oxalate content of amaranth

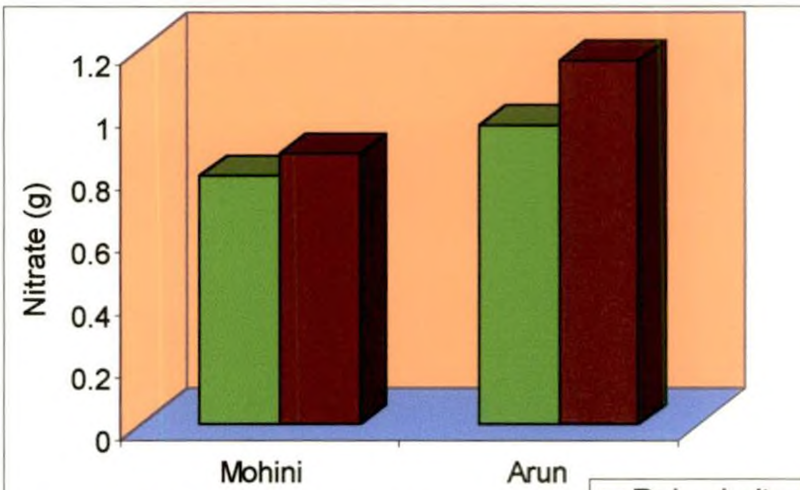

Fig.4.b. Nitrate content of amaranth

4.4. ORGANOLEPTIC EVALUATION OF VEGETABLES.

The acceptability of the vegetables were assessed using a score card for five quality attributes namely, appearance, colour, flavour, texture and taste. Each character was scored using five point hedonic scale by a panel of ten judges. Mann Whitney's test was worked out to assess the variation in acceptability of the vegetables.

4.4.1. Amaranth.

The organoleptic evaluation of amaranth both raw and cooked form cultivated under rain shelter and open field is given in table 6 and depicted in figure 5.

Table 6 revealed that appearance of 'Arun' in the raw form had better score (4.5) in the rain shelter cultivated crop than in the open field crop (2.8) and the difference is significant. Colour is more acceptable for open field crop with a mean score of 4.2, which was significantly higher than the mean score for rain shelter cultivated crop (3.5). Mean score for flavour was higher in rain shelter crop (3.3) than open field crop (3.0) but the difference was not significant. Texture was significantly better for rain shelter crop with a mean score of 3.7 than the open field crop (2.9). In Mohini (raw) mean score for appearance in rain shelter crop (4.0) was significantly higher than that of open field crop (2.7). Colour was also better for rain shelter crop with a mean score of 3.7 than open field crop (2.7) and the variations in colour was significant. Mean score for flavour (3.6) was significantly higher in rain shelter crop than in open field crop (3.0). Though there was a mean score of 3.4 for rain shelter crop with regard to texture the open field crop also had a mean score of 3.2 without significant variation.

Table.6. Organoleptic qualities of amaranth. (Mean scores).

Varieties	Appearance			Colour			Flavour			Texture			Taste		
	R	O	U	R	O	U	R	O	U	R	O	U	R	O	U
Arun (Raw)	4.5	2.8	5.0**	3.5	4.2	22.0**	3.3	3.0	39.5^{NS}	3.7	2.9	22.0**	-	-	-
Mohini (raw)	4.0	2.7	15**	3.7	2.7	16.5**	3.6	3.0	28.0**	3.4	3.2	44^{NS}	-	-	-
Arun (cooked)	3.0	3.9	28**	2.8	3.8	28.0**	3.0	3.4	37.0^{NS}	3.6	3.3	42.5^{NS}	2.7	3.6	24.0**
Mohini (cooked)	3.9	3.5	37.0^{NS}	3.8	3.4	29.0^{NS}	3.6	3.1	36.0^{NS}	3.5	3.1	37.5^{NS}	3.7	3.1	27**

** Significant at 5%level R-Rain shelter

NS-Non significant. O-Open field

U-Mann Whitney's coefficient

Figure. 5. continued

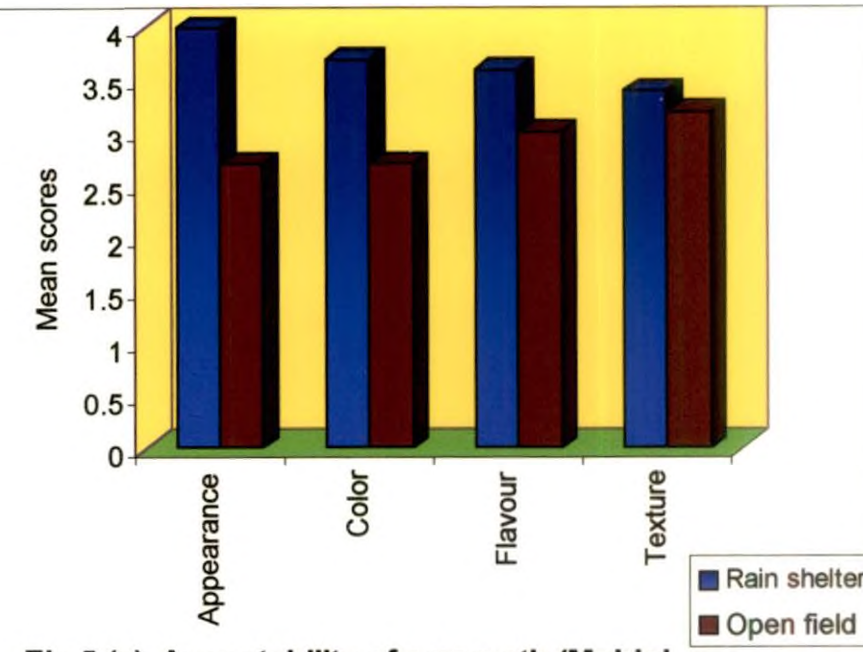

Fig.5.(a) Acceptability of amaranth (Mohini-raw)

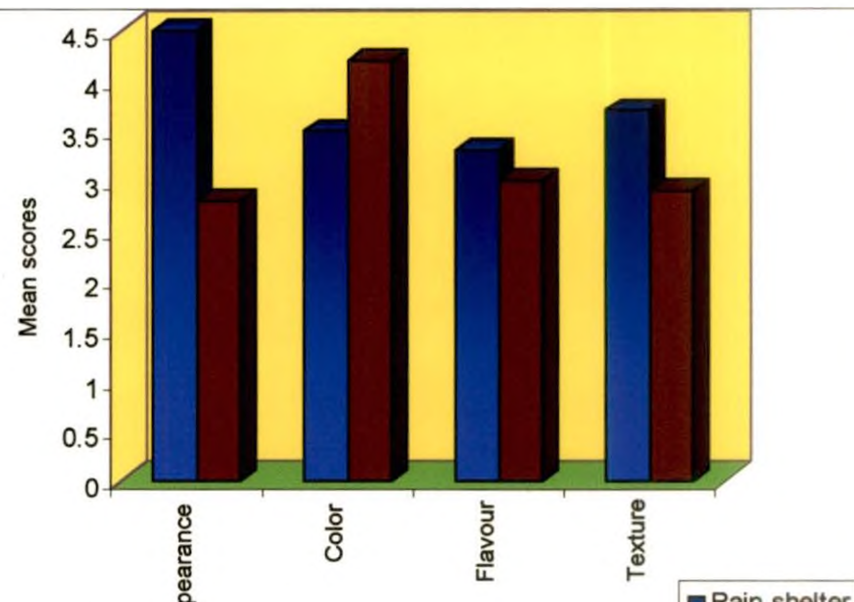

Fig.5.(b) Acceptability of amaranth (Arun-raw)

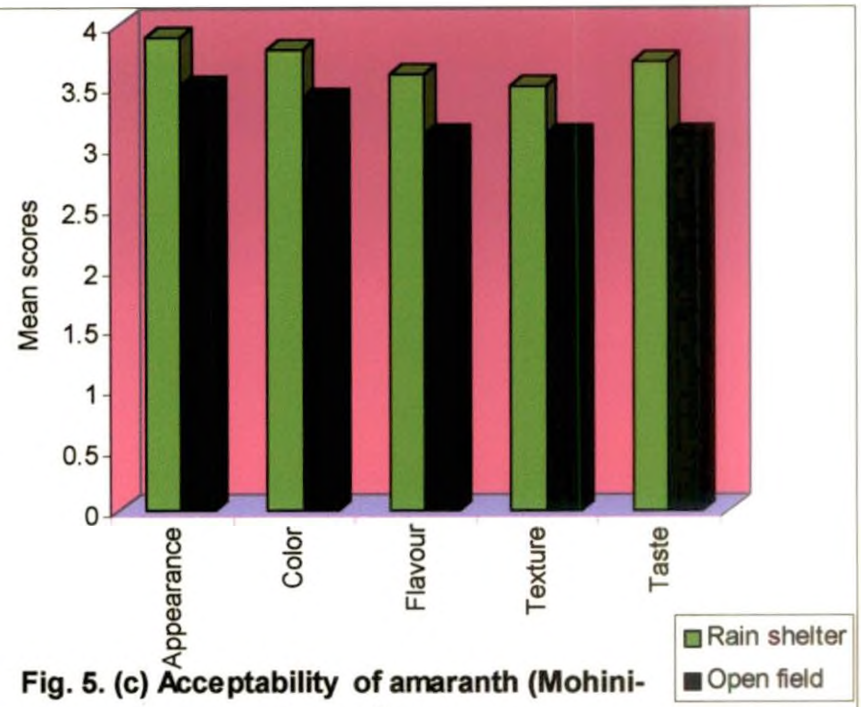

Fig. 5. (c) Acceptability of amaranth (Mohini-cooked)

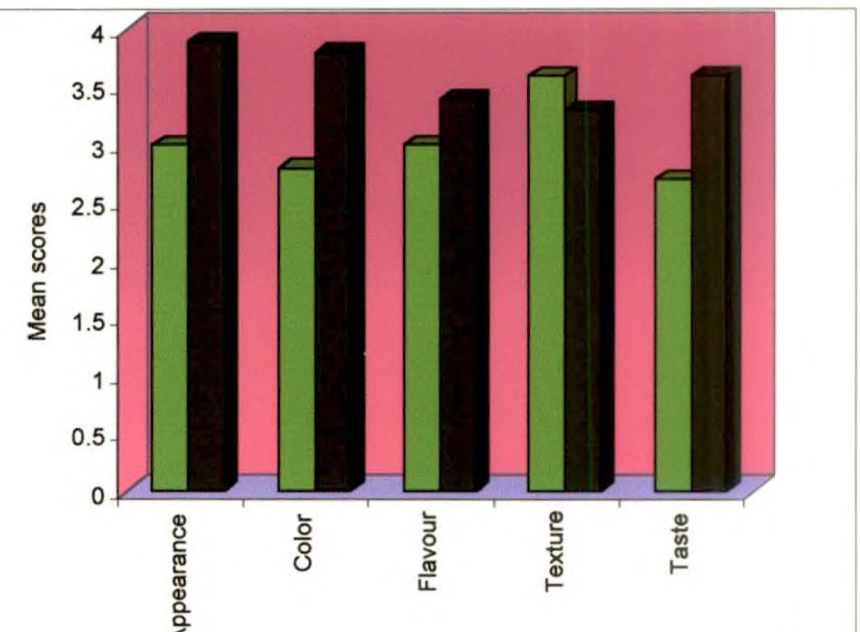

Fig.5. (d) Acceptability of amaranth (Arun - cooked)

After cooking appearance of 'Arun' had significantly higher score (3.9) in open field crop than the rain shelter crop (3.0). Mean score for colour was also higher in open field crop (3.8) than the rain shelter crop (2.8). Flavour of rain shelter crop with a mean score of 3.0 and open field crop 3.4, no significant variation was observed. Though higher mean score for texture was observed in rain shelter crop (3.6) than the open field crop (3.3) the difference was not significant. Regarding taste, significantly higher mean score was for the open field crop (3.6) than the rain shelter crop (2.7).

In 'Mohini', after cooking there was no significant variation in appearance as revealed in the mean score for rain shelter crop (3.9) and open field crop (3.5). Mean score for colour was significantly higher in ran shelter crop (3.8) than the open field crop (3.4). Even though the mean score for flavour in rain shelter crop was higher (3.6) than the open field crop (3.1) the difference was significant. Regarding taste significantly higher score was for rain shelter crop (3.7) than in open field crop (3.1).

4.4.2. Capsicum

The organoleptic evaluation of capsicum cultivated under rain shelter and open field conditions is presented in table 7 and is depicted in figure 6.

Mean score for appearance of 'California Wonder' (4.7) and 'Pusa Deepthi' (4.3) was a significantly higher in rain shelter crop than in open field crops (2.1 and 3.2 respectively). Regarding colour in 'California Wonder' significantly higher score was for the rain shelter crop (4.1) than the open field crop but in 'Pusa Deepthi' the difference in the mean score for colour in rain shelter crop (3.4) and open field crops (3.8) was not significant. Mean score for flavour showed no significant difference in rain shelter crop (3.9) and open field crop (3.5) in 'California Wonder', but in 'Pusa Deepthi' significantly higher score for favour was observed in open field crop (4.0) than in rain shelter crop (3.6).

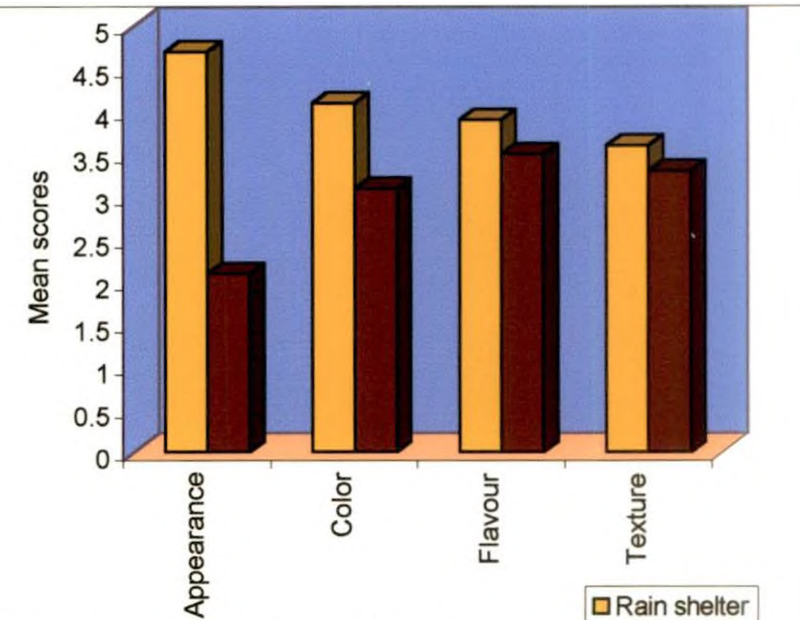

Fig.6.(a) Acceptability of capsicum (California Wonder)

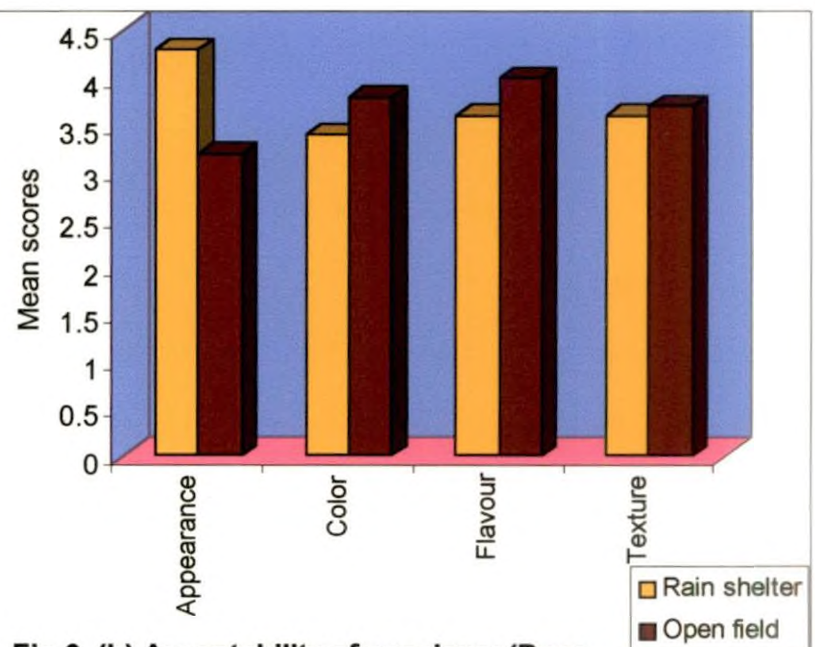

Fig.6. (b) Acceptability of capsicum (Pusa Deepthi)

Mean score for texture was higher in 'California Wonder' cultivated in rain shelter (3.6) than the open field crop (3.3) but the difference was not significant. In 'Pusa Deepthi' higher score for texture was for the open field crop (3.7) than the rain shelter crop (3.6) but the difference was not significant.

4.4.3. Tomato.

The organoleptic qualities of tomato cultivated under rain shelter and open field is presented in table 8 and depicted in figure 7.

In appearance 'Shakthi' showed significantly higher score in rain shelter crop (3.7) than the open field crop (2.9). Mean score for colour was also significantly high in rain shelter crop (3.9) than the open field crop (2.9). Flavour of the open field crop had significantly higher score (3.9) than the rain shelter crop (2.4). Even though texture showed higher score in open field crop (3.6) than in rain shelter crop (3.2) the difference was not significant. In 'Anagha' appearance and colour of the rain shelter crop had significantly higher scores (3.8 and 3.9 respectively) than open field crops (2.8 and 3.0 respectively). Higher score for flavour was observed in rain shelter crop (3.3) than in open field crop but the difference was not significant. Regarding texture higher score was observed in open field crop (3.0) than in rain shelter crop (2.8) but the difference was not significant.

Table.7. Organoleptic qualities of capsicum. (Mean scores)

Varieties	Appearance			Colour			Flavour			Texture		
	R	O	U	R	O	U	R	O	U	R	O	U
California Wonder	4.7	2.1	0.00**	4.1	3.1	16.0**	3.9	3.5	40^{NS}	3.6	3.3	42.5^{NS}
Pusa Deepthi	4.3	3.2	13.5**	3.4	3.8	33^{NS}	3.6	4.0	27.5**	3.6	3.7	43.5^{NS}

** Significant at 5 %level. R-Rain shelter

NS- Non-significant. O-Open field

U- Mann Whitney's coefficient

Table.8 .Organoleptic qualities of tomatoes (Mean scores).

Varieties	Appearance			Colour			Flavour			Texture		
	R	O	U	R	O	U	R	O	U	R	O	U
Shakthi	3.7	2.9	17**	3.9	2.9	13**	2.4	3.9	10**	3.2	3.6	33^{NS}
Anagha	3.8	2.8	15**	3.9	3.0	13.5**	3.3	3.2	44.5^{NS}	2.8	3.0	37^{NS}

** Significant at 5 % level. R-Rain shelter

NS- Non significant. O-Open field.

U-Mann Whitney's coefficient

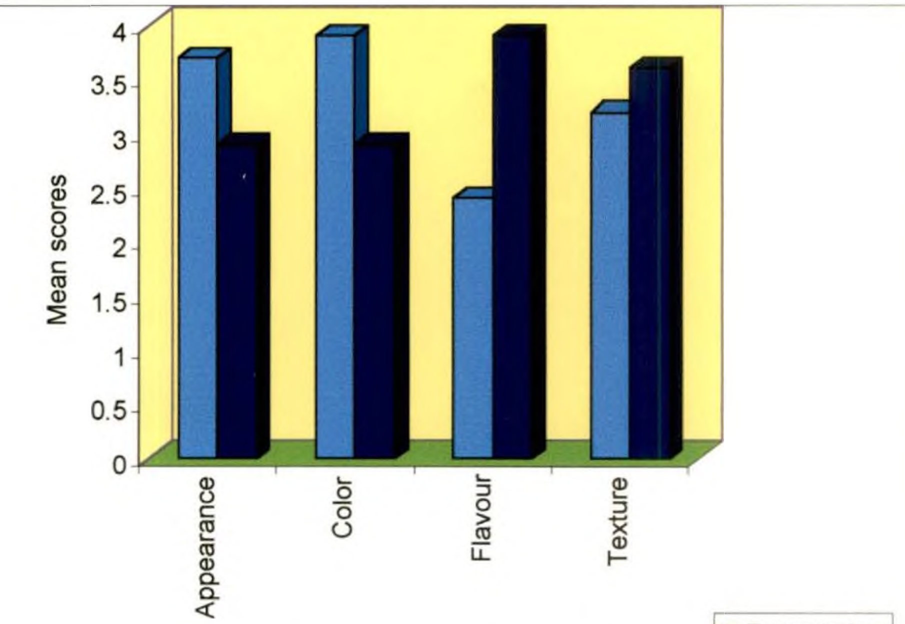

Fig.7.a. Acceptability of tomato (Shakthi)

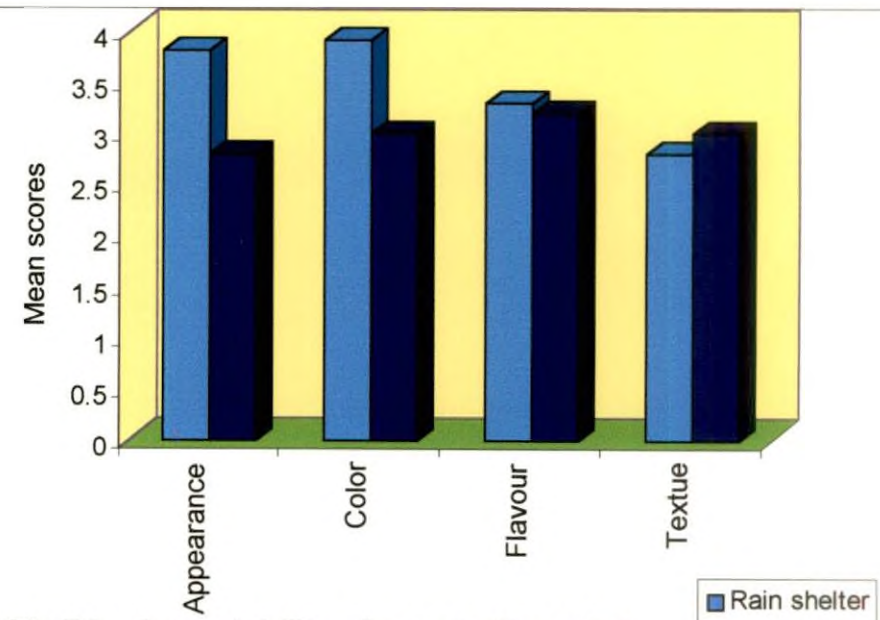

Fig.7.b. Acceptability of tomato (Anagha)

Discussion

5. DISCUSSION

The study entitled "Quality evaluation of selected vegetables growing under rain shelter and open field cultivation" was attempted to assess the nutritional composition, antinutritional factors and acceptability of two varieties of amaranth (Arun, Mohini), capsicum (California Wonder, Pusa Deepthi) and tomato (Shakthi, Anagha).

The vegetables were analysed for different nutrients like moisture, fibre, protein, starch, calcium, iron, phosphorous, sodium, potassium, vitamin C, β carotene and lycopene (tomato only). The anti nutritional factors like oxalates and nitrates present in amaranth were also analysed. The acceptability of vegetables was assessed through organoleptic evaluation using scorecard based on a five point hedonic scale. The results of the study are discussed under the following headings.

1.Duration of maturity.
2.Nutritional composition of vegetables.
3.Anti nutritional factors in amaranth.
4.Acceptability of vegetables.

5.1. DURATION OF MATURITY.

The quality of fruits and vegetables are affected markedly by such factors as variety, geographic location of growth, temperature, moisture, stage of maturity etc. In the present study duration of maturity for amaranth and capsicum was high in open field crops. Whereas in tomato duration of maturity was high in rain shelter crops irrespective of the varieties.

5.2. NUTRITIONAL COMPOSITION OF VEGETABLES.

5.2.1. Amaranth.

The mean moisture content of amaranth (both Mohini and Arun) varied from 80.5 to 85.01 percent. The moisture content of amaranth was found to be in accordance with the values reported by Longvah (2000), Mathew (2000), Mziray *et al* (2001) and Kumaran (2003). In both varieties the moisture content was significantly high in amaranth grown in rain shelter. This high moisture content may be due to decreased rate of transpiration inside the rain shelter.

The fibre content of amaranth varied from 1.04 to 1.7g $100g^{-1}$. This value is in line with the values reported by NIN (1994), Suman (2000), Mathew (2000) and Punia *et al.* (2004) in amaranthus. Among the varieties 'Mohini' (green) showed higher fibre than 'Arun' (red). This observation was in accordance with the results obtained by Jijiamma (1989) in red and green amaranthus. In both varieties the fibre content was less in amaranth cultivated in open field but the difference observed was not significant showing that there was no difference in the rain shelter and open field crops with respect to the fibre content.

Regardless of the varieties the protein content of amaranth ranged from 5.07 to 6.30 g $100g^{-1}$. The protein content of amaranth was found to be in accordance with the values reported by Punia *et al.* (2004). The authors observed a protein content of 5.44 g $100g^{-1}$ in amaranth. Among the varieties protein content was high for 'Arun' cultivated under rain shelter (6.30 g) and open field (5.28 g), when compared to 'Mohini' cultivated under rain shelter (6.21 g) and open field (5.07 g). This is similar to the results reported by KAU (1984) that reddish green varieties contained more protein than amaranth green. But in both varieties the rain shelter crop had significantly higher protein content than open field crops. The high protein content in the rain shelter crop may be due to less leaching of soil nutrients under protected cultivation.

The starch content of amaranth varied from 0.14 to 0.17 percent. In both varieties starch content was significantly high in rain shelter crops. Known technically as the C_4 carbon fixation pathway, this process is used by amaranth plants. This C_4 pathway is efficient at high temperature and make efficient use of carbon dioxide available in the air by concentrating it in the chloroplasts of specialized cells surrounding the leaf bundles. The photo respiratory loss of carbon dioxide, the basic unit of carbohydrate production is suppressed in C_4 plants. Consequently plants that use C_4 pathway can convert a higher ratio of carbon dioxide to plant sugars. The potential ability to photosynthesize at high rates under high temperature is another physiological advantage of C_4 photosynthesis. The increased starch content of amaranth leaves in rain shelter can be due to this ability of the C_4 plants.

The calcium content of amaranth ranged from 275.14 to 363.35 mg $100g^{-1}$. The calcium present in amaranth was found to be in accordance with the values obtained by Gopalan *et al.* (1989), Jijiamma (1989) and Hemalatha *et al.* (1999) who reported the values as 397.0 mg, 363.35 mg and 340.0 mg $100g^{-1}$ respectively. Calcium content of amaranth was high in the variety 'Mohini' than in 'Arun.' This was in accordance with the results obtained by Jijiamma (1989) who also reported a high calcium content in green amaranth variety. There was no significant variation in the calcium content of amaranth in rain shelter crops and open field crops in both the varieties indicating that rain shelter has no influence on the calcium content of amaranth.

The iron content of amaranth ranged from 24.2 to 29.27 mg $100g^{-1}$. The iron content of amaranth observed in the study was in accordance with the iron content of amaranth reported by Jijiamma (1989) and Mathew (2000), which was 27.29 and 26.74 mg $100g^{-1}$ respectively. In both the varieties iron content was significantly high in rain shelter crops than in open field crops. According to Harris and Karmas (1977) light increases the iron demands of the plants. This may be the reason for the low iron content in open field crops.

The phosphorous content of amaranth varied from 59.44 to 72.70 mg $100g^{-1}$ The phosphorous content of amaranth in the present study was in accordance with the results reported by NIN (1994) and Mathew (2000). Mziray *et al* (2001) reported a phosphorous content ranging from 500 to 553 mg $100g^{-1}$ on dry weight basis in amaranth from different location of Tanzania. In the present study the maximum phosphorous content was found in the variety 'Arun' cultivated under rain shelter (72.7 mg $100g^{-1}$). Which was significantly high when compared to open field cultivated crop (59.44 mg $100g^{-1}$). In 'Mohini' also there was significant variation in the phosphorous content in rain shelter and open field crop.

The potassium content of amaranth varied from 817.7 to 841.5 mg $100g^{-1}$. The potassium content of 'Mohini' was higher than 'Arun' in both rain shelter and open field crop. There was no significant variation with respect to potassium content of both the varieties of amaranth under rain shelter and open field cultivations. Kumaran (2003) analysed different unconventional leafy vegetables and reported a potassium content that varied from 116.96 to 757.4 mg $100g^{-1}$. Similar findings were reported by Hyder (2004) in different leafy vegetables consumed by the tribes of Kerala, which varied from 266.00 to 1231.37 mg $100g^{-1}$.

The sodium content of amaranth varied from 7.98 to 14.34mg$100g^{-1}$. Sodium content was more in the variety 'Arun' under both rain shelter (14.34 mg $100g^{-1}$) and open field (14.27 mg$100g^{-1}$) when compared to 'Mohini', which were 9.61 mg $100g^{-1}$ in rain shelter and 7.98 mg $100g^{-1}$ in open field crop. There was significant variation with respect to sodium content of amaranth in the variety 'Mohini' under rain shelter and open field crops.

The vitamin C content of amaranth varied from 33.2 to 55.56 mg $100g^{-1}$. The vitamin C content was more for the variety 'Mohini' cultivated under both rain shelter (53.56 mg $100g^{-1}$) and open field conditions (51.7 mg $100g^{-1}$) than in 'Arun'. There was no significant variation in the vitamin C content of amaranth cultivated in rain shelter and open field conditions. Here the variation observed in the vitamin C is only due to the varietal difference, but no significant variation was observed between rain shelter and open field crops. This holds that, light is not essential for the synthesis of ascorbic acid in plants as reported by Reid (1941) and Mapson *et al.* (1949). There is a mechanism in plants, which converts sucrose, hexose, or other precursors into ascorbic acid. But according to Somers (1950) it is not light, but temperature and carbon dioxide affect the accumulation of ascorbic acid in plants. A precursor of ascorbic acid is produced by photosynthesis and, this is then converted to ascorbic acid within the plant biologically. Because the loss of ascorbic acid is more rapid in detached than in intact leaves this is likely that this loss is caused more by metabolic activity than by oxidation. Variation in light can change the rate of formation of precursor; yet have no effect on conversion of these precursors to ascorbic acid or on the amount employed in the metabolic process of the plant. Variation in the temperature can change the metabolic activity or the rate of production of precursor but appear to have no important effect upon the amount of ascorbic acid synthesised from precursors. This may explain why the literature on the effect of light upon the ascorbic acid is often contradictory.

The β carotene content of amaranth varied from 1153.55 to 1361.70 μg $100g^{-1}$. The β carotene content was maximum for the variety 'Mohini' cultivated in open field (1361.70 μg $100g^{-1}$) but it was significantly reduced to 1153.55 μg $100g^{-1}$ in rain shelter crop. In 'Arun' also β carotene content was more in open field cultivated crop (1262.6 μg $100g^{-1}$) when compared to rain shelter crop (1252.6 μg $100g^{-1}$). But in 'Arun' the difference observed in β carotene content was not significant between rain shelter and open field crop. The result obtained in this study does not agree with the study conducted by Somers and Kelly (1957) in turnip plants. They observed that the turnip plants grown in full sunshine contained less carotene than those grown in shade.

5.2.2. Capsicum.

The moisture content of capsicum ranged from 91.24 to 93.91 per cent. The moisture content was maximum for the variety 'Pusa Deepthi' cultivated under rain shelter (93.91 %), which was significantly high when compared to the open field cultivated crop (91.24 %). This may be due to the low transpiration rate inside the rain shelter due to high humidity. In 'California Wonder' rain shelter cultivated crop showed higher moisture value (92.48 %) when compared to open field cultivated crop (92.24 %) but the difference was not significant.

The fibre content of capsicum varied from 6.21 to 6.36 g $100g^{-1}$. The result obtained was in line with the findings obtained by Gopalan *et al.* (1989) with regard to the fibre content of capsicum. The fibre content was maximum for the variety 'California Wonder' cultivated under rain shelter (6.36 g $100g^{-1}$), which showed no significant difference with that of open field cultivated crop. In 'Pusa Deepthi' also there was no significant difference in the fibre content of rain shelter (6.35 g $100g^{-1}$) and open field (6.22 g $100g^{-1}$) crops.

The protein content of capsicum ranged from 2.26 to 2.6 g $100g^{-1}$. The protein content of capsicum was maximum for the variety 'California Wonder' cultivated under rain shelter (2.6 g $100g^{-1}$), which was significantly high when compared to the open field cultivated crop (2.26 g $100g^{-1}$). Protein content for 'Pusa Deepthi' was also high in rain shelter crops (2.53 g $100g^{-1}$) when compared to open field crop (2.37 g $100g^{-1}$) and the differences were significant.

The starch content of capsicum ranged from 0.126 to 0.114 per cent. The starch content was more for 'Pusa Deepthi' and 'California Wonder' cultivated under rain shelter (0.12 %) and the difference in the starch content of rain shelter and open field crop was significant.

The calcium content of capsicum ranged from 29.24 to 31.71 mg 100 g^{-1}. The calcium content was maximum for the variety 'Pusa Deepthi' cultivated under rain shelter (31.71 mg 100g^{-1}) and it was 30.0 mg 100g^{-1} for open field crop. In 'California Wonder' also calcium content was higher in rain shelter crop (30 mg 100g^{-1}) than in open field crop (29.4 mg 100g^{-1}). The difference in calcium content was observed only with regard to the variety and not between rain shelter and open field crops.

The iron content of capsicum varied from 3.27 to 4.95 mg 100 g^{-1}. The iron content of capsicum was more for the variety 'California Wonder' cultivated under rain shelter (4.95 mg 100g^{-1}), which was significantly higher than open field crop (4.40 mg 100g^{-1}). In 'Pusa Deepthi' also rain shelter crop showed significantly higher iron content (4.27 mg 100g^{-1}) than open field crop (3.27 mg 100g^{-1}). According to Harris and Karmas (1977) light increases the iron demand of the plants. This may be the reason for the low iron content in capsicum grown in open field.

The phosphorous content of capsicum varied from 82.63 to 91.60 mg 100g^{-1}. The phosphorous content was maximum for the variety 'Pusa Deepthi' cultivated under rain shelter (91.6 mg100g^{-1}), which showed no significant difference with that of open field crop (89.8 mg100g^{-1}). In 'California Wonder' also there was no significant variation in phosphorous content of the crops cultivated under rain shelter (89.07 mg100g^{-1}) and open field condition (82.63 mg 100g^{-1}). Only varietal difference was observed with regard to phosphorous content of capsicum.

The potassium content of capsicum varied from 347.42 to 423.21 mg 100g^{-1}. The potassium content of capsicum was maximum for the variety 'California Wonder' cultivated under rain shelter (423.21 mg 100g^{-1}), which was significantly higher than the open field crop (365.2 mg 100g^{-1}). 'Pusa Deepthi' cultivated under rain shelter (347.65 mg 100g^{-1}) and open field (347.42 mg 100g^{-1}) showed no significant variation with respect to potassium content. So the effect of rain shelter on potassium content was observed only in the case of the capsicum variety 'California Wonder.'

The sodium content of capsicum ranged from 3.15 to 4.91 mg 100 g^{-1}. The sodium content of capsicum was maximum for the variety 'California Wonder' cultivated under rain shelter (4.91 mg100g^{-1}), which was significantly higher than the open field crop (3.35 mg 100g^{-1}). For 'Pusa Deepthi' also significantly higher sodium content was observed in rain shelter crop (3.7 mg 100g^{-1}) than in open field crop (3.15 mg 100g^{-1}). This shows better sodium content in capsicum varieties grown under rain shelter.

The vitamin C content of capsicum varied from 93.62 to 107.08 mg 100 g^{-1}. The vitamin C content of capsicum was maximum for the variety 'Pusa Deepthi' cultivated under rain shelter (107.08 mg 100g^{-1}), which was significantly higher than the open field cultivated crop (93.64 mg 100g^{-1}). But in 'California Wonder' higher vitamin C (104.32 mg 100g^{-1}) observed in rain shelter crop was not significantly higher than the open field crop. Kobryn (1998) had reported that high air humidity in glass houses had no much effect on the vitamin C content and Sreelathakumari (2000) also revealed that vitamin C content in plants did not vary significantly due to shade.

The β carotene content of capsicum varied from 283.26 to 962.3 μg 100g^{-1}. The β carotene content was maximum for the variety 'California Wonder' cultivated under open field condition (962.30 μg 100g^{-1}), which was significantly higher than rain shelter cultivated crop (784.14 μg 100g^{-1}). In 'Pusa Deepthi' also significantly higher β carotene content was observed in open field crop (444.68 μg 100g^{-1}) than in rain shelter crop (283.26 μg 100g^{-1}). The present study was in accordance with the results obtained by Sreelathakumari (2000) who reported that capsicum grown under open field condition recorded high carotenoid contents than in shade. Dorais and Papadapouloss (2001) also observed that low light intensity reduced pigment synthesis resulting in uneven fruit colouring.

5.2.3. Tomato.

The moisture content of tomato ranged from 94.48 to 95.43 per cent. The moisture content was more for the variety 'Shakthi' than 'Anagha' in both rain shelter and open field crop, but there was no significant variation in the moisture content of tomato grown in rain shelter and open field in both the varieties.

The fibre content of tomato varied from 0.693 to 0.907 g 100 g^{-1}. 'Shakthi showed more fibre content than 'Anagha' in rain shelter crop but in open field crop there was no change in the fibre content. No significant variation was observed in the fibre content of tomatoes in both rain shelter and open field conditions in both the varieties.

The protein content of tomato varied from 0.90 to 0.997 g 100 g^{-1}. No significant variation was observed in the protein content of tomatoes in both rain shelter and open field conditions in both the varieties.

The starch content of tomato varied from 0.113 to 0.119 per cent. The starch was more for the variety 'Anagha' cultivated under rain shelter (0.119 %) than open field crop (0.113 %). In 'Shakthi' also starch content of rain shelter crop (0.118 %) was high when compared to the open field crop (0.114 %). Though the difference obtained was not significant the comparatively high values in rain shelter crop agrees with Vezhavendan (2001) who reported that when tomato fruits were exposed to light in rain shelter they had greater capacity for storing starch.

The calcium content of tomato varied from 43.10 to 48.30 mg100g^{-1}. The calcium content was maximum for the variety 'Anagha' cultivated under rain shelter (48.30 mg 100g^{-1}), which was not significantly higher than the open field cultivated crop (43.80 mg 100g^{-1}). However 'Shakthi' showed significantly high calcium in rain shelter crop (47.75 mg 100g^{-1}) than in open field crop. But Dorais and Papadapouloss (2001) had reported that high humidity condition in the rain shelter crop can cause a decrease in calcium uptake, an increase in root pressure and generally favour fruit cracking in tomatoes. In the present study the high calcium content in tomatoes in rain shelter may be due to an increase in free calcium in tomato plants as a result of shading of calcium deficient plants as reported by Nightingale *et al.* (1931).

The iron content of tomato varied from 0.59 to 0.67 mg 100 g^{-1}. The iron content was maximum for the variety 'Anagha' cultivated under rain shelter (0.67 mg 100g^{-1}), which showed no significant variation with the open field crop (0.62 mg 100g^{-1}). In 'Shakthi' iron content was significantly high for rain shelter crop (0.65 mg 100g^{-1}).

The phosphorous content of tomato ranged from 20.48 to 23.34 mg 100 g^{-1}. The phosphorous content of tomato was maximum for the variety 'Anagha' cultivated under rain shelter (23.34 mg 100g^{-1}) which was significantly higher than the open field crop (20.48 mg 100g^{-1}).'Shakthi' also showed significantly higher phosphorous content in rain shelter crop (23.11 mg 100g^{-1}) than open field crop (21.56 mg 100g^{-1}).

The potassium content of tomato varied from 222.85 to 403.5 mg 100 g^{-1}. The potassium content was maximum for the variety 'Shakthi' under rain shelter (40.35 mg 100g^{-1}), which was significantly reduced in open field crop (352.78 mg 100g^{-1}). In 'Anagha' there was no significant variation in potassium content in rain shelter and open field crop. Adams (1990) reported that restriction in water supply increased the potassium content in tomato plants growing under water stress conditions.

The sodium content of tomato varied from 4.12 to 5.26 mg 100 g^{-1}. There was no significant difference in the sodium content of both varieties of tomato cultivated under two different conditions.

The vitamin C content of tomato was found to be maximum for the variety 'Anagha'cultivated under rain shelter (32.03 mg100g^{-1}), which was significantly higher than the open field crop (30.47mg100g^{-1}).'Shakthi' cultivated under rain shelter (31.81 mg 100g^{-1}), also showed significantly higher vitamin C content than open field crop (30.26 mg 100g^{-1}). The results are in line with the results of Smitha (2002) who reported that mild shade was found favourable for increasing vitamin C content in tomatoes.

The β carotene content of tomato varied from 346.73 to 406.28 μg 100 g^{-1}. The β carotene content of tomato was found to be maximum for the variety 'Anagha' in rain shelter (406.28 μg 100g^{-1}) and significant variation was not observed in open field crop. In 'Shakthi' also no significant difference was found in the β carotene content of rain shelter and open field crop. In contrast to this result Gould (1992) has reported that summer or winter cultivated green house tomato fruits has lower carotene concentration than summer field grown fruit. But the observation by Harris and Karmas (1977) that the carotene content in tomatoes is lower in summer than in spring had been interpreted to be caused by differences in light intensity. Kalloo (1986) had reported that synthesis of α and β carotene in tomato is least influenced by temperature.

The lycopene content of tomato varied from 2.18mg to 3.33 mg 100 g^{-1}. The lycopene content was maximum for the variety 'Anagha' cultivated under rain shelter (3.33 mg 100g^{-1}), which was significantly higher than the open field crop (2.49 mg 100g^{-1}). In 'Shakthi' also significantly high lycopene content was observed in rain shelter crop (3.02 mg 100g^{-1}) than in open field crop (2.18 mg 100g^{-1}). In contrast to this result Gould (1992) had reported that tomato fruits grown in green house either in summer or in winter are lower in lycopene content than fruits produced out door during summer.

5.3. ANTI NUTRTIONAL FACTORS IN AMARANTH.

The oxalate content of amaranth varied from 0.381 to 0.514 g $100g^{-1}$. The oxalate content of amaranth was found to be maximum for the variety 'Mohini' cultivated under open field condition (0.514 g $100g^{-1}$) but no significant difference was observed in the rain shelter crop (0.407g$100g^{-1}$). In 'Arun' also the variation observed in the oxalate content in open field and rain shelter crops was not significant.

The nitrate content of amaranth varied from 0.793 to 1.16 g 100 g^{-1} and the variation in the nitrate content observed in rain shelter and an open field crop was not significant. This was in line with the study conducted by Kobryn (1998) in Chinese cabbage and had reported that high air humidity in glass houses had no effect on the nitrate content. So rain shelter cultivation of amaranth had no influence on their anti nutritional factors viz nitrates and oxalates when compared with open field crop.

5.4. ACCEPTABILITY OF VEGETABLES.

Appearance is probably the most important quality factor determining the market value of produce as the people 'buy with their eyes'. They have learnt from past experience to associate desirable qualities with a certain external appearance. A rapid visual assessment cum with experience be made on the criteria of size, shape, colour, conditions (such as freshness) and the presence of defects or blemishes.

In the present study the mean score for appearance of 'Arun' and 'Mohini' cultivated in rain shelter was significantly high when compared to the open field crop (plate 2 and 3) but after cooking in 'Arun' the appearance had a significantly higher mean score for open field crop (3.9) than the rain shelter crop (3.0). This may be due to the changes in the anthocyanin pigments in 'Arun' after cooking, but in 'Mohini' there was no significant change in the appearance after cooking between rain shelter and open field crop.

Capsicum and tomato also revealed higher score for appearance in the rain shelter crops. This higher acceptability for appearance in these fruits were mainly attributed to their size, shape and freshness due to the high moisture content and the absence of defects or blemishes. Skin blemishes such as bruises, scorch marks, cuts etc detract from appearance. Thus appearance is a major determinant of quality because it is often the only criterion available to the buyer of the commodity and the three crops in this study, rain shelter crops revealed a better consumer acceptance for appearance (plate 4 & 5 and 6& 7).

One of the distinguishing features of fruits and vegetables is that they are only major group of natural foods with a variety of bright colours. They are often used merely to brighten up the presentation of foods. Colour changes have been correlated by the consumer with the conversion of starch to sugar, that is sweetening, and the development of other desirable attributes so that the correct skin colour is often all that is required for a decision to purchase a commodity.

In the present study even though the appearance of 'Arun' was better in rain shelter crop, colour was comparatively low in rain shelter crop (plate-3), which reflected, in a mean score of 3.5 where as the colour of the open field crop was highly acceptable with a mean score of 4.2. But in ' Mohini' (green variety amaranth) higher score for colour was for rain shelter crop (plate-4). Both 'Mohini' and 'Arun' had higher β carotene content in open field crop but this alone may not be a factor, which resulted in the less colour of 'Arun' in rain shelter crop and 'Mohini' having a higher colour score in rain shelter crop. This may be due to low anthocyanin development in 'Arun' (red variety) under low light intensity in rain shelter.

The effect of cooking on the acceptability of colour is also higher for ' Arun' (3.8) in open field crop than in rain shelter crop (2.8). So with regard to the variety 'Arun' the acceptability of colour is for the open field crop for both raw as well as cooked form. But colour of 'Mohini' was highly acceptable for rain shelter crop in both raw and cooked form.

In capsicum the variety 'California Wonder' showed better acceptance for colour in rain shelter crop (4.1) (plate-5) than open field crop (3.1) (plate-6) but in 'Pusa Deepthi' there was no significant variation in the colour scores indicating that better colour in capsicum can be retained in rain shelter crop. Consumers generally relate fruit colour to its organoleptic quality (Fraser *et al.*, 1994).

In tomatoes significantly higher scores for colour were obtained in rain shelter crops for both the varieties showing that colour of these tomato varieties were better in rain shelter crops. Fruit colour in tomato is mainly contributed by carotenoids especially lycopene content. In the present study even though β carotene showed no significant variation in rain shelter and open field crop, lycopene content was significantly high in rain shelter crop, which might have contributed to the better colour of tomato fruits in rain shelter. Ozbone *et al.* (1967) had reported that high potassium content of tomatoes had an effect on the colour of tomatoes. It is a dominant factor affecting the uniformity of colour in tomato fruits. In rain shelter crops potassium content was comparatively high which may also be a contributing factor for the better colour uniformity in rain shelter crop (plate 7 and 8).

Flavour in fruits and vegetables is mainly contributed by the particular organic acids present in them. By experience the consumers can attribute certain typical acceptable flavour for each vegetable as well as fruit. Any change in this will affect its consumer acceptability. In amaranth crops, no significant change in the flavour was noted in the rain shelter as well as open field crop both before as well as after cooking. But in 'Mohini' the flavour of the open field crop was comparatively less acceptable in fresh state.

In capsicum the rain shelter crop of 'Pusa Deepthi' revealed less acceptance for flavour (3.6) than open field crop (4.0). In 'California Wonder' there was no variation in the acceptability of flavour between rain shelter and open field crops.

In tomato there was no variation in the acceptability of flavour in rain shelter and open field crops of 'Anagha' but in 'Shakthi' better acceptability for flavour was observed in open field crop (3.9). Dalal *et al.* (1967) had reported that the concentration of volatile compounds are higher in field grown tomato than in green house grown tomato.

Texture is the overall assessment of the feeling the food gives on touching and in the mouth. The texture of fruits and vegetables is mainly contributed by the freshness (moisture content) and the intact cell walls. In amaranth better scores were obtained for texture for rain shelter crop in 'Arun' but no significant variation was observed in 'Mohini' between rain shelter and open field crop. After cooking there was no significant difference in the texture of both the varieties of amaranth cultivated in rain shelter and open field.

In capsicum and tomatoes also variations observed in the mean score for texture in the rain shelter and open field crops were not significant indicating that texture of these vegetables are not affected by rain shelter cultivation.

Taste is due to the sensation felt on the tongue. Since amaranth is mainly consumed in the cooked form, acceptability of the crop with respect to taste after cooking is also a very important criterion for consumer demand. In this study taste of 'Arun' cultivated in the open field was highly acceptable (3.6) than the rain shelter crop (2.7). But in 'Mohini' better acceptance was for rain shelter crop (3.7) than open field crop (3.1).

Thus as reported by Sirohi and Behera (2000) in protected environment the natural environment is modified to suitable conditions for optimum plant growth which ultimately provide quality fruits and vegetables.

Summary

SUMMARY

The study on 'Quality evaluation of selected vegetables under rain shelter and open field cultivations' was conducted to evaluate the duration of maturity, nutrient and anti nutrient compositions as well as the acceptability of two varieties of amaranth, capsicum and tomato cultivated in rain shelter, during rainy season in the department of Olericulture, College of Horticulture, Vellanikkara, Thrissur. The two varieties of amaranth were 'Arun' and 'Mohini', capsicum were 'Pusa Deepthi' and 'California Wonder' and tomato were 'Shakthi' and 'Anagha.'

The constituents such as moisture, fibre, protein, starch, calcium, iron, phosphorous, potassium, sodium, vitamin C, β carotene and lycopene (tomato only) and the antinutrient constituents like oxalates and nitrates in amaranth were estimated. The acceptability of selected vegetables was also evaluated.

The study revealed that the moisture content of amaranth varied from 80.5 to 85.01 per cent. The moisture content was significantly high in rain shelter crop in both the varieties than the open field crop.

The fibre content of amaranth varied from 1.04 to1.7 per cent. Which was only due to varietal difference. There was no significant difference in the fibre content of rain shelter and open field crop.

The starch content of amaranth varied from 0.14 to 0.17 per cent. In both the varieties starch content was significantly high in rain shelter crop.

The protein content of amaranth was higher in the variety 'Arun' than 'Mohini.' But in both the varieties rain shelter crop showed higher protein than open field crop.

Among minerals calcium content of amaranth was high for the variety 'Mohini' under rain shelter (363.35 mg $100g^{-1}$) and open field (342.28 mg $100g^{-1}$) when compared to 'Arun.' There were no significant variations in calcium content of rain shelter and open field crops in both the varieties. The iron content was maximum for the variety 'Mohini' under rain shelter (29.27 mg $100g^{-1}$) and minimum for 'Arun' under open field (24.2 mg $100g^{-1}$). Rain shelter crops showed higher iron content than open field crops in both varieties.

The phosphorous content of amaranth varied from 59.44 to 72.70 mg $100g^{-1}$ with highest phosphorous content in 'Arun' under rain shelter. The potassium content of amaranth varied from 817.17 to 841.50 mg $100g^{-1}$ and no significant variation was observed in the potassium content of rain shelter and open field crops.

The sodium content of amaranth varied from 7.98 to 14.34 mg 100 g^{-1}, which was only a variation due to variety and not due to rain shelter or open field cultivation.

The β carotene content of amaranth varied from 1153.55 to 1361.13 μg 100 g^{-1} with the highest value for 'Mohini' under open field condition and lowest for the same variety under rain shelter condition. Significant reduction in β carotene content was observed in 'Mohini' in rain shelter crop, but not in 'Arun'. The vitamin C content of amaranth varied from 33.2 to 55.56 mg 100g $^{-1}$, which was also due to the varietal difference, and no significant difference in vitamin C was observed in rain shelter and open field crop.

The moisture content of capsicum varied from 91.24 to 93.91 per cent with highest moisture for 'Pusa Deepthi' under rain shelter and lowest for same variety under open field condition. Higher moisture content was observed in rain shelter crops. The fibre content of capsicum varied from 6.21 to 6.36 $g100g^{-1}$ and there was no significant variation in fibre content in rain shelter and open field crops.

The starch content of capsicum varied from 0.114 to 0.126 per cent and significantly high value for starch was observed in rain shelter crops in both the varieties.

The highest protein content of capsicum was found in the variety 'California Wonder' cultivated under rain shelter condition (2.60 g 100 g^{-1}) and lowest for the same under open field condition (2.26 g 100 g^{-1}) and revealed a significant difference between rain shelter and open field crop. But in 'Pusa Deepthi' there was no significant difference in the protein content of rain shelter and open field crops.

Among minerals calcium content of capsicum varied from 30.0 to 31.71 mg $100g^{-1}$, which was only a varietal difference. The iron content of capsicum varied from 3.27 to 4.95 mg $100g^{-1}$ and in both the varieties rain shelter crop showed significantly high iron content. The phosphorous content of capsicum varied from 82.63 to 91.6 mg $100g^{-1}$ and there was no variation in the phosphorous content of both varieties of capsicum in rain shelter and open field conditions.

The sodium and potassium content of capsicum was found to be high in 'California Wonder' cultivated under rain shelter but in 'Pusa Deepthi' high sodium content was observed in rain shelter crop but no significant difference in the potassium content.

The β carotene content of capsicum varied from 283.26 to 962.3 μg 100 g^{-1} with highest value for 'California Wonder' cultivated under open field and lowest for 'Pusa Deepthi' under rain shelter. β carotene content was significantly high in open field in both the varieties. The vitamin C content was significantly high for 'Pusa Deepthi' under rain shelter. But in 'California Wonder' the difference in vitamin C content of rain shelter and open field crop was not significant.

The *moisture content of tomato* varied from 94.48 to 95.43 per cent and the difference in the moisture content was not significant between rain shelter and open field crops in both the varieties. The fibre content also showed no significant variation.

The starch content of tomato was in the range of 0.113 to 0.119 per cent with 'Anagha' under rain shelter having the highest content but the difference observed in starch content in rain shelter and open filed crop was not significant. The protein content of tomato varied from 0.90 to 0.997 g 100 g^{-1} and significantly high protein values were observed in rain shelter crops in both the varieties.

Among minerals, the calcium content of tomato varied from 48.3 to 43.1 mg100g^{-1} with highest value for 'Anagha' under rain shelter. In both the varieties calcium content was significantly reduced in open field crops. The iron content of 'Anagha' under rain shelter (0.67 mg100g^{-1}) showed no significant variation from open field crop (0.59 mg100g^{-1}) but in 'Shakthi' iron content was significantly high in rain shelter crops (0.65 mg100g^{-1}).

Both 'Anagha' and 'Shakthi' showed significantly high phosphorous values in rain shelter crop. Potassium content was significantly high in 'Shakthi' in rain shelter crop (403.50 mg100g^{-1}) but in 'Anagha' there was no significant variation between rain shelter and open field crops. Sodium content was also significantly high in rain shelter crops in both the varieties.

The β carotene content of tomato varied from 346.73 to 406.28 μg100g^{-1} and the difference was mainly due to the variety. Significant variation was not observed in β carotene content of rain shelter and open field crops in both the varieties. *Significantly high vitamin C content was observed both in* 'Anagha' (32.03 mg 100g^{-1}) and in 'Sakthi' (31.81 mg 100g^{-1}) in rain shelter.

The lycopene content of tomato varied from 2.18 to 3.33 mg 100 g^{-1} and significantly higher lycopene content was observed in rain shelter crops in both the varieties.

Considering the anti nutritional factors in amaranth, the oxalate and nitrate content showed no significant variation between rain shelter and open field crops in both the varieties.

The acceptability of selected vegetables was assessed by sensory evaluation using score card. The attributes evaluated were appearance colour, flavour, texture and taste (for amaranth only). The mean score for appearance of 'Arun' (4.0) and 'Mohini' (4.5) were significantly high for rain shelter crops. But after cooking, in 'Arun' the mean score for appearance was high in open field crop (3.9) than in rain shelter crop. There was no significant change in the mean score of appearance in 'Mohini' after cooking. Tomato and capsicum revealed a higher score for appearance in rain shelter crops than in open field crops in both the varieties. Thus the rain shelter crops revealed a better consumer acceptance for appearance.

The mean score for colour in 'Arun' was significantly high in open field crop (fresh-4.2) than in rain shelter crop (fresh-3.5). After cooking also colour was more acceptable for the open field crop. But colour for 'Mohini' was highly acceptable for rain shelter crop both in the fresh and cooked form. In capsicum 'California Wonder' had better acceptance for colour in rain shelter (4.1) than open field crops (3.1). But there was no significant variation in the acceptance of colour of 'Pusa Deepthi' in rain shelter and open field crops. In tomato mean score for colour was high in rain shelter crop for both the varieties.

There was no significant change in the mean score for flavour in 'Arun' in the rain shelter as well as open field conditions both before as well as after cooking. But in 'Mohini 'the flavour of the open field crop was comparatively less acceptable in fresh state. In capsicum the rain shelter crop of 'Pusa Deepthi' showed less acceptance for flavour (3.6) than open field crop (4.0). In 'California Wonder' there was no variation in the acceptability of flavour between rain shelter and open field crops. In tomatoes there were variations in the acceptability of flavour in rain shelter and open field crops of 'Anagha' but in 'Shakthi' better acceptability for flavour was observed in open field crop (3.9).

In amaranth the mean score for texture was high for rain shelter crop in 'Arun' but no significant variation was observed in 'Mohini'. After cooking there was no difference in the texture of both the varieties of amaranth cultivated in rain shelter and open field crops. In capsicum and tomato also no variations were observed in the mean score for texture in the rain shelter and open field crops. This showed that the texture of these vegetables were not affected by rain shelter cultivation.

The mean score for taste in 'Arun' was higher in open field than (3.6) in rain shelter (2.7) condition. But in 'Mohini' mean score for taste was high for rain shelter crop (3.7) than open field (3.1).

The results of the present study revealed that constituents like moisture, protein, starch, iron, phosphorous, sodium, and vitamin C were high in rain shelter crops and β carotene was high in open filed crops except in tomato. In tomato β carotene was high in rain shelter crop. Constituents like fibre, potassium and calcium showed no significant variation in open field and rain shelter crops. Anti nutritional factors also showed no significant variation in rain shelter crops. The results of organoleptic qualities of vegetables indicated that in general the appearance was more for rain shelter crop than open field crops. Flavour and texture showed no variation in acceptability between rain shelter and open filed crops. Colour of the open field cultivated amaranth was highly acceptable than rain shelter crops. But in capsicum and tomato acceptable colour was for rain shelter crops.

Under protected cultivation, crops like amaranth, capsicum and tomato can be grown in rainy season when it is not possible to grow under open fields and can ensure a constant production of vegetables round the year in a particular place. This is ideally suited for farmers having small holdings. Apart from this protected cultivation also provide quality fruits and vegetables with better consumer acceptance.

The present study was conducted in vegetables cultivated during rainy season. Changes in the nutrient content are to be studied in other seasons also, since light intensity, duration of light and temperature affect the chemical constituents in plants. In the present study, β carotene and lycopene in tomato and vitamin C in all the crops were high in rain shelter crops. But earlier studies had reported that these nutrients were high in field crops than in green house crops, since the intensity of light is a factor affecting their synthesis in plants. Hence extensive studies not only on the intensity of light but also on the quality of light, duration of light and other physiological parameters which can have an effect on these nutrients under rain shelter has to be studied.

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Appendices

APPENDIX 1

SCORE CARD FOR ORGANOLEPTIC EVALUATION
OF AMARANTH (COOKED)

Name :
Date :

A-Rain shelter
B-Open field

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

APPENDIX II

SCORE CARD FOR ORGANOLEPTIC EVALUATION OF AMARANTH (RAW)

Name:
Date:

Character	Score	Arun		Mohini	
		A	B	A	B
Appearance					
Excellent	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				
Colour					
Excellent	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				
Flavour					
Excellent	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				
Texture					
Excellent	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				
Total					

A-rain shelter
B- Open field

APPENDIX III

SCORE CARD FOR ORGANOLEPTIC EVALUATION
OF CAPSICUM

Name:
Date:

Character	Score	Pusa Deepthi		California Wonder	
		A	B	A	B
Appearance					
Excellent	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				
Colour					
Excellent	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				
Flavour					
Excellent	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				
Texture					
Excellent	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				
Total					

A-Rain shelter
B-Open field

APPENDIX IV

SCORE CARD FOR ORGANOLEPTIC EVALUATION
OF TOMATO

Name:
Date:

Character	Score	Anagha		Shakthi	
		A	B	A	B
Appearance					
Excellent	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				
Color					
Excellent	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				
Flavour					
Excellent	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				
Texture					
Excellent	5				
Good	4				
Fair	3				
Poor	2				
Very poor	1				
Total					

A-Rain shelter
B-Open field

QUALITY EVALUATION OF SELECTED VEGETABLES UNDER RAIN SHELTER AND OPEN FIELD CULTIVATION

By

NASHATH K. H.

ABSTRACT OF THE THESIS

submitted in partial fulfilment of the requirements for the degree of

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(FOOD SCIENCE AND NUTRITION)

Faculty of Agriculture
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KERALA, INDIA

2005

ABSTRACT

The study on "Quality evaluation of selected vegetables under rain shelter and open field cultivation" was aimed at assessing the duration of maturity, nutritional composition, anti nutritional factors and acceptability of the two varieties of amaranth, capsicum and tomato cultivated under rain shelter and open field in rainy season in the Department of Olericulture, College of Horticulture, Vellanikkara.

The vegetables are analysed for moisture, fibre, protein, starch, calcium, iron, phosphorous, potassium, sodium, vitamin C, β carotene and lycopene (tomato only). The results revealed that among the different constituents present in amaranth the mean content of moisture, protein, phosphorous and sodium were high in 'Arun' grown under rain shelter. The mean fibre, starch, calcium, iron, potassium and vitamin C contents were highest in the variety 'Mohini' under rain shelter. The β carotene content of amaranth was highest in the variety 'Mohini' under open field condition.

Regarding the nutrient constituents of capsicum the mean content of moisture, starch, calcium, phosphorous and vitamin C were highest in the variety 'Pusa Deepthi' growing under rain shelter where as the mean content of fibre, protein, iron, potassium and sodium were highest in the variety 'California Wonder' cultivated under same condition. The β carotene content was high in 'California Wonder' cultivated under open field condition.

In tomato the mean content of protein, starch, calcium, iron, phosphorous, vitamin C, β carotene and lycopene were highest in the variety 'Anagha' cultivated under rain shelter where as mean content of moisture, fibre, sodium and potassium were highest in the variety 'Shakthi' cultivated under the same condition.

The anti nutritional factors namely oxalates and nitrates present in amaranth cultivated under rain shelter and open field conditions were also analysed. The results revealed that the oxalate and nitrate content of amaranth showed no significant variation between rain shelter and open field crops in both the varieties.

Results of organoleptic evaluation of vegetables indicated that significant variation in acceptability between the vegetables cultivated under rain shelter and open field condition. The vegetables cultivated under rain shelter were found to be more acceptable.