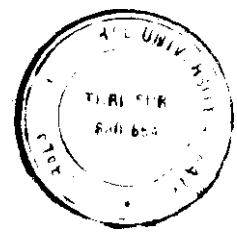
EFFECT OF HARVEST MATURITY ON QUALITY AND SHELF LIFE OF PUMPKIN (*Cucurbita moschata* Poir.)

By
M. VEENA



THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Horticulture

Faculty of Agriculture
Kerala Agricultural University

Department of Processing Technology
COLLEGE OF HORTICULTURE
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DECLARATION

I hereby declare that this thesis entitled **"Effect of harvest maturity on quality and shelf life of pumpkin (*Cucurbita moschata* Poir.)"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

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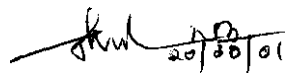
CERTIFICATE

Certified that this thesis, entitled **"Effect of harvest maturity on quality and shelf life of pumpkin (*Cucurbita moschata* Poir.)"** is a record of research work done independently by **Miss.M.Veena,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.



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M. VEENA

Dedicated to
my Achan and Amma

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LIST OF ABBREVIATIONS

g - gram

kg - kilogram

ml - millilitre

cm - centimetre

ß - beta

d.a.a. - days after anthesis

M_1 - 30 days after anthesis

M_2 - 45 days after anthesis

M_3 - 60 days after anthesis

Introduction

INTRODUCTION

Cucurbits form an important and vast group of vegetables cultivated extensively in Kerala. Of the four cultivated species of genus *Cucurbita,* pumpkin (*Cucurbita moschata* Poir) is the most widespread in tropics. The fruits with its high carotene content and seeds with high protein and oil content have good nutritive value. The fruits also serve as an industrial raw material for carotene production (Vucetic *et al.*, 1999). Pumpkin also has a longer shelf life as compared to most of the vegetables (Wills *et al.*, 1981). The innumerable therapeutic and dietetic values make it important among cucurbits. The fruits also find a place in processing industry due to the vast scope of diversified products like candy, jam, pickle, beverage and the use in bakery and confectionery.

The major conditions that produce the most important and clearest difference in postharvest behaviour of horticultural crops are climate, mineral nutrition and harvest maturity. These factors in turn depend upon the soil and genotypic characteristics (Monselise and Goren, 1987).

In crops like vegetables, the nutritive value is most important and is dependent on the stage of maturity at which the crop is harvested. An optimum quality is a standard measure of maturity for most of the vegetables which may reach well in advance of full maturity (Rawat *et al.*, 1979). Maturation, a natural process of growth and development in vegetables, brings about various changes in chemical constituents associated with certain physical changes. The changes in

chemical constituents govern the palatability and nutritional status of a vegetable, which are essential components of quality.

At present, fruits of pumpkin are harvested at different physiological maturity giving least emphasis to quality. The fruits are consumed both when young as well as ripe. They are used as fresh vegetables, processed food and as stock feed. Diversified uses of pumpkin fruits make it necessary to be harvested at correct stage of maturity for each specific use. In the preparation of sweets and jam fully riped ones due to their sweetness are preferred. Pumpkin fruits undergo considerable physico-chemical changes during maturation. A detailed study of the physico-chemical attributes at different stages of maturity would help to standardize the harvest indices. Harvesting at the optimum stage of maturity has a significant impact on postharvest shelf life also.

Crop nutrition is yet another important pre-harvest factor influencing the quality and storage behaviour of fruits and vegetables (Pantastico, 1975). One of the best method of maximizing the crop yield and its quality is the application of required amounts of nutrients. Among others, nitrogen is the most important nutrient which has direct effect on the quality and metabolism of plants. This nutrient is usually applied through organic or inorganic sources.

Both organic and chemical fertilizers have a role in agriculture. Chemical fertilizers claim to maintain high crop yields and provide cheap, abundant and diversified food (Barker, 1975). Fertilizers are increasingly used because of the quick availability of nutrients to plants. But they are costly and at time has adverse effects on the crop. Chemical fertilizer on continuous and heavy

application can affect the physical and chemical properties of soil adversely. It may also lead to soil infertility and increased vulnerability of crops to pests and diseases. Farming with organic manure gains yield potential importance as it is claimed that the crop raised with them grow and taste well and are more nutritious (Abusalcha and Shanmugavelu, 1988). The absence of residual chemicals has encouraged farmers to rely on organic vegetable production.

Consumer demands for organically produced food and the desire by many farmers to eliminate chemical fertilizers and pesticides are increasing the need for research and educational programme to support organic farming. A detailed study on all the chemical and physical components of the fruit as affected by source of nutrition may help to prove the importance of organic farming.

Pumpkins exhibit a great deal of varietal differences. The varieties show variation in the composition of their fruits. Differences in flavour, consistency and appearance of the varieties are related to their composition, which determine their suitability for various purposes. In canning industry, large fruited and heavy yielding varieties having proper flesh texture and yellow or light coloured rinds are preferred since green skinned varieties are likely to discolour the canned product (CSIR, 1950).

Hence the present investigation on pumpkin was carried out at the Kerala Agricultural University with the following objectives.

1. To study varietal differences in physico-chemical attributes of pumpkin.
2. To study the effect of harvest maturity on quality and shelf life of pumpkin.
3. To study the effect of source of nitrogen on physico-chemical constituents and shelf life of pumpkin.

Review of Literature

2. REVIEW OF LITERATURE

Pumpkin is an important cucurbitaceous vegetable grown in Kerala. Manures and fertilizer influence the produce quality and keeping quality of vegetables. Similarly determining the optimum harvest maturity of fruits may help to improve the quality of fruits and increase storage life. Hence the present investigation was carried out to study the effect of maturity stages in relation to source of nutrition on physiochemical constituents and shelf life of pumpkin. The available literature on the topic are reviewed below.

2.1 Varietal variation in physico-chemical constituents and shelf life of vegetables

2.1.1 Physico-chemical constituents

The different varieties of pumpkin exhibited marked difference in their composition. Varieties with high sugar had large amount of acid hydrolysable polysaccharide, those with high total solid were rich in soluble solids and moderately rich in total nitrogen (CSIR, 1950).

Marked difference in fruit acidity were consistently observed between varieites of tomato. The varietal differences in sugar content were generally smaller and not so clearly defined (Davies and Winsor, 1969).

A study on 25 watermelon varieties by Thakur and Nandpuri (1974) indicated significant differences among varieties for fruit weight, TSS, seeds per kilogram of fruit weight etc.

Kubiaki and Walezek (1976) reported large differences between and within varieties with regard to ß carotene content in 19 varieties of pumpkin.

Varietal differences in quality characters and chemical constituents have been reported by Kaur *et al.* (1977) in tomato.

Kalyanasundaram (1976) evaluated three muskmelon varieties and observed significant differences among the varieties for fruit weight, fruit cavity, diameter, flesh thickness etc.

Ramachandran (1978) worked on 25 bittergourd types and concluded that they differed in fruit weight, flesh thickness, 100 seed weight, TSS, vitamin C content etc.

Joseph (1978) studied the variability in 25 snakegourd types. They showed wide variation for fruit weight, flesh thickness, 100 seed weight, TSS and vitamin C content.

Gopalakrishnan *et al.* (1980) reported variability in 18 diverse pumpkin genotypes with respect to weight of first mature fruit and their respective components.

Sidhu *et al.* (1982) reported much variation in the biochemical constituents of 19 varieties of egg plant.

Doijode (1983) reported high variation in TSS and carotene content of different varieties of pumpkin.

Seven varieties of musk melon showed significant difference in TSS, ascorbic acid, acidity and total carotene and seasonal variation in ascorbic acid (Kaur *et al.*, 1987).

Vijay (1987) reported variability in 95 cultivars of muskmelon for TSS and flesh thickness. Four cultivars of Zucchini squash showed little difference in

vitamin C content but wide variation was observed in fruit size (Kmiecik and Lisiewska, 1989).

In kakrol 'Fatehpur Local' had higher percentage acidity than the other strains. 'Kanpur Local' had significantly higher percentage of reducing and nonreducing sugars (Dubey and Gaur, 1990).

Rastogi and Deep (1990) reported considerable variation in characters including days to fruit maturity in cucumber.

Highly significant differences in characters like weight of fruit, thickness of flesh, fruit size index etc. were observed in 20 genotypes of pumpkin (Borthakur and Shadeque, 1990).

A study in 64 lines of chilli for fruit and yield characters showed variability in these characters (Ahmed *et al.*, 1990).

Variability in characters like pod length, weight, width etc. was observed in ten varieties of french bean (Saha *et al.*, 1990).

Fruits of seven cultivars of bittergourd showed considerable variation in contents of protein, carbohydrate, sugar, vitamin C etc. (Jaiswal *et al.*, 1990).

Singh *et al.* (1990) reported variation in ascorbic acid and dry matter content of different varieties and hybrids of cauliflower.

Variability existed among the cultivars of pointed gourd in diameter of fruit, length of fruit and average fruit weight (Singh *et al.*, 1992). Similar results have been obtained by Singh *et al.* (1977) in bittergourd and Singh (1983) in pointed gourd.

Teotia (1992) reported varietal variation in different varieties of pumpkin with respect to storage life, carotene content, lycopene and vitamin C.

In lettuce, Rozek *et al.* (1995) proved that cultivar effects on plant composition was generally stronger than fertilizer effect.

The four varieties of tomato showed marked difference in physical and chemical constituents like colour, fruit firmness, juice and pulp content, number of locules etc. (Kumari *et al.*, 1998). Sheela (1998) reported significant variation among 25 bird pepper accessions for ascorbic acid, capsaicin, oleoresin and carotenoids. Sureshbabu (1996) reported wide variability in characters like fruit weight, flesh thickness and β carotene in different genotypes of pumpkin.

Wide variability was noticed in characters like length, diameter of fruit, number of fruits per plant etc. in 34 genotypes of *Coccinia grandis* (Sarnaik *et al.*, 1999).

High genetic variability was exhibited by 20 genotypes of pointed gourd in characters like number of fruits per plant, fruit length, fruit diameter, core diameter, number of seeds, fruit colour, fruit yield (Pariari *et al.*, 2000).

2.1.2 Shelf life

Desai *et al.* (1986) reported the shelf life of pumpkin to range between 24 to 36 days at 1.7 to 11.6°C and 70 to 75 per cent RH.

A study on storage behaviour of onion as influenced by nitrogen fertilization showed that when N level was beyond 60 kg ha^{-1} the total storage losses of 'Arka Niketan' was significantly lower than 'Arka Kalyan'. Arka Kalyan

could be stored for only three months while Arka Niketan had a storage life of six months (Rao and Srinivas, 1990).

Risse *et al.* (1990) reported that the small watermelon cultivar 'Minilee' was well superior to other cultivars in postharvest storage potential and exhibited least chilling injury and decay. Mickylee and Minilee cultivars were firmer and retained their firmness during storage.

Wide range of variation was observed for morphological and storage characteristics whereas it was comparatively narrow for chemical constituents of onion bulbs (Patil and Kale, 1990). Teotia (1992) reported that pumpkin varieties with highest initial pectin content had the best keeping quality.

A study on varietal influence on storage behaviour of tomato harvested at ripe and full ripe stage by Joshi and Khandekar (1993) revealed that PLW increased with duration of storage irrespective of varieties eventhough variation existed between them. Some varieties like 'Sonali' exhibited maximum shelf life but changes in chemical composition also varied with the varieties.

Luengo and Lopes (1995) have reported that *Cucurbita moschata* varieties showed moderate fresh weight loss and deterioration percentages (67 to 69%) when stored for a period of seven months. Significant intervarietal differences were also exhibited by the fruits of *C. moschata*, *C. maxima* and *C. pepo* after seven months of storage.

Considerable variation in quality characters and postharvest behaviour were reported between *C. moschata* cv. Waltham Butternut and *C. maxima* cv. Bingess strain Buttercap (Nerson, 1995). Mohanty *et al.* (2000) observed that among the 12 varieties of onion, Arka Niketan had better keeping quality.

2.2 Effect of harvest maturity on physico chemical constituents and shelf life of crops

2.2.1 Physico chemical constituents

Several chemical indices have been used to predict the correct stage of harvest in vegetables.

Sistrunk *et al.* (1960) stated that factors involved in pod maturity stage of okra were length, number of pods per unit weight, specific gravity, resistance to shrinkage and the percentage of seeds per pod. He also reported that maximum increase in pod weight, length and diameter occur during 4^{th} to 6^{th} day after anthesis.

Rao (1974) had reported that firmness and texture of vegetable products vary with maturity.

Mishra and Khatai (1969) observed a high content of ascorbic acid in red chillies than in green chillies. Gardiner (1970) reported that both alcohol insoluble solid and dry matter content increased with successive harvests in beans.

In carrots the biochemical maturity is reached when carotene as well as carbohydrate content has reached the maximum (Phan and Hsu, 1973). In hyacinth bean pod weight which depended on pod breadth was observed as the index of maturity (Jana and Chathopadhyay, 1977).

Physico chemical studies in tomato varieties carried out by Kaur *et al.* (1977) at different stages of ripening and storage revealed that vitamin C, acidity, TSS and weight of fruits increased with development of fruits.

A study by Rao and Sulladmath (1977) revealed that maturity of pods had significant effect on mucilage content and drained weight of okra.

A study on two varieties of snap bean to see the effect of maturity on the chemical constituents proved that nutritive characters, crude fibre, ascorbic acid, total and reducing sugars showed significant variation with advancement in maturity. The period around 22 days after anthesis was found suitable for picking pods (Rawat *et al.*, 1979).

Awasti and Singh (1979) had reported changes in ascorbic acid with maturity in *Capsicum annuum*.Fritz and Weichmann (1979) reported that earlier harvested carrots contained less carotene than late harvested ones.

A work by Bajaj *et al.* (1980) proved that in addition to varietal differences ascorbic acid content depended upon maturity of fruits also. With the increase in maturity, dry matter, carotenoid and ascorbic acid also increased.

Gaur and Bajpai (1982) observed that tomato fruits harvested at the pink stage had the best quality.

Field experiments undertaken to study the tuber quality and yield in sweet potato at different stages of harvest indicated that the quality deteriorated after fourth month of the crop (Indira and Lakshmi, 1984).

A study by Kaur and Baina (1988) concluded that physical characteristics like length, girth, weight and textural properties depends upon the stage of harvest in okra.

Teotia *et al.* (1988) reported that a wide variation was observed among cucurbitaceous cultivars in the ratio of total reducing sugars to non reducing sugars which was dependent on the cultivar and stage of maturity.

In okra cultivar Punjab Padmini, the maturity was attained seven days after anthesis (Kanwar and Saimbhi, 1989).

Dubey and Gaur (1990) confirmed that in kakrol, acidity increased with fruit age. The contents of ascorbic acid, TSS, protein and dry matter were highest in all varieties at the final age (22 days from fruit set).

In cucumber, Kaynas and Ozelkok (1991) observed that fruit growth followed a single sigmoid curve and content of soluble solids increased with time during the harvesting period. Commercial maturity was judged to be attained 17 days after anthesis, on the basis of weight loss and quality changes after 14 days of storage at 10°C.

In bottlegourd fruit length and diameter increased continuously especially upto 28 and 20 days after anthesis respectively. Ascorbic acid increased at an intermediate stage of fruit development and decreased thereafter while carotenoid content decreased during fruit development (Bhatnagar and Sharma, 1994).

In artichoke, Ben Chekrown *et al.* (1994) reported that the dry matter and total carbohydrate content of stalks and leaves decreased after flowering, stabilizing at a minimum level just before maturity.

Ernst *et al.* (1995) reported that in chicory, levels of sucrose and glucose in cv. Flash remained about the same over the growing season.

A study conducted by Ahmed *et al.* (1996) to study the effect of different fruit maturity stages on chemical composition in different varieties of sweet pepper revealed that chemical composition and market acceptability of fruits varied with maturity stages. Ascorbic acid and market acceptability were high in green edible stage followed by matured green stage, while it decreased at break and ripe stage. TSS and dry matter was low at edible stage but thereafter both increased and reached maximum at ripe stage.

In okra it was observed that optimum stage of harvest influenced the quality of seeds produced (Devadas *et al.* 1998). Sheela (1998) reported that ascorbic acid, oleoresin and carotenoids registered a significant increase with ripening in bird pepper accessions.

Baringer *et al.* (1999) reported that tomatoes are preferred to be harvested late since yield of red fruits increased with late harvest.

2.2.2 Shelf life

Kaur *et al.* (1977) reported that fruits harvested at turning pink stage gave best results in term of maximum quality and storage in tomato.

Kanellis *et al.* (1986) observed that cucumber fruits harvested six and nine days after anthesis had shelf life significantly longer than all other stages.

Shelf life of tomato fruits were indirectly correlated with the fruit maturity i.e., stage of harvest (Joshi and Khandkhar, 1993).

Singh *et al.* (1995) studied the effect of harvest stage on the quality of garlic cloves at room temperature. Discolouration of cloves which increased with advancement of stage of maturity was least in first stage of harvesting.

Nerson (1995) studied the performance of two winter squash cultivars harvested at different developmental stages. The first yield decreased with increasing age at harvest. It was observed that winter squash fruits when harvested 3-4 weeks after anthesis had best quality and longest shelf life.

Neri and Brigati (1996) suggested various qualitative indices for different melon cultivars for determining the right stage for harvesting inorder to extend postharvest shelf life based on skin and flesh colour.

Maw *et al.* (1997) had reported that harvest maturity had the greatest influence upon storability of sweet onions.

2.3 Effect of source of nutrition on physico-chemical constituents and shelf life of crops

2.3.1 Quality and yield

Attia and Nassar (1958) reported that application of pigeon manure increased sugar content in water melon. Haworth (1961) reported that application of farmyard manure produced large increase in the yield of potatoes, spring cabbage and leeks and reduced the responses of all crops except leeks to the nitrogenous fertilizer treatment.

The beneficial effects of poultry manure in vegetable production have been demonstrated by Puustjarvi (1962) in cucumber and Toth (1963) in snap bean.

Effect of four sources of organic manures at three levels of nitrogen was studied on *Allium sativum* in the field condition by Singh and Tewari (1968). The results revealed that 50 kg N gave best response in most characters and the

different sources did not have any significant difference between themselves on their effect on the plant characters.

In cauliflower, Dhesi *et al* (1964) have recommended 20 cartloads of farmyard manure, 80 to 100 lb N and 50 lb P_2O_5 for obtaining maximum yield.

Adverse effects of excessive application of fertilizer nitrogen on specific gravity and tuber grades have been reported by Murphy *et al.* (1967), Mass (1968) and Singh and Singh (1971) in potatoes.

Singh and Gill (1968) recommended 169 quintals of poultry manure for getting good yield in cauliflower. Application of 10 cartloads of farmyard manure along with 80 lb N, 40 lb P_2O_5 and 40 lb K_2O per acre was recommended as beneficial in cauliflower by Yawalkar (1969).

Additional application of nitrogen through fertilizer had neither any effect on curd size nor on yield of cauliflower (Saimbhi *et al* 1970).

The vitamin C content of cauliflower curds increased with higher levels of poultry manure. The carbohydrate content of curd was observed to be slightly increased at lower level and then decreased with the increasing levels of poultry manure (Singh *et al.*, 1970).

Brandt and Beeson (1950) found that ascorbic acid and carotene concentration in carrots, snap beans, potato tuber etc. fertilized with manure composts, mineral fertilizers or combination of both were not significantly different.

The optimum nitrogen suggested for pumpkin was 103 kg during summer and 96 kg for rainy season (Sharma and Shukla, 1972). Mahajan *et al.*

(1974) studied the responses of celery to application of graded dose of N and eight levels of farmyard manure. An increase in the level of N as well as farmyard manure induced significant increase in the yield of celery seed.

Dried cow manure produced lower yields than any of the other fertilizer with highly significant difference in spinach Hybrid 424 in spinach (Barker, 1975). Nitrogen fertilization increased plant growth, fruit yield and improved fruit quality in tomato (Gupta *et al.*, 1978).

A study on the chemical composition of vegetables like carrot, cabbage and leek revealed that the fertiliser used did not have any effect on characters like vitamin C, carbohydrate and storage ability while the dry matter increased significantly with organic fertiliser (Nilsson, 1979).

Application of nitrogen increased the fruit size and yield in pumpkin (Gupta and Srinivas, 1979). Preitas and Faria (1981) observed that application of NPK fertilizers and farm yard manure increased soil organic matter, nutrient levels and tomato production. The use of organic manure in combination with inorganic fertilizer have been advocated by Abusaleha (1981) in okra and Dhandapani (1982) in cauliflower.

Vogtmann (1981) observed reported the beneficial effect of organic nitrogen fertilisers used in organic systems on crop quality.

A favourable influence of organic fertilizer on ascorbic acid in sweet pepper fruits was reported by Valsikova (1983). Aseigbu and Uzo (1984) observed that in onion percentage of grade one bulbs increased with FYM application. Linardakis and Tsikalas (1984) noted that when farmyard manure was applied to

tomato at the rate of 10 m^3 per 100 m^2, plants, receiving farmyard manure gave highest yield in all the years.

Doikova *et al.* (1986) studied the effect of fertilization on the productivity, total nitrogen and nitrate content of Capsicum and found that highest total nitrogen and nitrate content was in the green fruits especially when farm yard manure was used as a source of nitrogen. Silva (1986) found that farmyard manure increased the head weight of cabbage CV. 'Gloria'.

A study by Jose *et al.* (1986) in brinjal to compare the efficacy of organic and inorganic sources of nitrogen revealed that at half N (50 kg) as poultry manure and half N (50 kg) as urea, the dry matter increased. The plants supplied with inorganic forms of fertilizer showed early flowering when compared to organic sources or their combination.

Perchova and Prugar (1986) studied the effect of different combinations of FYM and inorganic N in a three year trial in lettuce CV. Mayking. FYM positively affected nitrification process in the soil and nitrate accumulation in the crop.

Americana (1987) found that treatment with cornstover combined with cattle manure was found most profitable in tomato crop.

Increasing the levels of N increased yield, protein and vitamin C contents of cucumber fruits upto 80 kg ha^{-1} level (Maurya, 1987). Vitamin C content increased significantly with increased rate of nitrogen (Manchanda and Singh, 1987).

According to Ragimova (1987) FYM at 20 t ha^{-1} along with $N:P_2O_5:K_2O$ at 90:90:60 kg ha^{-1} and Mn + Cu + Mo produced the highest yield in cucurbits.

A study carried out by Abusaleha and Shanmugavelu (1988) on the efficacy of nitrogen of both organic and inorganic sources on growth, quality and yield of okra cultivar 'Pusa Sawani' revealed that to get good quality of okra fruits, combined application of organic and inorganic source of nitrogen are necessary. Such fruits had higher carbohydrate content, low crude fibre and high ascorbic content all of which were desirable characters. Significant increase in the starch and protein yields of potatoes were found upto the application of 200 kg ha^{-1} in the absence and 250 kg N ha^{-1} in the presence of FYM which shows that response to nitrogen increased when applied along with FYM (Sharma and Arora, 1988).

Segovia (1988) observed that in the case of melons in tunnels, yields were highest in plants treated with cattle manure at 80 t ha^{-1} and poultry manure at 10 t ha^{-1}. In summer cabbage crop response to base levels of ammonium nitrate was greater than to the organic materials below an application rate of 350 kg N ha^{-1} (Smith and Hadley, 1988).

Subhan (1988) reported that application of 25 or 30 t ha^{-1} of cattle manure gave the largest cabbages and highest yield per plot. Nitrogen application appreciably increased seed yield in two out of three season in onion (Mohamedali and Nourai, 1988).

The maximum yield and superior quality parameters like TSS, total sugars, ascorbic acid, volatile oil etc were observed at 90 kg N ha^{-1} in onion (Shanthi and Balakrishnan, 1989).

Meirproeger *et al* (1989) observed that compost from biogenic waste gave superior results for qualities like organoleptic quality, storage quality, contents of desirable nutrients like vitamin C and sugar in crops like tomato, beetroots and cabbages.

A study by Montagu and Goh (1990) on the effect of forms of nitrogen fertilisers on quality indices of tomato revealed that the form of N did not affect measured quality indices other than fruit quality.

Storage behaviour of onion bulbs grown with application of graded level of nitrogen (10, 40, 80, 120, 160 and 200 kg N ha^{-1}) indicated significant differences in bulb firmness, TSS and sugars. Nitrogen significantly decreased the dry matter, increased the average weight and yield of bulbs but there was no change in weight loss during storage (Rao and Srinivas *et al.,* 1990).

Highest early yield and largest size were observed in feather meal (180 N) treated plots of bell pepper. Compost at 180 N had highest economic return per fertilizer dollar (Gaskell, 1990).

Subbiah *et al.* (1982) Dart (1986) and Gaur (1990) have reported that application of plant nutrients through organic sources like compost, farmyard manure and biofertilizer remain the alternative choice of the grower for maintaining sustainable production in okra.

Singogo *et al.* (1991) reported that addition of cattle manure increased total weight of melons per hectare in comparison with complete fertilizer.

Annanurova *et al.* (1992) observed that in tomato addition of FYM to the basic NPK fertilizer increased the number and mean weight of fruits. Pimpini *et al.* (1992) found that application of fertilizers or poultry manure at a lower rate gave the best source of processing suitability of potatoes. Nitrogen rates increased sugar and ascorbic acid content in potato (Sud *et al.*, 1992).

Lacatur and Botez (1993) observed that high quality processing tomatoes were obtained with NPK at the rate of 300, 150 and 75 kg ha^{-1} plus 20 t FYM ha^{-1}.

A work by Rozek *et al.* (1995) in lettuce grown in soil tunnel revealed that 'N' form had no effect on fruit weight, dry matter content, soluble sugar, starch, total protein or ascorbic acid concentration. Sharma and Bhalla (1995) observed that in okra full dose of fertilizer or compost or biofertilizer proved better than control for yield and profit but fertilizer application was significantly superior in this regard.

In chinese cabbage increase in N fertilization showed a negative effect on dry matter content which in turn reduced storage life (Guttormsen, 1996). Application of farmyard manure resulted in a marginal increase in yield of about 8 per cent over control in sweet potato (Behura and Swain, 1996).

Mahendran and Kumar (1997) reported that in cabbage CV. Hero highest TSS and ascorbic acid contents were produced by applying 75 per cent of the recommended rate of NPK combined with digested organic supplement and

vermicompost. The polar and euqatorial diameters of cabbage heads and net weight were also significantly influenced by applying organic manure.

In a study conducted by Yamazaki and Roppongi (1998) in leafy vegetables better quality were obtained with pig manure and cattle dung mixed with saw dust than with chemical fertilizer. Abdalla *et al.* (1998) studied the effect of nitrogen on yield and quality of salad crops. Application of organic manure produced plant height, total yield, dry matter content etc. almost equal to that obtained from 40 or 20 kg N per feddar.

The yield of organically grown lettuce, basal Filipino spinach and Zucchini after application of 20 MT compost/ha/crop was compared to yield obtained with standard synthetic fertilizer application (150 kg N ha^{-1}) and several combinations of compost : synthetic fertilizer ratios in a study by Valenzuela and Crosby (1998). Yields of plant receiving composts alone were comparable to those obtained by plants receiving synthetic fertilizer application. Higher yield was obtained with 20 MT ha^{-1} of compost plus supplemental N application, depending on the length of harvesting period.

Nandini (1998) had recorded maximum starch content in okra supplied with vermi-compost at 75 kg N ha^{-1}. Prasanna (1998) had reported that organic manures had a significant influence on quality parameters like ascorbic acid, TSS and starch content in brinjal.

A study on the effect of form of fertiliser on different vegetables by Segura *et al.* (1999) revealed that application of commercial manures resulted in higher early marketable yields in melons and tomato but final total yields were similar with FYM or commercial manure.

2.1.2 Shelf life

High levels of both farmyard manure and nitrogen proved detrimental to keeping qualities of potatoes stored at room temperature (Singh, 1973).

Yano and Hayani (1976) observed that mineral sources of 'N' decreased the storage quality of cabbage more than organic 'N'.

Joseph (1986) had reported a definite advantage of organic form of manures over inorganic fertilizers in respect to the storability of oriental pickling melon.

Rao and Srinivas, 1990 reported steep increase in total storage loses in onion bulbs with the increase in N levels.

The effect of fertilizer on quality and storage life of fresh pumpkin was studied by Teotia (1992). The results showed that weight losses after 140 days were 15.8 per cent for both control and fertilized pumpkins and after 200 days further weight losses were 11.8 per cent and 9.7 per cent for fertilized fruit. Effect of individual fertilizer elements on storage life and quality of fruits were not be ascertained.

According to Vogtomonn *et al.* (1993) composts prepared from kitchen and yard wastes positively affected food quality, improved storage performance and superior quality of tomatoes. Prasanna (1998) had reported that organic manure enhanced storage life of brinjal.

A study on the effect of nitrogen on fruit quality of snake gourd revealed that higher levels of nitrogen exerted a negative effect on the shelf life of fruits under ambient conditions (Syriac and Pillai, 1999).

Materials and Methods

3. MATERIALS AND METHODS

The present investigation on the "Effect of harvest maturity on quality and shelf life of pumpkin" was carried out at the Department of Processing Technology, College of Horticulture, Vellanikkara, Thrissur, Kerala during November 1999 to January 2001. Vellanikkara lies between 10°32' N latitude and 76°17' E longitude at an altitude of 23 m above MSL and enjoys a warm humid climate.

In the present study an attempt has been made to study the effect of maturity stages in relation to source of nutrition on physico-chemical constituents and shelf life of three varieties of pumpkin.

The study was carried out under two experiments, viz.,

E 1 - Effect of organic and inorganic sources of nitrogen on physico-chemical constituents and shelf life of pumpkin.

E 2 - Effect of harvest maturity on physico-chemical constituents and shelf life of pumpkin.

Details of materials and methodology adopted for the two experiments are narrated below.

3.1 Effect of organic and inorganic sources of nitrogen on shelf life of pumpkin

3.1.1 Experimental materials

The experiment was carried out using three varieties of pumpkin viz., Co.1, Ambili and Suvarna (Plate 1). Variety Co.1 was released from Tamilnadu Agricultural University and Ambili and Suvarna from Kerala Agricultural University.

Plate 1. Varieties used for the study

A standard description of varieties is presented in Table 1.

Table 1. Standard description of varieties

Varieties	Yield (tonnes/ha)	Size of fruit	Shape of fruit	Colour of fruit
Co.1	30	Medium large	Fruits have broad proximal end with the distal end slightly tapering to form a tip.	Immature fruits dark green. At full maturity brownish orange.
Ambili	34	Medium	Flat round fruits with shallow furrows	Green at immature stage and tan at mature stage
Suvarna	37	Medium	Flat round fruits with shallow furrows	Green at immature stage and tan at mature stage, attractive orange coloured flesh

3.1.2 Source of nutrition

The crop was raised under two different nutritional management practices as given below.

T_1 - with organic and inorganic manures as per the package of practice recommendation of the Kerala Agricultural University (KAU, 1996a). The fertilizer dose as per pit basis was 28:10:10 g NPK. FYM was applied @ 20 t per ha as basal dose along with half dose of N and full doses of P and K. The remaining dose of N was applied as top dressing, one month after basal application.

The inorganic sources of nitrogen, phosphorus and potassium were Urea, Factomphos and Muriate of potash.

T_2 - with organic sources alone. Farm yard manure equivalent to 37.5 kg N ha^{-1} was supplied in addition to basal dose of 20 t ha^{-1}.

3.1.3 Season, weather and soil condition

Crops were laid out in two seasons, November-April 1999 and May-September 2000. The weather data is furnished in Appendix - I.

The soil type was deep well drained sandy loam with pH 5.1.

3.1.4 Layout

The experiment was laid out in Randomised Block Design with three replications.

Plot size - 1000 m^2

Spacing - 4.5 x 2 m

There were 4 pits per treatment. Two plants were retained in each pit.

3.1.5 Cultural practices

The crop was irrigated and weeded at regular intervals. Top dressing was done after one month followed by earthing up.

Need based spraying of organic and inorganic pesticides were carried out due to the infestation of pests like mites, fruit borer, termites etc. and occurrence of mosaic disease.

Plant protection of crop raised with organic nutrition was done as follows

a) *Capsicum frutescens* fruit paste in water @ 50 gm/10 l

b) Basella leaf paste in water @ 500 gm/5 l

c) Neem-garlic emulsion

Plant protection of crop raised with inorganic nutrition was done with the following pesticides

a) Confidor @ 2.5 ml/10 l

b) Akomin @ 3 ml/l

c) Ekalux @ 2 ml/l

The fruits were harvested at different stages and used for the study.

3.2 Effect of harvest maturity on shelf life and physico-chemical constituents

The crop raised for Experiment I formed the material for experiment II also.

The female flowers were tagged on the day of opening and fruits were harvested at three stages of maturity viz., 30, 45 and 60 days after anthesis.

3.3 Observations recorded

The fruits were collected from the same plants for both the experiments. The following observations were recorded for Experiment I and Experiment II.

3.3.1 Physical characteristics

3.3.1.1 Weight of the fruit

Individual fruit weight was recorded and expressed in gram.

3.3.1.2 Circumference

The circumference of the fruit was measured by using a thread and read on a meter scale and expressed in cm.

3.3.1.3 Polar diameter

Polar diameter of the fruit was noted by cutting the fruit longitudinally into two halves through the centre and the length was measured using a thread and read on a meter scale and expressed in cm.

3.3.1.4 Flesh thickness

The thickness of the flesh was measured using a scale and expressed in cm.

3.3.1.5 Cavity volume

Cavity volume was determined by measuring the volume of water that the fruit cavity could hold and expressed in ml.

3.3.1.6 Cavity index

Fruit volume was recorded by displacement method and cavity index was calculated by the formula

$$\frac{\text{Cavity volume}}{\text{Fruit volume}} \times 100$$

and expressed as per cent.

3.3.1.7 Physical composition of fruit

Weight of the fruit was recorded. Then the fruit was separated into different components by cutting and peeling with a peeler (Plate 2). Weight of pulp, peel, seed and placenta were recorded separately and relative proportion of each of these to total weight was worked out and expressed as per cent.

3.3.1.8 Flesh colour

Visual evaluation of the colour of the flesh at different stages of maturity was carried out.

3.3.1.9 Seed colour

The colour of the seeds were visually evaluated.

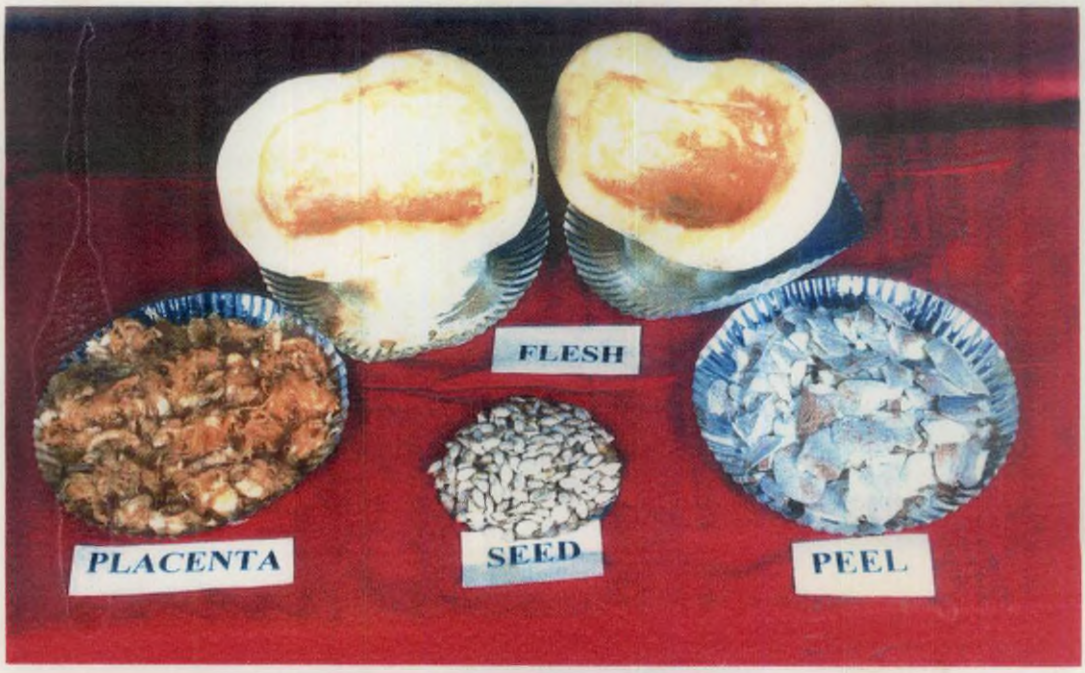


Plate 2. Physical composition of fruit of Suvarna

3.3.2 Chemical characteristics

The following chemical constituents were analysed at each stage of maturity employing standard chemical procedure.

3.3.2.1 TSS

TSS was estimated directly using a Erma Hand Refractometer (range 0° to 32°brix) and expressed in degree brix.

3.3.2.2 Total, reducing and non-reducing sugars

Total, reducing and non-reducing sugars were determined as per the procedure described by Ranganna (1986) using Fehlings solution in titrimetric method and expressed as percentage.

3.3.2.3 Acidity

Titrable acidity was estimated as per the procedure described by Ranganna (1986).

A known weight of the pulped fruit was digested with boiling water. An aliquot of the digest was treated with standard alkali using phenophthalein as indicator. The acidity was expressed in terms of the most predominant organic acid in the fruit viz., citric acid.

3. 3. 2. 4 β carotene

β carotene was estimated colorimetrically by dissolving the powdered sample in saturated n-butanol and reading the absorbance at 435.8 nm wave length (AOAC, 1970).

3.3.2.5 Ascorbic acid

Ascorbic acid content of the fruits were estimated by 2,6-dichloro phenol indophenol dye method (Mahadevan and Sridhar, 1974).

3.3.2.6 Starch

The starch content was analysed colorimetrically using anthrone reagent as suggested by Sadasivam and Manickam (1997).

Starch content was colorimetrically estimated by hydrolysing starch into simple sugars. The sample was treated with 80 per cent alcohol to remove sugars and then starch was extracted with perchloric acid. The starch was then hydrolysed to glucose and dehydrated to hydroxymethyl furfural. This compound formed a green coloured product with anthrone and its absorbance was measured at 630 nm. Starch content was expressed as percentage.

3.3.2.7 Crude fibre

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

The samples were first treated with acid and subsequently with alkali. The residue obtained after final filtration was weighed, incinerated, cooled and weighed again. The crude fibre was given by the difference in weight and expressed as percentage.

3.3.3 Storage studies

The fruits harvested at different maturity stages from both the treatments were stored under ambient laboratory conditions for the storage studies.

The laboratory temperature ranged from 26 to 30°C and the humidity between 60 to 85 per cent.

3.3.3.1 Physiological loss in weight (PLW)

Weight of fresh fruits were recorded immediately after harvest and subsequent reduction in weight was recorded at one week interval as long as the fruits remained in the marketable stage upto a maximum period of four months. Fruits were declared unmarketable when it exhibited symptoms of decay or mould growth or shrivelling to the tune of 50 per cent or more.

$$\text{PLW \%} = \frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \times 100$$

3.3.3.2 Keeping quality / shelf life

The shelf life was calculated as number of days till the fruit remained marketable as described in 3.3.3.1.

3.3.3.3 Acceptability scoring

Acceptability scoring was carried out by sensory evaluation with the help of a semi-trained panel consisting of eight members. The samples were evaluated for fruit colour, texture, flavour and overall appearance on a five point Hedonic scale.

The ratings were as follows

1 - Very poor

2 - Poor

3 - Satisfactory

4 - Good

5 - Very good

3.3.3.4 Statistical analysis

Data pertaining to each character was tabulated separately and subjected to appropriate statistical analysis.

Results

4. RESULTS

Results of the experiments conducted are presented below.

4.1 Effect of variety, maturity stage and source of nutrition on physical parameters of pumpkin fruit

4.1.1 Fruit weight

Season I

In S_1 significant difference in fruit weight between the varieties was not observed. Suvarna had the maximum (2.34 kg) and Ambili the minimum (2.01 kg) fruit weight (Table 2).

The fruit weight differed significantly with the different maturity stages. As the maturity progressed fruit weight also increased. Fruits harvested at 30 days after anthesis (d.a.a.) (M_1) recorded minimum weight (1.74 kg) and those harvested after 60 days after anthesis (M_3) had the maximum weight (2.55 kg).

Varieties Co.1 and Ambili had maximum weight when harvested at M_2 (45 d.a.a.) (2.51 and 2.25 kg respectively). M_1 differed significantly from M_2 which was on par with M_3 in both the varieties. In Suvarna, fruits harvested 60 days after anthesis (M_3) recorded the maximum weight (3.12 kg). The source of nutrition did not have any effect on fruit weight.

Season II

The varieties did not exhibit significant difference in fruit weight during this season also. Co.1 had the maximum (2.83 kg) and Ambili the minimum (2.13 kg) fruit weight.

Table 2. Effect of variety, harvest maturity and source of nutrition on fruit weight (kg)

Season	Variety	Maturity stages									Source of Nutrition		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	1.40	1.47	1.44	2.91	2.11	2.51	2.43	2.44	2.43	2.25	2.01	2.13
	Ambili	1.46	1.91	1.69	2.15	2.35	2.25	2.05	2.10	2.08	1.89	2.12	2.01
	Suvarna	2.17	2.01	2.09	1.80	1.83	1.85	3.19	3.05	3.12	2.38	2.30	2.34
	Mean	1.68	1.80	1.74	2.29	2.10	2.19	2.56	2.53	2.55	2.17	2.14	2.16
S_2	Co.1	2.72	2.55	2.63	2.90	1.70	2.30	2.31	4.81	3.56	2.64	3.02	2.83
	Ambili	1.87	2.32	2.09	2.07	2.39	2.23	2.47	1.65	2.06	2.14	2.12	2.13
	Suvarna	1.93	2.31	2.12	2.39	2.87	2.63	3.82	2.92	3.37	2.71	2.70	2.71
	Mean	2.17	2.394	2.282	2.45	2.32	2.39	2.87	3.13	2.99	2.50	2.61	2.56

	S_1	S_2
CD (0.05) for comparison of source of nutrition	NS	NS
CD (0.05) for comparison of maturity stages	0.3077	NS
CD (0.05) for comparison of varieties	NS	NS
CD (0.05) for comparison of source of nutrition x maturity stages	NS	NS
CD (0.05) for comparison of source of nutrition x varieties	NS	NS
CD (0.05) for comparison of maturity stages x varieties	0.5328	NS
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	NS	1.5720

Maturity stages did not have any significant effect on fruit weight during this season though it was seen to increase with the increase in maturity.

Eventhough source of nutrition did not in general affect the fruit weight, at M_3 (60 d.a.a.) inorganic nutrition gave a significantly higher value than organic in variety Co.1 (4.81 kg and 2.31 kg respectively).

4.1.2 Circumference

Season I

Variety Co.1 recorded the minimum circumference (57.61 cm) and differed significantly from Ambili (62.25 cm) and Suvarna (63.72 cm) which were on par with each other (Table 3).

Significant difference existed between the fruits harvested at the three different maturities in the first season. As the harvesting was delayed the circumference also increased, with the fruits harvested at M_3 (60 d.a.a.) recording the maximum value (65.41 cm) and those harvested at M_1 (30 d.a.a.) the minimum value (56.78 cm).

The circumference of variety Co.1 did not differ significantly when harvested at different stages of maturity while in Ambili, M_3 (68.50 cm) and M_2 (63.08 cm) differed significantly from M_1 (55.17 cm). In Suvarna, M_1 and M_2 were on par with each other both recording 60.33 cm and differed significantly from M_3 (70.50 cm). Source of nutrition did not have significant effect on the circumference.

Table 3. Effect of variety, harvest maturity and source of nutrition on circumference (cm)

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	54.33	55.33	54.83	61.13	60.40	60.77	54.67	59.77	57.22	56.71	58.50	57.61
	Ambili	50.33	60.00	55.17	63.00	63.17	63.08	68.00	69.00	68.50	60.44	64.06	62.25
	Suvarna	59.17	61.50	60.33	60.00	60.67	60.33	70.33	70.67	70.50	63.17	64.28	63.72
	Mean	54.61	58.94	56.78	61.38	61.41	61.39	64.33	66.48	65.41	60.11	62.28	61.19
S_2	Co.1	65.67	65.17	65.42	61.67	54.67	58.17	55.67	68.67	62.17	61.00	62.83	61.92
	Ambili	59.33	70.67	65.00	60.67	66.00	63.33	64.00	62.00	63.00	61.33	66.22	63.78
	Suvarna	59.33	64.33	61.83	58.83	68.33	63.58	82.00	74.00	78.00	66.72	68.89	67.81
	Mean	61.44	66.72	64.80	60.39	63.00	61.69	67.22	68.22	67.72	63.02	65.98	64.50

	S_1	S_2
CD (0.05) for comparison of source of nutrition	NS	NS
CD (0.05) for comparison of maturity stages	3.8455	NS
CD (0.05) for comparison of varieties	3.8455	NS
CD (0.05) for comparison of source of nutrition x maturity stages	NS	NS
CD (0.05) for comparison of source of nutrition x varieties	NS	NS
CD (0.05) for comparison of maturity stages x varieties	6.660	NS
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	NS	NS

Season II

The different varieties did not exhibit significant difference with respect to fruit circumference.

Eventhough no significant difference in fruit circumference was observed with respect to different stages of maturity, in general fruits harvested at M_3 (60 d.a.a.) gave the highest circumference reading (67.72 cm).

Source of nutrition did not have any significant effect in both the seasons, though in general inorganic nutrition gave slightly higher fruit circumference than organic nutrition.

4.1.3 Polar diameter

Season I

During the first season it was observed that as the harvesting was delayed polar diameter also increased significantly. M_1 had the minimum polar diameter (16.42 cm) while M_3 had the maximum (19.35 cm) (Table 4).

There was no significant difference in polar diameter with respect to varieties and sources of nutrition.

Season II

The varieties Ambili and Suvarna (18.58 and 18.98 cm respectively) differed significantly from Co.1 which had the maximum polar diameter (20.81 cm).

Polar diameter was the maximum for fruits harvested at M_3 (60 d.a.a.) (20.95 cm). M_3 differed significantly from M_2 which was on par with M_1.

Table 4. Effect of variety, harvest maturity and source of nutrition on polar diameter (cm)

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	16.50	15.67	16.08	19.53	17.53	18.53	19.50	19.10	19.30	18.51	17.43	17.97
	Ambili	15.63	17.40	16.52	17.77	17.40	17.58	20.50	19.70	20.10	17.97	18.17	18.07
	Suvarna	16.83	16.50	16.67	16.40	16.53	16.47	18.63	18.67	18.65	17.29	17.23	17.26
	Mean	16.32	16.52	16.42	17.90	17.16	17.53	19.54	19.16	19.35	17.92	17.61	17.77
S_2	Co.1	21.27	22.37	21.77	19.67	16.43	18.05	19.41	26.20	22.81	20.08	21.67	20.81
	Ambili	17.50	20.20	18.85	16.97	18.50	17.73	21.20	17.13	19.17	18.56	18.61	18.58
	Suvarna	16.17	17.83	17.00	18.05	20.07	19.06	22.32	19.43	20.88	18.85	19.11	18.98
	Mean	18.28	20.13	19.21	18.23	18.33	18.28	20.98	20.92	20.95	19.16	19.80	19.46

	S_1	S_2
CD (0.05) for comparison of source of nutrition	NS	NS
CD (0.05) for comparison of maturity stages	0.9491	1.6269
CD (0.05) for comparison of varieties	NS	1.6269
CD (0.05) for comparison of source of nutrition x maturity stages	NS	NS
CD (0.05) for comparison of source of nutrition x varieties	NS	NS
CD (0.05) for comparison of maturity stages x varieties	NS	NS
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	NS	3.9850

In general at all stages of maturity, irrespective of varieties inorganic nutrition gave slightly higher polar diameter compared to organic nutrition. However the interaction effect showed that at M_3 (60 d.a.a.) inorganic nutrition (26.20 cm) was significantly superior over organic nutrition (19.41 cm) in variety Co.1 while in Ambili and Suvarna organic was superior.

4.1.4 Flesh thickness

Season I

Variety Suvarna (3.27 cm) had significantly higher flesh thickness than Ambili (2.79 cm) in the season (Table 5). Co.1 fruits when harvested at M_1 (30 d.a.a.) had minimum flesh thickness (2.67 cm) and differed significantly from M_2 (3.25 cm) and M_3 (3.38 cm) (Table 5). In Ambili all the three maturity stages were on par with each other. Fruits harvested at M_1 had maximum flesh thickness in variety Suvarna (3.50 cm).

Source of nutrition in general did not have significant effect on flesh thickness. Inorganic nutrition slightly increased flesh thickness over organic in Ambili and Suvarna while in Co.1 the reverse was observed.

Season II

Variety Co.1 gave maximum flesh thickness (3.64 cm) and differed significantly from Ambili (3.14 cm) and Suvarna (3.28 cm).

Flesh thickness was observed to increase with the increase in maturity. Fruits harvested after 60 days after anthesis (M_3) recorded the maximum flesh thickness (3.64 cm) and differed significantly from the two earlier stages.

Table 5. Effect of variety, harvest maturity and source of nutrition on flesh thickness (cm)

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	2.83	2.50	2.67	3.17	3.83	3.25	3.33	3.43	3.38	3.11	3.09	3.10
	Ambili	2.50	2.83	2.67	2.67	3.13	2.90	2.80	2.83	2.82	2.66	2.93	2.79
	Suvarna	3.33	3.67	3.50	2.50	3.23	2.87	3.23	3.67	3.45	3.02	3.52	3.27
	Mean	2.89	3.00	2.94	2.78	3.28	3.01	3.12	3.31	3.22	2.93	3.18	3.06
S_2	Co.1	3.50	3.50	3.50	3.50	3.17	3.33	3.33	4.83	4.08	3.44	3.83	3.64
	Ambili	2.83	3.17	3.00	3.17	3.33	3.25	3.50	2.83	3.17	3.17	3.11	3.14
	Suvarna	2.67	3.17	2.83	2.83	3.67	3.25	3.67	3.67	3.67	3.06	3.50	3.28
	Mean	3.00	3.28	3.14	3.17	3.39	3.28	3.50	3.78	3.64	3.22	3.48	3.35

	S_1	S_2
CD (0.05) for comparison of source of nutrition	NS	NS
CD (0.05) for comparison of maturity stages	NS	0.3801
CD (0.05) for comparison of varieties	0.3370	0.3801
CD (0.05) for comparison of source of nutrition x maturity stages	NS	NS
CD (0.05) for comparison of source of nutrition x varieties	NS	NS
CD (0.05) for comparison of maturity stages x varieties	0.5839	NS
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	NS	0.9307

The type of nutrition did not significantly affect the flesh thickness in any of the varieties at different stages of harvest except in Co.1 when harvested at M_3 (60 d.a.a.). Here inorganic fertilization (4.83 cm) was found to have significant advantage over organic (3.33 cm).

4.1.5 Cavity volume

Season I

During the first season it was observed that varieties did not differ significantly in cavity volume whereas increase in maturity increased the cavity volume. M_3 (886.67 ml) was significantly higher than M_1 (604.72 ml) (Table 6).

Cavity volume was maximum at M_2 (45 d.a.a.) and was significantly higher than M_1 in Co.1 and Ambili while in Suvarna the cavity volume was maximum at M_3 (1030.00 ml) and differed significantly from M_1 and M_2.

Season II

Significant varietal variation was not observed in cavity volume in this season also.

When the harvesting was delayed,significant increase was observed in cavity volume. It was highest when harvested at M_3 (60 d.a.a.) and lowest in M_1 (30 d.a.a.).

When fruits of Ambili and Suvarna were harvested at M_1 and M_2 inorganic nutrition increased the cavity volume slightly over organic.

At M_3 (60 d.a.a.) organic and inorganic nutrition were on par with each other in variety Ambili with values 1036.67 ml and 975.00 ml respectively while in Suvarna organic gave significantly higher cavity volume as compared to

Table 6. Effect of variety, harvest maturity and source of nutrition on cavity volume (ml)

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	611.67	610.00	610.83	1110.00	715.00	912.50	878.33	675.00	776.67	866.67	666.67	766.67
	Ambili	510.00	713.33	611.67	931.67	970.00	950.83	856.67.	850.00	853.33	766.11	844.44	805.28
	Suvarna	593.33	590.00	591.67	360.00	430.00	395.00	1046.67	1013.33	1030.00	666.67	677.78	672.22
	Mean	571.67	637.78	604.72	800.56	752.78	927.78	927.22	846.11	886.67	766.48	729.63	748.06
S_2	Co.1	886.67	736.67	811.67	1036.67	408.33	722.50	836.67	2670.00	1753.33	920.00	1271.67	1095.83
	Ambili	616.67	1190.00	903.33	673.33	1100.00	886.66	1036.67	975.00	1005.83	775.56	1088.33	931.84
	Suvarna	546.67	1040.00	793.33	823.33	1476.67	1150.00	2180.00	1046.67	1613.33	1183.33	1187.78	1185.56
	Mean	683.33	988.89	836.11	844.44	995.00	919.72	1351.11	1563.89	1457.50	959.63	1172.59	1071.07

	S_1	S_2
CD (0.05) for comparison of source of nutrition	NS	NS
CD (0.05) for comparison of maturity stages	182.3408	390.6140
CD (0.05) for comparison of varieties	NS	NS
CD (0.05) for comparison of source of nutrition x maturity stages	NS	NS
CD (0.05) for comparison of source of nutrition x varieties	NS	NS
CD (0.05) for comparison of maturity stages x varieties	315.8230	NS
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	NS	956.8052

inorganic fertilization with values 2180.00 ml and 1046.67 ml respectively. At M_1 (30 d.a.a.) it was observed that in Co.1 both organic and inorganic source of nutrition were on par with each other. Fruits when harvested at M_3 inorganic fertilization (2670.00 ml) was significantly superior to organic fertilization (836.67 ml).

4.1.6 Cavity index

Season I

In S_1 variety Suvarna had the minimum cavity index (30.50%) while Ambili and Co.1 had significantly higher cavity index (42.21% and 42.14% respectively) (Table 7).

As the maturity increased in Co.1,cavity index decreased (50.33% and 39.13% at M_1 and M_2 respectively). M_1 differed significantly from M_3 (36.97%). In Ambili eventhough cavity index increased with maturity the differences were not significant. Fruits harvested at M_2 (45 d.a.a.) had the least (24.75%) and those harvested at M_3 had the highest (35.87%) cavity index in Suvarna.

Season II

In S_2 Ambili had the highest cavity index (49.83%) which differed significantly from Co.1 with the minimum (38.14%) cavity index.

Fruits harvested at M_1 (30 d.a.a.) registered the minimum cavity index (40.61%) slightly increasing at M_2 (45 d.a.a.) (41.22%) and then reaching a maximum value of 52.22 per cent at M_3 (60 d.a.a.). M_3 differed significantly from M_1 and M_2.

Table 7. Effect of variety, harvest maturity and source of nutrition on cavity index (%)

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	53.60	47.07	50.33	41.40	36.87	39.13	42.17	31.77	36.97	45.72	38.57	42.14
	Ambili	37.43	40.07	38.75	42.70	42.83	42.77	45.10	45.10	45.10	41.74	42.67	42.21
	Suvarna	29.63	32.13	30.88	23.17	26.33	24.75	36.17	35.57	35.87	29.66	31.34	30.50
	Mean	40.22	39.76	39.99	35.76	35.34	35.55	41.14	37.48	39.31	39.04	37.53	38.23
S_2	Co.1	34.80	31.60	33.20	38.97	27.00	32.98	40.53	55.93	48.23	38.10	38.17	38.13
	Ambili	36.67	57.61	47.13	36.83	51.53	44.18	50.00	66.67	58.33	41.17	58.60	49.83
	Suvarna	31.53	51.43	41.48	37.93	55.03	46.48	61.30	39.03	50.17	43.59	48.50	46.04
	Mean	34.33	46.88	40.61	37.91	44.52	41.22	50.61	53.88	52.22	40.95	48.26	44.69

	S_1	S_2
CD (0.05) for comparison of source of nutrition	NS	NS
CD (0.05) for comparison of maturity stages	NS	4.8773
CD (0.05) for comparison of varieties	6.1835	4.8773
CD (0.05) for comparison of source of nutrition x maturity stages	NS	NS
CD (0.05) for comparison of source of nutrition x varieties	NS	6.8970
CD (0.05) for comparison of maturity stages x varieties	10.7100	NS
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	NS	11.9467

Inorganic nutrition was found to increase the cavity index in all the varieties, but the increase was significant only in variety Ambili.

At M_3 (60 d.a.a.) inorganic fertilization significantly increased the cavity index compared to organic fertilization in Co.1 (55.93% and 40.33% respectively), whereas the reverse trend was observed in Suvarna. At all maturity stages,inorganic fertilization significantly increased the cavity index in Ambili.

4.1.7 Flesh percentage

Season I

Among the varieties Co.1 (84.35%) and Ambili (84.95%) were on par with each other and showed significant increase in flesh percentage from Suvarna (81.32%) (Table 8).

The proportion of flesh showed a continuous increase from 30 d.a.a. to 60 d.a.a. The flesh percentage increased from 79.81 per cent at M_1 to 83.56 per cent at M_2 and eventually to 87.26 per cent at M_3. The increase in flesh percentage from M_1 to M_3 was significantly high in Co.1 and Suvarna.

Significant differences between organic and inorganic nutrition was observed at M_1 and M_2 in variety Suvarna. In both cases inorganic nutrition was found to increase the flesh percentage over organic nutrition.

Season II

Varietal variation in flesh percentage was not significant in the second season.

Table 8. Effect of variety, harvest maturity and source of nutrition on flesh percentage (%)

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	76.93	81.87	79.40	86.67	86.57	86.62	85.37	88.70	87.03	82.99	85.71	84.35
	Ambili	83.57	83.47	83.52	85.30	84.53	84.92	84.23	88.60	86.42	84.37	85.53	84.95
	Suvarna	68.53	84.47	76.50	75.03	83.27	79.15	91.20	85.43	88.32	78.26	84.39	81.32
	Mean	76.34	83.27	79.81	82.33	84.79	83.56	86.93	87.58	87.26	81.87	85.21	83.54
S_2	Co.1	83.60	81.03	82.32	77.30	89.10	83.20	86.03	85.17	85.90	82.31	85.30	83.81
	Ambili	82.23	83.80	83.02	86.00	88.93	87.47	82.67	88.17	85.42	83.63	86.97	85.30
	Suvarna	82.90	85.97	84.43	78.53	85.90	82.22	83.40	92.20	87.80	81.61	88.02	84.82
	Mean	82.91	83.60	83.26	80.61	87.98	84.29	84.03	88.71	86.37	82.52	86.76	84.64

	S_1	S_2
CD (0.05) for comparison of source of nutrition	NS	0.7946
CD (0.05) for comparison of maturity stages	2.9040	1.7075
CD (0.05) for comparison of varieties	2.9040	NS
CD (0.05) for comparison of source of nutrition x maturity stages	NS	2.4149
CD (0.05) for comparison of source of nutrition x varieties	NS	NS
CD (0.05) for comparison of maturity stages x varieties	5.0308	2.9575
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	7.1148	4.1828

Increase in maturity increased the flesh percentage. Fruits harvested at 60 d.a.a. (M_3) had significantly higher flesh percentage (86.37%) than at 30 and 45 days after anthesis stages.

In general inorganic nutrition was found to increase the flesh percentage over organic nutrition in S_2 (86.76% and 82.52% respectively).

Variety Ambili when harvested at M_2 gave maximum percentage of flesh (87.47%) while Suvarna had the maximum flesh percentage at M_3 (87.80%).

4.1.8 Seed percentage

Season I

Suvarna with a seed content of 6.19 per cent differed significantly from Co.1 (4.2%) and Ambili (3.72%) in the first season (Table 9).

The seed percentage was observed to decrease slightly when the fruits matured from M_1 (30 d.a.a.) to M_2 (45 d.a.a.) but the decrease was rapid from M_2 to M_3 (5.07% to 2.856%).

During this season organic nutrition was observed to give significantly higher seed percentage than inorganic nutrition especially at M_1 (30 d.a.a.) and M_2 (45 d.a.a.) stages.

Both source of nutrition had the same effect on seed percentage in variety Ambili while in Co.1 and Suvarna organic was found superior.

At M_1 the seed percentage in Co.1 with inorganic fertilization (1.67%) was significantly low compared to the corresponding values of organic nutrition (8.73%).

Table 9. Effect of variety, harvest maturity and source of nutrition on seed percentage (%)

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	8.73	1.67	5.20	4.43	5.00	4.72	3.37	2.00	2.68	5.51	2.89	4.20
	Ambili	4.40	4.63	4.52	4.00	4.00	4.00	2.43	2.87	2.65	3.61	3.83	3.72
	Suvarna	14.03	3.70	8.87	10.70	2.27	6.48	1.97	4.50	3.23	8.90	3.49	6.19
	Mean	9.06	3.33	6.19	6.38	3.76	5.07	2.59	3.12	2.86	6.07	3.33	4.71
S_2	Co.1	3.20	3.45	3.32	4.93	1.83	3.38	2.60	3.07	2.83	3.58	2.78	3.18
	Ambili	4.93	4.17	4.55	3.30	3.63	3.47	6.13	1.67	3.90	4.79	3.16	3.97
	Suvarna	4.067	3.93	4.00	6.13	4.37	5.25	4.60	1.03	2.82	4.93	3.11	4.02
	Mean	4.07	3.85	3.96	4.79	3.28	4.03	4.44	1.92	3.18	4.43	3.02	3.73

	S_1	S_2
CD (0.05) for comparison of source of nutrition	0.7392	NS
CD (0.05) for comparison of maturity stages	1.4931	NS
CD (0.05) for comparison of varieties	1.4931	NS
CD (0.05) for comparison of source of nutrition x maturity stages	2.1117	1.1692
CD (0.05) for comparison of source of nutrition x varieties	2.1170	NS
CD (0.05) for comparison of maturity stages x varieties	NS	NS
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	3.6577	2.0253

Season II

The percentage of seeds neither did differ significantly between the varieties nor between the maturity stages in the second season.

The fruits harvested at all maturity stages gave a higher percentage of seed when organic nutrition was supplied.

Organic nutrition significantly increased the seed percentage at M_2 in Co.1 and at M_3 (60 d.a.a.) in Ambili and Suvarna.

4.1.9 Peel percentage

Season I

Variety Ambili with a peel percentage of 6.21 per cent differed significantly from Co.1 (4.79%) and Suvarna (4.55%) (Table 10).

During this season significant variation was not observed in the peel percentage between various stages of harvest and different sources of nutrition.

Season II

All varieties differed significantly between themselves with respect to peel percentage. Suvarna recorded highest (7.02%) and Co.1 (4.13%) the lowest peel percentage.

In variety Ambili inorganic gave significantly higher peel percentage while the reverse was observed in Suvarna. The peel percentage in Co.1 with both sources of nutrition were on par with each other.

At M_1 (30 d.a.a.) and M_3 (60 d.a.a.) inorganic nutrition gave significantly higher peel percentage in Ambili while at M_2 the reverse was observed.

Table 10. Effect of variety, harvest maturity and source of nutrition on peel percentage (%)

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	5.60	6.70	6.15	4.47	3.40	3.95	4.76	3.80	4.28	4.94	4.64	4.79
	Ambili	7.70	6.80	7.25	6.70	6.07	6.38	6.46	3.53	5.00	6.96	5.47	6.21
	Suvarna	3.47	4.60	4.03	3.59	4.73	4.16	4.63	6.63	5.45	3.90	5.20	4.55
	Mean	5.59	6.03	5.81	4.92	4.74	4.83	5.29	4.53	4.91	5.26	5.04	5.15
S_2	Co.1	4.13	4.03	4.08	3.63	3.63	3.63	4.23	5.13	4.68	4.00	4.27	4.13
	Ambili	5.20	8.97	7.08	6.20	4.20	5.20	5.10	8.37	6.73	5.50	7.18	6.34
	Suvarna	6.73	7.37	7.05	8.07	6.67	7.37	8.83	4.47	6.65	7.88	6.17	7.02
	Mean	5.36	6.79	6.07	5.97	4.83	5.40	6.06	5.99	6.02	5.79	5.87	5.83

	S_1	S_2
CD (0.05) for comparison of source of nutrition	NS	NS
CD (0.05) for comparison of maturity stages	NS	NS
CD (0.05) for comparison of varieties	1.3920	1.1480
CD (0.05) for comparison of source of nutrition x maturity stages	NS	NS
CD (0.05) for comparison of source of nutrition x varieties	NS	1.6240
CD (0.05) for comparison of maturity stages x varieties	NS	NS
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	NS	2.812

4.1.10 Placenta percentage

Season I

The varieties differed significantly between themselves in the first season for this parameter. Suvarna had the highest value (7.90%) and Ambili the lowest (5.12%) for placenta percentage (Table 11).

The percentage of placenta decreased significantly with increase in maturity (8.19% to 4.94%).

Co.1 and Ambili had the least placenta percentage at M_2 (4.72% and 4.70% respectively). The percentage of placenta at M_1 and M_2 were on par with each other (10.6% and 10.22% respectively) and decreased drastically at M_3 (2.88%) in variety Suvarna.

Season II

Co.1 had significantly higher percentage of placenta (8.90%) than Ambili (4.39%) and Suvarna (4.15%).

The percentage of placenta was on par with each other at M_1 (6.72%) and M_2 (6.29%) but decreased significantly at M_3 (4.422%).

In general organic nutrition gave significantly higher placenta percentage in the second season. The significant increase due to organic nutrition was observed at M_2 in Co.1 (14.27%) and at M_1 and M_2 in Ambili and Suvarna.

4.1.11 Flesh colour

Season I

In variety Co.1 the flesh was observed to be whitish cream at 30 d.a.a. (M_1). The colour changed to cream with yellow tinges towards the edge of the fruit at M_2. At 60 d.a.a. the colour of the flesh was observed to be creamish yellow.

Table 11. Effect of variety, harvest maturity and source of nutrition on placenta percentage (%)

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	8.73	9.76	9.25	4.43	5.00	4.72	6.50	5.50	6.00	6.56	6.76	6.66
	Ambili	4.30	5.10	4.72	4.00	5.40	4.70	6.87	5.00	5.93	5.07	5.17	5.12
	Suvarna	13.97	7.23	10.60	10.70	9.73	10.22	1.97	3.80	2.88	8.88	6.92	7.90
	Mean	9.01	7.36	8.19	6.38	6.71	6.54	5.11	4.77	4.94	6.83	6.28	6.56
S_2	Co.1	9.07	11.47	10.27	14.27	5.43	9.85	7.13	6.03	6.58	10.16	7.64	8.90
	Ambili	7.63	3.07	5.35	4.50	3.23	3.87	6.10	1.80	3.95	6.08	2.70	4.39
	Suvarna	6.37	2.73	4.55	7.27	3.07	5.17	3.17	2.30	2.73	5.60	2.70	4.15
	Mean	7.69	5.76	6.72	8.68	3.91	6.29	5.47	3.38	4.42	7.28	4.35	5.81

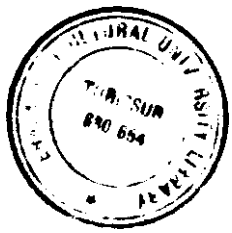
	S_1	S_2
CD (0.05) for comparison of source of nutrition	NS	0.6812
CD (0.05) for comparison of maturity stages	1.7430	1.3889
CD (0.05) for comparison of varieties	1.7430	1.3889
CD (0.05) for comparison of source of nutrition x maturity stages	NS	NS
CD (0.05) for comparison of source of nutrition x varieties	NS	NS
CD (0.05) for comparison of maturity stages x varieties	3.0200	NS
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	NS	3.4025

The colour of the flesh of the fruits of Ambili changed from light yellow at M_1 to dark yellow at M_2. The colour did not change much with maturity after this stage.

In fruits of Suvarna the flesh colour was observed to change from light yellow at M_1 to deep yellow with orangish tinge at M_2 which later change to yellowish orange.

Season II

The change in colour with maturity in the three varieties in this season was same as in season I.



4.1.12 Seed colour

Season I and II

The seed colour in all the varieties were observed to be light cream at 30 d.a.a. (M_1). With the increase in maturity the edges of the seed turned brown in colour. At 60 d.a.a. (M_3) the seeds were observed to be light brown in colour with dark brown edges.

4.2 Effect of variety, maturity stage and source of nutrition on chemical constituents of pumpkin fruit

4.2.1 T.S.S.

Season I

Among the varieties Suvarna (11.33°Bx) and Ambili (11°Bx) had significantly higher TSS than CO 1 (6.78°Bx) (Table 12). During this season TSS significantly increased with the increase in maturity (8.11°Bx to 11.17°Bx). The effect of organic nutrition (10.33°Bx) on an overall was significantly higher than

Table 12. Effect of variety, harvest maturity and source of nutrition on TSS (°Brix)

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	7.00	6.00	6.50	5.67	7.33	6.50	7.00	7.67	7.33	6.56	7.00	6.78
	Ambili	10.00	7.33	8.67	13.33	10.33	11.83	12.67	12.33	12.50	12.00	10.00	11.00
	Suvarna	10.67	7.67	9.17	12.00	10.33	11.17	14.67	12.67	13.60	12.44	10.22	11.33
	Mean	9.22	7.00	8.11	10.33	9.33	9.83	11.44	10.89	11.17	10.33	9.07	9.70
S_2	Co.1	6.00	7.00	6.50	6.00	7.33	6.67	6.67	8.00	7.33	6.22	7.44	6.83
	Ambili	11.00	11.00	11.00	14.67	12.33	13.50	12.67	12.67	12.67	12.78	12.00	12.39
	Suvarna	12.00	10.66	11.83	12.00	12.67	12.33	15.33	12.00	13.67	13.11	12.11	12.61
	Mean	9.67	9.89	9.78	10.89	10.78	10.83	11.56	10.89	11.22	10.70	10.51	10.61

	S_1	S_2
CD (0.05) for comparison of source of nutrition	0.5262	NS
CD (0.05) for comparison of maturity stages	0.4019	0.7139
CD (0.05) for comparison of varieties	0.4019	0.7139
CD (0.05) for comparison of source of nutrition x maturity stages	0.8041	NS
CD (0.05) for comparison of source of nutrition x varieties	0.8041	1.0090
CD (0.05) for comparison of maturity stages x varieties	0.9847	1.2370
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	NS	1.7490

inorganic (9.07°Brix) in this season. In particular organic nutrition significantly increased the TSS over inorganic nutrition in Ambili and Suvarna.

At 45 d.a.a. the TSS was significantly higher (11.83°Bx) than at 30 d.a.a. (8.67°Bx) in variety Ambili and reached the maximum value at 60 d.a.a. (12.5°Bx). In Suvarna also the TSS significantly increased with the increase in maturity from 30 d.a.a. to 60 d.a.a. stage (9.17°Bx to 13.6°Bx).

Season II

In the second season Suvarna (12.61°Bx) and Ambili (12.39°Bx) had significantly higher TSS than Co.1 (6.83°Bx).

As the maturity advanced the TSS was also found to increase. It was significantly higher at M_3 (60 d.a.a.) (11.22°Bx) and M_2 (45 d.a.a.) (10.83°Bx) than at 30 d.a.a. (M_1) (9.78°Bx).

The different sources of nutrition did not have any significant effect on the TSS in general but when the interaction was studied inorganic nutrition gave significantly higher TSS than organic nutrition in variety CO.1 (7.44°Bx and 6.22°Bx respectively).

The TSS was highest at 45 d.a.a. (13.5°Bx) which was significantly higher than 30 d.a.a. (11°Bx) in Ambili while in Suvarna the highest was observed at 60 d.a.a. (13.67°Bx).

In Suvarna at 30 and 60 d.a.a. organic nutrition was found to significantly increase the TSS than inorganic while in Ambili the same was observed at 45 d.a.a..

4.2.2 Reducing sugars

Season I

Co.1 (3.68%) had significantly higher percentage of reducing sugars than Ambili (2.83%) and Suvarna (2.87%) which were on par with each other (Table 13).

Maturity did not significantly affect the percentage of reducing sugar in this season.

During this season organic (3.26%) gave higher per cent reducing sugar than inorganic nutrition (2.98%).

Eventhough no significant difference was observed percentage of reducing sugar was observed to increase with maturity in variety Co.1 while the reverse was observed in Suvarna. The increase in per cent reducing sugar with the increase in maturity was significant in variety Ambili.

Season II

The varieties signifcantly differed from one another with regard to the per cent of reducing sugars with Ambili recording the minimum (2.15%) and Co.1 the maximum (3.09%).

A progressive increase in reducing sugars with maturity was observed. M_3 (2.88%) recorded significantly higher percentage of reducing sugar than M_1 (2.39%).

Organic nutrition was found to give higher percentage of reducing sugar (2.82%) than inorganic nutrition (2.43%).

Table 13. Effect of variety. harvest maturity and source of nutrition on reducing sugars (%)

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	3.51	3.50	3.50	3.73	3.73	3.73	3.92	3.68	3.80	3.72	3.64	3.68
	Ambili	2.68	2.39	2.54	2.97	2.59	2.78	3.04	3.29	3.16	2.89	2.76	2.83
	Suvarna	3.62	2.83	3.22	2.85	2.55	2.90	3.07	2.27	2.67	3.18	2.55	2.87
	Mean	3.27	2.91	3.09	3.18	2.96	3.07	3.34	3.08	3.21	3.26	2.98	3.13
S_2	Co.1	2.70	2.23	2.46	3.33	2.81	3.07	4.13	3.37	3.75	3.39	2.80	3.09
	Ambili	2.00	1.47	1.74	2.08	2.03	2.05	2.83	2.49	2.66	2.30	2.00	2.15
	Suvarna	3.35	2.64	2.99	2.50	2.79	2.67	2.46	2.04	2.25	2.77	2.49	2.63
	Mean	2.68	2.11	2.39	2.63	2.54	2.59	3.14	2.63	2.88	2.82	2.43	2.62

	S_1	S_2
CD (0.05) for comparison of source of nutrition	0.0594	0.0508
CD (0.05) for comparison of maturity stages	NS	0.2158
CD (0.05) for comparison of varieties	0.2445	0.2158
CD (0.05) for comparison of source of nutrition x maturity stages	NS	NS
CD (0.05) for comparison of source of nutrition x varieties	NS	NS
CD (0.05) for comparison of maturity stages x varieties	0.4237	0.3737
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	NS	NS

In varieties Co.1 and Ambili the reducing sugars increased significantly with the increase in maturity while the reverse was observed in Suvarna.

4.2.3 Non reducing sugars

Season I

The maturity stages and varieties did not have any effect on per cent non reducing sugars.

In general inorganic nutrition significantly increased per cent non reducing sugars over organic in this season (2.08% and 1.13% respectively) (Table 14).

However the interaction effects revealed that inorganic nutrition significantly increased the per cent non reducing sugars in Co.1 and Suvarna while in Ambili both sources of nutrition were on par with each other.

The per cent non reducing sugar decreased with the increase in maturity in varieties Co.1 and Ambili while in Suvarna the reverse was observed. The interaction effect of maturity stages and nutrition showed that at all stages of maturity inorganic gave higher percentage of non reducing sugars than organic nutrition. At M_1 and M_2 inorganic significantly increased the non reducing sugar over organic in Co.1 while in Ambili this was observed at M_2 only. In Suvarna the significant effect of inorganic over organic nutrition was observed at M_2 and M_3.

Season II

Among the varieties Ambili (2.3%) had significantly higher per cent non reducing sugars than Suvarna (1.13%) and Co.1 (1.05%).

Table 14. Effect of variety, harvest maturity and source of nutrition on non-reducing sugars (%)

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	1.99	3.29	2.64	0.25	2.95	1.60	0.56	1.02	0.79	0.93	2.42	1.68
	Ambili	1.95	2.09	2.02	1.06	2.01	1.54	1.69	1.37	1.53	1.57	1.82	1.69
	Suvarna	0.35	0.90	0.63	1.28	2.21	1.75	1.05	2.85	1.95	0.89	1.99	1.44
	Mean	1.43	2.09	1.76	0.86	2.39	1.63	1.10	1.75	1.42	1.13	2.08	1.60
S_2	Co.1	0.31	1.57	0.94	0.14	2.21	1.17	0.43	1.65	1.04	0.29	1.81	1.05
	Ambili	3.21	1.47	2.34	3.35	1.44	2.40	2.24	2.10	2.17	2.93	1.67	2.30
	Suvarna	0.34	0.52	0.45	1.71	0.54	1.13	1.54	2.06	1.80	1.20	1.05	1.13
	Mean	1.29	1.20	1.24	1.73	1.39	1.56	1.40	1.93	1.67	1.47	1.51	1.49

	S_1	S_2
CD (0.05) for comparison of source of nutrition	0.2167	NS
CD (0.05) for comparison of maturity stages	NS	0.1025
CD (0.05) for comparison of varieties	NS	0.1025
CD (0.05) for comparison of source of nutrition x maturity stages	0.4682	0.1449
CD (0.05) for comparison of source of nutrition x varieties	0.4682	0.1449
CD (0.05) for comparison of maturity stages x varieties	0.5736	0.1777
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	0.8113	0.2512

Significant increase in per cent non reducing sugars was observed from M_1 (1.24%) to M_3 (1.67%).

Organic nutrition gave significantly higher per cent non reducing sugars in varieties Ambili and Suvarna than inorganic nutrition while the reverse was observed in Co.1.

As the maturity increased per cent non reducing sugar also increased in variety Suvarna while the highest per cent non reducing sugar was observed at 45 d.a.a. in Ambili and Co.1.

When the overall effect was studied, at 30 d.a.a. (M_1) and 45 d.a.a. (M_2) organic gave higher per cent reducing sugars than inorganic nutrition.

At all stages of maturity inorganic nutrition gave significantly higher per cent of non reducing sugars than organic nutrition in variety Co.1 while the reverse was observed in Ambili. The per cent non reducing sugars increased with the maturity in Suvarna with inorganic fertilization.

4.2.4 Total sugar

Season I

Varieties Ambili (4.46%) and Suvarna (4.32%) were on par with each other with respect to the percentage of total sugars while Co.1 had significantly higher per cent total sugars (5.36%) (Table 15).

During this season the per cent total sugars decreased with the increase in maturity.

Table 15. Effect of variety, harvest maturity and source of nutrition on total sugars (%)

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	5.50	6.79	6.15	4.01	6.68	5.34	4.48	4.70	4.59	4.66	6.06	5.36
	Ambili	4.62	4.48	4.55	4.03	4.60	4.31	4.73	4.33	4.53	4.46	4.47	4.46
	Suvarna	4.80	3.72	3.86	4.20	4.77	4.48	4.11	5.13	4.62	4.10	4.54	4.32
	Mean	4.71	5.00	4.85	4.08	5.35	4.71	4.44	4.72	4.58	4.41	5.02	4.71
S_2	Co.1	3.01	3.80	3.41	3.50	5.01	4.26	4.56	5.02	4.79	3.69	4.61	4.15
	Ambili	5.21	2.94	4.08	5.43	3.47	4.45	5.07	4.58	4.82	5.23	3.66	4.45
	Suvarna	3.70	3.21	3.45	4.21	3.32	3.77	4.00	4.10	4.05	3.97	3.54	3.76
	Mean	3.97	3.32	3.64	4.38	3.93	4.16	4.54	4.57	4.56	4.30	3.94	4.12

	S_1	S_2
CD (0.05) for comparison of source of nutrition	0.1535	0.1624
CD (0.05) for comparison of maturity stages	0.1883	0.1345
CD (0.05) for comparison of varieties	0.1883	0.1345
CD (0.05) for comparison of source of nutrition x maturity stages	0.2664	0.2472
CD (0.05) for comparison of source of nutrition x varieties	0.2664	0.2472
CD (0.05) for comparison of maturity stages x varieties	0.3264	0.3026
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	0.4616	0.4277

Inorganic nutrition significantly increased the per cent total sugars over organic nutrition at all maturity stages, in general. Within the varieties also the same was observed.

No significant difference in total sugar content was observed with increase in maturity in variety Ambili whereas in variety Co.1 per cent total sugars decreased significantly with maturity. The reverse was observed in Suvarna eventhough the increase was not significant.

Inorganic nutrition gave higher per cent total sugar at all stages in variety Co.1. The same was observed at M_2 in Ambili and at M_2 and M_3 in Suvarna.

Season II

The varieties differed significantly from one another in the content of total sugars. Ambili had the highest per cent of total sugars (4.45%) and Suvarna the lowest (3.76%).

The total sugars increased significantly with increase in maturity with M_3 recording the highest value (4.56%).

In general, organic nutrition recorded significantly higher per cent total sugars (4.3%) than inorganic nutrition (3.94%). This was true in the case of Ambili and Suvarna while in Co.1 the reverse was observed. When the effect of maturity stage on source of nutrition was studied, at 30 d.a.a. and 45 d.a.a. organic nutrition gave significantly high per cent total sugars while at 60 d.a.a. both were on par with each other.

The total sugar content increased during maturation in all the three varieties.

Inorganic nutrition increased the per cent total sugar at all the stages in variety Co.1 whereas organic nutrition was effective in increasing total sugar content in variety Suvarna and Ambili.

4.2.5 Acidity

Season I

Varieties Suvarna (0.21%) and Ambili (0.19%) had significantly higher acidity than Co.1 (0.09%) (Table 16).

The effect of harvest maturity on acidity revealed that in general the fruits harvested 60 d.a.a. (0.28%) recorded higher per cent acidity than two earlier stages (0.12 and 0.08 for M_1 and M_2 respectively). With respect to varieties the increase at M_3 (60 d.a.a.) was significant in Ambili and Suvarna.

Organic nutrition was observed to give significantly higher per cent acidity in Ambili and Suvarna while the reverse was observed in Co.1.

In general at 60 d.a.a. (M_3) inorganic nutrition (0.47%) gave a higher percentage acidity over organic nutrition (0.08%). However this effect was significant in varieties Ambili and Suvarna at 60 d.a.a..

Season II

Varieties did not differ significantly in ascorbic acid content.

Inorganic nutrition (0.17%) gave significantly higher per cent acidity in variety Ambili than organic nutrition (0.05%). The per cent acidity was highest when fruits were harvested at 30 d.a.a. (M_1) stage in Co.1 and Ambili (0.18% and

Table 16. Effect of variety, harvest maturity and source of nutrition on Acidity (%)

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	0.11	0.23	0.17	0.04	0.03	0.03	0.07	0.04	0.05	0.07	0.10	0.09
	Ambili	0.090	0.202	0.14	0.03	0.14	0.09	0.06	0.59	0.32	0.06	0.31	0.19
	Suvarna	0.050	0.060	0.06	0.04	0.19	0.12	0.11	0.79	0.45	0.07	0.35	0.21
	Mean	0.08	0.17	0.12	0.04	0.12	0.08	0.08	0.47	0.28	0.07	0.25	0.16
S_2	Co.1	0.269	0.092	0.18	0.04	0.03	0.03	0.05	0.03	0.04	0.12	0.05	0.08
	Ambili	0.064	0.268	0.17	0.02	0.17	0.10	0.06	0.06	0.06	0.05	0.17	0.11
	Suvarna	0.051	0.051	0.05	0.04	0.26	0.15	0.17	0.10	0.13	0.09	0.14	0.11
	Mean	0.13	0.14	0.13	0.03	0.15	0.09	0.09	0.06	0.08	0.09	0.12	0.10

	S_1	S_2
CD (0.05) for comparison of source of nutrition	NS	NS
CD (0.05) for comparison of maturity stages	0.0921	NS
CD (0.05) for comparison of varieties	0.0921	NS
CD (0.05) for comparison of source of nutrition x maturity stages	0.1300	0.0795
CD (0.05) for comparison of source of nutrition x varieties	0.1300	0.0795
CD (0.05) for comparison of maturity stages x varieties	0.1593	0.0973
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	0.2253	NS

0.17% respectively) while in Suvarna the highest acidity was observed at 45 d.a.a. (0.15%).

4.2.6 β carotene

Season I

The varieties significantly differed between themselves with Suvarna (200.17 µg/g) recording the highest β carotene content and Co.1 the lowest (99.89 µg/g) (Table 17).

β carotene content increased significantly with maturity. The highest was recorded at 60 d.a.a. (M_3) stage (266.39 µg/g).

Nutrition also influenced the β carotene content. Organic nutrition(193.52) had significantly higher value than inorganic nutrition (177.52 µg/g). This was true in the case of individual varieties also.

The varieties also showed considerable variation in β carotene content at different stages of maturity. In all the varieties the lowest value was observed at 30 d.a.a. and the highest at 60 d.a.a. stage.

Season II

The effect of variety, source of nutrition and maturity stages were similar as in season I.

Suvarna had the highest β carotene content (288.33 µg/g). At 60 d.a.a. the average β carotene of varieties content was 276.94 µg/g. In this season also organic increased β carotene content over inorganic nutrition. In Ambili both sources of nutrition were on par with each other with respect to β carotene content.

Table 17. Effect of variety, harvest maturity and source of nutrition on β carotene (µg/g of dried sample)

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	56.00	47.00	51.50	107.33	89.33	98.33	154.33	145.33	149.83	105.89	93.89	99.89
	Ambili	107.33	106.33	106.83	173.00	171.33	172.17	252.00	249.00	250.50	177.44	173.56	176.50
	Suvarna	186.67	167.00	176.83	288.67	241.00	264.33	416.33	381.33	398.83	297.22	263.11	200.17
	Mean	116.62	106.78	111.72	189.67	167.20	178.44	274.22	258.56	266.39	193.52	177.52	185.52
S_2	Co.1	69.00	50.00	59.50	104.33	101.67	103.00	148.33	133.67	141.00	107.22	95.11	101.17
	Ambili	108.00	114.00	111.00	178.33	182.00	180.17	272.00	262.67	267.33	186.11	186.22	186.17
	Suvarna	196.67	168.00	182.33	293.33	227.00	260.17	475.33	369.67	422.50	321.78	254.89	283.33
	Mean	124.56	110.67	117.61	192.00	170.22	181.11	298.56	255.33	276.94	205.04	178.74	191.89

	S_1	S_2
CD (0.05) for comparison of source of nutrition	5.3105	3.1748
CD (0.05) for comparison of maturity stages	11.4624	5.3887
CD (0.05) for comparison of varieties	11.4624	5.3887
CD (0.05) for comparison of source of nutrition x maturity stages	NS	7.6212
CD (0.05) for comparison of source of nutrition x varieties	16.2105	7.6212
CD (0.05) for comparison of maturity stages x varieties	19.8536	9.3340
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	NS	13.2000

This was also observed at the different stages of maturity in Ambili and Co.1. But in case of Suvarna at the different stages of maturity organic nutrition significantly increased the β carotene content over inorganic nutrition.

4.2.7 Ascorbic acid

Season I

All varieties significantly differed between themselves in ascorbic acid content during this season. Variety Co.1 (1.43 mg/100 gm) had significantly higher ascorbic acid content than Suvarna (1.32 mg/100 gm) and Ambili (1.15 mg/100 gm) (Table 18).

In general the ascorbic acid content showed a decreasing trend during maturation (1.37 to 1.18 mg/100 gm from M_1 to M_3).

Organic nutrition gave significantly higher ascorbic acid content than inorganic nutrition (1.30 and 1.26 mg/100 gm respectively).

At 30 d.a.a. inorganic gave significantly higher ascorbic acid content than organic nutrition when the overall effect with regard to varieties was studied. Organic gave higher ascorbic acid in Ambili and Suvarna while the reverse was observed in Co.1.

Ascorbic acid content showed significant decline with the increasing maturity in varieties Ambili and Suvarna while in Co.1 the highest value was recorded at 45 d.a.a..

Season II

Variety Suvarna (1.16 mg per 100 gm) had significantly higher ascorbic acid content than Co.1 and Ambili.

Table 18. Effect of variety, harvest maturity and source of nutrition on Ascorbic acid (mg/100 g)

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IC	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	1.38	1.29	1.34	1.28	1.96	1.62	1.48	1.16	1.32	1.38	1.47	1.43
	Ambili	1.19	1.40	1.30	1.29	0.82	1.06	1.09	1.03	1.08	1.19	1.10	1.15
	Suvarna	1.40	1.56	1.50	1.52	1.15	1.34	1.32	0.93	1.12	1.42	1.21	1.32
	Mean	1.33	1.42	1.37	1.36	1.31	1.34	1.38	1.06	1.18	1.30	1.26	1.30
S_2	Co.1	1.32	1.80	1.56	0.63	0.50	0.57	1.08	1.00	1.04	1.01	1.10	1.06
	Ambili	1.28	1.61	1.44	0.80	0.81	0.81	1.06	1.01	1.03	1.04	1.14	1.09
	Suvarna	1.43	1.43	1.43	0.99	1.27	1.23	0.91	0.95	0.93	1.11	1.22	1.16
	Mean	1.34	1.61	1.48	0.81	0.86	0.83	1.02	0.91	1.00	1.05	1.13	1.10

	S_1	S_2
CD (0.05) for comparison of source of nutrition	0.0310	NS
CD (0.05) for comparison of maturity stages	0.0556	0.1260
CD (0.05) for comparison of varieties	0.0556	NS
CD (0.05) for comparison of source of nutrition x maturity stages	0.0789	NS
CD (0.05) for comparison of source of nutrition x varieties	0.0789	NS
CD (0.05) for comparison of maturity stages x varieties	0.9646	0.2176
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	0.1366	NS

In all the varieties ascorbic acid content was highest at 30 d.a.a..

In general nutrition and harvest maturity did not have significant effect on ascorbic acid content in this season.

4.2.8 Starch

Season I

The varieties differed significantly in starch percentage. Ambili (38.90%) recorded the highest starch percentage while Co.1 had the lowest (23.96%) (Table 19).

The overall effect of maturity stages on starch content revealed significant differences at the different maturity stages. The starch content increased significantly from 30 d.a.a. (17.61%) to 45 d.a.a. (45.33%). Significant reduction in starch content was observed between 45 d.a.a. and 60 d.a.a. in all the varieties.

Season II

In the second season variety Ambili (38.79%) differed significantly from Co.1 (31.23%) and Suvarna (32.85%).

In this season also the starch content increased considerably from M_1 (30 d.a.a.) to M_2 (45 d.a.a.) but decreased at M_3 (60 d.a.a.). This was true in all varieties.

Nutrition in general did not have any effect on starch content. But the interaction effect of maturity and nutrition revealed that at 45 d.a.a. (M_2) organic gave significantly higher starch content than inorganic nutrition (57.33% and 50.49%, respectively).

Table 19. Effect of variety, harvest maturity and source of nutrition on starch (% of dried sample)

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	8.10	12.70	10.40	36.07	40.30	38.19	21.80	24.77	23.28	21.99	25.92	23.96
	Ambili	23.30	25.10	24.20	54.67	48.33	51.50	42.33	39.67	41.00	40.10	37.70	38.90
	Suvarna	16.20	20.23	18.22	53.00	47.41	50.20	22.67	23.93	23.30	30.62	30.52	30.57
	Mean	15.87	19.34	17.61	47.91	45.35	46.63	28.93	28.46	29.19	30.90	31.38	31.14
S_2	Co.1	10.53	24.91	17.72	45.70	48.26	46.98	28.14	29.82	28.98	28.12	34.33	31.23
	Ambili	24.27	20.69	22.48	59.67	52.33	56.00	40.34	35.43	37.89	41.42	36.15	38.79
	Suvarna	13.73	19.03	16.38	66.63	50.89	58.76	25.80	21.03	23.42	35.39	30.32	32.85
	Mean	16.18	21.54	18.86	57.33	50.49	53.91	31.43	28.76	30.09	34.98	33.60	3429

	S_1	S_2
CD (0.05) for comparison of source of nutrition	NS	NS
CD (0.05) for comparison of maturity stages	2.7405	3.9072
CD (0.05) for comparison of varieties	2.7405	3.9072
CD (0.05) for comparison of source of nutrition x maturity stages	NS	5.5258
CD (0.05) for comparison of source of nutrition x varieties	NS	5.5258
CD (0.05) for comparison of maturity stages x varieties	4.7466	6.7677
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	NS	NS

Similarly the interaction effect of nutritional and varieties revealed that in variety Co.1 inorganic (34.33%) gave higher starch content than organic nutrition (28.12%).

4.2.9 Crude fibre

Season I

The varieties significantly differed with respect to crude fibre content. Ambili had the highest (9.78%) and Co.1 (7.87), the least value for crude fibre (Table 20).

Crude fibre content increased significantly with advancing maturity in all the varieties. It was highest when fruits were harvested after 60 d.a.a. (M_3). In general organic nutrition gave significantly less crude fibre content than inorganic nutrition (8.49% and 9.08% respectively).

Season II

During this season Co.1 (10.06%) gave significantly higher value for crude fibre than Ambili (9.27%) and Suvarna (7.5%).

There was significant increase in the crude fibre content during maturation of fruits. The fruits harvested at 30 d.a.a. recorded the minimum (4.68%) and those harvested at 60 d.a.a. recorded the maximum (8.62%) value. This was evident in all varieties.

Inorganic gave higher crude fibre content (9.26%) than organic nutrition (8.62%) in general. This was also observed in case of individual varieties except Co.1 where both sources of nutrition were on par with each other.

Table 20. Effect of variety, harvest maturity and source of nutrition on crude fibre (% of dried sample)

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	3.20	4.10	3.65	7.53	8.43	7.98	11.87	12.10	11.99	7.53	8.21	7.87
	Ambili	5.10	5.53	5.32	10.30	10.80	10.55	13.23	13.73	13.48	9.54	70.02	9.78
	Suvarna	4.40	5.30	4.85	8.19	8.87	8.53	12.60	12.83	12.72	8.40	9.00	8.70
	Mean	4.23	4.98	4.61	8.67	9.37	9.02	12.57	12.89	12.73	8.49	9.08	8.73
S_2	Co.1	4.60	4.13	4.37	11.90	11.57	11.73	14.03	14.10	14.07	10.18	9.93	10.06
	Ambili	5.70	6.13	5.92	9.10	10.90	10.00	11.40	12.37	11.88	8.77	9.80	9.27
	Suvarna	3.10	4.40	3.75	7.90	8.33	8.12	9.82	11.43	10.63	6.94	8.06	7.50
	Mean	4.47	4.89	4.68	9.63	10.27	9.95	11.75	12.63	12.19	8.62	9.26	8.94

	S_1	S_2
CD (0.05) for comparison of source of nutrition	0.1366	0.0944
CD (0.05) for comparison of maturity stages	0.3249	0.4852
CD (0.05) for comparison of varieties	0.3249	0.4852
CD (0.05) for comparison of source of nutrition x maturity stages	NS	NS
CD (0.05) for comparison of source of nutrition x varieties	NS	0.6861
CD (0.05) for comparison of maturity stages x varieties	0.5629	0.8402
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	NS	NS

4.3 Effect of variety, maturity stage and source of nutrition on shelf life of pumpkin fruit

4.3.1 Shelf life

Season I

In the summer season varieties did not differ significantly in shelf life eventhough Suvarna had the maximum shelf life (80.22 days) (Table 21).

Maximum shelf life was observed when the fruits were harvested 45 d.a.a. (82.33 days) stage. This was significantly higher than M_1 (62.06 days).

Nutrition in general did not have any effect on shelf life. But when variety Suvarna was harvested at 45 d.a.a. inorganic nutrition (125 days) gave significantly longer shelf life than organic nutrition (88.67 days).

Season II

In the second season variety Suvarna (77.11 days) had significantly longer shelf life than variety Co.1 (59.72 days). Ambili had a shelf life of 68.06 days.

Fruits harvested at M_1 (30 d.a.a.) and M_2 (45 d.a.a.) from crops raised under both organic and inorganic nutrition had shelf life which were on par with each other while at M_3 organic (83.89 days) gave significantly longer shelf life than inorganic nutrition (56.56 days).

4.3.2 Physiological loss in weight (PLW)

Season I

In the first season all the fruits could be retained for a maximum period of six weeks. Varieties showed significant variation in cumulative PLW when

Table 21. Effect of variety, harvest maturity and source of nutrition on shelf life of pumpkin fruits

Season	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF			O	IO	
		O	IO	M	O	IO	M	O	IO	M			
S_1	Co.1	49.00	74.33	61.67	90.00	62.00	76.00	77.00	74.00	76.50	72.00	70.11	71.06
	Ambili	52.68	67.00	59.83	56.33	72.00	64.17	78.33	58.33	68.33	62.44	65.78	64.11
	Suvarna	74.33	55.00	64.67	88.67	125.00	106.83	73.67	64.67	69.17	78.99	81.56	80.22
	Mean	58.67	65.44	62.06	78.33	86.33	82.33	76.33	65.67	71.00	71.11	72.48	71.74
S_2	Co.1	48.67	64.33	56.50	58.33	54.67	56.50	76.00	53.33	64.67	61.00	57.44	59.22
	Ambili	60.00	54.00	57.00	98.67	75.00	86.83	68.00	52.67	60.00	75.56	60.56	68.06
	Suvarna	74.67	66.67	70.67	72.00	78.00	75.00	107.67	63.67	85.67	84.78	69.44	77.11
	Mean	61.11	61.67	61.39	76.33	69.22	72.78	83.89	56.56	70.22	73.78	62.48	68.13

	S_1	S_2
CD (0.05) for comparison of source of nutrition	NS	NS
CD (0.05) for comparison of maturity stages	14.1375	NS
CD (0.05) for comparison of varieties	NS	3.7157
CD (0.05) for comparison of source of nutrition x maturity stages	NS	15.0857
CD (0.05) for comparison of source of nutrition x varieties	NS	NS
CD (0.05) for comparison of maturity stages x varieties	NS	18.4762
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	34.6296	NS

observed at the end of each week upto a total period of six weeks. Varieties Co.1 and Ambili were on par with each other with high physiological loss in weight. Suvarna had significantly lower PLW than these two varieties (Table 22a).

Upto third week of storage maturity of fruits did not exhibit a significant influence on PLW after which fruits harvested at M_1 (30 d.a.a.) recorded higher PLW as compared to the later stages. Ambili when harvested at M_2 (45 d.a.a.) registered significant reduction in PLW while in Suvarna and Co.1 harvest maturity did not have any significant effect on PLW.

The source of nutrition had a significant impact on PLW only during the later stages of storage. In the fifth and sixth week of storage organic nutrition reduced PLW significantly over inorganic nutrition.

Season II

The PLW during storage in the different varieties recorded at weekly intervals did not exhibit significant variation except at the end of second week of storage. The physiological loss in weight was significantly high for Co.1 (6.14%) than Suvarna (4.18%) and Ambili (4.57%) (Table 22b).

During this season also harvest maturity of fruits had a significant influence on PLW, only from third week of storage. Three weeks after storage fruits harvested at M_1 (8.6%) showed significant PLW compared to M_2 and M_3.In the fourth week of storage fruits harvested at M_1 (10.87%) and M_2 (10.19%) had significantly high PLW than M_3 (7.73%).

Table 22a. Effect of variety, harvest maturity and source of nutrition on PLW (%) - Season I

Week	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF					
		O	IO	M	O	IO	M	O	IO	M	O	IO	
First	Co.1	2.80	2.80	2.80	4.43	5.10	4.767	3.80	4.17	3.98	3.68	4.02	3.85
	Ambili	2.87	3.27	3.067	1.40	2.53	1.967	2.40	2.93	2.67	2.22	2.91	2.57
	Suvarna	1.13	2.10	1.617	3.13	2.23	2.683	2.00	2.93	2.47	2.09	2.42	2.26
	Mean	2.27	2.72	2.49	2.99	3.29	3.14	2.73	3.34	3.04	2.66	3.12	2.90
Second	Co.1	6.03	4.43	5.23	5.77	7.63	6.70	5.53	6.90	6.22	5.78	6.32	6.05
	Ambili	6.67	7.83	7.25	2.00	4.33	3.17	3.77	5.90	4.83	4.14	6.02	5.08
	Suvarna	2.97	3.80	3.38	3.73	3.83	3.78	2.60	5.03	3.82	3.10	4.22	3.66
	Mean	5.22	5.36	5.29	3.83	5.27	4.55	3.97	5.94	4.96	4.34	5.22	4.93
Third	Co.1	8.00	6.30	7.15	7.60	10.33	8.97	7.00	9.93	8.46	7.53	8.86	8.19
	Ambili	13.53	9.97	11.75	2.90	6.20	4.55	5.50	8.73	7.12	7.31	8.30	7.81
	Suvarna	6.50	6.20	6.35	4.13	5.80	4.97	3.63	6.87	5.25	4.76	6.29	5.52
	Mean	9.34	7.49	8.42	4.88	7.44	6.16	5.38	8.51	6.94	6.53	7.82	7.17
Fourth	Co.1	10.14	9.62	9.90	9.07	13.60	11.33	9.67	14.07	11.87	9.62	12.44	11.03
	Ambili	20.13	13.50	16.82	5.70	8.73	7.23	7.07	13.53	10.30	10.98	11.92	11.45
	Suvarna	8.69	8.93	8.81	5.30	7.90	6.60	5.47	9.17	7.32	6.49	8.67	7.58
	Mean	12.99	10.70	11.84	6.70	10.08	8.39	7.40	12.26	9.83	9.03	11.01	10.02
Fifth	Co.1	12.93	13.10	13.02	11.43	17.00	14.22	11.63	18.63	15.13	12.00	16.24	14.12
	Ambili	30.57	17.90	24.25	7.63	11.33	9.48	9.03	18.07	13.55	15.74	15.78	15.76
	Suvarna	9.67	11.20	10.43	7.13	10.17	8.65	7.50	12.80	10.15	8.10	11.39	9.74
	Mean	17.72	14.08	15.90	8.73	12.83	10.78	9.39	16.50	12.94	11.95	14.47	13.21
Sixth	Co.1	16.83	16.37	16.60	14.20	21.27	17.73	14.83	22.47	18.65	15.29	20.03	17.66
	Ambili	40.67	21.87	31.27	8.10	13.53	10.82	10.67	24.67	17.67	19.81	20.02	19.92
	Suvarna	12.87	14.10	13.48	8.83	13.10	10.97	9.57	16.57	13.07	10.42	14.59	12.51
	Mean	23.46	17.44	20.45	10.38	15.97	13.17	11.69	21.23	16.46	15.17	18.21	16.69

	First	Second	Third	Fourth	Fifth	Sixth
CD (0.05) for comparison of source of nutrition	NS	NS	NS	NS	0.8354	0.9264
CD (0.05) for comparison of maturity stages	NS	NS	1.7350	2.1590	2.2950	3.0629
CD (0.05) for comparison of varieties	0.8454	1.4160	1.7350	NS	2.2950	3.0629
CD (0.05) for comparison of source of nutrition x maturity stages	NS	NS	NS	3.0534	3.2460	4.3315
CD (0.05) for comparison of source of nutrition x varieties	NS	NS	NS	3.0534	NS	NS
CD (0.05) for comparison of maturity stages x varieties	NS	2.4520	3.0050	3.7395	3.9758	5.3053
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	NS	NS	NS	NS	5.6225	7.5026

Table 22b. Effect of variety, harvest maturity and source of nutrition on PLW (%) - Season II

Week	Variety	Maturity stages									Nutritional mean		Grand mean
		30 DAF			45 DAF			60 DAF					
		O	IO	M	O	IO	M	O	IO	M	O	IO	
First	Co.1	4.07	4.07	4.07	3.93	2.50	3.22	2.77	2.60	2.68	3.59	3.06	3.32
	Ambili	2.37	2.87	2.62	2.87	4.40	3.63	1.27	0.47	0.87	2.17	2.58	2.37
	Suvarna	2.53	2.80	2.67	0.88	2.20	1.54	1.97	2.70	2.33	1.79	2.57	2.18
	Mean	2.99	3.244	3.12	2.56	3.03	2.80	2.00	1.92	1.96	2.52	2.73	2.62
Second	Co.1	6.63	7.17	6.90	5.03	6.50	5.77	5.77	5.73	5.75	5.81	6.47	6.14
	Ambili	6.03	4.70	5.37	4.94	6.30	5.62	3.03	2.40	2.72	4.67	4.47	4.57
	Suvarna	3.13	6.47	4.80	2.53	4.93	3.73	3.90	4.70	4.30	3.19	5.37	4.28
	Mean	5.27	6.11	5.69	4.17	5.91	5.04	4.23	4.28	4.26	4.56	5.43	4.99
Third	Co.1	9.17	11.37	10.27	6.80	9.10	7.95	6.83	7.47	7.15	7.60	9.31	8.46
	Ambili	9.37	7.40	8.38	7.60	9.77	8.68	3.77	4.33	4.05	6.91	7.17	7.04
	Suvarna	4.53	9.77	7.15	3.57	6.97	5.27	6.07	6.77	6.42	4.72	7.83	6.28
	Mean	7.69	9.51	8.60	5.99	8.61	7.30	5.56	6.19	5.87	6.41	8.10	7.26
Fourth	Co.1	11.43	14.67	13.05	9.00	12.47	10.73	9.07	9.83	9.45	9.83	12.32	11.78
	Ambili	11.63	9.07	10.33	11.83	12.07	11.95	5.50	6.43	5.97	9.66	9.19	9.42
	Suvarna	5.90	12.63	9.27	6.33	9.43	7.88	6.77	9.07	7.92	6.33	10.38	8.36
	Mean	9.76	12.22	10.89	9.06	11.32	10.19	7.11	8.44	7.78	8.61	10.63	10.18

	First	Second	Third	Fourth
CD (0.05) for comparison of source of nutrition	NS	0.2988	0.6393	NS
CD (0.05) for comparison of maturity stages	NS	NS	2.0408	2.5760
CD (0.05) for comparison of varieties	NS	1.5660	NS	NS
CD (0.05) for comparison of source of nutrition x maturity stages	NS	NS	NS	NS
CD (0.05) for comparison of source of nutrition x varieties	NS	NS	NS	NS
CD (0.05) for comparison of maturity stages x varieties	NS	NS	NS	NS
CD (0.05) for comparison of source of nutrition x maturity stages x varieties	NS	NS	NS	NS

During this season also organic nutrition was found effective in reducing PLW throughout the storage period, even though the effect was significant only after second and third week of storage.

4.3.3 Organoleptic quality

Scores obtained in organoleptic evaluation of fruits by a panel of eight members are presented in Table 23.

4.3.3.1 Colour

Season I

Lowest score for colour, based on visual scoring was obtained for organically fertilised Co.1 fruits when harvested at 30 d.a.a. (M_1) stage, closely followed by the same harvested at 60 d.a.a. (M_3). Inorganically fertilized Suvarna when harvested at 30 d.a.a. was also on par with them.

The highest score was observed for organically grown Ambili and inorganically grown Suvarna fruits both harvested at 45 d.a.a. (M_2) stage indicating its superior colour.

Season II

The highest score for colour in this season was observed for fruits of Ambili followed by Co.1 both inorganically grown and harvested at M_2 (45 d.a.a.). Inorganically grown Co.1 fruits harvested at M_1 was least preferred as indicated by the lowest score.

Table 23. Effect of variety, harvest maturity and source of nutrition on sensory attributes of pumpkin

Treatment	Colour		Texture		Flavour		Overall	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
$N_1V_1M_1$	266.0	475.5	242.0	483.5	310.0	660.0	319.0	170.5
$N_1V_1M_2$	507.0	238.0	607.0	443.0	513.0	560.0	563.5	443.5
$N_1V_1M_3$	300.0	559.0	699.0	545.5	888.0	578.0	732.0	578.5
$N_2V_1M_1$	813.0	301.5	470.5	505.0	536.5	342.0	732.0	468.0
$N_2V_1M_2$	514.5	821.5	572.0	629.0	638.0	808.5	392.0	781.0
$N_2V_1M_3$	813.0	475.5	773.0	586.0	789.0	719.0	732.0	713.5
$N_1V_2M_1$	421.5	388.5	443.0	524.0	497.5	401.0	732.0	290.0
$N_1V_2M_2$	848.0	793.0	837.5	835.0	825.5	619.0	800.0	603.0
$N_1V_2M_3$	592.0	666.0	736.0	834.0	700.5	601.0	664.0	578.5
$N_2V_2M_1$	379.0	325.0	441.0	340.5	411.5	342.0	460.0	443.5
$N_2V_2M_2$	720.0	856.5	634.5	834.0	661.5	560.0	732.0	906.5
$N_2V_2M_3$	656.0	793.0	634.5	586.0	638.0	660.0	732.0	578.5
$N_1V_3M_1$	379.0	388.5	341.5	443.0	333.5	208.0	355.5	357.5
$N_1V_3M_2$	656.0	758.0	763.5	772.0	700.5	778.0	523.0	578.5
$N_1V_3M_3$	592.0	622.5	406.0	669.0	536.5	898.0	528.0	713.5
$N_2V_3M_1$	315.0	325.0	634.5	238.0	286.0	219.0	319.0	443.5
$N_2V_3M_2$	848.0	729.5	570.0	586.0	599.0	719.0	614.0	578.5
$N_2V_3M_3$	720.0	666.0	634.5	586.0	575.5	837.0	460.0	713.5
Kruskal Wallis 'H' value	39.51	29.99	31.59	33.90	36.28	57.99	32.99	NS

4.3.3.2 Texture

Season I

Maximum score for texture was observed for Ambili fruits harvested at 45 d.a.a. (M_2) stage and supplied with organic nutrition while the lowest was obtained for organically grown Co.1 fruits at M_1 stage (30 d.a.a.).

Season II

In case of texture organically grown Ambili fruits harvested at M_2 (45 d.a.a.) and M_3 (60 d.a.a.) and inorganically grown Ambili at 45 d.a.a. were on par with each other with the highest score whereas inorganic Ambili at M_2 (45 d.a.a.) secured the lowest score.

4.3.3.3 Flavour

Season I

Least score for flavour was obtained for fruits of Suvarna raised both organically and inorganically and harvested at 30 d.a.a. (M_1) with organically grown Co.1 fruits at M_1 stage (30 d.a.a.) following closely behind. The highest score was observed for organic Co.1 harvested at 60 d.a.a..

Season II

Organically grown Suvarna at M_3 (60 d.a.a.) had the highest score for flavour in this season while the same at M_1 (30 d.a.a.) had the lowest score.

4.3.3.4 Overall appearance

Season I

The best preference as indicated by overall acceptability score was obtained for organically fertilized Ambili fruits harvested at M_2 (45 d.a.a.) while

the lowest score was recorded for organically grown Co.1 fruits at M_1 stage and inorganically grown Suvarna fruits at M_1 stage.

Season II

In the second season the highest score for overall acceptability was obtained for inorganic Ambili harvested at 45 d.a.a. (M_2) eventhough there was no significant differences between the different treatments.

Discussion

5. DISCUSSION

Pumpkin (*Cucurbita moschata* Poir) is one of the most popular cucurbits grown in India. Low cost of production, long keeping quality and comparatively high content of carotene in fruits have enhanced the usefulness of the crop.

Palatability and taste of fruits and vegetables are closely associated with the amount and type of chemical constituents and physical nature of the commodity at the time of harvest (Pantastico, 1975). Fruit quality is largely determined before harvest, while postharvest treatments generally aim at maintaining this quality (Hofman and Smith, 1994). Salunkhe and Desai (1984) has reported these preharvest factors as climatic conditions, cultural practices and nutrition.

A study on the published reports of the chemical composition of pumpkin makes it apparent that in addition to variation attributable to climate and soil conditions there are consistent inherent differences in composition among varieties and also significant difference between the various stages of maturity in any given variety (Culpepper and Moon, 1945).

Eventhough pumpkins are mainly consumed as fresh vegetable, it is also used for preparation of processed foods. The varied use of fruit makes it necessary to be harvested at different maturity stages. Quality of fruits cannot be improved but it can be preserved and good quality is obtained when harvesting is done at the optimum stage of maturity.

Stage of maturity of harvesting a fruit or vegetable is crucial not only for quality but also for its subsequent storage and marketable life. The measurement of various qualitative and quantitative parameters of fruits may serve as an index for assessing the optimum harvest maturity. Storage potential is normally given as the postharvest life of a commodity held at its optimum storage temperature. Apart from harvest maturity this potential is also dependent on variety, preharvest environment and cultural and storage conditions (Paull, 1993).

Manures and fertilizers play an important role in increasing the production and improving the quality of vegetables. An awareness on the unscientific use of chemical fertilizers and plant protection chemicals has led to the idea of a non-chemical farming or organic farming which attempts to provide a balanced environment by the improvement of soil fertility and control of pests and diseases with organic form of energy and resources.

The results of the present study on the effects of organic and inorganic fertilisers on physico-chemical attributes and storability of three varieties of pumpkin harvested at three different stages of maturity are discussed below.

5.1 Effect of variety, harvest maturity and source of nutrition on physical parameters

5.1.1 Varietal variation in physical parameters

Significant differences were not observed between the varieties in case of fruit weight. In the present study it was observed that fruits of variety Ambili had the minimum fruit weight in both the season. The maximum weight was observed for Suvarna (2.71 kg) during summer season and Co.1 (2.34 kg) during

the rainy season. Suvarna fruits were reported to have a fruit weight of 3.5 kg on an average (The Hindu, 1999).

Variety Co.1 recorded the minimum and Suvarna the maximum circumference in both the seasons. The circumference of pumpkin genotypes have been reported to vary from 44.67 to 113.07 cm (Gopalakrishnan *et al.*, 1980). The standard shape of Co.1 fruits which is oblong and tapering towards the promixal end accounted for the least circumference and maximum polar diameter in that variety. Considerable variation in fruit weight, length and diameter of pumpkin fruits had also been reported by Sureshbabu *et al.* (1996).

Ambili was observed to have the minimum flesh thickness in both seasons. The flesh thickness of Suvarna remained almost the same in both seasons (3.27 and 3.23 cm). Fruits of Suvarna were reported to have a flesh thickness of 5 cm (KAU, 1996b), Co.1, 4-5 cm and Ambili, 4.3 cm (Chadha and Lal, 1993). The flesh thickness range of pumpkin fruits were reported to vary between 2.66 to 4.40 cm by Borthakur and Shadeque (1990) and Sureshbabu *et al.* (1996).

Observations on the percentage composition of fruits revealed that Ambili had the maximum flesh percentage in both seasons (Fig.1). Compared to the other two varieties though fruit weight was low in Ambili, it also had the minimum waste index as indicated by the high flesh percentage and low seed and placenta percentage.

Seshadri (1985) and Chadha and Lal (1993) had suggested that early maturity, high carotenoids, thick flesh, minimum seed cavity and higher flesh per volume of fruit are some desirable attributes of pumpkin fruits. The seed

percentage was significantly high for Suvarna compared to the other varieties. Pumpkin when used for vegetable purpose high seed percentage is undesirable especially when harvested before seed maturity. However, for seed production purpose high seed content is a desirable attribute.

5.1.2 Harvest maturity and physical parameters

The fruit weight increased with the increase in maturity eventhough it was significant only in summer season (Fig.2). The increase in fruit weight of vegetables with increase in maturity have been reported by Kaur *et al.* (1977), Kakaty (1987), Devadas *et al.* (1998) etc.

The growth in respect with fruit weight in pumpkin followed a single sigmoid growth pattern characterised by an initial period of rapid growth and then slowing down in a typical sigmoid manner. Kanellis *et al.* (1986) had observed a similar pattern of growth in cucumber.

A developing fruit is a complex system of actively metabolizing tissue and acts as a sink that diverts and draws water and solutes from other regions of plant. Fruit growth generally starts by a short but rapid cell multiplication followed by cell enlargement (Pantastico, 1975). Leopold and Kreidmann (1980) had reported a brief period of cell division following pollination in cucurbits. Bollard (1970) reported that the major increase in fruit weight towards maturity could be attributed to an increase in both cell size and amount of intercellular space in the flesh, which enables the maximum possible accumulation of food substances.

In the present study it was observed that days taken to attain maximum fruit weight varied with the varieties (Fig.3). This result indicated that days to

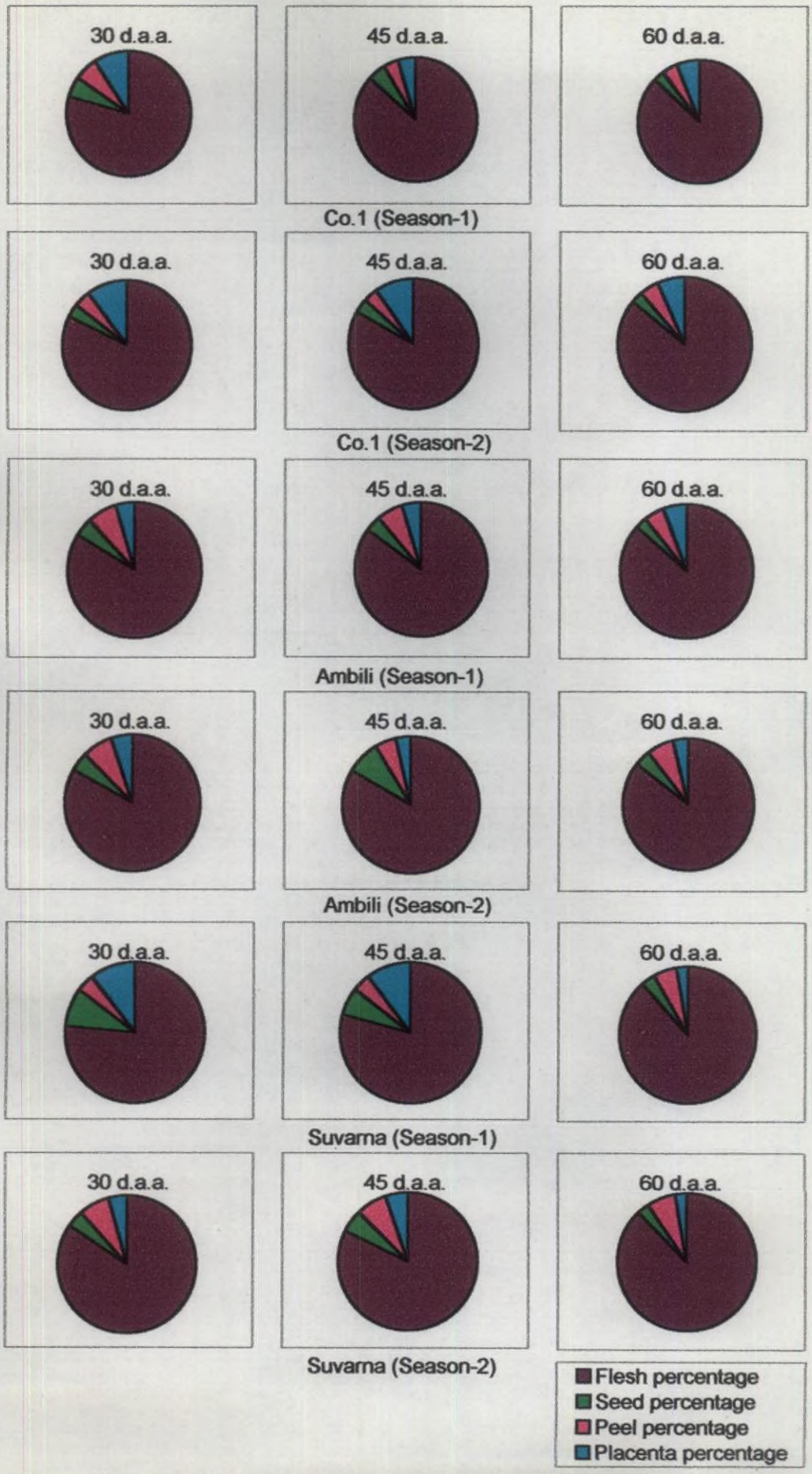


Fig. 1. Changes in physical composition with maturity in pumpkin

maturity is a varietal character and can be used as an index for harvesting. Ambili was observed to have maximum weight at 45 d.a.a. (M_3) in both summer and rainy season. Early maturity is a desirable character in pumpkin (Chadha and Lal, 1993). Suvarna attained maximum weight at 60 days after anthesis in both seasons while in Co.1 maximum fruit weight was attained 45 d.a.a. in summer and 60 d.a.a. in rainy season. The reduced sunshine hours in rainy season might have delayed the maturity in Co.1. The weight of fruits at different stages as a valuable index for harvesting has been reported by Jana and Chathopadhyay (1977).

In case of variety Ambili, fruits attained maximum weight and volume at 45 d.a.a. thereafter showing a decline (Fig.4). Such a trend in developing fruits were reported in *Cucumis melo* (Mann and Robinson, 1950 and Pratt *et al.*, 1977), bottle gourd (Chandrashekaran, 1979), bitter gourd (Varatharaj, 1979), watermelon (Hedayat, 1987) and ash gourd (Kannath, 1996). The loss in weight of fruits after reaching the maximum weight was associated with changes in moisture content in maturing fruits (Showalter, 1961; Kolhe and Chavan, 1964; Manohar and Sachan, 1974). As the fruits matured and the resultant loss in moisture content due to drying, a reduction of volume occur. Such reduction in fruit volume at later stages of maturity was reported by Sinnott (1945) in many species of cucurbits.

There was a general resemblance in the development pattern of fruits and seeds upto 30 d.a.a. after which the seed development did not exactly follow the pattern of fruit development (Fig.5). A similar trend was observed in ashgourd also (Kannath, 1996).

In both the seasons, circumference and polar diameter increased with an advance in fruit maturity. Increase in weight of a fruit is directly dependent on the length and thickness of the fruit (Kolhe and Chawan, 1964). Hulme (1970) reported that the enlargement of fruit in terms of length and breadth was due to cell elongation. The increase in length, breadth and weight of fruit with maturity is in agreement with results obtained by Jana and Chathopadhyay (1977); Kaur and Baina (1988) and Bhatnagar and Sharma (1994).

In the present study the flesh thickness increased considerably with the increase in maturity. The maximum flesh thickness for Ambili was observed at M_2 (45 d.a.a.) in both seasons. Cavity volume of pumpkin fruits were observed to increase with the increase in maturity. The increase in cavity volume with maturity has been reported by Reni (1997) in papaya.

With the increase in maturity the flesh percentage also increased. But this increase was significant only in Co.1 and Suvarna in both seasons. The increase in flesh percentage with maturity is probably due to increased food accumulation in the flesh.

The seed percentage showed a decreasing trend with maturity. The initial seed filling and seed coat hardening is followed by expulsion of moisture from seeds. The decrease in seed weight with maturation could be attributed to the decrease in water content of seeds and steady accumulation of dry matter during later stages of seed maturation phase (Kannath, 1996). Moreover the number of seeds and their size is predetermined. It does not change with advancement of maturity.

The peel percentage did not vary significantly with the maturity. Along with the increase in fruit weight a corresponding increase in peel weight due to thickening of the peel was observed which resulted in the almost constant percentage of peel throughout the development period.

There was considerable decrease in placenta percentage with the increase in maturity in both seasons. This may be due to the shrinkage of placenta after providing nourishment for seeds in initial stages. In Ambili the placenta percentage was lowest at M_2 (45 d.a.a.) stage.

From the observations of the present study on physical parameters it can be concluded that for vegetable purpose Ambili should be harvested at 45 d.a.a. (M_2) stage in both rainy and summer seasons. This stage in Ambili is characterized by maximum fruit weight, flesh thickness, flesh percentage and minimum placenta percentage while in Suvarna all these desirable characters were observed at M_3 (60 d.a.a.) which makes M_3 the most suitable age of harvesting Suvarna. For economic yield Co.1 can be harvested at M_3 (60 d.a.a.) in rainy season and M_2 (45 d.a.a.) in summer.

5.1.3 Source of nutrition and physical parameters

Source of nutrition did not have any significant effect on physical parameters like fruit weight, polar diameter, flesh thickness, circumference, cavity volume, cavity index and peel percentage (Plate 3 and 4). Similar results were reported by Singh and Tewari (1968). But inorganic nutrition had a favourable effect on physical composition of fruit. It increased flesh percentage and decreased the seed and placenta percentage.

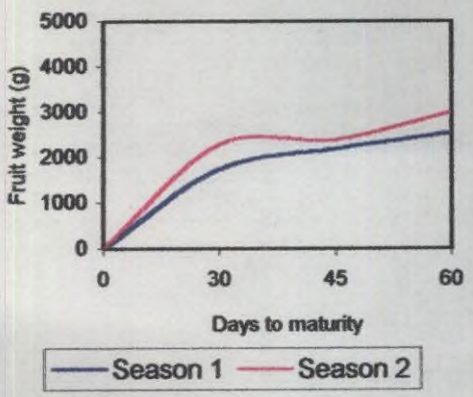


Fig. 2. Growth pattern with respect to fruit weight in pumpkin

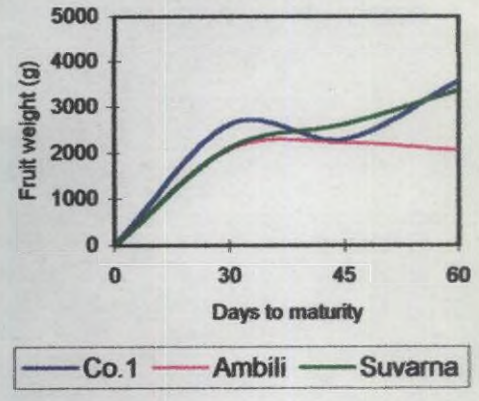


Fig. 3. Growth pattern with respect to fruit weight in three varieties of pumpkin

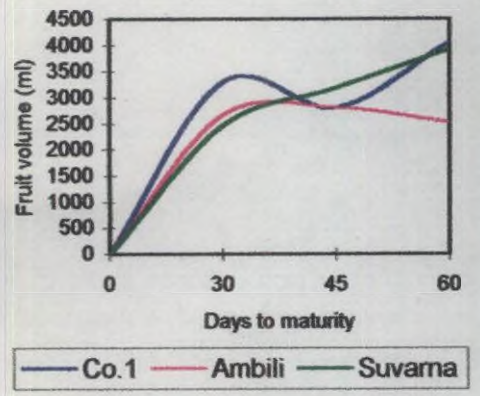


Fig. 4. Growth pattern with respect to fruit volume in three varieties of pumpkin

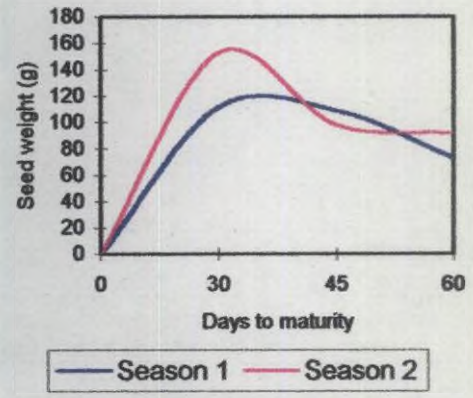


Fig. 5. Growth pattern with respect to seed weight in pumpkin

Plate 3. Fruits of Co.1, Ambili and Suvarna raised with organic nutrition

Plate 4. Fruits of Co.1, Ambili and Suvarna raised with inorganic nutrition

The nitrogen in the organic manure is released slowly, to the extent of 25 to 50 per cent in the first year. This may be beneficial in conditions of high leaching but slow availability may not be a boon for quick growing vegetables like cucurbits. Rubin and Bear (1943) had reported that dried cow manure mineralize slowly not providing N, P, K rapidly enough to meet crop needs. Most of the nitrogen in organic wastes is in protein form. For making it available for plant consumption it needs to be converted to ammoniacal and nitrate forms of nitrogen through microbial decomposition. Nitrogenous fertilizers as most of them contain nitrogen in readily available nitrate form have much higher efficiency as compared to FYM. The recovery of nitrogen from FYM and fertiliser were reported to be 29 per cent and 58 per cent respectively in an experiment conducted at Hissar (Srivastava and Khanna, 1974).

5.2 Effect of variety, harvest maturity and source of nutrition on chemical constituents

Beeson (1946) and Allaway (1971) have reported that the nutrient content of fresh vegetable usually depend upon factors such as cultivar, environment and maturity and are synthesized in a plant or in its parts while growing.

5.2.1 Varietal variation in chemical constituents

Total soluble solids (TSS) was significantly high in varieties Ambili and Suvarna in both the seasons (Fig.6). The characteristic feature of pumpkin fruits is their mild sweetness at maturity for which they are relished. Varieties with high TSS is ideal for processing. TSS is highly correlated with sugar, titrable acid and

ascorbic acid content. The high TSS content of Suvarna had been reported earlier (The Hindu, 1999). The variation in the TSS content of pumpkin varieties is in conformity with the reports by CSIR (1950) and Teotia (1992). The range of TSS content in the present study (6.78 to 12.61°Brix) is in accordance to the values given by Culpepper and Moon (1945) (6.4 to 15.7°Brix).

Varieties differed significantly in their sugar content (Fig.7). Co.1 had the maximum reducing and total sugar percentage. The difference in sugar percentage of varieties is in agreement with the results of Dubey and Gaur (1990) and Jaiswal *et al.* (1990).

The acid content of Co.1 fruits were lower than Ambili and Suvarna even though the difference was significant only in summer season. Titrable acidity and sugar content are responsible for flavour in fruits. The characteristic pumpkin flavour was less prominent in Co.1 which incidentally had low acidity also.

The nutritive value of pumpkin fruit depends on the content of ascorbic acid and β carotene. Variety Co.1 had the highest ascorbic acid content in summer while the minimum was observed for Ambili. In the present study ascorbic acid content of pumpkin fruits were less which indicates that pumpkins are not good sources of vitamin C. The ascorbic acid which is present in fruit tissue is synthesised from hexose sugar precursors. In the rainy season the varieties did not differ significantly in the ascorbic acid content and it was comparatively lower than summer season. The ascorbic acid content is adversely affected by high soil moisture, but this differs with variety (Kalloo, 1986). The concentration of

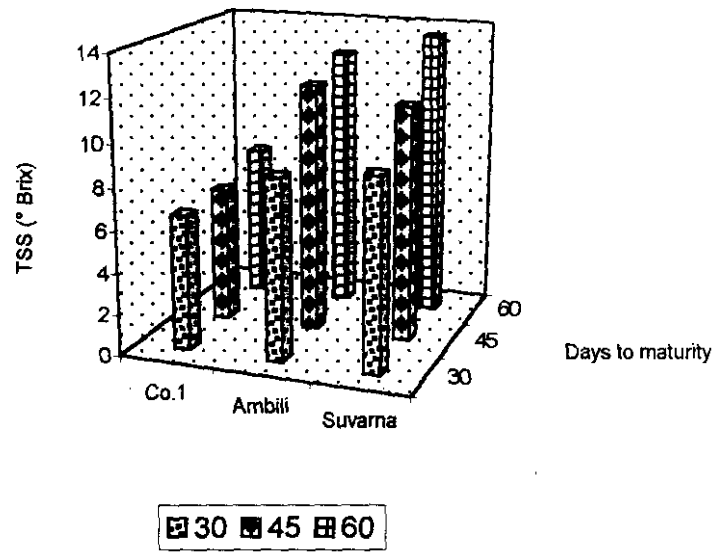


Fig. 6. Changes in TSS content with maturity

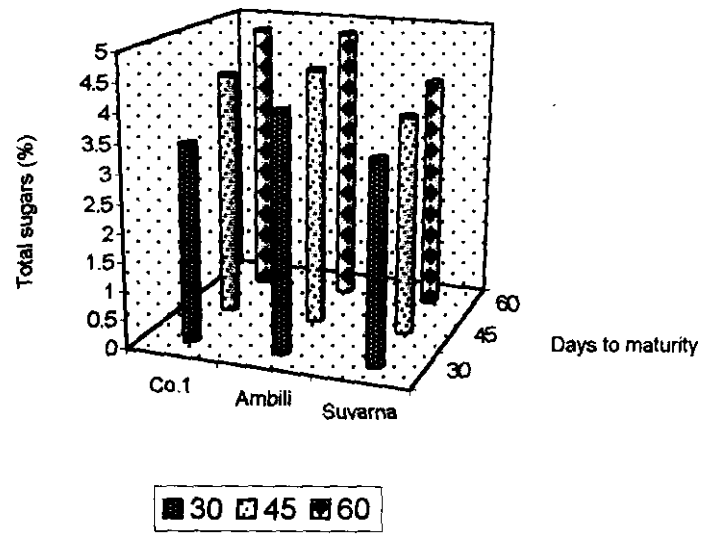


Fig. 7. Changes in total sugar content with maturity

ascorbic acid varies with the degree to which a fruit is exposed to sunlight (Kaur *et al.*, 1987; Nagi and Wardowski, 1988 and Shewfelt, 1990).

In the present study, content of ß carotene also varied significantly with varieties (Fig.8). As reported in Hindu (1999) Suvarna was observed to have a high ß carotene content. Hence this variety is highly preferable from nutritive point of view. Pumpkins are considered nutritively significant due to their high carotene content which acts as a precursor for vitamin A. Carotenoids also impart the characteristic colour to pumpkin fruits. The pulp of fruits of Suvarna had yellowish orange colour indicating its high carotene content (Plate 5). Sureshbabu *et al.* (1996) reported ß carotene content of pumpkin genotypes to range between 4.46 to 215.00 mg 100 g^{-1} of fruit. The present finding of variation in ß carotene is in confirmity with reports of Kubasaki and Walzek (1976) and Gopalakrishnan *et al.* (1980) in pumpkin.

Starch content was highest in Ambili and lowest in Co.1 in both seasons (Fig.9). The results of the study indicated variation in crude fibre content between pumpkin varieties (Fig.10), but the relative content in the varieties differed in the two seasons. The varietal variation in pumpkin genotypes with respect to crude fibre content had been reported by Teotia (1992).

Suvarna fruits had superior attributes like yellowish orange colour, high β carotene, TSS, acid and fairly high sugar content.

The varietal variation in chemical constituents of cucurbits have been reported by a number of workers (Thakur and Nandpuri (1974) in watermelon,

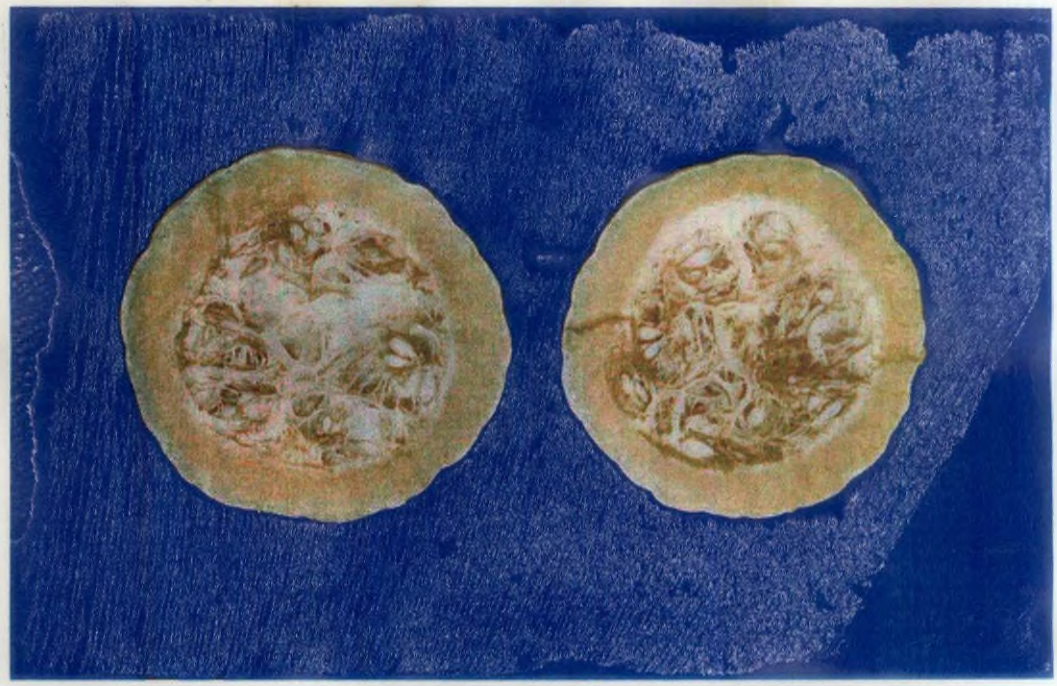


Plate 5. Fruit of Suvarna with yellowish orange flesh

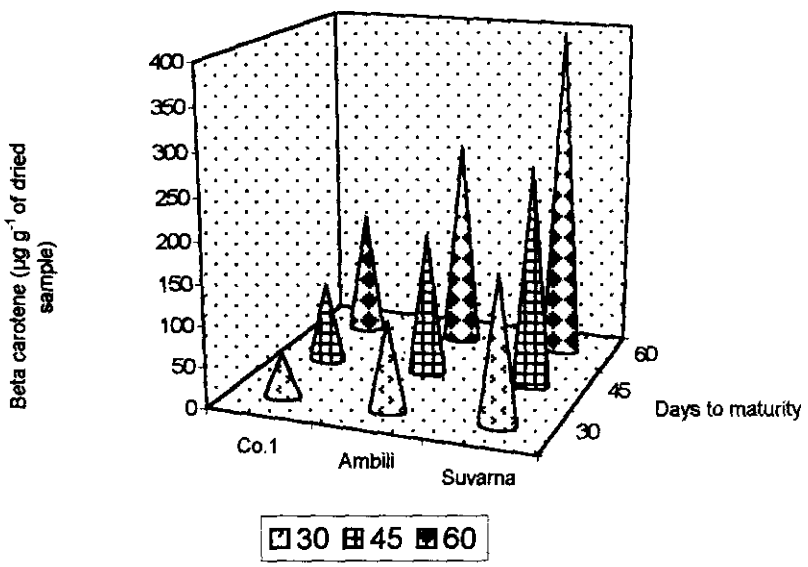


Fig. 8. Changes in beta carotene content with maturity

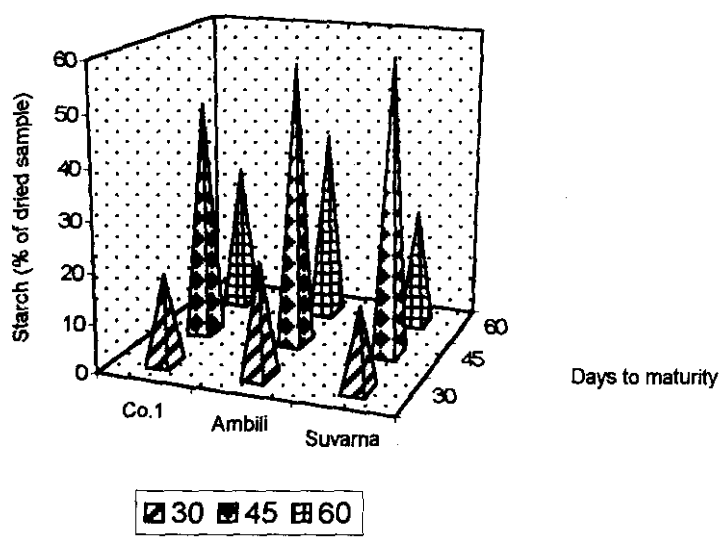


Fig. 9. Changes in starch content with maturity

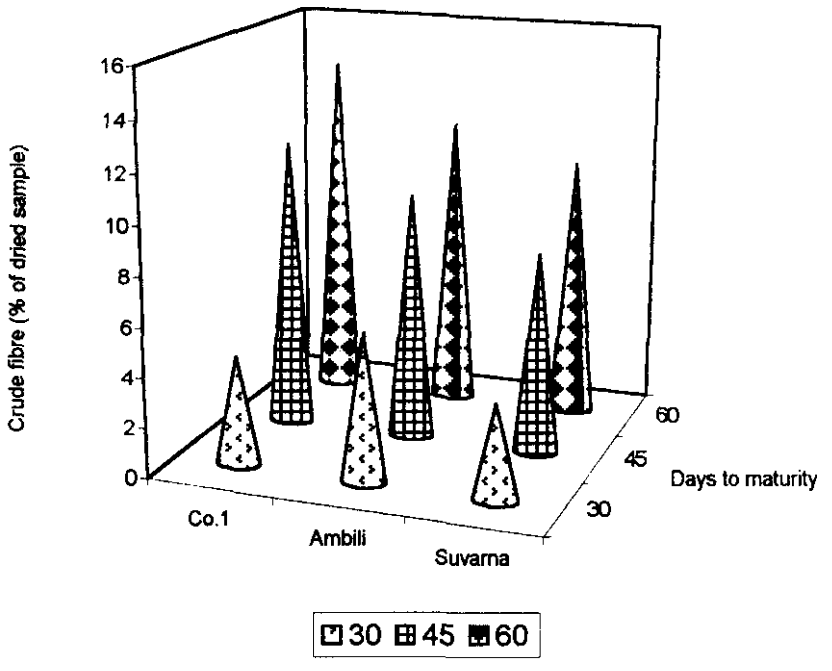


Fig. 10. Changes in crude fibre content with maturity

Kalyanasundaram (1976) in muskmelon, Joseph (1978) and Ramachandran (1978) in bittergourd, Kaur *et al.* (1987) and Vijay (1987) in muskmelon).

5.2.2 Harvest maturity and chemical constituents

TSS was observed to increase with maturity in all the varieties during both the seasons (Fig 6). Culpepper and Moon (1945) had observed an increase in TSS from the 30 day stage till the end of harvest in pumpkin fruits.

The present study is also in confirmity with the report of Teotia (1988) that a wide variation was observed in the ratio of total reducing sugar to non reducing sugar which was dependent on the cultivar and stage of maturity.

Acidity increased with maturity in the summer season (Fig.11) whereas no significant difference was observed in rainy season. Increase in acidity with advancement of maturity is in confirmity with results reported by Dubey and Gaur (1990) in kakrol. At 60 d.a.a. TSS was highest in Suvarna followed by Ambili. The high sugar and acid content at this stage might have contributed to the high TSS in these varieties. The increase in sugar and acid at later stages may be due to increased translocation of photosynthate from other parts of the plants towards the sink (Whiting, 1970).Similarly an increasing trend in ß carotene was also observed in the varieties with advancement of maturity. Hence harvesting the varieties at 60 d.a.a. stage not only provides maximum ß carotene but at this stage the fruit is rich in TSS, sugar and acid also. The increase in carotene content of vegetables with maturity have been reported by Phan and Hsu (1973), Fritz and Weichmann (1979) and Sheela (1998).

Ascorbic acid content in pumpkin fruits registered a decreasing trend during development (Fig.12). A reduction in ascorbic acid with advancing maturity was also observed by Bhatnagar and Sharma (1994) in bottlegourd. The starch content in pumpkin fruits showed an increasing trend up to 45 d.a.a. stage, thereafter which it declined. The breakdown of starch to sugar must have resulted in the decrease in content during the later stages. This is evident from the corresponding increase in total sugar content after 45 d.a.a. in all varieties except Co.1 in summer. Starch which is commonly found in fruit as a product of photosynthesis will be hydrolysed and converted to sugar (Gupta *et al.*, 1984).

The crude fibre content of pumpkin fruits were observed to increase with the advancement of age in the present study. Similar results were recorded by Culpepper and Moon (1945) and Rawat *et al.* (1979).

5.2.3 Source of nutrition and chemical constituents

Fertilizer do have an effect on the mineral composition of vegetables but their effects on the contents of vitamins, protein, fats, carbohydrates and other nutritional factors are much more complex, undoubtedly because of the masking effects of environmental and genetic factors.

In the present study organic fertilizers increased the TSS (Fig.13) and reducing sugar of the varieties in both the season. Similar result had been observed in brinjal also (Prasanna, 1998).

The acid content of fruits were not influenced by sources of nitrogen. A similar observation was made by Yoshida *et al.* (1984) and Prasanna (1998).

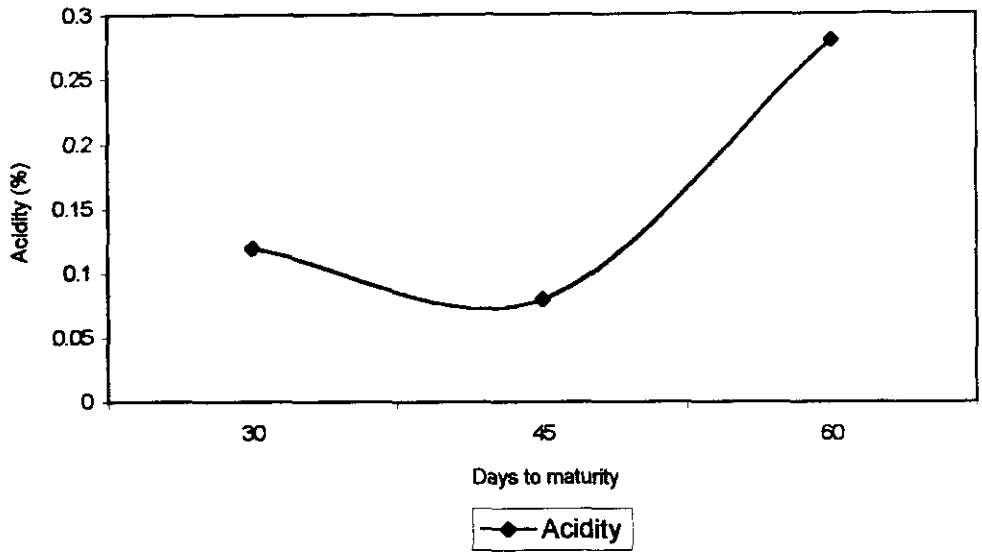


Fig. 11. Change in acid content with maturity in pumpkin

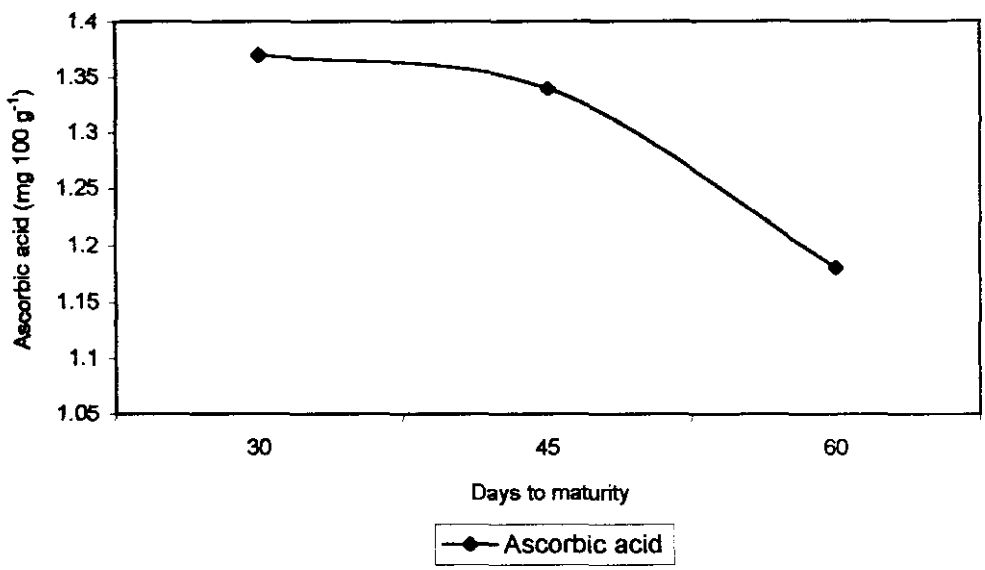


Fig. 12. Change in ascorbic acid content with maturity in pumpkin

Organic nutrition significantly increased the ß carotene content in all varieties in both stages (Fig.14). Composts and manures are known to contain many vitamins and have been reported to affect vitamin synthesis in certain plant parts (Maronick and Vasilehenko, 1964). The vitamin C content also was observed to increase with organic fertilization in summer (Fig.15).

The crude fibre content in tomato was observed to be significantly lower with organic fertilization (Fig.16). Hence it may be concluded that with respect to chemical constituents, organic fertilization was found to have a slight advantage over inorganic fertilization. It increased TSS, reducing sugars, vitamin C and ß carotene and decreased the crude fibre content.

In vegetables with fruits as harvested plant parts, long transport of photosynthates from leaves to the fruits is of high importance. In crops like cucumber growth of leaves and stem may compete with the reproductive organ for photosynthates. Such competitiveness may retard growth and development of fruits and impair quality. Hence in such crops the nitrogen supply should be gradual for development of the fruit. This gradual release is ensured when organic manures are supplied (Mengel, 1979). Improved fruit quality in terms of high TSS, reducing sugars, ascorbic acid and β carotene in organically raised pumpkin was observed due to better availability of nutrients at the time of fruit development. The better availability was ensured due to the slow release of nutrients from organic manures.

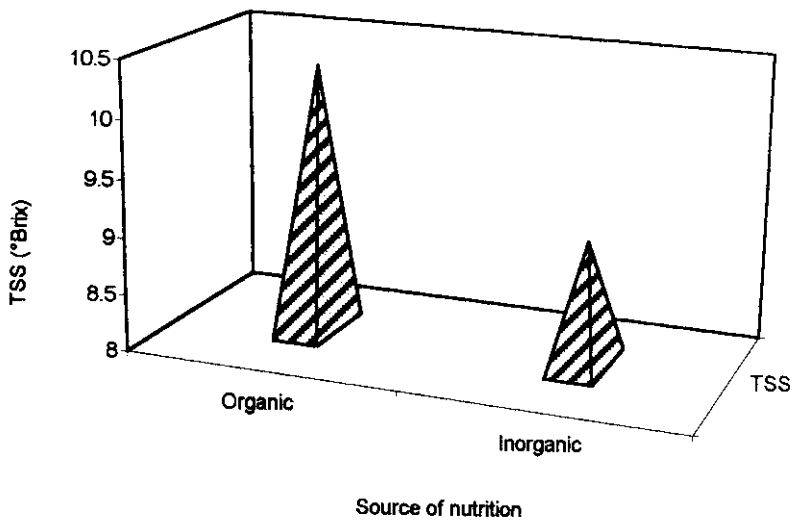


Fig. 13. Effect of source of nutrition on TSS content in pumpkin

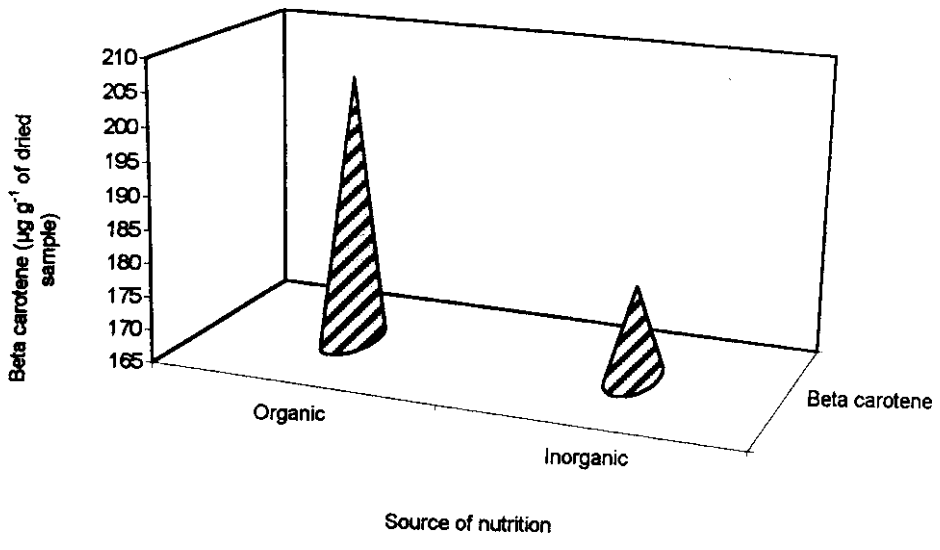


Fig. 14. Effect of source of nutrition on beta carotene content in pumpkin

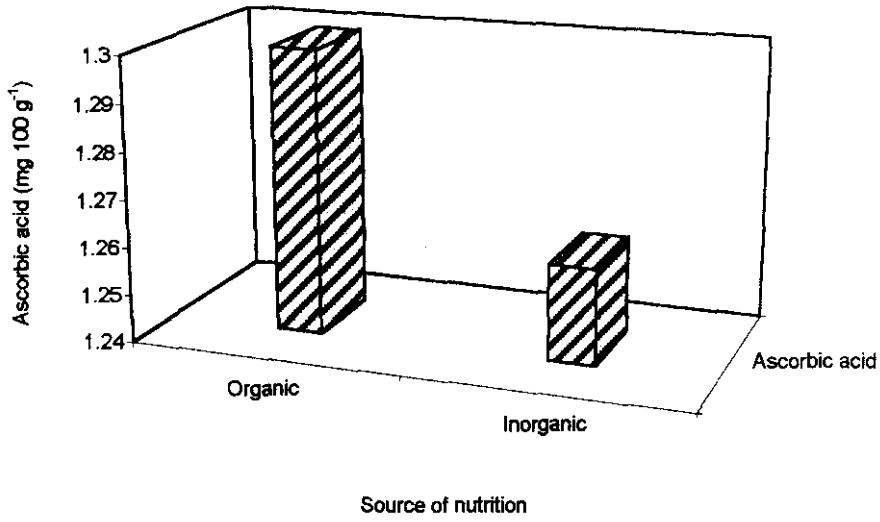


Fig. 15. Effect of source of nutrition on ascorbic acid content in pumpkin

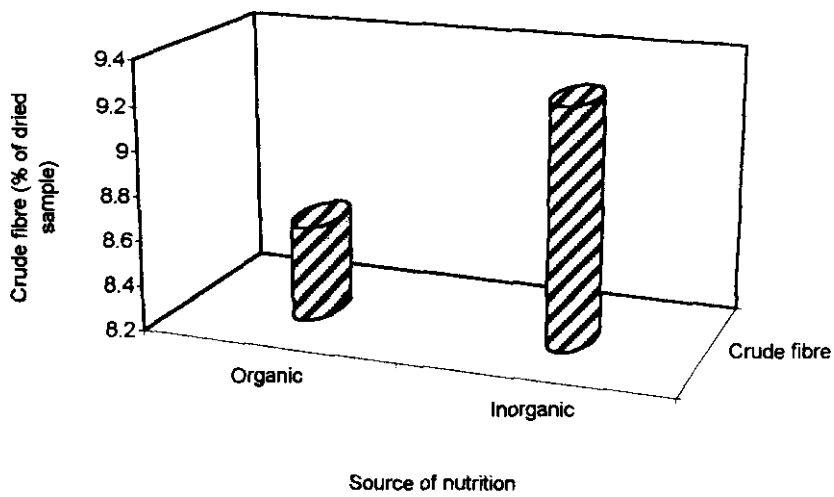


Fig. 16. Effect of source of nutrition on crude fibre content in pumpkin

5.3 Effect of variety, harvest maturity and source of nutrition on storage life of pumpkin fruits

5.3.1 Varietal variation in shelf life

In both the seasons variety Suvarna had a longer shelf life even though significant only in the rainy season (Fig.17). Fruits of Suvarna also exhibited low physiological loss in weight in both seasons which may have accounted for its extended shelf life. The minimum PLW on a per day basis was also observed in Suvarna. The shelf life of Suvarna was 80.22 days in summer season and 77.11 days in rainy season. Desai *et al* (1986) reported the shelf life of pumpkin to range between 24 to 36 days at 1.7 to 11.6°C and 70 to 75 per cent RH.

Varietal influence on storage behaviour have been reported by Teotia (1992) in pumpkin and Risse (1990) in watermelon. The shelf life of pumpkin was shorter in the rainy season as compared to summer season. Considerable rotting of fruits in storage was observed during rainy season, the spoilage was aggravated by the high humidity prevailing during that period due to continuous rains.

5.3.2 Shelf life and harvest maturity

Harvesting the fruits at 45 d.a.a. stage (M_2) enhanced the storage life of pumpkin fruits even though significant only in summer season (Fig.18).

The PLW of fruits were reduced considerably when the harvesting was delayed. The fruits harvested at M_1 (30 d.a.a.) showed considerable physiological loss in weight especially after third week of storage in Ambili (Fig. 19a, 19b, 19c). The influence of harvest maturity on shelf life of cucurbits were also reported by Kanellis (1986); Nerson (1995) and Neri and Brigati (1996).

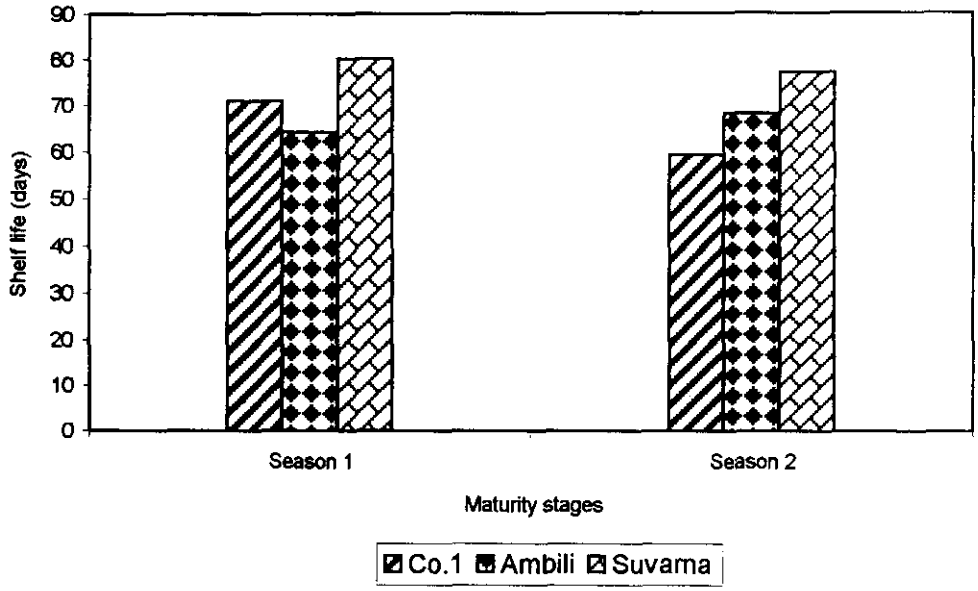


Fig. 17. Shelf life of three varieties of pumpkin

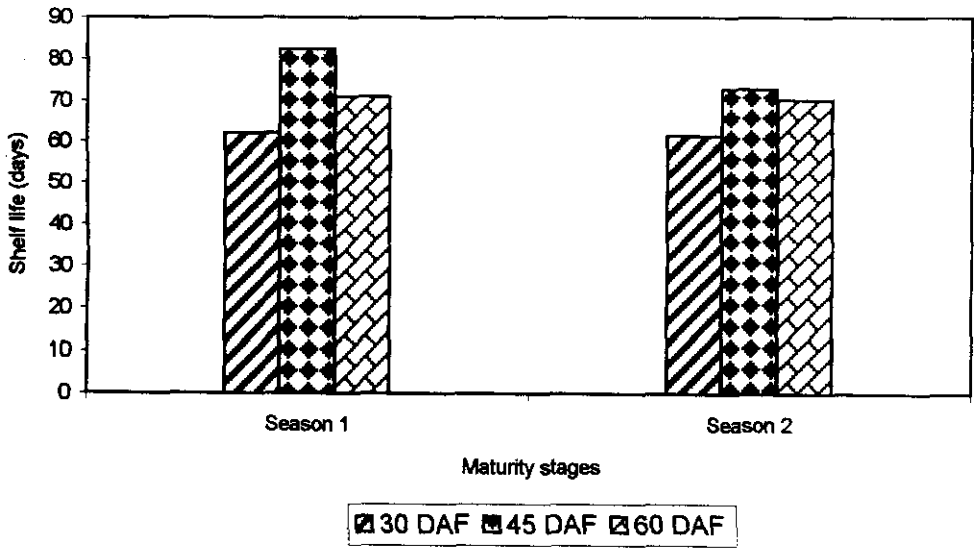


Fig. 18. Effect of harvest maturity on shelf life of pumpkin

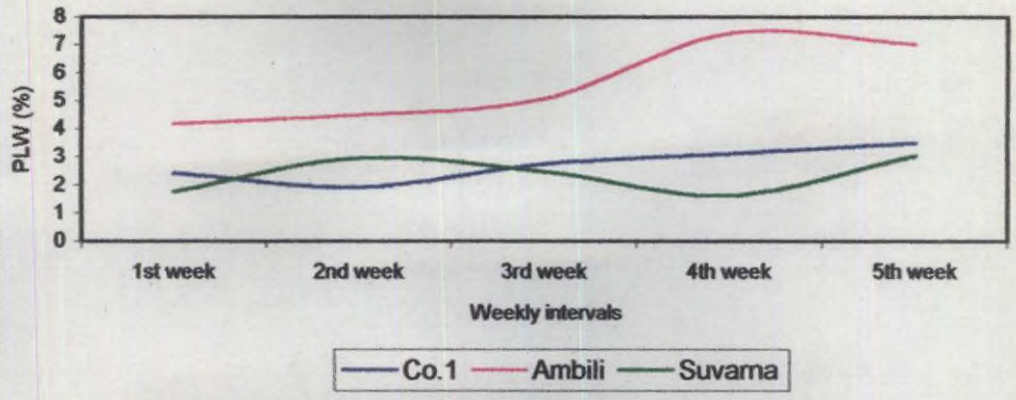


Fig. 19a. Physiological loss in weight at weekly intervals in pumpkin when harvested at 30 d.a.a.

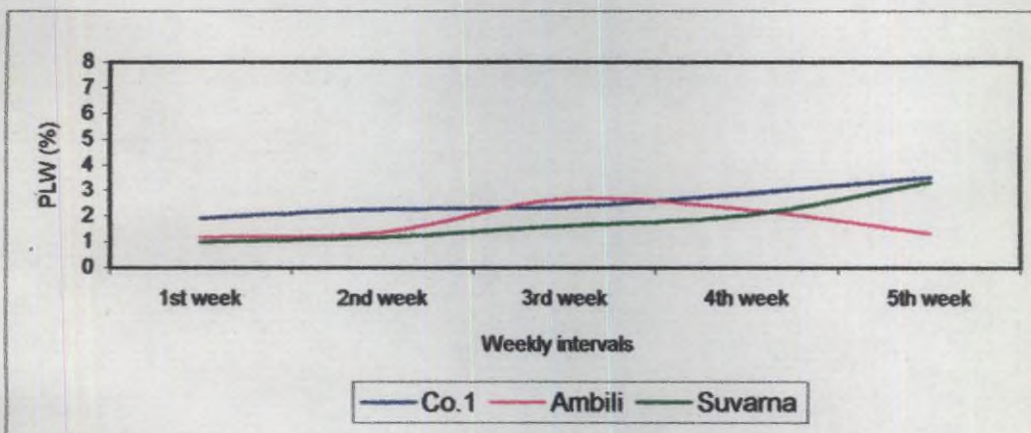


Fig. 19b. Physiological loss in weight at weekly intervals in pumpkin when harvested at 45 d.a.a.

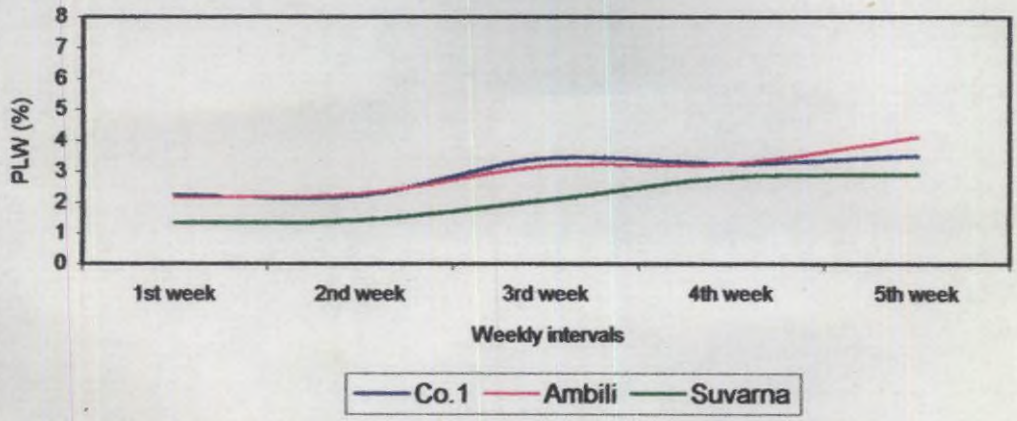


Fig. 19c. Physiological loss in weight at weekly intervals in pumpkin when harvested at 60 d.a.a.

Physiological maturity at harvest, structure of the peel and volume of intercellular spaces have influence on the respiratory activity of the produce to be stored (Desai *et al.*, 1986). Respiration rate per unit weight is highest for immature vegetable and then steadily declines with age. The storage life of produce is related to the rate of respiration. In general there is an inverse relation between respiration rate and storage life, so the produce with a low respiration rate generally keeps longer (Wills *et al.*, 1981). The high respiration rate might have resulted in high PLW in fruits harvested at 30 d.a.a.

Fruits of Ambili showed considerable reduction in PLW when harvested at M_2 stage which is an added advantage of harvesting Ambili at M_2 (45 d.a.a.) (Fig.19b). Effect of harvest maturity on shelf life has also been observed by Kaur *et al.* (1977), Kanellis *et al.* (1986), Joshi and Khandekar (1993), Nerson (1995) and Maw *et al.* (1997).

5.3.3 Shelf life and source of nutrition

Nutrition did not have much effect on shelf life of pumpkin fruits. But physiological loss in weight was minimum for fruits raised upon organic manures in both seasons. Rapid loss of harvested produce was seen in the case of fruits from plots supplied with inorganic fertilizer (Joseph, 1985 and Prasanna, 1998). Yano and Hayani (1976) and Vogtmann (1993) also had reported the effectiveness of organic N in extending shelf life of vegetables.

5.4 Sensory attributes

Organoleptic evaluation of fruits revealed that in general the sensory attributes like colour, flavour, texture and overall appearance was influenced by neither the maturity stage nor source of nutrition in varieties Co.1 and Suvarna.

In both seasons Ambili harvested at 45 d.a.a. had better colour, texture and overall appearance irrespective of the source of nutrition. The absence of influence of source of nutrition on colour has been reported by Miller *et al.* (1934) in carrots.

General Conclusion

The results of the present study has revealed that the source of nutrition had a significant impact on some of the physico-chemical constituents of pumpkin fruits. Inorganic nutrition had a favourable effect on physical composition of fruit. It increased flesh and decreased seed and placenta percentage. Fruit quality parameters like TSS, reducing sugars and β carotene was improved by application of organic fertilizers. Though the shelf life was not influenced by source of nutrition, PLW was the least in fruits raised organically.

In a fertile soil, the function of organic matter is both direct and indirect. The direct role is concerned with the provision of plant nutrients viz. the process of decomposition and mineralization, its indirect role is associated with its effect on the physico-chemical properties of the soil. Content of organic carbon, nitrogen, phosphorus and potassium is built up gradually in soil only through continuous application of organic manures (Yamada and Kamata, 1989 and Roe *et al.*, 1997). This is further supported by findings of Prasanna (1998) in brinjal. In the present study the crop was raised organically for two seasons only, a period too short to bring about a tremendous change in soil properties which in turn may alter the physico-chemical constituents of fruits. Conclusive results can be achieved only

through further studies including more sources of organic manures at different levels and through continuous application.

The present study also revealed that variety and harvest maturity had a profound influence on some quality attributes and shelf life of pumpkin.

Summary

6. SUMMARY

The present investigation on "Effect of harvest maturity on quality and shelf life of pumpkin" was conducted at the Department of Processing Technology, College of Horticulture, Kerala Agricultural University, during November 1999 to January 2001.

The study was conducted to determine the effect of two preharvest factors, maturity and source of nutrition, on quality and shelf life of three varieties of pumpkin viz., Co.1, Ambili and Suvarna.

The observations recorded in two seasons on physico-chemical attributes and shelf life were statistically analysed and the results are summarised below.

1. Varieties differed significantly between themselves in circumference, polar diameter, flesh thickness, cavity index and physical composition of fruits.
2. Ambili had the maximum flesh percentage and low waste index as indicated by the low seed and placenta percentage.
3. Physical parameters like fruit weight, polar diameter, circumference, flesh thickness and cavity volume increased with maturity.
4. The increase in flesh percentage with advancement of maturity was significant only in Co.1 and Suvarna.
5. Seed and placenta percentage decreased with the maturity of fruits while peel percentage remained constant throughout.

6. Variety Ambili attained maximum fruit weight at 45 d.a.a. and Suvarna at 60 d.a.a. in both seasons. The time taken to attain the maximum weight in Co.1 was 45 d.a.a. in Summer and 60 d.a.a. in rainy season.

7. Source of nutrition did not have any significant effect on parameters like fruit weight, circumference, polar diameter, cavity volume, cavity index and peel percentage.

8. Inorganic nutrition had favourable effect on physical composition of fruit. It increased flesh percentage and decreased the seed and placenta percentage.

9. Varieties showed significant variation in contents of TSS, sugars, ascorbic acid, acidity, β-carotene, starch and crude fibre.

10. Varieties Ambili and Suvarna had significantly higher TSS than Co.1.

11. The β-carotene content of variety Suvarna was significantly higher (200.17 $\mu g\ g^{-1}$ and 283.33 $\mu g\ g^{-1}$ of dried sample in S_1 and S_2 respectively) than Co.1 and Ambili.

12. Variety Ambili had a higher starch content (38.90% and 38.79% in S_1 and S_2 respectively) than Suvarna and Co.1.

13. TSS, total sugar, acidity, β-carotene and crude fibre content showed an increasing trend with maturity.

14. An initial increase in starch content with a subsequent decrease at 45 d.a.a. was observed in all varieties.

15. Source of nutrition did not affect constituents like starch and acidity.

16. Organic nutrition increased TSS, reducing sugars, β-carotene and decreased the crude fibre content over inorganic nutrition.

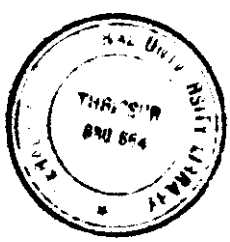
17. Physiological loss in weight was minimum for Suvarna in both seasons, which accounted for its longer shelf life (80.22 days in summer and 77.11 days in rainy season) than the other two varieties.

18. Harvesting the fruits at 30 d.a.a. increased the PLW significantly in all the varieties.

19. In general fruits harvested at 45 d.a.a. had longer shelf life in both seasons.

20. Source of nutrition did not have any effect on shelf life. But the PLW was considerably reduced during the later stages of storage when organic nutrition was provided.

21. In general the sensory attributes of fruits were not affected by harvest maturity or source of nutrition. But Ambili fruits harvested at 45 d.a.a. had better colour, texture and overall appearance.



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Appendix

APPENDIX

Weather Data

Period	Mean maximum temperature (°C)	Mean minimum temperature (°C)	Relative humidity (%)	Rainfall (mm)
November 1999	31.4	22.7	69	9.1
December 1999	30.7	22.7	60	0.0
January 2000	32.9	23.2	60	0.0
February 2000	33.3	22.8	67	4.6
March 2000	35.6	23.9	67	0.0
April 2000	34.0	24.6	74	67.9
May 2000	33.7	24.4	72	117.2
June 2000	29.6	22.8	86	602.0
July 2000	28.8	21.9	82	354.0
August 2000	29.1	22.6	87	518.8
September 2000	30.7	23.4	81	198.1
October 2000	30.7	23.2	80	262.2
November 2000	33.3	22.7	66	41.3
December 2000	30.4	22.7	59	11.2
January 2001	32.6	23.2	56	0.0

EFFECT OF HARVEST MATURITY ON QUALITY AND SHELF LIFE OF PUMPKIN (*Cucurbita moschata* Poir.)

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ABSTRACT OF THE THESIS

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ABSTRACT

The research project "Effect of harvest maturity on quality and shelf life of pumpkin (*Cucurbita moschata* Poir)" was carried out at the Department of Processing Technology, College of Horticulture, Kerala Agricultural University, Thrissur during the period November 1999 to January 2001.

The major objective was to study the effect of harvest maturity in relation to source of nutrition on the physico-chemical constituents and shelf life of three varieties of pumpkin viz., Co.1, Ambili and Suvarna.

The observations revealed that the varieties differed significantly in physical attributes like circumference, polar diameter, flesh thickness, cavity index and physical composition. Varieties also showed significant variation in content of TSS, sugar, ascorbic acid, β carotene, starch and crude fibre.

Ambili had the ideal characteristics required of a pumpkin variety viz., early maturity, high flesh recovery and low seed and placenta per cent and hence a low waste index. Suvarna had better nutritional and processing attributes as indicated by yellowish orange colour, high β carotene, TSS and acidity.

The physical parameters like fruit weight, polar diameter, circumference, flesh thickness and cavity volume showed an increasing trend while seed and placenta percentage showed a decreasing trend with maturity. Chemical constituents like TSS, total sugars, acidity, β carotene and crude fibre increased with maturity while starch declined after reaching a maximum value at 45 days

after anthesis (d.a.a.). Fruits harvested at 45 d.a.a. had longer shelf life. The physiological loss in weight was maximum when fruits were harvested at 30 d.a.a.

Fruits of variety Ambili can be harvested 45 days after anthesis for better fruit weight, maximum flesh thickness, sensory quality and less PLW in storage. The optimum maturity for harvest of variety Suvarna is 60 days after anthesis in both seasons for maximum fruit weight, β carotene, TSS, total sugars and longer shelf life. For economic yield Co.1 should be harvested at 45 d.a.a. in summer and 60 d.a.a. in rainy season. However in all the varieties an improvement in quality of fruits as evidenced by high β carotene, TSS, total sugars and acidity was observed when harvest was delayed upto 60 days after anthesis.

Inorganic nutrition had a favourable effect on physical composition of fruits while organic nutrition improved the quality by increasing TSS, reducing sugars, β carotene and decreasing crude fibre content.