PRE AND POSTHARVEST TREATMENTS ON STORAGE LIFE AND QUALITY OF FRESH AND DRIED BITTERGOURD
(Momordica charantia L.)

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "**Pre and postharvest treatments on storage life and quality of fresh and dried bittergourd** (*Momordica charantia* L.)" is a bonafide record of research work done by me during the course of research and that this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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9th-Oct-1992.

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CERTIFICATE

Certified that this thesis entitled "Pre and postharvest treatments on storage life and quality of fresh and dried bittergourd (*Momordica charantia* L.)" is a record of research work done independently by Ms. Veenakumari, D. 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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CERTIFICATE

We, the undersigned members of the Advisory Committee of **Ms. Veenakumari, D.**, a candidate for the degree of Master of Science in Horticulture with Major in Processing Technology agree that the thesis entitled **"Pre and postharvest treatments on storage life and quality of fresh and dried bittergourd (*Momordica charantia* L.)"** may be submitted by Ms. Veenakumari, D. in partial fulfilment of the requirement for the degree.

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Veenakumari, D.

To my parents

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Introduction

INTRODUCTION

Bittergourd occupies a prominent position among the vegetables grown in India. It is believed to have originated in the tropical regions of the Old World and is widely distributed in India, China, Malaysia and Tropical Africa (Shanmughavelu, 1989). Bittergourd is a vegetable of choice to keralites on account of its high iron content. The importance of bittergourd has long been recognised due to its nutritive value and medicinal properties. The nutritive status of bittergourd is as follows, 83.2 g moisture, 2.1 g protein, 1.0 g fat, 1.41 g minerals, 1.7 g fibre, 10.6 g carbohydrate, 60 K calories of energy, 23.0 mg calcium, 38.0 mg phosphorus, 2.0 mg iron, 126 mg carotene, 0.07 mg thiamine, 0.09 mg riboflavin, 0.5 mg niacin and 88.0 mg ascorbic acid per 100 g edible portion (Gopalan et al., 1982). Fruits are used as a remedy for diabetes and for skin and lever troubles (Nadkurni, 1954). It is also reported to possess cooling, stomachic, appetising, carminative, antipyretic, antihelminthic, aphrodisiac and vermifuge properties (Blatter et al., 1935; Chaudhury, 1967).

The fruits contain two alkaloids viz., momordicine and cucurbitacine. The former is more specific to bittergourd while the latter occur in other genera of cucurbitaceae (Anon, 1962).

Although fruits are bitter, they are wholesome and esteemed as a vegetable when tender or pickled. It can also be preserved for later use in the form of dried slices. Because of these unique qualities there is always a consumer preference for this vegetable, moreover bittergourd is also exported to foreign countries and stands third after onion and okra (Anon, 1992).

Major problem associated with bittergourd is the highly perishable nature of the fresh fruits resulting in produce loss in large quantities during transit and marketing. Any effort, therefore, to reduce the postharvest loss in bittergourd is as important as the improvement of the production technology. This also will add to much needed foreign exchange earnings by promoting exports.

Crop nutrition is one of the preharvest factors influencing the quality and storage behaviour of fruits and vegetables (Pantastico, 1975). Negative influence of excessive dose of fertilizers on the storage life of produce has become a matter of serious concern to farmers, traders and consumers. At the same time methods to improve shelf life of fruits and vegetables through various methods like use of growth regulating chemicals either before or after harvest are also being tried. The enhanced storage life of fresh fruits and vegetables as a result of application of growth regulators and other chemicals have been proved in many horticultural crops. But such trials are not reported in bittergourd.

The only processed form of bittergourd is the sundried slices which is hot oil fried and consumed as a side dish along with rice meals. No standardisation has been done in this line of processing of bittergourd.

During the present investigation, influence of different pre and postharvest treatments on the storage life and quality of fresh bittergourd (Momordica charantia L.) was studied. Further, standardisation of present technology of processing of bittergourd was also done. The objectives of the investigations were:

1. To study the effect of organic and inorganic sources of nitrogen on shelf life of fresh fruits of bittergourd.

2. To study the effect of preharvest sprays of growth regulators on shelf life of bittergourd fruits.

3. To study the effect of postharvest treatments on shelf life of bittergourd fruits.

4. To standardise drying technique(s) suitable for bittergourd.

5. To study the storage behaviour of dehydrated bittergourd in selected packaging.

Review of Literature

REVIEW OF LITERATURE

Several methods have been tried to improve the storage life of perishables. Some of them are, using the most appropriate combination of organic and inorganic sources of plant nutrients, pre or postharvest application of different growth regulating chemicals and storage under controlled atmospheric conditions. Processing into value added products with long storage life is the other method of utilization of fresh produce. Most of the studies on these aspects were concentrated on fruit crops and so literature on postharvest technology of vegetables is comparatively limited. The available literature is reviewed here under the following titles:

2.1 Effect of manures and fertilizers on postharvest life and quality.

2.2 Effect of growth regulators on storage life and quality.

2.3 Effect of pretreatments on the quality of dehydrated vegetables.

2.4 Packaging of dehydrated products.

2.1 Effect of manures and fertilizers on postharvest life and quality

2.1.1 Storage life

Reports available propose diverging results with regard to the effect of fertilizers on the storage life of fruits and vegetables.

In tomato, lack of potassium produced firmer fruits which softened more rapidly in storage (Beaumont and Chandler, 1933). Maiwald (1942) conducted experiments to test the effect of fertilizers on the storage life of potatoes, beets and onion and obtained inconsistent results. Elliot (1956) reported that tomatoes grown in soil-less plots receiving all nutrients in the inorganic form were more nutritious, had less disease and kept better than the tomatoes grown under standard conditions.

Singh and Kumar (1969) found that rotting, sprouting and weight losses were higher in onions grown at 112 kg N ha^{-1}, whereas keeping quality was improved by higher P level (50 kg ha^{-1}). Basoccu and Liuzzo (1970) conducted trials with 320 kg ha^{-1} P_2O_5 and K_2O each to study their effect on quality and storage life of celery. The results did not indicate any suitable fertilizer formula.

Qureshi et al. (1972) found that storage life of tomato was reduced by increasing doses of N. In cabbage application of 120 kg P_2O_5 together with 240 kg K_2O ha^{-1} improved the storability. Sypien et al. (1973) observed that medium level of N (150 kg ha^{-1}) gave maximum storage life in onion. In onion, N application had no effect on keeping quality during storage at

-1°C to +2°C, whereas N application increased sprouting during storage at 12 to 14°C (Henricksen, 1984).

Bhatnagar et al. (1985) observed that higher level of N (120 kg ha^{-1}) with low irrigation in tomato gave fruits with longest shelf life. These fruits kept best for about 10 days at room temperature and 20 days at 5°C. Joseph (1985) studied the influence of major nutrients on the storage life of oriental pickling melon (Cucumis melo var conomon L.) and reported increased degree of rotting in treatments which received inorganic form of N, P and K. The organic form of manures showed a definite advantage over inorganic fertilizers in respect of storage life of fruits.

Kato et al. (1987) observed increased rotting of onion bulbs stored under room conditions with increasing application of nitrogenous fertilizers. Rao and Srinivas (1990) found significant difference in the storage behaviour of onion with respect to bulb firmness, total soluble solids and sugars with the application of graded levels of nitrogen. Nitrogen significantly decreased the dry matter, increased the average weight and yield of the bulb; but there was no change in weight loss during storage. Rotting and sprouting were higher (31.14 per cent and 7.59 per cent after 6 months of storage) with N 200 kg ha^{-1}, which reduced the storability. Storage loss was 56.65 per cent and 62.1 per cent respectively with N 160 and 200 kg ha^{-1} after 6 months of storage.

2.1.2 Quality

It was observed that levels of N applied had little effect on ascorbic acid content of peas (Wilcox and Morrel, 1948) and tomato (Dastane et al., 1963). However, a reduction in ascorbic acid under high N level was reported by Anisimov (1953) in onion tops, cress leaves and pea leaves. Singh (1957) found that application of sulphate of ammonia alone or in combination with FYM to onion did not affect storage quality. Schremer and Warner (1957) reported that in vegetables N had negative effect while K had pronounced positive effect and P did not affect vitamin C content. In irrigated cucumber NPK application improved dry matter and vitamin C contents (Bolotaskish, 1969).

High rates of N increased ascorbic acid content in cabbages (Largskij, 1969). However he did not observe any effect of N on the ascorbic acid content in cucurbits. Gnanakumari and Satyanarayana (1971) studied the effect of graded levels of NPK fertilizers on the composition of brinjal var. Pusa Purple Long. Vitamin C content was maximum in the fruits from the treatment that received all the major three nutrients at the rate of 280 kg ha^{-1}. In cucumber N rates above 60 kg ha^{-1} inhibited ascorbic acid accumulation, whereas higher P rates enhanced it (Largskii, 1971). According to Roy and Seth (1971) vitamin C content of radish increased significantly with the application of fertilizers. P and K levels had a significant positive effect whereas effect of N was insignificant. Sharma and Mann (1971) reported an increase in ascorbic acid content of tomato fruits by the application of nitrogenous and phosphatic fertilizers. Lachover (1972) found that application of K greatly increased yield and quality in potted tomato plants.

Tseng (1972) observed that storage quality of onion bulb was improved by potassic fertilizers. In carrot, fertilizers had only a slight effect on the nutritional value of the roots (Adrianov, 1973). Summarising a three years manurial trial in leek, Kolota (1973) reported that N and P reduced the leek vitamin C content whereas K increased it. Sypien et al. (1973) reported best bulb quality in onion with the application of 150 kg N ha^{-1} before sowing.

In a twelve year experiment with vegetables during 1960-1972, Schuphan (1974) observed that organically grown spinach, celeriac, savoy cabbage, carrots and lettuce had high drymatter, relative protein, ascorbic acid, total sugars, K, Ca, P and Fe contents, lower nitrate, free amino acids and sodium contents. Tolkynbaev (1974) recorded that tomatoes grown with the application of 20 t FYM and 120 kg N, 150 kg P_2O_5 and 60 kg K_2O ha^{-1} produced fruits with the highest content of ascorbic acid (26.5 mg/100 g). When the N content was raised from 120 kg to 180 kg ha^{-1}, the ascorbic acid was decreased by 2.6 mg.

Randhawa and Bhail (1976) found that increased N application significantly increased the ascorbic acid content in cauliflower. In cucumber vitamin C content rose with increasing NPK rates (Krynska et al., 1976). According to Feher (1979) increasing K level had a favourable effect on tomato fruit quality in terms of refractive index, sugar and acid contents whereas vitamin C content was not affected by nutrient levels. Results of a leaf analysis in tomato by Genechev et al. (1979) showed that high N and Ca levels promoted chlorophyll a chlorophyll b and carotenoid accumulation whereas high P and S reduced them. Pandita and Bhatnagar (1981) observed that, the T.S.S. juice and ascorbic acid content were higher in tomato fruits from plants received 120 kg N and 90 kg P_2O_5 ha^{-1}. Bubiez et al. (1981) opined that in capsicum fruits highest content of ascorbic acid and capsaicin were in plants that received K_2O at the rate of 180 kg ha^{-1}. In spinach grown on sandy loam soil, the highest yield and ascorbic acid content were in response to the application of a higher dose of 90 kg ha^{-1} N and 20 t ha^{-1} FYM (Kansal et al. 1981). Shinohara and Suzuki (1981) opined that ascorbic acid and sugar content of spinach leaves were higher in plants grown in quarter strength of standard nutrient solutions. Subbiah and Ramanathan (1982) found that added N enhanced crude protein and carotene contents while it decreased the ascorbic acid content in amaranthus. Added K had no marked effect on carotene and ascorbic acid content.

Joseph (1985) reported that in oriental pickling melon maximum vitamin C content was found in fruits that received the standard dose of major nutrients in the inorganic form. Irrespective of fertiliser treatments vitamin C content of the fruits decreased constantly with increasing periods of storage. Maximum T.S.S. of 3.54° Bx was recorded in the treatment which received the highest dose of major nutrients completely through inorganic form. T.S.S. increased during storage upto three months and then slightly declined. In radish, root ascorbic acid content was highest at the lowest N and highest P rates (Joshi and Patil, 1988).

Zhang *et al*. (1988) found that, the combined use of N with phosphatic and potassic fertilizers or with soybean meals supplied the nutrients in balanced manner to tomato and resulted in better fruit quality rather than the application of nitrogenous fertilizers alone. According to Abusaleha and Shanmugavelu (1988) combination of organic and inorganic fertilizers at higher levels increased the ascorbic acid content of okra. The fruits of the plants applied with inorganic form alone recorded the lowest ascorbic acid content compared with plants supplied with organic form of manures Shanthi and Balakrishnan (1989) reported higher ascorbic acid content (10.37 mg/100 g), total sugars (4.93 per cent) and T.S.S. (14.62 per cent) in onion plants that received N 90 kg ha^{-1}.

2.2 Effect of growth regulators on quality and storage life

2.2.1 Gibberellic acid (GA)

Gibberellins have been recognised as a natural growth substance in higher plants and it is generally agreed that these substances are likely to play direct or indirect roles in almost every physiological process of plants. A significant increase in the ascorbic acid content of tomato fruits was reported with GA spray at 50 ppm (Srivastava and Srivastava, 1964). Similar results were reported by Oza and Rangnekar (1969) in tomato. They also observed that GA applied at fruit setting stage resulted in accumulation of significantly more ascorbic acid than when applied at the bud and flowering stages.

In fruits of Early Pak No.7 and Ace varieties of tomato, postharvest dip treatment of GA (10 to 100 ppm) retarded ripening and extended storage life (Kader et al., 1966). Dostal and Leopold (1967) found that mature green fruits of tomato when dipped into solutions of 10^{-4} M GA retarded the development of red colour and delayed the rise in carotenoid level. Chlorophyll content remained high when GA was applied at 10^{-7} M and GA prevented any rise in lycopene content. Tagmazjan (1968) reported that the cucumber plants treated with 0.002 per cent GA together with NPK fertilisation showed less sugar and vitamin C content and enhanced flowering. Contrary to this, gibberellin delayed the appearance of female flowers and reduced their number in glass house cucumber (Stambera and Zeman, 1969).

Chauhan and Singh (1970) observed that foliar spraying of GA 15 ppm at two and three weeks after transplanting produced an early and high yield with good quality cabbage. GA accelerated ripening in tomato fruits by two and three weeks in plants grown at high temperature regime (35°C day and 25°C night) and normal temperature regime (22°C day and 18°C) respectively (Abdalla and Verkerk, 1970).

Herregods (1971) reported that spraying brussel sprouts and leeks one week before harvest with GA 100 ppm extended their shelf life upto 9 to 10 days from seven days. They also reported that preharvest spray and postharvest immersion with GA delayed colouration at 14°C by eight and two days respectively in tomato. GA reduced the leaf chlorophyll content in cucumber plants (Sedlovskii, 1972).

Irulappan (1972) studied the effect of different growth regulators in tomato and reported that GA 200 ppm increased the ascorbic acid content of fruits by 27 per cent. Fruits treated with GA (100/200 ppm) started to show symptoms of spoilage on twelfth day and these fruits lost their lustre, market appearance and were spoiled mainly due to shrinkage only on fourteenth day, as compared to eight days in control at room temperature. Under cold storage condition GA treated fruits had 30 to 35 days storage life whereas control had acceptability only upto 20 to 30 days. It was also found that GA increased the chlorophyll content of fruits by 20 per cent.

Postharvest dip treatment of okra var. Pusa Sawani with GA at 100 or 250 ppm and subsequent polythene packaging and storing at room temperature gave nine days storage life (Singh and Dhankar, 1980). In tomato GA 5 ppm as seedling treatment enhanced the quality of fruits (Mohan and Sinha, 1988).

2.2.2 Cycocel (CCC)

Dichloro ethyl trimethyl ammonium chloride an analogue of choline is also known as chlormequat or chlorocholine chloride which is abbreviated as CCC. The action of CCC is apparently antagonistic to that of gibberellines i.e., this compound shortens stem elongation.

Abdalla and Verkerk (1970) observed that CCC treated tomato plants had dark green leaves. CCC inhibited chlorophyll degradation and carotenoid formation in ripening tomato and red pepper fruits (Kamienska and Chrominski, 1971). Irulappan (1972) reported that the shelf life of tomato was doubled by postharvest dips in CCC.

In an experiment CCC improved tomato fruit quality at 500 to 1500 ppm (Metwally et al., 1979). Postharvest dip treatment of okra fruits in 100 ppm CCC gave three days shelf life at room temperature and 12 days at 10°C (Singh et al., 1979). Chlormequat 2000 ppm treatment gave the best overall fruit quality in tomato (Fonseca et al., 1980).

In a study Grape Var Perlette were given preharvest dip treatment with CCC and it was observed that with 2000 ppm CCC physiological loss in weight was only 6.11 per cent after 35 days in cold storage. This treatment also controlled berry rot and berry shatter during storage (Kalhon and Dhillon, 1980).

2.2.3 Maleic hydrazide (MH)

Maleic hydrazide (MH) is a plant growth regulator which has wide practical utility. Schoene and Hoffman (1949) was the first to report the inhibitory effect of MH on plant growth.

The greatest practical use of MH lies in its property to prolong the storage life of many food crops. This property of the chemical has extensively been studied and reported by many workers. Zukel (1950) reported the inhibitory effect of MH on potato tubers under storage. He found that high concentration of MH upto 0.3 per cent inhibited sprouting of tubers at room temperature for over five months. In the following years several workers produced evidence on the effectiveness of this chemical in inhibiting the sprouting of potato tubers in storage. Kennedy and Smith (1951 and 1953) obtained considerable reduction in sprouting of tubers when the vines were sprayed with MH, six to ten weeks before harvest. Chaudhary and Bhatnagar (1954) in their studies in radish found that water holding capacity of roots was increased by treating the crop with MH, thereby improving their keeping quality.

Rakitin *et al*. (1973) reported improved storability of onion bulbs by preharvest application of 30 per cent MH-D or 40 to 80 per cent MH-Na preparations. These treatments inhibited bulb sprouting and bulb water loss during storage. Being nontoxic to man, sodium salt of MH was recommended.

In carrots preharvest spraying of MH or postharvest immersion in solutions of MH inhibited both sprouting and rooting during storage at 0°C, compared with water dipped or untreated control (Rahman and Isenberg, 1974). Respiration rate of MH treated plants were lower, especially at high temperature, despite the absence of visible sprouting (Tucker, 1974).

Omar and Arafa (1979) found that MH at 2500 and 5000 ppm inhibited sprouting of garlic in storage upto 300 days in both seasons. These treatments reduced bulb weight loss during storage. In three years trial with the onion cv. Stuttgart Giant, the plants were treated with MH at 0.35 to 0.7 per cent, 15 to 18 days before harvest. The least sprouting during storage was in onion treated with MH at 0.43 per cent. With this treatment storage losses were 11.5 per cent after 330 days whereas in control losses amounted to 21.6 per cent (Iordachescu and Mihailescu, 1980).

Kaynas and Ertan (1983) observed that MH at 500, 1000 and 2500 ppm as both pre and postharvest application was effective in extending the storage life by preventing sprouting in onion bulbs. In onion, cholinic salt of MH at 0.2 to 0.4 per cent applied 20 days before harvest reduced storage losses by 32.5 to 45.9 per cent (Rojancovschi and Mihailescu, 1984). Sinclair (1985) reported that spraying of potassium salt of MH at the rate of 14 l ha^{-1} three weeks before harvest, reduced the incidence of clove rotting in garlic from 33 per cent in control to five per cent. Moreover sprouting of cloves were completely controlled compared to 52 per cent in control.

In trials with nutrients, spacing and MH in onion, Shanthi and Balakrishnan (1989) concluded that the lowest storage losses in terms of sprouting, rotting, rooting and weight loss were obtained by MH at 2000 ppm. They also reported that MH treatment improved quality parameters like TSS, total sugars, ascorbic acid, volatile oil and sulphur content. Similar results were obtained by Kulwal et al. (1989). In potato crop also reduction in storage loss was reported by MH treatment. The tubers of crop sprayed with 0.3 per cent MH two weeks before harvesting had significantly less sprouting than those of untreated control under both low temperature and at room temperature (Kaul and Mehta, 1991).

2.2.4 Calcium chloride ($CaCl_2$)

The importance of calcium in the regulation of fruit ripening and vegetable maturation is well established (Ferguson, 1984; Pooviah, 1986). Calcium have been shown to inhibit specific aspects of abnormal senescence in numerous fruits and vegetables (Pooviah, 1986). There has been extensive research on the use of calcium to delay ripening of various fruits. However, little attention has been given on the effect of calcium on the storage life of vegetables and practically no work on bittergourd is reported.

Wills et al. (1977) reported a delay in ripening of tomato fruits by vacuum infilterating green tomato fruits with 8 to 12 per cent $CaCl_2$ solution at 50 to 550 mg Hg. They observed that the normal Ca content of 11 mg/100 g fresh weight had to be increased to 40 mg/100 g fresh weight for ripening to be appreciably delayed.

Calcium has been associated with many deficiency disorders and some of these disorders such as blossom end rot of tomatoes can be readily eliminated by the application of calcium salts to fruits, either as preharvest sprays or as postharvest dipping at sub-atmospheric pressures (Wills et al., 1989). Calcium binds with pectic substances in the middle lamella and with membranes generally and may strengthen the structural components of cell wall. Calcium has been shown to affect the activity of many enzyme systems and metabolic sequence in plant tissues. The addition of calcium to intact fruit or fruit slices generally suppresses respiration, depending on the concentration used. Calcium is needed for the activity of exopolygalacturonase, kinases and range of other enzymes. The ability of calcium to regulate these various systems has led to the speculation that Ca may have a role in the initiation of normal fruit ripening process (Wills et al., 1989).

2.3 Effect of pretreatment on the quality of dehydrated vegetables

2.3.1 Effect of blanching on quality

Blanching can cause an increased crystallinity of the cellulose in the product. Blanching or scalding of vegetables for a few minutes in boiling water or steam serve as an additional cleaning operation. By this the properties of the final product are improved and inactivation of enzymes takes place (Salunkhe et al., 1976).

Blanching time of different vegetable in different blanching media were determined by Tandon and Virmani (1949). They reported that, for bittergourd, blanching in boiling water will inactivate catalase and peroxidase enzymes. When water at 200°F was used for blanching, three minutes blanching was needed. Kuppuswamy and Rao (1970) conducted studies on dehydration of green peas and revealed that blanching time vary with type of blanching. A four minute blanching in water containing preservatives had a favourable effect from the point of view of reduction in cooking time. But further increase in time made the product mushy after reconstitution. In steam blanching three minutes was found to be the optimal time.

Ratnatunga *et al*. (1978) reported that spinach blanched by hot gas retained 34 mg per cent ascorbic acid as compared to 21 mg per cent by hot water blanching. Luhadiya and Kulkarni (1978) studied the effect of pretreatments on the quality of dehydrated chillies and found that drying time decreased from 12 h in unblanched to 10 h in blanched sample. Unblanched chillies were yellowish green whereas blanched product were brownish green. Both dehydration ratio and rehydration ratio were increased by blanching. Chlorophyll content was also more in blanched chillies (53 to 65 mg/100 g) than in unblanched product (43 to 62 mg/100 g). Quality of rehydrated product was also betterin the blanched sample.

Patil *et al*. (1978) studied the effect of blanching on the quality of dehydrated fenugreek. They observed that samples treated with preservatives potassium metabisulphite (KMS) magnesium oxide (MgO) and blanched in boiling water for two minutes showed more retention of green colour, ascorbic acid and carotenes. When hot water at 80°C was used for blanching the time required for blanching was one to five minutes. By increasing the temperature of blanching water to 90°C and 100°C, the time of blanching was reduced to three and two minutes respectively. They also reported that with increase in temperature of blanching water, the percentage loss of chlorophyll and ascorbic acid showed an increasing trend.

Chaudhary and Roy (1979) carried out dehydration studies in fenugreek leaf. Dehydration of fenugreek was carried out without blanching and after blanching in boiling water and also blanching in 0.2 per cent KMS solution. They found that there were considerable losses in total chlorophyll and ascorbic acid during dehydration. Retention of chlorophyll was considerably improved by blanching to 62.2 per cent from 33.8 per cent in unblanched. This was further improved by blanching in sulphite solution to 70.6 per cent. But ascorbic acid retention was more in unblanched sample (69.8 per cent) compared to simply blanched sample (43.3 per cent). The ascorbic acid content in sulphite treated sample was 56.5 per cent which was about 15 per cent more than that in the hot water blanched sample. Better dehydrated okra was produced by blanching in boiling solution of 0.1 per cent sulphur dioxide for three minutes (Krutman, 1981). Akpapunam (1984) found that leafy vegetables blanched in water at 98°C retained more amount of ascorbic acid. In dehydrated pumpkin ascorbic acid losses were more in control than in blanched and sulphited samples (Pawar et al., 1985).

Goyal and Mathew (1990) studied the effects of different drying methods with or without blanching on the quality of dried cauliflower including ascorbic acid content and iron. Results showed that blanching followed by drying reduced the drying time, produced best organoleptic properties and caused nutrient losses. CFTRI (1990) reported the drying procedure for bittergourd as removing both ends with steel knife and cut into 6 mm thick slices and blanching in boiling water for 8 minutes. The recommended drying temperature was 60°C. During dehydration of bittergourd, unblanched samples retained only 13.75 mg chlorophyll/100 g whereas hot water blanched samples retained 19.1 mg of chlorophyll/100 g of sample (Kumar et al., 1991).

2.3.2 Effect of sulphiting on quality

Preparation of sample for dehydration involves a variety of pretreatments, hence the chance for loss of nutrients during dehydration and subsequent storage is more. The extent of nutrient loss and development of foreign flavour can be controlled by exercising care in preparing the material and by adopting suitable techniques to prevent the undesirable changes. Since vegetables contain significant quantities of vitamins and minerals, some loss of these are inevitable during drying. Sulphur dioxide (SO_2) being a reducing agent protects oxygen sensitive vitamins like vitamin A and ascorbic acid. Salunkhe et al. (1976) reported that the presence of SO_2 enhances the retention of vitamin C to the extent of 50 per cent in the dried product. Patil et al. (1978) found that use of blanching liquid without any chemicals caused severe loss of nutrients in fenugreek. In this type of blanching 34 per cent chlorophyll and 60 per cent ascorbic acid were lost, while blanching in water containing 0.5 per cent KMS, 0.1 per cent MgO and

0.1 per cent $NaHCO_3$ retained more green colour and ascorbic acid. In the latter treatment the loss of chlorophyll and ascorbic acid was only 24 and 48 per cent respectively. In contrast to these results, sulphur dioxide treatment resulted in poor retention of chlorophyll in both blanched and unblanched green chillies (Luhadiya and Kulkarni, 1978). Chaudhary and Roy (1979) observed that sulphite treated and dried fenugreek pieces of one inch size retained 70.6 per cent chlorophyll and 56.5 per cent ascorbic acid whereas hot water blanched samples retained only 56 and 43 per cent of chlorophyll and ascorbic acid respectively. Krutman (1981) reported that okra blanched in boiling solutions of 0.1 per cent SO_2 for three minutes gave best results in terms of sensory quality, colour and ascorbic acid.

It was reported that in mushroom SO_2 besides acting as a preservative also allows for higher temperature of dehydration. Mushroom polyphenolase activity was completely suppressed at 2000 ppm SO_2. The colour and flavour of sulphited mushrooms were superior to steam blanched mushrooms (Deshpande and Tamhane, 1981). Similar results were reported by Mudahar and Bain (1982). They found that <u>Agaricus</u> <u>bisporus</u> mushroom blanched in water containing 0.5 per cent sodium metabisulphite and 0.2 per cent citric acid and dehydrated product had satisfactory colour, shelf life and culinary properties.

Sethi and Anand (1982) prepared intermediate moisture carrot preserve and found that slices treated with 500 ppm sulphur dioxide and 0.45 per cent potassium sorbate remained free from microbiological spoilage at 39.2 per cent moisture level. During the preparation of dried pumpkin, sulphitation helped in preventing the loss of ascorbic acid (Pawar *et al*., 1985). Sulphitation treatment with 0.25 per cent potassium metabisulphite for five minutes led to complete prevention of pink discolouration of onion flakes dried in solar driers. The duration of dehydration was less for sulphited slices than for control samples. Retention of ascorbic acid was more in sulphited samples than in the control. Sulphited sampls showed less browning during storage than the untreated control (Pawar *et al*., 1988).

2.3.3 Effect of other pretreatments on quality

Kuppuswamy and Rao (1970) reported that soaking in two per cent sodium citrate had a very favourable effect on retention of natural colour and reduction in the cooking time in dehydrated green peas. Chillies pricked, blanched and treated with two per cent sodium carbonate had poorer retention of chlorophyll whereas those treated with two per cent sodium hydroxide for 10 to 20 minutes, washed from excess alkali and dehydrated gave the best product. This product possessed characteristic green colour with almost 91 per cent chlorophyll retention and had an attrative shiny appearance without wrinkling on the pods. The product had a high rehydration ratio of 7.2.

An investigation was carried out for preparation of intermediate moisture okra by Thorat et al. (1988) and it was found that the sample treated with 7.5 per cent brine was superior for good chlorophyll retention, rehydration ratio and organoleptic quality. Intermediate moisture mushroom of moisture content about 20 and 40 per cent and salt content about 8 to 10 per cent have been successfully prepared by steeping overnight in 10 per cent brine containing 0.2 per cent citric acid (Bhatia and Mudahar, 1982).

2.3.4 Effects of drying methods on quality

Vegetables can be sundried, dehydrated or processed by a combination of these methods. Sundrying causes large losses in carotene and ascorbic acid.

In onion artificial drying reduced microbial infestation (Grone, 1971). Sehgal et al. (1975) evaluated the effect of sundrying on the nutritive value of three green leafy vegetables viz., mustard, 'raya' and spinach. The protein content in these leaf vegetables increased from three to about 32 per cent which was due to loss of moisture. The loss of ascorbic acid and carotene contents of sundried leaves varied from 34.4 to 63.5

per cent and 48.0 to 89.8 per cent respectively. The ash percentage of dehydrated samples were 20.7, 21.3 and 25.9 in raya, spinach and mustard respectively.

Patil et al. (1978) compared sundried fenugreek with machine dried product. It was revealed that sundried product had severe losses of nutrient than cabinet dried product. By giving the pretreatment of blanching in boiling water containing 0.5 per cent KMS, 0.1 per cent MgO and 0.1 per cent $NaHCO_3$, loss of chlorophyll was ten per cent in sundried and 7.25 per cent in cabinet dried. The loss of ascorbic acid was 15.21 and 12.91 per cent respectively in sundried and dehydrated product. Maeda and Salunkhe (1981) compared different drying methods viz., sundrying and drying in conventional enclosed solar driers, for African spinach, cowpea, sweet potato and cassava leaves. The study showed that maximum retention of the two vitamins A and C were obtained by drying the vegetables in enclosed solar driers. Direct sundrying resulted in marginal retention of the vitamins.

Pawar et al. (1985) conducted dehydration studies in pumpkin and reported that losses of ascorbic acid, carotenoids and reducing sugars were more in shreds dried under sun than cabinet dried samples. After storage of three months, loss of ascorbic acid was maximum in sundried control samples than in the cabinet dried blanched and sulphited samples. Rehydration ratio was also more in cabinet dried samples than in sundried.

Ramana *et al*. (1988) compared the effect of dehydration methods on the colour of dehydrated fenugreek and mustard leaves. They reported that sundried samples showed considerable change in hue as well as chlorophyll content when compared to the solar cabinet dried and tray dried samples.

A comparison of drying in solar driers with that in mechanical and open air drying in onion indicated that the drying rate was faster in mechanical cabinet drier. Solar dried samples retained slightly less ascorbic acid than mechanically dried. Ascorbic acid content in open air dried sample vary from 1.95 to 3.1 mg/100 g, whereas that in mechanical cabinet dried sample was 2.78 to 4.6 mg/100 g. Solar cabinet dried samples showed higher scores for colour, flavour, texture and overall acceptability than the dehydrated samples (Pawar *et al*., 1988). Jayaraman *et al*. (1991) reported a significant loss of pigments and development of rancid odour due to lipid oxidation in direct sundrying of carrots and green peas. While indirect sundrying inside a cabinet minimised these changes and gave products comparable to artificially dried.

2.4 Packaging of dehydrated products

The hygroscopic nature of low moisture food makes it imperative that special precaution must be taken against moisture absorption. The low moisture products must be packaged as soon as possible after removal from the dehydrator. For packaging, sealed containers must be used to prevent absorption of moisture and subsequent loss of quality during extended storage. Gooding and Duckworth (1958) reported that inpackage dessication clearly provided protection against browning and deterioration in flavour and texture of dehydrated cabbage. There was three to four fold increase in storage life by using inpackage dessicants. Dessication reduced the rate of deterioration of flavour, texture, ascorbic acid content and colour.

Balasubramanyam and Anandaswamy (1979) studied the packaging requirements for fried potato chips and found that potato chips had 15 days storage life in 100 gauge high density polyethylene, 200 gauge low density polyethylene and cello/poly laminate.

Kalra (1981) studied the storage problems of solar dehydrated peas. The dehydrated peas were stored in high density (HD) polyethylene, black polyethylene and butter paper pouches at ambient temperature (23 to 36°C). The initial moisture of four to five per cent changed very little in butter paper but varied in the other two. Most of the samples in HD polyethylene and black polyethylene were spoiled within two months of storage while butter paper bags proved more suitable. Kaur and Singh (1981) reported that high density polyethylene bags of 500 gauge were best compared to aluminium foil laminated polyethylene bags for the storage of dehydrated cauliflower.

Intermediate moisture mushroom with 20 per cent moisture content packed in 300 gauge polyethylene pouches, with an outer card board cover had a shelf life of about three months at 37°C and 42 to 74 per cent relative humidity (Bhatia and Mudahar, 1982). Gvozdenovic *et al*. (1983) reported that optimum quality retention of tomato powder was achieved with a paper/polyethylene/aluminium foil/polyethylene laminate. This packaging retained the nutrient contents in a better way.

Thorat *et al*. (1988) reported 40 days shelf life for intermediate moisture okra packed in low density polyethylene bags. Dehydrated coconut chutney had three months storage life at 37°C and 6 months at ambient temperature when packed in flexible pouches (Rao *et al*., 1991). Colocassia snack product was acceptable only upto 30 days storage at 30 to 35°C and RH 30 to 65 per cent, when packed in 120 gauge polypropylene pouches. The product stored better in friction top tins (Manan *et al*., 1991). Premavalli *et al*. (1991) reported that potassium sorbate treated carrot and pumpkin halwa remain stable upto one and two months in polypropylene pouches and three and six months in aluminium foil polyethylene laminate puches respectively.

Materials and Methods

MATERIALS AND METHODS

Investigations on some aspects of postharvest technology of bittergourd (Momordica charantia L.) were conducted in the Department of Processing Technology, College of Horticulture, Vellanikkara, Thrissur, Kerala, from June 1991 to September 1992. The area enjoys warm humid climate throughout the year with little fluctuation in daily temperature. The area is situated at 10° 32'N latitude, 76° E longitude and at an altitude of 40 m above MSL.

Bittergourd is a vegetable of choice to the people of Kerala. Though bitter in taste it is generally liked by all age groups of the family. The fresh fruits of bittergourd is highly perishable because of its high moisture content, soft and spiny rind with corky parenchymatous inner tissues. Hence, in the present study an effort was made to enhance the storage life of fresh bittergourd through modified cultural management and also through the application of some chemicals.

In addition to the use as a fresh vegetable for curry preparations, bittergourd is also used in the sundried form, to be consumed as an oil fried wafer *(Kondattom)* along with meals. However, scientific dehydration technique of bittergourd has not been standardised so far with respect to the eating habits of

Keralites. Thus the study also included comparison of some dehydration procedures with sundrying so that a suitable method can be developed for commercial dehydration of bittergourd. The dehydrated samples were subsequently subjected to different packaging environments to study the suitability of packages and the package-product interaction.

The study was divided into five experiments as given below:

1. Effect of organic and inorganic sources of nitrogen on shelf life of fresh bittergourd fruits.

2. Effect of preharvest sprays on the shelf life of fruits of bittergourd.

3. Effect of postharvest treatments on the shelf life of fruits of bittergourd.

4. Standardisation of drying technique for bittergourd.

5. Comparison of different packaging materials for storage of dehydrated bittergourd.

Field experiments were conducted in the experimental plots of Department of Olericulture. Chemical analyses were done in the analytical laboratory attached to the Department of Processing Technology. Process standardisation was done in the Processing unit of Department of Processing Technology.

3.1 Soil

Soil of the experimental area is a well drained sandy loam soil with total nitrogen, available phosphorus and potassium content as 0.186 per cent, 5.08 ppm and 201.66 ppm respectively. This soil comes under high fertility class.

3.2 Cropping history

The land used for cultivation was primarily under rubber plantation. After the felling of rubber trees, it was kept as fallow for five years upto the year of raising the crop.

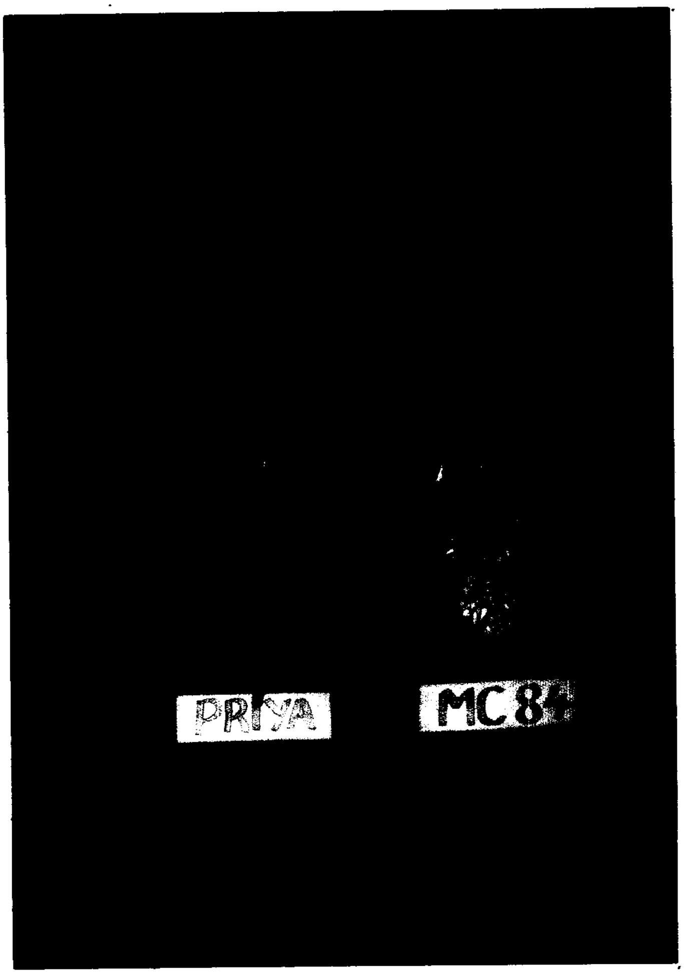
3.3 Experiment 1 - Effect of organic and inorganic sources of nitrogen on shelf life of fresh bittergourd fruits

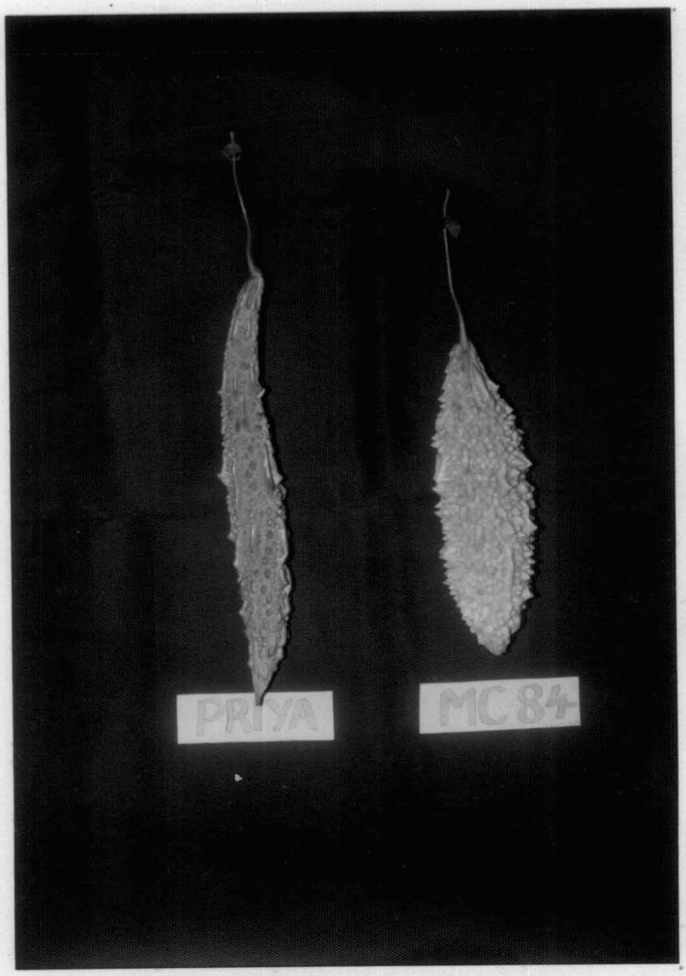
3.3.1 Season and weather conditions

The experiment was conducted during the period from August to December 1991. Details of the meteorological observation for this period are presented in Appendix I.

2.3.2 Varieties

Bittergourd varieties Priya and MC-84 developed by Kerala Agricultural University were used for the study. Fruits of Priya are dark green coloured with white tinge at the tip. Average length of the fruit is 36 cm and girth at the centre is 13 cm. Individual fruits weigh 220 to 230 g. Fruits are spiny.


PRIYA
MC 8


PRIYA
MC 84

Fruits of MC-84 have a shade of very light green. Average length of the fruit is 30 cm and girth at the centre is 17 cm. Weight of individual fruit is 260 to 270 g and fruits are spiny without ridges (Plate 1).

3.3.3 Manures and fertilisers

Farm yard manure was used as organic source of nutrients. Urea, Factomphos, Superphosphate and Muriate of potash were used as inorganic source. Nutrient content of the manures and fertilisers used, are given in Appendix II.

3.3.4 Layout

The experiment was laid out in factorial randomised block design with three replications. Total number of treatment plots were 30 with four pits per plot. Each pit had two plants. Spacing given was 2 m x 2 m. Net plot size of the experiment was 16 m^2 and gross plot size was 48 m^2.

3.3.5 Treatments

The treatments of this experiment were as follows:

T_1 - KAU Package of practices recommendations (KAU, 1989). Crop was raised as per the package of practices recommended by Kerala Agricultural University. The plants were supplied with 20 t FYM and 70:25:25 kg NPK ha^{-1} through fertilisers.

3.3.6.2 Application of manures and fertilisers

Manures and fertilisers were applied to the plots in accordance with the treatments. Farm yard manure were applied at the time of filling of pits. Full dose of phosphorus and potassium and half the dose of nitrogen were applied as basal dressing. The remaining dose of nitrogen was applied in two equal split doses. One split was applied at the time of vining (two to three weeks, after germination) and the next split at the time of full blooming (seven to eight weeks after germination).

3.3.6.3 Sowing

Seeds presoaked in water for 12 h were sown in pits at the rate of five seeds per pit. When the seeds germinated, two healthy seedlings were retained per pit and the excess seedlings were thinned out.

3.3.6.4 Other cultural practices

In order to control fruit fly attack a bait containing jaggery (10 g/l) and Malathion (0.2 per cent) was used. Coconut shells half filled with the sweetened insecticide solution were hung on the frames from the start of flowering onwards to attract fruit flies.

Dimethoate 0.05 per cent was sprayed at fortnightly intervals to prevent the attack of jassids till the onset of flowering.

Irrigation was given on alternate days from the second half of November till the end of December. Plants were trailed on circular iron frames of 0.75 m diameter and 1.8 m height. Field was always kept clean.

3.3.6.5 Harvesting

A test harvest conducted showed that fruits attained vegetable maturity by about fourteen to fifteen days (Plate 2). Fourteen to fifteen days old fruits were harvested at three days interval. The harvested fruits were used for subsequent analyses and storage studies.

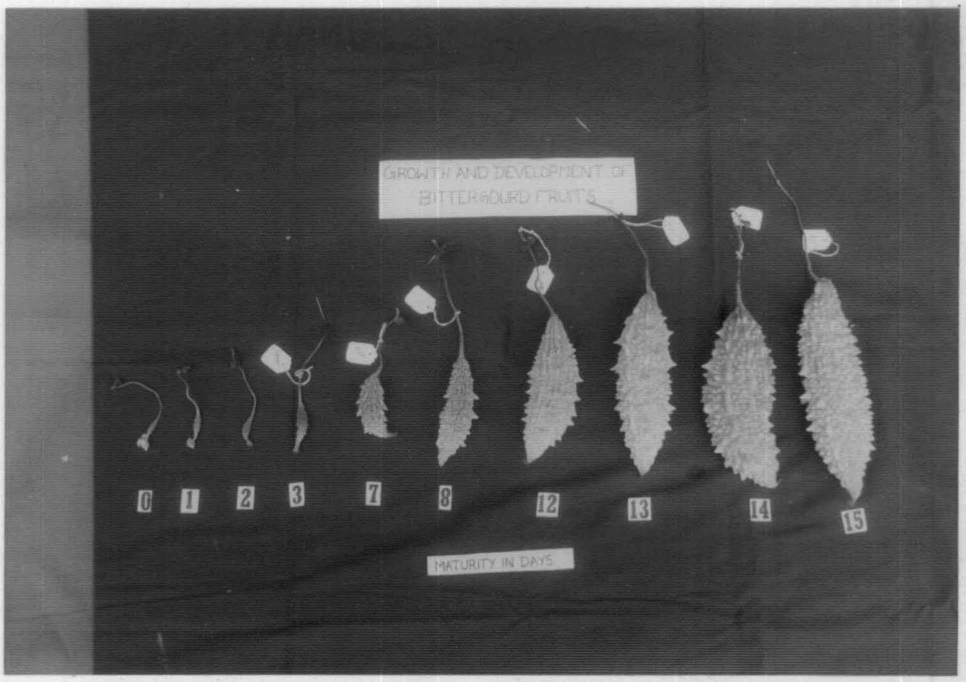
3.3.7 Observations

The following observations were recorded from the experiment.

1. Days to first female flower opening

   Number of days for the opening of first female flower were counted from the date of sowing onwards.

2. Number of harvests


GROWTH AND DEVELOPMENT OF
BITTERGOURD FRUITS
0
1
2
3
7
8
12
13
14
15
MATURITY IN DAYS

3. Fruits per plot

4. Yield per plot (kg)

5. Fruit length (cm)

Average length of a sample consisting of ten fruits weretaken.

6. Fruit girth (cm)

Girth at the centre of the fruit was measured. A representative sample consisting of ten fruits were selected for taking observations.

7. Qualitative characters

Freshly harvested fruits were analysed for the following quality components.

a. Moisture

Moisture content was estimated gravimetrically by drying the sample in a hot air oven at 70°C for 18 to 20 h. Drying was repeated till the sample attained constant weight. Moisture content was expressed in percentage (Ranganna, 1977).

b. Ash

Ash content of the sample was estimated by ashing the sample in a muffle furnace at 420°C and expressed in percentage (Ranganna, 1977).

c. Ascorbic acid

Ascorbic acid content of the fruit was estimated volumetrically by titration with 2,6-dichlorophenol-indophenol dye (A.O.A.C., 1960). The value was expressed as mg of ascorbic acid per 100 g of fruit.

d. Total phenol

Total phenol content of the fruit juice was determined by developing colour using Folin Ciocalteau reagent. Intensity of the colour developed was measured using a Spectrophotometer at 650 nm (Bray and Thorpe, 1954).

e. Iron

Iron content of the sample was determined by converting the iron to ferric form using oxidising agent potassium persulphate and treating thereafter with potassium thiocyanate. The red colour developed was measured at 480 nm in a Spectrophotometer (Ranganna, 1977).

f. Chlorophyll

Chlorophyll content of the fruit was estimated spectrophotometrically. Acetone extract of the sample was prepared and colour of the extract was found out by measuring the absorbance of the solution at 645 and 663 nm in a Spectrophotometer (A.O.A.C., 1960).

g. NPK level of experimental plots and FYM

Nitrogen content was estimated by Microkjeldhal digestion method. Available phosphorus content was determined by chlorostannous molybdophosphoric blue colour method. Exchangeable potassium content was determined flame photometrically (Jackson, 1958).

8. Incidence of spoilage

Fruits were stored at room temperature. Fruits showing yellowing were discarded and spoilage was calculated and expressed in percentage. Physiological loss of weight was also calculated at intervals of 48 h and expressed as percentage. Mould growth appeared on the fruits were separated and the fungus was identified by microscopic examination.

9. Colour of fresh fruits, and fruit malformation

Colour of the fruits and the change of colour of the fruits were recorded based on a score chart prepared (Plate 3). Details of the score chart are given below.

Characteristic	Score
Green colour, fresh and firm without any symptoms of shrinkage	0
Green with shrivelled appearance	1

Characteristic	Score
Slight yellowing starting from the fruit tip	2
50 per cent yellowing	3
Whole fruits turning yellow, rind remaind firm	4
Whole but yellow, soft and decayed	5

Malformed fruits were separated through visual assessment and expressed as percentage.

3.4 Experiment 2 - Effect of preharvest sprays on the shelf life of fruits of bittergourd

3.4.1 Season and weather conditions

The experiment was conducted during the period from May to September 1992. Details of the meteorological observations for this period are presented in Appendix I.

3.4.2 Variety

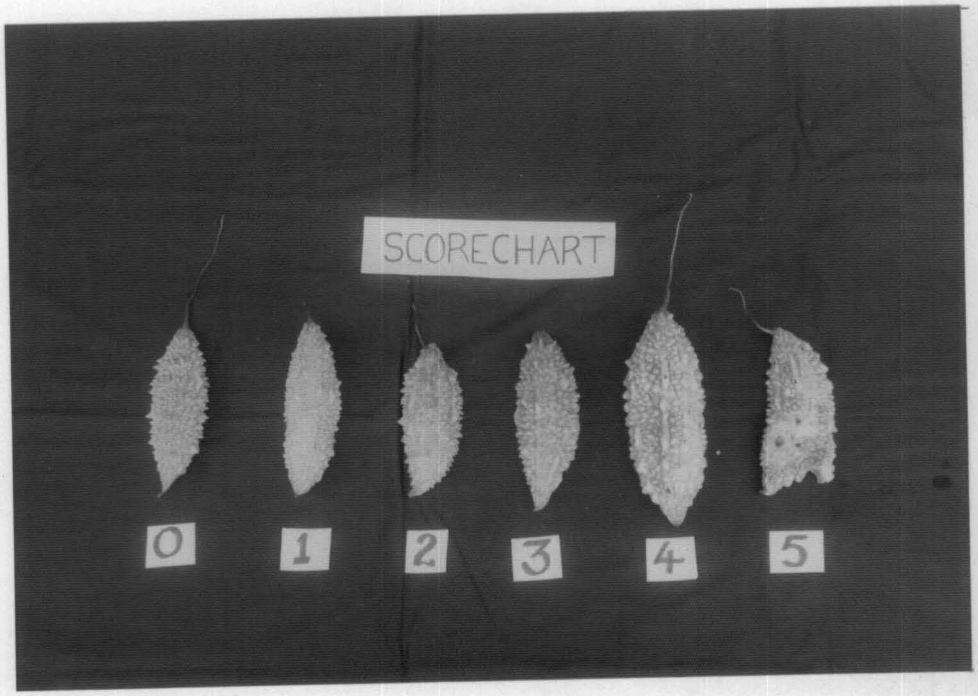
The bittergourd variety MC-84 was used for the study.

3.4.3 Manures and fertilisers

Farm yard manure, Factomphos and Muriate of potash were used to supply the nutrients as per KAU recommendation, i.e., 20 t FYM and 70:25:25 kg NPK ha^{-1} (KAU, 1989).

Figure 1. Score chart for different stages of [illegible]

in [illegible]


SCORECHART
0
1
2
3
4
5

3.4.4 Layout

The experiment was laid out in randomised block design with seven treatments and four replications. There were four pits per plot.

3.4.5 Field operations

The field was prepared as per KAU package of practices recommendation. Five seeds were sown per pit and later thinned to retain two healthy plants in each pit. Field was kept free of weeds, pests and diseases through proper prophylatic measures. Plants were trailed on iron frames.

3.4.6 Treatments

Following spray treatments were given twice during the flowering phase.

T_1 - GA 200 ppm

T_2 - GA 300 ppm

T_3 - CCC 250 ppm

T_4 - CCC 500 ppm

T_5 - Maleic hydrazide 500 ppm

T_6 - Maleic hydrazide 1000 ppm

T_7 - Control

While preparing the growth regulators first a stock solution of 10,000 ppm was prepared and then diluted to the required concentration. Required quantity of growth regulators were dissolved in ethyl alcohol to avoid precipitation and the volume was made up with distilled water. Before spraying two to three drops of Teepol was added to the solution to increase the adhesiveness. First spray was given 10 days after first fruit set and 15 days thereafter, the second spray was given.

3.4.7 Harvesting

Fruits were harvested as described under 3.3.6.5.

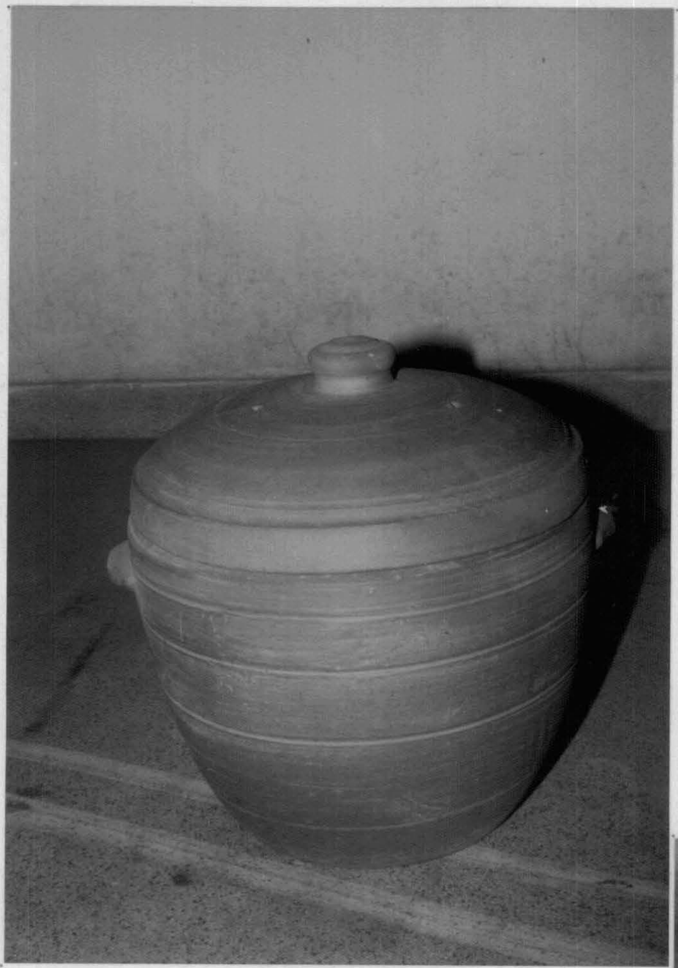
3.4.8 Observations

All the observations described under 3.3.7 were recorded in this experiment, except days for first female flower appearance.

3.5 Experiment 3 - Effect of postharvest treatments on the shelf life of fruits of bittergourd

3.5.1 Variety

Fruits of bittergourd variety Priya was used for the study.



T_4 - Dip treatments of 20 minutes in GA 50 ppm and subsequent storage in open condition.

T_5 - Dip treatment for 20 minutes in 4 per cent calcium chloride and subsequent storage in open condition.

T_6 - Control - The harvested fruits were stored in open condition

3.5.4 Observations

1. Change of colour of bittergourd under storage

Colour change was recorded as mentioned in 3.3.7.9.

2. Incidence of spoilage of fresh fruits under storage at interval of 48 hours

The discoloured fruits were removed and spoilage percentage was calculated.

Fungal growth that developed on the fruits were isolated and identified by microscopic observation.

3. Physiological loss in weight during storage

The fresh weight of the fruits used and subsequent weight loss during storage were found out at intervals of 48 h.

3.6 Experiment 4 - Standardisation of drying technique for bittergourd

3.6.1 Variety

Two weeks old fruits of bittergourd variety Priya were used for the study.

3.6.2 Season

The experiment was conducted during November and December 1991. Meteorological data for the period is given in Appendix I.

3.6.3 Layout

The experiment was carried out under laboratory condition. Statistical design of the experiment was completely randomised design with 9 treatments and 3 replications.

3.6.4 Treatments

T_1 - Sundrying

Freshly harvested bittergourd fruits after washing were cut into slices of 1 cm thickness. Slices were sundried by spreading in aluminium trays to a moisture content of 8 $\pm$ 1 per cent. Trays were kept in sun from 8.00 am to 4.00 pm.

T_2 - Sundrying as in T_1 after blanching the slices in boiling water

The slices were tied loosely in a nylon net and blanched in boiling water for 3 minutes. After blanching sample was dried in sun by spreading in aluminium trays to a moisture content of 8 $\pm$ 1 per cent.

T_3 - Sundrying as in T_1 after blanching in steam

The sample after slicing was blanched in steam produced in a pressure cooker for 3 minutes. The blanched sample were sundried to a moisture content of 8 $\pm$ 1 per cent.

T_4 - Dehydration at constant temperature in a cabinet drier

Freshly sliced samples were spread in perforated aluminium trays and kept in a cabinet drier at 60 $\pm$ 2°C for 14 h.

T_5 - Dehydration at constant temperature in cabinet drier after blanching as in T_2

The samples were hot water blanched as explained in T_2 and then dried in a cabinet drier at 60 $\pm$ 2°C for 14 h.

T_6 - Dehydration at constant temperature in a cabinet drier after blanching as in T_3

The samples were steam blanched and then dried in a cabinet drier at 60 $\pm$ 2°C for 14 h.

T_7 - Sulphiting and dehydration

The prepared samples were blanched in boiling water for 3 minutes and allowed to cool to room temperature and subsequently soaked in water containing 0.1 per cent potassium metabisulphite (KMS) for 10 minutes and then dried in a cabinet drier at 60 ± 2°C for 14 h.

T_8 - Steeping in 5 per cent sodium chloride and drying

The prepared slices were blanched in boiling water for 3 minutes, allowed to cool to room temperature and subsequently soaked in water containing 5 per cent sodium chloride (brine) for 4 minutes and then dried in a cabinet drier at 60°C for 14 h.

T_9 - Intermediate moisture bittergourd (IM bittergourd)

The sliced samples were blanched for 3 minutes in boiling water. After cooling to room temperature, they were dipped over-night in 10 per cent brine containing 0.2 per cent potassium metabisulphite (KMS) and 0.2 per cent citric acid. After draining, slices were dried in a cabinet drier at an initial temperature of 80°C for one hour and subsequently at 60 ± 2°C for 10 h to a final moisture content of 30 per cent (Bhatia and Mudahar, 1982).

3.6.5 Observations

The following observations were recorded from the study.

1. Quality analysis

All the quality parameters listed under experiment 1 were determined in this study also.

2. Dehydration ratio

The prepared slices were weighed before drying. After the completion of drying also weight was found out. From these dehydration ratio was calculated.

3. Incidence of spoilage on dried bittergourd

Spoilage as evidenced by mould growth, change in texture, were recorded and expressed as percentage.

4. Rehydration studies

Rehydration ratio of dehydrated samples were determined by rehydrating the samples for 10 minutes in boiling water. From the weight of dehydrated sample and corresponding weight of the rehydrated sample rehydration ratio was calculated (Anon, 1944).

3.7 Experiment 5 - Comparison of different packaging materials for storage of dehydrated bittergourd

Based on the results of the experiment 4, following four treatments were selected for storage studies.

T_1 - Sundrying freshly sliced fruits.

T_4 - Dehydration at 60°C for 14 + 1 h in a cabiner drier.

T_8 - Blanching in boiling water containing 5 per cent sodium chloride for four minutes and drying in a cabinet drier at 60°C for 14 $\pm$ 1 h.

T_9 - Intermediate moisture bittergourd.

3.7.1 Layout

The experiment was carried out under laboratory condition. Daily mean temperature and relative humidity during the storage trial is given in Appendix I. Statistical design for the experiment was completely randomised design with ten treatments in three replications. Total number of experimental units were 30 in each case.

3.7.2 Treatments

T_1 - Packaging in low density polyethylene (LDPE) bags of 150 gauge thickness

T_2 - Packaging in LDPE bags of 300 gauge thickness

T_3 - Packaging in LDPE bags of 450 gauge thickness

T_4 - Packaging in LDPE bags of 600 gauge thickness

T_5 - Packaging in black polythene bags of 150 gauge thickness

T_6 - Packaging in polypropylene bags of 100 gauge thickness

T_7 - Packaging in LDPE bags of 150 gauge thickness with inpackage desiccants.

Silicagel was used for this purpose. Five g silicagel was kept in separate cloth bag inside the packages.

T_8 - Packaging in opaque plastic containers

T_9 - Packaging in transparent jars

P_{10} - Open air storage

3.7.3 Observations

1. Sensory evaluation

Four characters viz., colour, texture, overall appearance and consumer acceptability were evaluated based on the 5 point hedonic scale given below:

a. Score chart for colour

Description	Score
A. Green	1
B. Light green	2
C. Brownish green	3
D. Light brown	4
E. Burnt appearance	5

b. Score chart for texture

Description	Score
A. Very crisp	1
B. Moderately crisp	2
C. Neither crisp nor soft	3
D. Soft	4
E. Very soft	5

c. Score chart for overall appearance

Description	Score
A. Like very much	1
B. Like moderately	2
C. Neither like nor dislike	3
D. Dislike slightly	4
E. Dislike very much	5

d. Consumer acceptability

Description	Score
A. Acceptable fully	1
B. Acceptable somewhat	2
C. Neither acceptable nor unacceptable	3
D. Unacceptable somewhat	4
E. Not acceptable	5

Scoring was done by a panel of judges consisting of twelve semitrained persons. Consumer acceptability was scored after packaging the dehydrated bittergourd as mentioned in 3.7.3.

Sensory evaluation was arranged at monthly intervals. First at the time of storing and then at the end of each month till the end of the study.

3.8 Statistical analysis

The data in different aspects of growth and quality of bittergourd were subjected to the statistical analysis suggested by Panse and Sukhatme (1954). The mean value were worked out for different parameters and analysed by analysis of variance technique. Critical difference were calculated for the comparison of treatments. The data obtained in the individual scores for colour, texture, overall appearance and consumer acceptability were analysed by Friedman two way analysis of variance technique and Kruskel Wallis one way analysis of variance (Seigal, 1956).

RESULTS

Results of the five experiments conducted are presented in the following sections.

4.1 Effect of organic and inorganic sources of nitrogen on shelf life of fresh bittergourd fruits

4.1.1 Days to first female flower opening

Observations on the days to first female flower opening showed that treatments were on par. There was no significant difference between varieties also (Table 1).

4.1.2 Number of harvests

There was no significant difference among the treatments on the number of harvests (Table 1). The two varieties were also on par with each other.

4.1.3 Fruits per plot

Number of fruits obtained from each treatment are presented in Table 1. Treatments and varieties did not differ significantly. The interaction between varieties and treatments were also not significant.

Table 1. *Influnence* of the sources and quantity of nitrogen on the days for first female flower opening, number of harvests and fruits per plot

Treatments	Number of days for first female flower opening			Number of harvests			Number of fruits per plot		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	50.67	51.67	51.61	6.00	5.33	5.67	56.67	54.67	55.67
T_2	50.67	50.67	50.67	5.33	5.00	5.17	52.67	55.33	54.00
T_3	52.33	52.00	52.17	6.00	5.67	5.84	57.00	52.67	54.83
T_4	50.33	49.67	50.00	6.00	5.33	5.67	60.00	54.33	57.17
T_5	52.33	51.00	51.67	6.00	5.33	5.67	58.67	55.67	57.17
Mean	51.63	51.00	--	5.87	5.33	--	57.00	54.53	--
CD for									
Treatments (T)		NS			NS			NS	
Varieties (V)		NS			NS			NS	
T x V		NS			NS			NS	

T_1 - 20 t FYM, 70:25:25 kg NPK through fertilisers.

T_2 - 20 t FYM, 70 kg N through FYM, and 25.25 kg NPK through fertilisers

T_3 - 30 t FYM, 70:25:25 kg NPK through fertilisers

T_4 - 20 t FYM, 35:25:25 kg NPK through fertilisers

T_5 - 20 t FYM, 140:25:25 kg NPK through fertilisers

V_1 - Priya

T_2 - MC-84

Table 2. Influence of sources and quantity of nitrogen on yield per plot, fruit length and fruit girth

Treatments	Yield per plot (kg)			Fruit length (cm)			Fruit girth (cm)		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	10.20	11.02	10.61	24.51	22.26	23.38	13.59	16.33	14.96
T_2	9.87	12.30	11.08	25.61	21.09	23.35	13.96	16.80	15.38
T_3	10.37	11.28	10.82	27.24	22.56	24.90	14.05	18.21	16.13
T_4	13.18	11.64	12.42	28.33	22.26	25.30	14.59	16.97	15.78
T_5	12.55	12.55	12.55	26.27	20.59	23.43	13.27	16.34	14.80
Mean	11.23	11.76		26.39^a	21.75^b		13.89^a	16.93^b	
CD for									
Treatments (T)		NS			NS			NS	
Varieties (V)		NS			1.037*			0.472*	
T x V		NS			NS			NS	

* Significant at 5 per cent level

4.1.4 Yield per plot

Data on the yield are presented in Table 2. Results indicated that treatments and varieties did not differ significantly with respect to yield. The interaction between varieties and treatments for yield also were not significant.

4.1.5 Fruit length

Data on fruit length are presented in Table 2. The treatments did not differ significantly with respect to the length of the bittergourd harvested.

There was significant difference between varieties. The fruits were longer in Priya than in MC-84 (Plate 1). There was no significant interaction between varieties and treatments for this character.

4.1.6 Fruit girth

As in fruit length, girth of fruit was also not influenced by the treatments (Table 2). However, varieties differed significantly for fruit girth with MC-84 having a mean fruit girth of 16.9 cm as compared to Priya with 13.9 cm. The interaction between varieties and treatments showed no significant difference in this case.

Table 3. Influence of sources and quantity of nitrogen on the moisture, total ash, ascorbic acid, total phenol and iron content

Treatments	Moisture (%)			Total ash (%)			Ascorbic acid (mg/100 g)			Total phenol (mg/100 g)			Iron content (mg/100 g)		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	93.33	94.43	93.88	7.81	8.42	0.592	74.20	71.34	72.77^{c}	10.07	10.42	10.24	1.85^{bc}	1.69^{b}	1.77
T_2	93.33	93.33	93.33	8.50	5.83	0.417	46.98	59.41	53.20^{b}	8.68	17.36	13.02	2.13^{ab}	1.56^{a}	1.85
T_3	92.33	94.77	93.55	7.52	11.92	0.479	52.39	54.60	53.90^{b}	5.56	11.46	8.51	1.85^{bc}	1.54^{a}	1.69
T_4	92.97	93.97	93.17	8.25	9.76	0.449	24.96	43.01	33.98^{a}	4.86	9.72	7.29	2.11^{bc}	1.43^{a}	1.77
T_5	93.03	93.07	93.05	8.50	7.92	0.520	55.19	61.77	58.79^{bc}	11.45	14.58	13.02	1.40^{a}	1.61^{ab}	1.51
Mean	92.99	93.91	-	8.12	8.77	-	50.87	58.03	-	8.12^{a}	12.71^{b}	-	$1.87^{a'}$	$1.57^{b'a}$	-
CD for															
Treatments (T)		NS			NS			16.91*			NS			NS	
Varieties (V)		NS			NS			NS			2.5523*			0.1204*	
T x V		NS			NS			NS			NS			0.2689	

* Significant at 5 per cent level

Phenol content was not significantly affected by the treatments (Table 3). However difference between varieties was significant. MC-84 recorded a phenol content of 12.7 mg per cent as compared to 8.1 mg per cent for Priya. The variety x treatment interaction was not significant.

The treatments showed significant effect on the iron content of fruits (Table 3). Iron content was highest in T_2 (20 t FYM, 70 kg N through FYM and 25:25 kg P and K) which was on par with T_1 (KAU recommendation), T_3 (30 t FYM, 70:25:25 kg NPK) and T_4 (20 t FYM, 35:25:25 kg NPK). The lowest content of iron was recorded in T_5 (20 t FYM, 140:25:25 kg NPK through fertilisers) which was on par with T_1, T_3 and T_4. Difference between varieties was also significant. Priya had higher iron content than MC-84. The interaction between varieties and treatments was not significant.

Chlorophyll a, chlorophyll b, and total chlorophyll content of the fresh bittergourd fruits are presented in Table 4. The treatments showed no significant effect on total chlorophyll content. There was significant difference in chlorophyll a and chlorophyll b contents between the two varieties. In both cases Priya recorded higher values for chlorophyll a and b content of 0.08 mg per cent and 0.101 mg per cent against the corresponding values of 0.05 mg per cent and 0.057 mg per cent in the case of MC-84. The variety x treatment interaction was not significant for this character.

Table 4. Influence of sources and quantity of nitrogen on the chlorophyll content (mg/100 g)

Treatments	Chlorophyll a			Chlorophyll b			Total chlorophyll		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	0.095	0.056	0.076	0.085	0.074	0.079	0.172	0.130	0.151
T_2	0.075	0.027	0.051	0.118	0.018	0.068	0.195	0.039	0.117
T_3	0.074	0.050	0.062	0.097	0.058	0.078	0.171	0.108	0.139
T_4	0.076	0.042	0.059	0.074	0.054	0.064	0.150	0.096	0.123
T_5	0.082	0.053	0.067	0.130	0.083	0.107	0.212	0.136	0.174
Mean	0.080[a]	0.046[b]		0.101[a]	0.057[b]		0.180[a]	0.102[b]	
CD for									
Treatments (T)		NS			NS			NS	
Varieties (V)		0.0092*			0.0208*			0.029*	
T x V		NS			NS			NS	

* Significant at 5 per cent level

4.1.8 Incidence of spoilage

Spoilage was recorded based on weight loss during storage (Table 5) and also on the rotting percentage of fruits (Table 6). Organic and inorganic sources had a significant influence on the shelf life of bittergourd (Table 5). The gourds from T_2 (20 t FYM, 70 kg N through FYM, 25:25 kg P and K through fertilisers) had the longest shelf life of 5.5 days. This treatment was on par with T_3 (30 t FYM, 70:25:25 kg NPK through fertilisers) and T_4 (20 t FYM and 35:25:25 kg NPK through fertilisers). Shortest shelf life of 2.4 days were observed in T_1 (KAU recommendation) which was on par with T_5 (20 t FYM, 140:25:25 kg NPK through fertilisers). T_1 and T_5 were significantly inferior to T_2, T_3 and T_4. There was no statistical difference between varieties for their shelf life. The interaction between treatments and varieties was also not significant.

Treatments showed significant variation with respect to weight loss during storage (Table 5). In the storage period upto 48 h minimum weight loss was recorded by T_4. Maximum weight loss was observed in T_5 which was on par with T_1, T_2 and T_3. When the storage period from 48 to 96 h were considered T_4 again recorded lowest weight loss which was on par with T_3. The treatment T_5 sustained maximum weight loss, which was significantly inferior to all the other treatments.

Table 5. Influence of sources and quantity of nitrogen on the shelf life and weight loss of fruits during storage

Treatments	Shelf life (days)			Weight loss (%) 0 to 48 hours			Weight loss (%) 48 to 96 hours			Cumulative weight loss (%) After 96 hours		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	2.17	2.67	2.42^{a}	12.60	8.63	10.61^{b}	7.38$^{d'}$	5.10$^{b'c'}$	6.24^{b}	18.36$^{c'd'}$	13.36$^{b'c'}$	15.86^{bc}
T_2	5.33	5.67	5.50^{b}	9.64	8.05	8.84^{b}	6.85$^{c'd'}$	5.58$^{b'c'd'}$	6.22^{b}	15.82$^{b'c'}$	13.29$^{b'}$	14.55^{b}
T_3	5.00	5.00	5.00^{b}	9.73	8.37	9.05^{b}	4.79$^{a'b'}$	5.12$^{b'c'}$	4.96^{ab}	12.35$^{a'b'}$	13.06b'	12.71^{ab}
T_4	5.33	5.33	5.33^{b}	6.99	4.33	5.66^{a}	6.27$^{b'c'd'}$	3.19$^{a'}$	4.73^{a}	13.05$^{b'}$	7.38$^{a'}$	10.22^{a}
T_5	3.00	2.00	2.50^{a}	9.80	10.94	10.37^{b}	5.68$^{b'c'd}$	9.64$^{c'}$	7.66^{c}	14.83$^{b'}$	23.25$^{d'}$	19.04^{c}
Mean	4.16	4.13		9.75	8.06		6.19	5.73		14.88	14.00	

CD for	Shelf life	Weight loss 0 to 48 hours	Weight loss 48 to 96 hours	Cumulative weight loss
Treatments (T)	0.792*	2.394*	1.302*	3.554*
Varieties (V)	NS	NS	NS	NS
T x V	NS	NS	1.8415*	5.025*

* Significant at 5 per cent level

V_1 - Priya V_2 - MC-84

Treatments T_1, T_2 and T_3 were on par. There was no significant difference between varieties. However, the variety x treatment interaction was significant. Lowest weight loss was recorded in the combination T_4V_2 (20 t FYM, 35:25:25 kg NPK in MC-84). This was on par with T_3V_1 (30 t FYM and 70:25:25 kg NPK in Priya).

When cumulative weight loss upto 4 days was taken into account, the treatments showed significant difference (Table 5). T_4 recorded lowest weight loss which was on par with T_3. T_5 recorded highest weight loss which was on par with T_1. Here again variety x treatment interaction was significant. T_4V_2 recorded minimum weight loss which was on par with T_3V_1. Maximum weight loss was in T_5V_2, which was on par with T_1V_1.

Data on rotting percentage are presented in Table 6. Rotting percentage differed significantly upto 4 days of storage. Rotting percentage was lowest in T_4 after two days which was on par with T_2 and T_3. Maximum rotting after two days of storage was recorded in T_1 which was on par with T_5. When storage period upto 4 days was considered the lowest rotting percentage was in T_4, which was on par with T_3. Rotting was maximum in T_5 followed by T_1. On completion of six days in storage the spoilage was nearly 100 per cent in all the treatments. There was no significant interaction between varieties and treatments for this character.

Table 6. Influence of sources and quantity of nitrogen on the rotting percentage of bittergourd fruits during storage

Treatments	Rotting (per cent)								
	After 2 days			After 4 days			After 6 days		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_1	85.28	92.31	88.79^{c}	93.61	97.44	95.52^{cd}	100.00	100.00	100.00
T_2	74.31	28.11	51.21^{ab}	88.43	76.11	82.27^{bc}	97.92	93.33	95.63
T_3	56.95	56.94	56.95^{ab}	74.88	76.39	75.64^{ab}	93.93	100.00	96.97
T_4	44.47	50.74	47.62^{a}	74.58	54.45	64.51^{a}	97.50	88.89	93.20
T_5	79.63	73.33	76.48^{c}	96.67	97.22	96.95^{d}	100.00	100.00	100.00
Mean	68.13	60.29		85.63	80.32		97.87	96.45	
CD for									
Treatments (T)	18.93*			13.54*			NS		
Varieties (V)	NS			NS			NS		
T x V	NS			NS			NS		

* Significant at 5 per cent level

Rotting seemed to be closely associated with the establishment of microbial growth in fruits. Symptoms of rotting was closely followed by appearance of fungal mass which was identified as Fusarium Spp. The extent of damage by the microorganism was not assessed, as it was beyond the scope of the present study.

4.1.9 Change of colour during storage

Data on the change in colour of bittergourd fruits during storage are presented in Table 7. Perusal of the data showed a gradual degradation in green colour with increase in duration of storage. Fruits in all the treatments were fresh and green on the day of harvest with the score of zero. As the storage period increased, green colour of the fruit faded and the scores attributed were subjected to Friedman two way analysis, which showed that the treatments differed significantly with respect to change in colour. This change was slowest in T_4V_2 (20 t FYM and 35:25:25 kg NPK through fertilisers in MC-84) followed by T_1V_1 (KAU recommendation in Priya). The disappearance of the green colour was faster in T_5V_2 (20 t FYM and 140:25:25 kg NPK in MC-84).

4.2 Effect of preharvest sprays on the shelf life of fruits of bittergourd

4.2.1 Number of harvests

Data on the number of harvests presented in Table 8 showed that treatments had no effect on the number of harvests.

Table 7. Colour change of bittergourd fruits during storage as influenced by different sources and quantity of nitrogen

Treatments	Colour score after				Total score
	0 day	2 days	4 days	6 days	
T_1V_1	0	2.00	3.50	5.00	10.50
T_2V_1	0	2.75	3.80	4.90	11.45
T_3V_1	0	2.50	4.20	5.00	11.70
T_4V_1	0	3.00	3.40	5.00	11.40
T_5V_1	0	3.30	5.00	5.00	13.30
T_1V_2	0	3.40	5.00	5.00	13.40
T_2V_2	0	2.25	3.50	5.00	10.75
T_3V_2	0	3.00	3.25	5.00	11.25
T_4V_2	0	2.25	3.40	5.00	10.65
T_5V_2	0	3.50	5.00	5.00	13.50
Score	0	27.95	40.05	49.90	

V_1 - Priya

V_2 - MC-84

Score: 0 - Green colour, fresh and firm without any symptoms of shrinkage

1 - Green with shrivelled appearance

2 - Slight yellowing starting from the fruit tip

3 - 50 per cent yellowing

4 - Whole but yellow, soft and decayed

4.2.2 Fruits per plot

Data presented in Table 8 indicated that there was significant variation between treatments on the number of fruits harvested. Maximum number of fruits were obtained from T_7 (control) which was on par with T_1 (GA 200 ppm), T_2 (GA 300 ppm) and T_3 (CCC 250 ppm). Minimum number of fruits were obtained from T_6 (MH 1000 ppm) which was on par with T_4 (CCC 500 ppm) and T_5 (MH 500 ppm).

4.2.3 Yield per plot

Data on yield recorded in each treatment are presented in Table 8. The treatments had significant effect on yield. Maximum yield was recorded in T_2 (GA 300 ppm). This treatment was on par with T_1 (GA 200 ppm). Yield was minimum in T_4 (CCC 500 ppm).

4.2.4 Fruit length

Preharvest application of growth regulators showed a significant influence on fruit length (Table 8). APplication of GA both at 200 ppm (T_1) and 300 ppm (T_2) increased the length significantly. These treatments were superior to all other treatments. MH at 1000 ppm (T_6) produced the shortest fruits. This was on par with all the other treatments except T_1 and T_2.

Table 8. Effect of preharvest application of growth regulators on the number of harvest, fruits per plot, yield per plot, fruit length and fruit girth

Treatments	Number of harvests	Fruits per plot	Yield per plot (kg)	Fruit length (cm)	Fruit girth (cm)
T_1 - GA 200 ppm	9.00	62.00[b]	15.32[c]	18.65[b]	16.43[bc]
T_2 - GA 300 ppm	8.25	62.75[b]	16.82[c]	19.43[b]	17.15[c]
T_3 - CCC 250 ppm	7.50	62.00[b]	12.09[b]	15.23[a]	14.40[a]
T_4 - CCC 500 ppm	8.00	55.25[a]	10.44[a]	15.50[a]	13.95[a]
T_5 - MH 500 ppm	7.75	56.23[a]	10.71[ab]	15.75[a]	14.40[a]
T_6 - MH 1000 ppm	7.75	54.75[a]	10.63[ab]	14.42[a]	14.38[a]
T_7 - Control	8.25	63.75[b]	11.95[ab]	15.86[a]	15.38[b]
CD	NS	2.17*	1.53*	2.15*	0.90*

* Significant at 5 per cent level

4.2.5 Fruit girth

Girth of the fruits as influenced by preharvest application of growth regulators are presented in Table 8. Observations showed significant effects on fruit girth. As for fruit length, GA increased fruit girth also. Maximum girth was recorded in T_2 (300 ppm GA). This was followed by T_1, which received 200 ppm GA. Fruits from control (T_7) were on par with T_1. Lowest fruit girth was recorded in T_4 (500 ppm CCC).

4.2.6 Qualitative characters

Data on the quality components as influenced by preharvest application of growth regulators are presented in Table 9.

Perusal of data in Table 9 showed that maximum moisture content was in T_3 (CCC 250 ppm) which was significantly higher to all other treatments except T_7 (control). Moisture content was lowest in T_6 (MH 500 ppm).

The influence of growth regulators were not significant for the ash content of the fruits (Table 9).

Maximum ascorbic acid content was recorded in T_1 (GA 200 ppm) which was significantly superior to all other treatments. It was followed by T_6 (MH 1000 ppm). T_6, T_2

Table 9. Effect of preharvest application of growth regulators on the moisture, total ash, ascorbic acid, chlorophyll, total phenol and iron content of bittergourd fruits

Treatments	Moisture (%)	Total ash (%)	Ascorbic acid (mg/100 g)	Chlorophyll a	Chlorophyll b	Total chlorophyll	Total phenol (mg/100g)	Iron (mg/100g)
T_1	93.18^{c}	8.14	88.80^{d}	0.035	0.036	0.042	9.90	1.43
T_2	92.63^{b}	8.54	74.67^{c}	0.025	0.010	0.037	9.63	1.27
T_3	94.15^{d}	9.29	70.28^{c}	0.029	0.022	0.049	9.37	1.42
T_4	92.45^{b}	6.87	44.81^{ab}	0.020	0.009	0.029	7.29	1.46
T_5	93.35^{c}	8.44	52.61^{b}	0.013	0.006	0.020	6.77	1.12
T_6	89.69^{a}	8.60	77.11^{c}	0.025	0.018	0.043	9.38	1.47
T_7	94.08^{d}	7.68	39.22^{a}	0.026	0.009	0.036	11.46	1.33
CD	0.346*	NS	7.87*	NS	NS	NS	NS	NS

*Significant at 5 per cent level

(GA 300 ppm) and T_3 (CCC 250 ppm) were on par with each other. Lowest ascorbic acid content was recorded in T_7 (control), which was on par with T_4 (CCC 500 ppm).

There was no significant variation between treatments on the chlorophyll, phenol and iron contents of fruits (Table 9).

4.2.7 Incidence of spoilage

Incidence of spoilage was measured based on rotting percentage of fruits and weight loss during storage. Data on these aspects are presented in Table 10.

Data on the shelf life of fruits (Table 10) showed significant variation among treatments. Shelf life was maximum in T_5 (MH 500 ppm), followed by T_1 (GA 200 ppm) and T_4 (CCC 500 ppm). Shelf life was lowest in control (T_7).

Rotting percentage of fruits recorded at two days interval are presented in Table 10. During the first two days, rotting was lowest in T_1 (GA 200 ppm), followed by T_5 (MH 1000 ppm). Rotting percentage was maximum in control (T_7).

With increase in the storage period rotting percentage also increased in all the treatments. After 4 days of storage rotting percentage was lowest in T_1, which was followed by T_5.

Table 10. Shelf life, weight loss, fruit malformation and rotting percentage of bittergourd fruits as influenced by preharvest application of growth regulators

Treatments	Shelf life	Weight loss during storage (%)			Fruit mal-formation (%)	Rotting (%) of fruits		
		0-2 days	2-4 days	Cumulative		2 days	4 days	6 days
T_1	4.00^{b}	8.36	5.95	13.70	0.78^{a}	11.64^{a}	53.80^{a}	95.52
T_2	3.46^{b}	6.24	4.83	12.25	0.77^{a}	44.77^{bc}	71.00^{ab}	99.99
T_3	3.75^{b}	7.99	5.68	13.31	4.04^{b}	24.63^{ab}	73.24^{abc}	98.42
T_4	4.00^{b}	7.76	9.14	15.93	8.11^{c}	30.12^{abc}	78.16^{bc}	95.25
T_5	4.06^{b}	6.31	5.87	11.36	7.28^{c}	19.08^{a}	69.29^{ab}	99.41
T_6	3.25^{ab}	7.31	3.99	11.22	12.84^{d}	26.44^{abc}	77.35^{bc}	100.00
T_7	2.29^{a}	10.12	5.91	14.12	0.00^{a}	46.14^{c}	95.67^{c}	100.00
CD	1.12*	NS	NS	NS	2.194*	21.24*	23.46*	NS

* Significant at 5 per cent level

Maximum rotting was recorded in control. When the storage period increased to 6 days, rotting percentage was more than 95 per cent in all the treatments.

Weight loss during the storage of fruits were not significant either for the first two days or the next two days (Table 10). The pattern of spoilage was uniform in all treatments and was similar to that in the previous experiment.

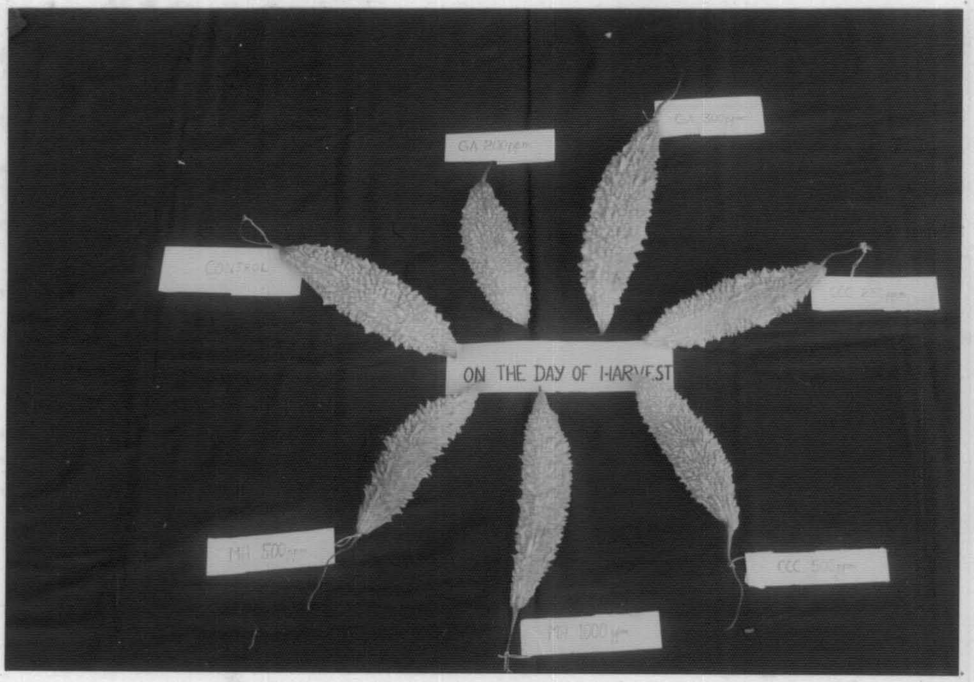
4.2.8 Colour of fruit and fruit malformation

Change in colour during storage as influenced by preharvest application of growth regulators are presented in Plates 6, 7, 8, 9, 10 and 11 and its colour score in Table 11. The treatments differed significantly. Slowest change in colour was recorded in T_5 (MH 500 ppm). This was followed by T_6 (MH 1000 ppm). Change in colour was faster in control (T_7) followed by T_1 (GA 250 ppm).

Data on fruit malformation are presented in Table 10. The treatments differed significantly. In control (T_7) no fruit malformation was recorded. In T_1 (GA 200 ppm) and T_2 (GA 300 ppm) fruit malformation was less than one per cent. Whereas T_6 (MH 1000 ppm) recorded maximum fruit malformation which was significantly inferior to all other treatments.

Plate 6 Effect of preharvest growth regulator sprays on storage life of bittergourd - On the day of harvest

Plate 7 Effect of preharvest growth regulator sprays on storage life of bittergourd - Two days after harvest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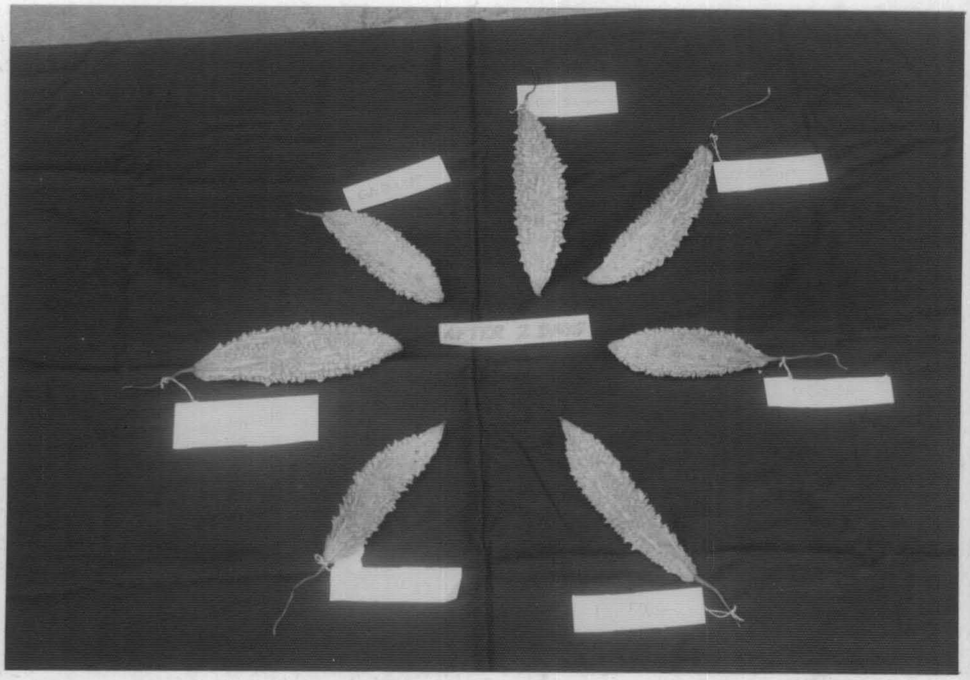
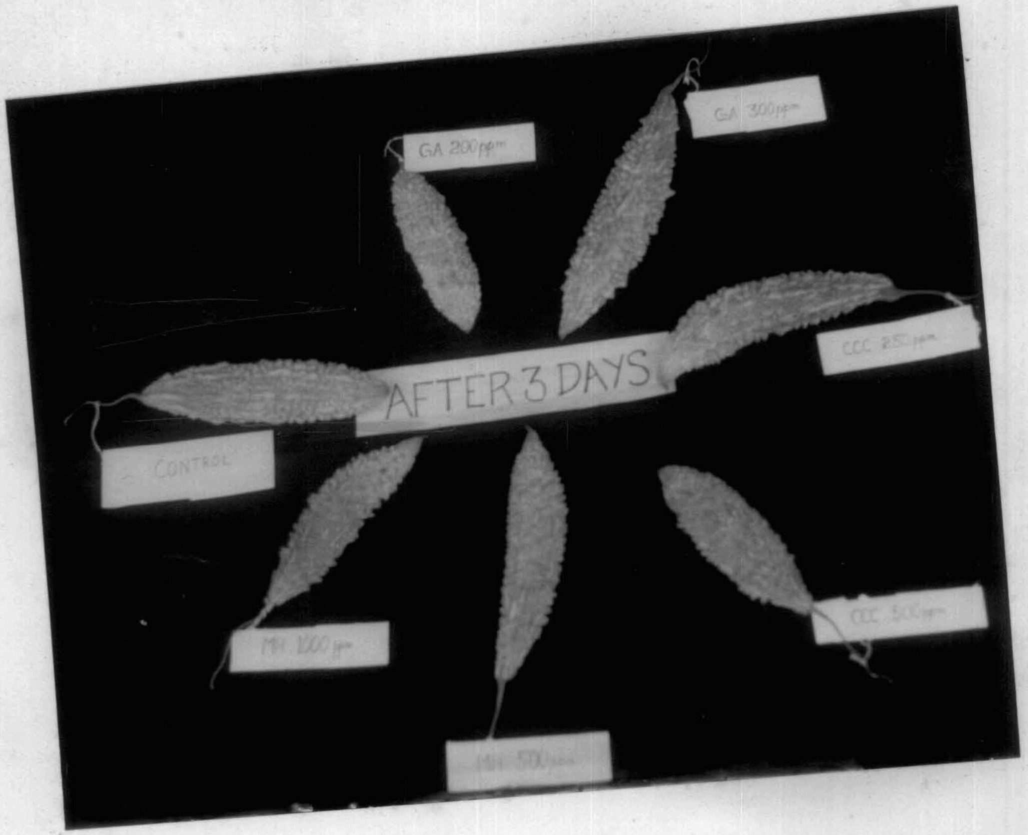
CONTROL
ON THE DAY OF HARVEST
MH 500ppm
CCC 500ppm
MH 1000ppm

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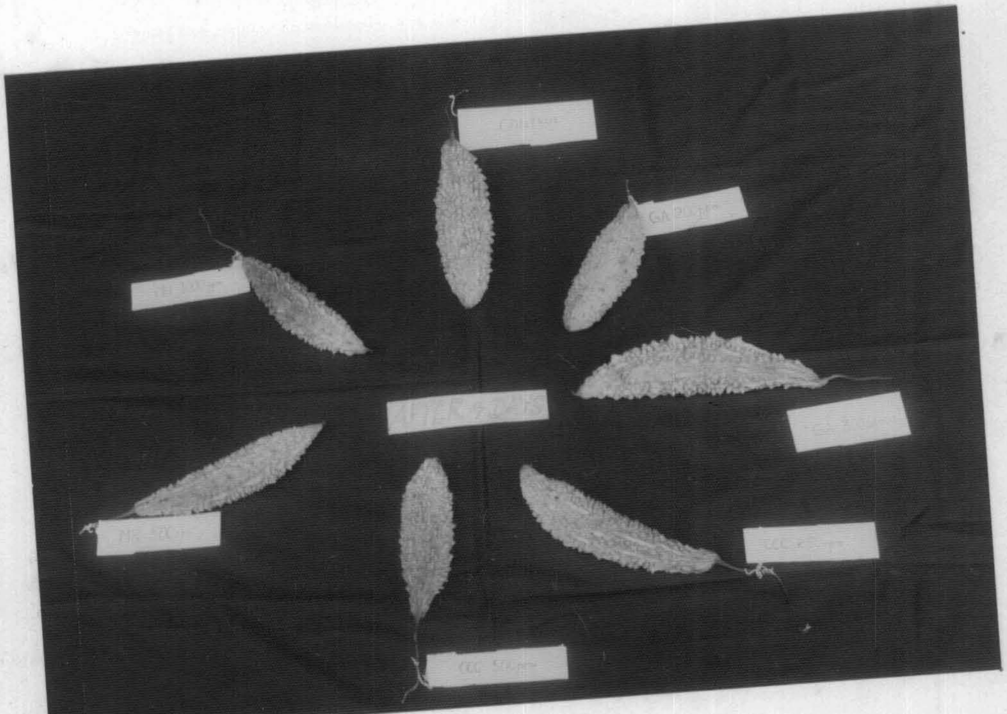
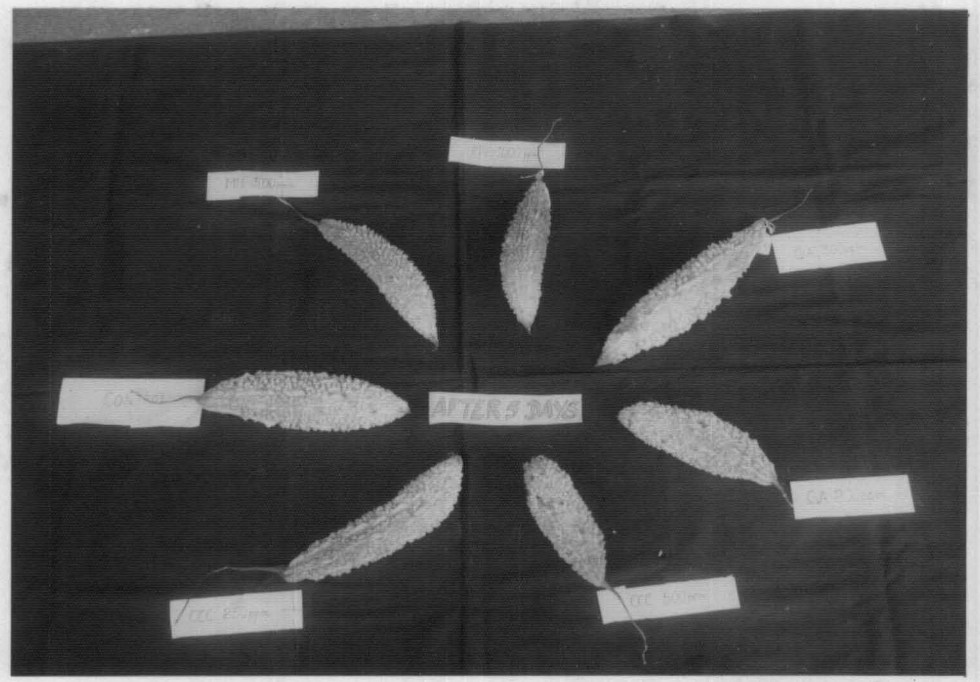
GA 300ppm
CCC 250ppm
AFTER 3 DAYS
CONTROL
MH 1000ppm
CCC 500ppm




AFTER 5 DAYS


AFTER 6 DAYS

4.3 Effect of postharvest treatments on the shelf life of fruits of bittergourd

4.3.1 Incidence of spoilage of fresh fruits under storage at 48 hours interval

Spoilage of fruits are expressed based on rotting of the fruits and the data on the rotting and storage life are presented in Table 12. Postharvest treatment of fruits had significant influence on the storage life of bittergourd. Maximum storage life was recorded in T_2 (fruit dipped in 4000 ppm CCC for one minute and stored in refrigerator). This treatment was significantly superior to all the other treatments. Both in T_1 (CCC 4000 ppm treatment and subsequent storage in open condition) and T_3 (stored in village model cooling chamber), storage life was on par. Lowest shelf life was recorded in T_6 (control) which was on par with T_4 (GA 50 ppm) and T_5 ($CaCl_2$ 4 per cent).

Mean value for rotting percentage (Table 12) varied significantly during first two days. Lowest value was recorded in T_2 and the highest in T_6. When the duration of storage increased to four days, rotting percentage also increased in all the treatments. Lowest rotting percentage was recorded in T_2. The control (T_6) recorded highest value for rotting. T_1 and T_4 were on par with each other. Even after 6 days only 18.35 percentage of rotting was observed in

Table 12. Effect of postharvest treatment of growth regulators and calcium chloride on the weight loss, rotting percentage and storage life of bittergourd fruits

Treatments	Weight loss during storage (%)			Rotting (%)			Shelf life (day)
	0-2 days	2-4 days	Cumulative	2 days	4 days	6 days	
T_1 - CCC 4000 ppm	11.36^{ab}	7.96^{ab}	24.13^{ab}	10.40^{b}	57.71^{bc}	87.15^{bc}	3.75^{b}
T_2 - CCC 4000 ppm + Refrigeration	5.48^{a}	4.29^{a}	10.02^{a}	1.01^{a}	4.98^{a}	18.35^{a}	7.50^{c}
T_3 - Village model cooling chamber	5.34^{a}	4.45^{a}	9.40^{a}	15.75^{d}	55.55^{b}	86.23^{b}	3.75^{b}
T_4 - GA 50 ppm	18.84^{abc}	11.03^{bc}	29.86^{ab}	23.50^{e}	65.75^{bc}	89.72^{bc}	3.25^{ab}
T_5 - $CaCl_2$ 4%	26.11^{c}	16.98^{c}	43.06^{b}	12.87^{c}	67.70^{c}	92.56^{cd}	3.25^{ab}
T_6 - Control	21.21^{bc}	19.50^{ab}	30.71^{b}	25.75^{f}	90.45^{d}	98.25^{d}	2.50^{a}
CD	14.83*	6.36*	20.59*	5.29*	10.67*	5.99*	1.21*

* Significant at 5 per cent level

Room temperature during the experiment

Maximum temperature - 31.4°C

Minimum temperature - 22.8°C

T_2. But during the same period 98.25 per cent rotting was observed in the untreated control. Treatments T_1 and T_4 were on par with each other after six days of storage.

Fungal growth appeared on the fruits were identified as Fusarium sp. In T_2 fungal growth was not seen even after eight days of storage.

4.3.2 Colour change of fruits during storage

The cumulative scores obtained for the deterioration of colour during storage is presented in Table 13. The data showed that maximum retention of green colour was in T_2 (CCC 4000 ppm + refrigeration). In all the other treatments yellow colour indicating advanced senescence manifested after a period of four days.

4.3.3 Physiological loss in weight

Data on the loss in weight of fruits as expressed in percentage at 48 h interval are presented in Table 12. After 48 h of storage, weight loss was minimum in fruits stored in cooling chamber (T_3), which was on par with T_2 (CCC 4000 ppm and refrigerated storage). In all the other treatments weight loss was more than 10 per cent. Weight loss was maximum in T_5 ($CaCl_2$ 4 per cent). During the next 48 h weight loss was lower compared to the first 48 h. During this period also

Table 13. Colour change of bittergourd fruits as influenced by postharvest treatment with chemicals

Treatments	Days after harvest (score)					Total
	0	2	4	6	8	
T_1 - CCC 4000 ppm	0	0	2	4	5	11
T_2 - CCC 4000 ppm + Refrigeration	0	0	0	1	2	3
T_3 - Village model cooling chamber	0	0	2	4	5	11
T_4 - GA 50 ppm	0	1	3	4	5	13
T_5 - $CaCl_2$ 4 per cent	0	2	4	5	5	16
T_6 - Control	0	2	4	4	5	15

x^2 = 3 (Not significant)

lowest weight loss was recorded in T_2 which was on par with T_3. Highest value was recorded in T_5. When the cumulative weight loss was taken into account it was lowest in T_3 which again was on par with T_2. Highest value was recorded in T_5, which was on par with all other treatments except T_2 and T_3.

4.4 Standardisation of drying technique for bittergourd

4.4.1 Quality

The influence of drying methods on the quality characters are presented in Table 14.

Dehydration methods had significant influence on the final moisture content of dried sample (Table 14). Minimum moisture content was recorded in T_8 (steeped in 5 per cent brine and dehydrated), which was on par with T_5 (hot water blanched and dehydrated) and T_4 (dehydrated). Dehydration was stopped at 30 per cent moisture level in intermediate moisture bittergourd (T_9) purposively.

Perusal of data in Table 14 indicates that total ash content of the prepared sample varied significantly among treatments. Maximum ash content of 11.13 per cent was recorded in the sulphited sample (T_7). Ash content was minimum in T_9 (intermediate moisture bittergourd) followed by T_6 (steam blanched and dehydrated).

Data on ascorbic acid content are presented in Table 14. Highest ascorbic acid content was recorded in T_9 (intermediate moisture sample) which was significantly superior to all other treatments. This was followed by T_4 (dehydrated) and T_1 (sundried). Lowest ascorbic acid content was recorded in T_8 (brine treated and dehydrated). T_8 was on par with T_2 (hot water blanched and sundried), T_7 (sulphited) and T_5 (hot water blanched and dehydrated).

There was significant differences in chlorophyll a, chlorophyll b and total chlorophyll content of different treatments. Chlorophyll a was maximum in T_4 (dehydrated) which was on par with T_6 (steam blanched and dehydrated). Minimum content of chlorophyll a was recorded in intermediate moisture bittergourd. Similar to chlorophyll a, chlorophyll b content was also maximum in T_4. In addition to T_4, sulphited sample (T_7) also recorded higher chlorophyll b. This was followed by T_6. Brine treated sample (T_8) had minimum chlorophyll b. Maximum total chlorophyll was in T_4, which again was on par with T_7. Total chlorophyll content was minimum in T_8.

Data in Table 14 showed that phenol content was minimum in T_2 (hot water blanched and sundried) which was significantly lower compared to other treatments. Maximum phenol content was recorded in T_4 (dehydrated).

Iron content of different sample varied significantly among treatments (Table 14). Maximum iron content was recorded in brine treated sample (T_8), which was followed by T_2 (hot water blanched and sundried). These two treatments were on par with each other. Iron content was lowest (8.00 m/100 g) in dehydrated sample T_4. However, this was on par with T_9.

4.4.2 Dehydration ratio

Highest dehydration ratio of 5.3:1 was recorded in intermediate moisture bittergourd (T_9) which was significantly superior to all other treatments (Table 15). This was followed by T_2 (hot water blanched and sundried). T_2 was on par with all the other treatments except T_9, T_5 (hot water blanched and dehydrated) and T_8 (brine treated). T_8 was recorded lowest dehydration ratio.

4.4.3 Rehydration studies

Maximum rehydration ratio of 1:5.1 (Table 15) was recorded in T_1 (sundried) which was followed by 1:5.03 in T_8 (brine treated sample). These treatments were on par with each other and also with T_4 (dehydrated) and T_7 (sulphited). Rehydration ratio was lowest in T_9 (intermediate moisture sample).

Table 15. Influence of drying methods on dehydration ratio and rehydration ratio of dried bittergourd

Treatments	Dehydration ratio	Rehydration ratio
T_1	$12.4 : 1^{ab}$	$1 : 5.11^{a}$
T_2	$11.8 : 1^{ab}$	$1 : 3.84^{bc}$
T_3	$12.5 : 1^{ab}$	$1 : 3.41^{b}$
T_4	$12.8 : 1^{ab}$	$1 : 4.96^{d}$
T_5	$13.5 : 1^{ab}$	$1 : 3.91^{bc}$
T_6	$12.8 : 1^{ab}$	$1 : 3.40^{b}$
T_7	$12.2 : 1^{ab}$	$1 : 4.37^{cd}$
T_8	$13.7 : 1^{a}$	$1 : 5.03^{d}$
T_9	$5.3 : 1^{c}$	$1 : 5.03^{d}$
CD	1.09*	0.78*

* Significant at 5 per cent level

4.4.4 Colour, texture and overall appearance

Scores obtained for colour, texture and overall appearance are presented in Table 16.

Lowest score for colour, based on visual scoring was obtained in T_4 (dehydrated) closely followed by T_7 (sulphited). Maximum score for colour was in T_6 (steam blanched and dehydrated), which indicate the poor colour of the product.

Lowest score for texture indicating its superiority was in T_7 (sulphited) closely followed by T_8 (brine treated). While ranking for texture T_9 (IM bittergourd) was not taken into account as this product had a texture similar to fresh product. Maximum score for texture was in sundried sample (T_1), which showed a poor crisp. T_7 and T_8 were very crisp.

Highest preference as indicated by lowest score was obtained in T_4 (dehydrated) followed by T_9 (intermediate moisture bittergourd), T_8 (brine treated) and T_1 (sundried). T_5 (hot water blanched) and T_7 (sulphited) had an overall inferior appearance.

4.5 Comparison of different packaging materials for storage of dehydrated bittergourd

Out of the nine processes tried for drying of bittergourd, four treatments viz., T_1 (sundried), T_4

Table 16. Sensory evaluation of dehydrated bittergourd based on colour, texture and overall appearance (score)

Treatments	Score obtained for		
	Colour	Texture	Overall appearance
T_1	2.75	2.33	2.15
T_2	2.83	2.25	3.17
T_3	3.00	2.16	2.67
T_4	2.17	1.67	1.75
T_5	3.00	1.67	3.42
T_6	3.17	1.67	3.12
T_7	2.42	1.42	3.42
T_8	2.92	1.50	2.33
T_9	3.33	--	1.92
H*	17.72	18.59	37.06

H is the statistic computed as per Kruskel-Wallis one way analysis of variance.

Hedonic scale for

a. Colour : 1. Green, 2. Light green, 3. Brownish green, 4. Light brown, 5. Burnt appearance

b. Texture : 1. Very crisp, 2. Moderately crisp, 3. Neither crisp nor soft, 4. Soft, 5. Very soft

c. Overall appearance : 1. Like very much, 2. Like moderately, 3. Neither like nore dislike, 4. Dislike slightly 5. Dislike very much.

(dehydrated), T_8 (brine treated and dehydrated) and T_9 (IM bittergourd) were selected for the packaging and storage studies based on the overall merits of each process. These four products were packed and stored under nine different packaging materials/containers along with an unpacked control. The sensory qualities like colour, texture, overall appearance and consumer acceptability were evaluated at the commencement of storage and thereafter at monthly intervals for a period of three months. The objective of the experiment was to find out the cheapest packaging system for both marketing and household storage that will retain the sensory qualities satisfactorily over the storage period. The results of the experiment are presented below.

4.5.1 Sensory qualities of the dehydrated products during storage

The statistical analysis of the sensory quality as per Cruskel Wallis one way analysis showed there was significant variations between packages on colour, texture, overall appearance and consumer acceptability.

The results of the sensory evaluation at the commencement of the study are presented in Table 17. There was no significant variation between treatments on the colour and overall appearance whereas significant variation was observed between treatments with respect to texture. The dehydrated

Table 17. Sensory quality of dehydrated bittergourd at the commencement of storage (score)

Treatments	Score obtained for		
	Colour	Texture	Overall appearance
T_1 - Sundried	2.92	2.25	2.67
T_4 - Dehydrated	2.83	1.67	2.10
T_8 - Brine treated and dehydrated	2.92	1.75	3.10
T_9 - IM bittergourd	3.10	--	2.00
H*	NS	25.99	NS

H - Kruskel-Wallies statistic

Hedonic scale for

a. Colour : 1. Green, 2. Light green, 3. Brownish green, 4. Light brown, 5. Burnt appearance

b. Texture : 1. Very crisp, 2. Moderately crisp, 3. Neither crisp nor soft, 4. Soft, 5. Very soft.

c. Overall appearance : 1. Like very much, 2. Like moderately, 3. Neither like nor dislike, 4. Dislike slightly, 5. Dislike very much

(T_4) and brine treated + dehydrated (T_8) samples were crisp in texture while the intermediate moisture product was soft.

Results of the consumer acceptability of the products in different packages are presented in Table 18. In all the treatments there was significant variation between packaging on the consumer acceptability. The treatment T_4 (600 gauge LDPE) was rated as the best for the sundried product. The treatment T_9 (transparent plastic jar) was equally acceptable. In the case of dehydrated product best consumer acceptability was for the treatment T_4 (600 gauge LDPE), followed by T_2 (300 gauge LDPE). In the brine treated and cabinet dried product, consumer acceptability was best in T_4, which was followed by T_3 (450 gauge LDPE). Evaluation of the IM bittergourd under different packages revealed that T_4 was adjudged as the best packaging material.

The unpacked samples kept as control developed mould growth on the nineth day for dehydrated, brine treated and sundried samples, whereas the IM bittergourd developed symptoms of spoilage at a later stage i.e., after 15 days. Spoilage was mainly due to the growth of Penicillium sp.

The results of the sensory evaluation for colour of the packaged products conducted during one to three months of storage are presented in Table 19. The data revealed that the

Table 18. Consumer acceptability of brine treated and intermediate moisture bittergourd during storage (score)

Treatments	Brine treated and dehydrated				Intermediate moisture			
	At the start of storage	One month after storage	Two months after storage	Three months after storage	At the start of storage	One month after storage	Two months after storage	Three months after storage
T_1 - 150 gauge LDPE	1.83	2.83	3.00	3.42	2.67	2.67	2.25	3.00
T_2 - 300 gauge LDPE	1.93	3.33	3.67	3.25	1.92	2.50	2.08	3.00
T_3 - 450 gauge LDPE	1.75	2.58	3.00	3.12	2.58	2.92	2.00	2.92
T_4 - 600 gauge LDPE	1.42	1.92	2.25	3.08	1.50	2.42	1.07	2.83
T_5 - Black polythene	3.33	3.42	4.00	3.75	3.25	4.50	3.58	3.92
T_6 - 100 gauge PP	2.50	2.92	4.00	3.67	2.10	2.50	2.67	3.50
T_7 - 150 gauge LDPE + IPD	3.10	3.58	3.75	4.00	3.50	3.58	3.33	3.58
T_8 - Opaque container	2.75	2.92	3.08	3.83	2.60	2.75	3.08	3.92
T_9 - Transparent container	2.83	4.20	3.75	3.67	3.75	3.92	4.17	3.83
T_{10} - Open	4.00	--	--	--	4.58	--	--	--
H*	70.67	226.96	32.23	NS	70.76	259.25	62.07	27.60

H - Kruskel-Wallies Statistic -- - Sample spoiled

LDPE - Low density polyethylene; IPD - Inpackage desiccant; PP - Polypropylene

Scire: 1. Acceptable fully, 2. Acceptable somewhat, 3. Neither acceptable nor unacceptable, 4. Unacceptable somewhat, 5. Not acceptable

Table 18. Consumer acceptability of the sundried and dehydrated bittergourd during storage (score)

Treatments	Sundried				Dehydrated			
	At the start of storage	One month after storage	Two months after storage	Three months after storage	At the start of storage	One months after storage	Two months after storage	Three months after storage
T_1 - 150 gauge LDPE	2.67	3.00	3.08	3.16	2.10	2.67	3.07	3.33
T_2 - 300 gauge LDPE	2.42	2.75	2.83	3.00	1.92	2.25	2.58	3.08
T_3 - 450 gauge LDPE	2.83	2.17	2.25	2.67	1.75	2.25	2.50	2.92
T_4 - 600 gauge LDPE	1.58	1.83	2.08	2.67	1.13	1.50	1.58	2.58
T_5 - Black polythene	2.85	3.58	3.75	3.67	3.17	3.83	3.92	4.17
T_6 - 100 gauge PP	2.33	2.58	2.92	3.08	2.33	2.33	2.42	2.92
T_7 - 150 gauge LDPE + IPD	2.67	4.17	4.25	4.33	3.50	3.67	3.33	3.67
T_8 - Opaque jar	2.83	3.67	3.25	3.75	2.75	2.83	4.25	3.67
T_9 - Transparent jar	1.58	4.00	4.00	4.00	3.42	4.00	4.00	3.75
T_{10} - Control	3.00	-	-	-	3.75	-	-	-
H	51.56	62.00	NS	15.40	52.50	78.04	61.54	NS

* Kruskel-Wallies statistic   - Samples spoiled

Table 19. Colour of sundried, dehydrated, brine treated and intermediate moisture bittergourd during storage (score)

Treatments	Sundried			Dehydrated			Brine treated			Intermediate moisture		
	After one month	After two months	After three months	After one month	After two months	After three months	After one month	After two months	After three months	After one month	After two months	After three months
T_1 - 150 gauge LDPE	3.67	3.83	3.80	3.00	3.17	3.25	2.75	2.83	3.00	2.00	2.17	2.67
T_2 - 300 gauge LDPE	3.64	3.67	3.58	2.75	2.75	3.00	3.33	3.42	3.50	2.00	2.08	2.58
T_3 - 450 gauge LDPE	3.33	3.50	3.50	1.75	2.00	2.33	4.12	4.42	4.42	2.25	2.42	2.50
T_4 - 600 gauge LDPE	2.75	3.00	3.25	2.17	2.10	2.25	3.75	3.83	3.75	2.25	2.33	2.42
T_5 - Black polythene	3.33	3.58	3.50	1.83	2.10	2.42	3.92	4.00	4.08	2.12	2.33	2.42
T_6 - 100 gauge PP	3.33	3.58	3.67	1.75	1.92	2.25	2.75	2.92	3.17	2.10	2.17	2.50
T_7 - 150 gauge LDPE + IPD	3.50	3.67	3.75	1.83	2.25	2.42	3.42	3.58	3.58	2.25	2.42	2.58
T_8 - Opaque jar	3.50	3.75	3.75	2.75	2.42	2.25	3.50	3.67	3.75	2.42	2.83	2.83
T_9 - Transparent jar	2.83	3.50	3.50	2.17	1.92	2.25	2.75	3.00	3.08	2.25	3.08	3.08
T_{10} - Control	-	-	-	-	-	-	-	-	-	-	-	-
H*	NS	11.41	23.60	48.94	20.05	16.88	50.22	116.56	14.42	NS	NS	NS

* Kruskal-Wallies statistic - Spoiled

Score: 1. Green, 2. Light green, 3. Brownish green, 4. Light brown, 5. Burnt appearance treatment T_4 was maintaining its superiority as the best package throughout the storage period. This trend was shown by the sundried and cabinet dried products, whereas best colour was in T_6 (polypropylene) and T_8 (transparent container) for the brine treated, T_1 (150 gauge LDPE), T_2 (300 gauge LDPE) and T_6 (polypropylene package) for the IM bittergourd. This trend of preference with respect to colour remained same throughout the storage period of three months.

With respect to the texture of the product (Table 20) after one month of storage the treatments T_5, T_4 and T_7 (polypropylene with inpackage desiccant) were superior in the sundried product, whereas treatments T_5, T_6, T_7 and T_9 were superior in the dehydrated product. In the case of brine treated product, treatments T_4, T_8 and T_9 were the best, whereas in the IM bittergourd T_5, T_6, T_7 and T_9 were adjudged as the superior packages. At the end of two months of storage the treatments T_4, T_6 and T_5 were adjudged as superior in the sundried product whereas in the dehydrated products, treatments T_7, T_6 and T_5 were superior. The better treatments at the end of two months of storage in the brine treated product was same as for the first month of storage i.e., T_4, T_8 and T_9. In the case of IM bittergourd, T_6, T_7 and T_9 were the superior treatment after two months storage for texture. At the end of the study i.e, after three months of storage in

Table 20. Texture of sundried, dehydrated, brine treated and intermediate moisture bittergourd during storage (score)

Treatments	Sundried			Dehydrated			Brine treated			Intermediate moisture		
	After one month	After two months	After three months	After one month	After two months	After three months	After one month	After two months	After three months	After one month	After two months	After three months
T_1 - 150 gauge LDPE	3.00	3.17	3.33	2.42	2.67	2.75	3.92	3.92	4.00	4.75	4.83	4.92
T_2 - 300 gauge LDPE	2.58	2.67	3.25	2.75	2.15	2.75	2.42	1.58	2.50	4.83	4.83	4.92
T_3 - 450 gauge LDPE	2.42	2.50	3.08	2.17	2.42	2.80	1.42	2.50	2.33	4.50	4.26	4.81
T_4 - 600 gauge LDPE	2.00	2.08	2.67	1.10	1.25	1.83	1.00	1.17	1.83	5.00	5.00	5.00
T_5 - Black polythene	1.92	2.17	2.75	1.00	1.17	2.01	1.58	1.58	1.92	2.83	4.15	4.92
T_6 - 100 gauge PP	2.92	2.08	2.92	1.00	1.08	2.05	2.10	2.42	2.58	3.67	3.83	4.25
T_7 - 150 gauge LDPE + IPD	2.00	3.19	2.67	1.00	1.00	1.17	1.00	1.42	1.33	3.67	2.25	2.83
T_8 - Opaque jar	3.33	3.33	3.50	2.58	2.75	2.67	1.00	1.17	2.67	4.00	4.00	4.33
T_9 - Transparent jar	3.25	3.33	3.50	1.00	1.25	2.17	1.00	1.17	2.75	3.67	3.92	4.50
T_{10} - Control	-	-	-	-	-	-	-	-	-	-	-	-
H*	45.11	44.38	14.12	65.50	81.43	44.64	37.14	58.02	48.53	39.51	68.30	47.55

* Kruskel-Wallies statistic   - Sample spoiled

Score: 1. Very crisp, 2. Moderately crisp, 3. Neither crisp nor soft, 4. Soft, 5. Very soft the case of sundried product the treatments that were rated as superior were T_4, T_7 and T_5 whereas in the dehydrated, it was T_7, T_4 and T_5. In the brine treated products at the end of three months storage the products adjudged as best were those packaged in T_7, T_4 and T_5. In the case of IM bittergourd the same trend of preference at the end of two months storage.

As far as the overall appearance of the packaged products (Table 21) at the end of the first month of storage in the sundried sample treatments T_4, T_8 and T_5 were rated superior and for the dehydrated sample, treatments T_2, T_3, T_6 and T_7 were found to be preferred ones. Out of the brine treated samples, treatments T_8, T_6, and T_4 were selected as the better packages at the end of first month's storage whereas in the case of IM bittergourd T_6, T_7 and T_1 were rated as superior ones. At the end of the second month in the sundried product T_4, T_3 and T_8 were preferred by the panel of judges, whereas in the dehydrated sample the same trend as for the first month was shown. In the case of brine treated samples the packages found superior at the end of second month storage were T_4, T_6 and T_1. Of this T_4 and T_6 were preferred in the third month also. In the case of the IM bittergourd the results followed a similar trend as that for the first month's storage. The package selected at the end of the storage study in the sundried samples were T_4, T_8 and T_6,

Table 21. Overall appearance of the sundried, dehydrated, brine treated and intermediate moisture product during storage (score)

Treatments	Sundried			Dehydrated			Brine treated			Intermediate moisture		
	After one month	After two months	After three months	After one month	After two months	After three months	After one month	After two months	After three months	After one month	After two months	After three months
T_1 - 150 gauge LDPE	2.50	2.58	2.75	2.75	3.50	3.58	2.50	2.58	3.58	2.75	3.00	3.08
T_2 - 300 gauge LDPE	2.42	2.60	2.83	1.50	1.67	2.25	3.00	3.25	3.25	3.83	3.92	3.00
T_3 - 450 gauge LDPE	2.33	2.42	2.83	1.92	1.83	2.33	3.33	3.25	3.42	3.10	3.33	2.92
T_4 - 600 gauge LDPE	1.67	1.92	2.25	2.75	2.58	2.33	2.17	2.25	2.00	4.10	4.25	2.83
T_5 - Black polythene	2.50	2.58	2.75	2.33	2.58	4.08	3.33	3.50	4.33	3.33	3.25	3.83
T_6 - 100 gauge PP	2.42	2.60	2.75	2.00	2.17	2.42	2.00	2.25	2.83	2.33	2.50	3.50
T_7 - 150 gauge LDPE + IPD	3.67	3.75	3.83	2.00	2.50	3.58	3.00	3.25	3.35	2.50	2.83	3.33
T_8 - Opaque jar	2.33	2.50	2.67	2.67	2.83	2.75	2.00	2.75	3.17	3.42	3.75	3.83
T_9 - Transparent jar	2.50	2.58	2.75	2.33	2.92	2.92	3.25	3.50	3.50	3.67	3.83	3.83
T_{10} - Control	-	-	-	-	-	-	-	-	-	-	-	-
H*	32.85	31.41	14.32	18.61	12.99	16.88	10.25		14.42	NS	NS	NS

* Krustel-Wallies statistic   - Sample spoiled

Score: 1. Like very much, 2. Like moderately, 3. Neither like nor dislike, 4. Dislike slightly, 5. Dislike very much whereas in the case of dehydrated sample the preferred package were T_2, T_3 and T_4. At the end of three months of storage in the brine treated sample preference went for the packages T_4, T_6 and T_8. In the case of IM bittergourd the treatments that retained maximum overall appearance were in the packages T_4, T_3 and T_2.

Sensory evaluation of the consumer acceptability (Table 18) at the end of one month's storage for the sundried product was in favour of packages T_4, T_3 and T_6 and for the dehydrated products it was in favour of T_4, T_2 and T_3. In the brine treated products the better packages were T_4, T_3 and T_1 and for the IM bittergourd the choice was in favour of T_4, T_6 and T_2. At the end of the two months of storage in the sundried sample the packages selected were T_4, T_3 and T_2. In the case of dehydrated sample the packages selected were T_4, T_3 and T_6. The choice of packages in the case of brine treated products were in favour of T_4, T_3 and T_1 and in the case of the IM bittergourd the packages preferred were T_4, T_3 and T_2. At the end of the storage study in the sundried sample the preference were the same as for the second month whereas in the dehydrated sample the order of preference was T_4, T_3 and T_6. In the brine treated samples at the end of the storage study the packages selected were same as those selected at the end of the second months storage. Similar

Table 22. Weight gain of dried bittergourd as influenced by different packages (g)

Treatments	Sundried			Dehydrated			Brine treated			Intermediate moisture		
	After 1 month	After 2 months	After 3 months	After 1 month	After 2 months	After 3 months	After 1 month	After 2 months	After 3 months	After 1 month	After 2 months	After 3 months
T_1	4.18	5.42	6.24	3.10	4.31	5.48	3.56	5.51	7.51	3.53	5.86	9.16
T_2	2.81	4.06	5.22	2.65	4.03	4.60	3.23	5.05	7.30	3.30	5.00	7.80
T_3	2.92	3.92	4.82	2.63	3.46	3.99	2.40	4.90	6.90	2.10	2.30	3.30
T_4	3.70	4.21	4.73	2.60	3.20	4.03	2.06	4.53	6.06	3.03	3.10	4.20
T_5	4.57	5.21	5.28	4.03	4.73	5.15	4.00	9.46	11.57	5.86	9.23	17.71
T_6	1.21	2.68	3.42	0.73	1.76	2.40	0.20	2.20	3.93	1.30	2.38	4.38
T_7	1.02	2.24	3.24	0.46	1.16	2.10	0.13	2.16	4.30	0.70	2.20	3.41
T_8	2.22	2.07	4.67	1.66	2.06	3.13	1.56	2.56	3.86	2.93	4.53	6.18
T_9	3.40	4.52	6.25	2.80	3.73	5.73	1.16	4.39	5.76	2.30	4.03	5.60
CD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

trend followed in the case of the intermediate moisture product also.

4.5.2 Weight gain of the packaged product during storage

There was a gain in weight by the different packages when recorded at monthly intervals. The data are presented in Table 22. The results did not show any significant variation with respect to weight gain as compared to the original weight of the sample at the commencement of storage.

Discussion

DISCUSSION

Fruits and vegetables are highly perishable. Postharvest losses amount to 20 to 30 per cent of the harvested produce. Bittergourd is an important cucurbitaceous vegetable of Kerala State. It is consumed in the fresh, pickled and dehydrated forms. It is also exported to foreign countries in the fresh form. A study was conducted on bittergourd to understand the effect of different sources and quantity of nitrogen on the postharvest behaviour of the vegetable. Another object of the study was to assess the effect of pre and postharvest application of some chemicals on the shelf life of bittergourd. Efforts were also made to standardise a technique of dehydration for bittergourd and to find out a suitable packaging material for the product. The results obtained from the five experiments are discussed in this chapter.

5.1 Effect of organic and inorganic sources of nitrogen on the shelf life of bittergourd fruits

Earlier work has revealed that organic manuring has a positive effect on the shelf life of perishable commodities (Joseph, 1985). Excessive application of N also was reported to reduce the shelf life. Hence an experiment was laid out with five treatments comprising different doses of organic manure and nitrogenous fertilisers with two varieties of bittergourd viz., MC 84 and Priya, to investigate further into the above assumptions. The results of the experiment are discussed below.

The treatments did not affect the days for the appearance of first female flower, number of harvests, fruits per plot, fruit length, fruit girth, yield per plot, moisture content of fruits, chlorophyll content and phenol content. This shows that neither the source nor the quantity of nitrogen had any significant effect on the expression of these traits. Similar findings have been reported in bittergourd by Thomas (1984) who observed that levels of fertiliser had no effect on girth of fruit and days for flowering. In cowpea also Chandran (1981) had reported that neither the level of NPK nor their interaction had any effect on days to first flowering and flowering period.

The reason for the failure of the response to higher levels of inorganic N and FYM may be due to the initially high status of soil of experimental plot with respect to N and K. The available nutrients of the experimental plot together with the added FYM and fertilisers even at half the recommended dose of N might have been sufficient for normal crop production. It is also worth mentioning here that the experimental plots were almost like a virgin land as it was lying fallow for about five years prior to raising this crop.

Even in the above background the treatments significantly influenced quality characters such as ascorbic acid, iron content, shelf life of fruits and colour change during storage. Sharma and Singh (1989) have reported that a proper supply of N and P is needed for new growth and better supply of photosynthates which provides a better frame work for enhanced flowering, fruiting and better fruit quality. As far as ascorbic acid content of fruit was concerned the highest level was found in T_1 (KAU recommendation) and the lowest in T_4 (20 t FYM and 35:25:25 kg, NPK through fertilisers). Wilcox and Morrel (1948), Sharma and Mann (1971) have also reported similar trends in the ascorbic acid content of tomato fruits.

Anisimov (1953) reported that moderate levels of N increased vitamin C content of onion tops and pea leaves whereas excessive doses depressed it. Joseph (1985) observed higher ascorbic acid content in oriental pickling melon fruits raised by adopting KAU recommendations of NPK doses in the inorganic form under Vellanikkara conditions. Another report by Stanilova *et al.* (1972) says that a proper combination of N, P and K produced good quality in terms of ascorbic acid content in Spinach. The higher ascorbic acid content in response to increase of N to a moderate level may be due to the increased activity of ascorbic acid oxidase enzyme (Kocchar, 1970; Singh and Dhankar, 1989). This trend points to the fact that an optimum combination of all nutrients may be needed for the synthesis of ascorbic acid in bittergourd. Lower ascorbic acid content in T_4 may be due to the reduced availability of N, which might have slowed down the metabolic process of ascorbic acid synthesis in the plant system, consequently reducing its content.

With respect to the iron content of the bittergourd fruits maximum amount was noticed in T_2 which received N through FYM alone. Similar findingshas been reported by Schuphan (1974) who observed that organically grown spinach, celeriac, savoy cabbage, carrots and lettuce had higher iron content.

The shelf life of the harvested fruits in the study were assessed based on the incidence of spoilage, and also on the physiological loss in weight. It was observed that longer shelf life was in $T_2$and T_3 which received the maximum quantity of organic manure as compared to other treatments. Moreover in T_2, N was supplied solely through FYM. The positive effect of FYM on the shelf life of oriental pickling melon has been reported by Joseph (1985). In the case of rotting percentage also better treatments were T_2, T_3 and T_4 which received lesser amounts of inorganic N. Shanthi and Balakrishnan (1989) have reported that increased dosages of N improves the efficiency of metabolism. In the present study the increased metabolic efficiency due to N application might have resulted in a faster senescence process resulting in an early spoilage. The same reason can be attributed to the increased physiological loss in weight of fruits from the treatments receiving higher amounts of nitrogen in the inorganic form. Similar results were reported by Quereshi(1972) in tomato, Kato et al. (1987) and Rao and Srinivasan (1990) in onion.

Change in colour of the fruits after harvest as recorded by visual scoring was slowest in T_4V_2 which received 20 t FYM and 35:25:25 kg NPK through fertilisers in variety MC-84. The points discussed above hold valid for the slower colour change due to reduced metabolic activity in a lower dose treatment of inorganic N. The reason for the colour difference between the two varieties Priya and MC-84 is more genotypic in nature as Priya is dark green and MC-84 light green. Hence the colour loss was apparent earlier in MC-84 as the initial intensity of green colour was less.

The two varieties did not differ significantly on the characters viz., days for flowering, number of harvests, fruits per plot, yield per plot, moisture content of fruits, ascorbic acid content of fruits and shelf life. This indicates that the two varieties are similar for many of the vegetative, yield quality and postharvest parameters. This is supported by the fact that Priya and MC-84 were grouped together in a divergence study involving 50 genotypes of bittergourd (Vahab, 1989).

The two varieties differed significantly in fruit length, fruit girth, chlorophyll, phenol, ash, and iron content. Probably these are peculiarities due to the genetic set up of the two varieties which make them distinctly different from each other.

5.2 Effect of preharvest sprays on the shelf life of fruits of bittergourd

Results obtained due to two preharvest sprays with GA (200 and 300 ppm), CCC (250 and 500 ppm) and MH (500 and 1000 ppm) given at an interval of 15 days from the fruit set did not affect significantly the number of harvest, number of fruits per plot, ash, chlorophyll, phenol and iron content of the fruit. Since bittergourd is a monoecious crop, the growth regulator sprays at a post flowering stage probably might not have affected the number of female flowers which ultimately determines the number of harvest and the number of fruits per plot.

General time of application of growth regulators for the modification of sex expression in cucurbits is in the two or four leaf stage of seedling. No reports are available as to the influence of GA, MH and CCC on the ash, phenol and iron content of bittergourd, though these growth regulators have specific influence on the growth and development of bittergourd fruits. The concentration and mode of application of the above three growth regulators probably was not effective to bring any significant change in the ash, phenol and iron contents. Kurup (1969) and Abdalla and Verkerk (1970) have reported increased chlorophyll content due to CCC application in the leaves of potato and tomato respectively. However, in the present study there was no significant response in chlorophyll content of the gourds. This may be due to the specificity of the growth regulator on the metabolism of different crops. This indicates that detailed studies are required with different concentrations of growth regulators to see whether it can improve the chlorophyll content so that appearance of the fresh as well as dehydrated bittergourd is better.

Preharvest growth regulator sprays significantly influenced the fruit length, fruit girth, yield per plot, moisture, ascorbic acid content and shelf life of fruits.

Maximum fruit length, fruit girth and yield per plot were recorded in T_2 (GA 300 ppm) which was on par with T_1 (GA 200 ppm). This response of GA may be due to its specific influence on the cell division and cell elongation (Leopold and Kriedmann, 1975; Bidwell, 1979). The other growth regulators used in this experiment, (CCC and MH) were growth retardants which might have suppressed the growth of plants. Thus growth promoting activity of GA was more highlighted. Similar findings were reported in tomato by Irulappan (1972).

High moisture content in CCC treated fruits can be attributed to the antitranspirant activity of the growth regulator (Usha and Peter, 1988). Ravidas (1990) has reported a similar effect with CCC 500 ppm treatments on spikes of gladiolus.

Maximum ascorbic acid content was recorded in T_1 (GA 200 ppm). Many workers have reported the influence of GA in increasing the ascorbic acid content. Srivastava and Srivastava (1964), Oza and Rangnekar (1969), Irulappan (1972) in tomato and Khader (1989) in mango. GA promotes cell division which increases the number of ascorbic acid molecules which cumulatively amounts to increased ascorbic acid content. MH 1000 ppm also had a significant positive effect in the ascorbic acid content of bittergourd. Similar findings have been reported by Shanthi and Balakrishnan (1989) in onion.

Growth regulators significantly influenced the shelf life of bittergourd fruits. Maximum shelf life was recorded in T_5 (MH 500 ppm), and all other treatments except T_7 (control) were on par with this treatment. Enhanced shelf life of crop produce by treatment with MH is well established as evident from the reports of Zukel (1950), Kennedy and Smith (1951) in potato, Rakitin et al. (1972) and Shanthi and Balakrishnan (1989) in onion. Sen and Sen (1968) have reported that MH treatment results in a disturbed carbohydrate and mineral metabolism. This together with the increased water holding capacity as a result of MH treatment resulted in increased shelf life. Results also revealed that lowest weight loss and lowest rotting percentage occurred in MH treated fruits. These effects cumulatively resulted in the maximum storage life for MH treated fruits.

The enhancement of shelf life due to GA treatment might be due to the retarded senescence process. GA treatment might have suppressed ethylene accumulation in fruit tissue (Dilley, 1969; Khader, 1989). Ripening process in fruits does not generally get initiated until ethylene level has reached a critical stage (Burg and Burg, 1962). In this experiment GA treatment might have retarded biochemical change resulting in ethylene production or the ripening process. The extended shelf life due to CCC treatment might be attributed to the inhibitory effect of CCC on chlorophyll degradation and carotenoid formation (Kamienska and Chrominski, 1971). They have also reported that CCC and gibberellin may interfere with the action of ethylene.

Al Juboory et al. (1990) have reported that in grapes preharvest treatments of CCC resulted in the best over all keeping quality as compared to GA, IAA and ethephon application. Malformation was more in fruits treated with MH 1000 ppm and CCC 500 ppm. This indicates that the concentration were probably higher than the tolerance limits of bittergourd variety MC-84.

Rotting per cent of the bittergourd fruits were lowest when GA 200 ppm and MH 500 ppm was applied. MH might have inhibited the growth and multiplication of pathogens responsible for rotting as reported in onion by Nawaz *et al*. (1988), Shanthi and Balakrishnan (1989). Weight loss during storage was lowest in MH 1000 ppm followed by MH 500 ppm. This reflects the increased water holding capacity of MH treated fruits. Results in this line have been reported in onion by Rakitin *et al*. (1973), Nawaz *et al*. (1988) and in garlic by Omar and Arafa (1979).

The influence of MH and CCC on the better retention of green colour was in line with the reports of Date and Mathur (1959) and Garg *et al*. (1976) in mango who opined that development of yellow colour was retarded by MH and CCC treatment.

5.3 Effect of postharvest treatments on the shelf life of fruits of bittergourd

Postharvest dip treatments were given to bittergourd fruits with CCC (4000 ppm), GA (50 ppm) and $CaCl_2$ (4 per cent). Maximum storage life of 7.5 days was recorded for the fruits dipped in 4000 ppm CCC and kept in a refrigerator. This was significantly superior to the open storage of bittergourd fruits dipped in 4000 ppm CCC. The advantage of low temperature in the storage of fruits and vegetables is a commercially exploited technology (Wills *et al*., 1989). However under open conditions the dip treatments with $CaCl_2$, CCC or GA did not produce any extension of storage life of economic relevance. However, the village model cooling chamber where evaporative cooling of water is employed to provide a cool microclimate has resulted in a storage life equal to CCC 4000 ppm treatment in open condition. This result has some economic relevance especially in villages which are not electrified. In the case of the village model cooling chamber, without any value addition treatment to the bittergourd fruits, we can expect a storage life of about 3.75 days as compared to 2.5 days in the open condition. There was a reduction of 4°C inside the cooling chamber than the maximum mean temperature of the outer environment, which explains the increased storage life.

The weight loss during storage statistically on par in the refrigerated storage and village model cooling chamber. This may be due to the reduced rate of respiration and other metabolic processes and also due to the reduced water loss due to a more humid outer environment (Wills et al., 1989). In the open storage minimum weight loss was observed in CCC 4000 ppm treated fruits, the reasons of which are discussed already in the previous section of this chapter. Similar findings were reported by Kalhon and Dhillen (1980), who explained that the decreased weight loss was due to better cutinisation of fruits.

Rotting percentage was studied with respect to storage

Plate 12 Dehydrated and rehydrated bittergourd life upto 6 days. It was found that refrigerated storage was significantly superior to all the other treatments. The reason for this is the reduced microbial activity at lower temperatures. Among the other treatments CCC 4000 ppm, GA 50 ppm and storage in village model cooling chamber were on par with each other. The effect of GA and CCC in delaying the senescence process might be the reason for the reduced rate of rotting (Khader, 1989; Kamienska and Chrominski, 1971), whereas in the village model cooling chamber it might be due to the temperature reduction.

The pattern of colour change was similar for the preharvest spray treatments. Here again refrigerated storage proved its effectiveness as a means for extending shelf life of fresh vegetables by delaying the degradation of green colour.

In the present study $CaCl_2$ dip treatment did not influence the storage life, physiological loss in weight and rotting percentage of the bittergourd fruits significantly. In all these three cases it was on par with the control. However, this result does not confirm to the earlier reports on beneficial effects of $CaCl_2$. Singh et al. (1987) reported that the treatment of 11 per cent $CaCl_2$ prolonged the storage life of mango fruits by delaying the onset of senescence under storage. El-Hammady et al. (1987) reported that $CaCl_2$ at concentration over one per cent and upto five per cent minimised the values of fruit delayed, fruit softening and prolonged shelf life in apple.

Nayital et al. (1990) also reported beneficial effect of $CaCl_2$ in prolonging the shelf life of apples. The reason for the non significant response of postharvest treatment of $CaCl_2$ cannot be properly explained with the information obtained from the study. In vegetable studies on this line is rather limited. More detailed studies with different concentrations and treatment time with $CaCl_2$ involving more varieties of bittergourd have to be taken up for understanding the effect of $CaCl_2$ on the shelf life of bittergourd.

5.4 Standardisation of drying technique for bittergourd

In this experiment nine techniques were tried for drying bittergourd. Out of the nine treatments, three were subjected to sundrying, and the rest six was dehydrated in a cabinet drier. Of these six dehydration treatments one was to standardise an intermediate moisture bittergourd. Hence for the purpose of a more realistic comparison these nine treatments are considered as three subgroups as mentioned above. The different drying methods tried showed significant influence on the final moisture, ascorbic acid, chlorophyll, phenol, iron and total ash content, dehydration ratio and rehydration ratio.

The final moisture content showed significant variation among the nine treatments. The intermediate moisture bittergourd as the name indicates was purposively prepared with a moisture content of 30 per cent and evidently this was significantly different from the other products with respect to moisture content. But this was a result of the change in the process i.e. drying in the cabinet drier for one h at 80°C followed by 10 h at 60°C whereas in the other dehydration treatments the process was drying at 60°C for 14 h. The development of intermediate moisture food is of recent origin so as to develop products with low dehydration ratio and near natural texture of the fresh vegetable but at the same time with storage stability (Salunkhe et al., 1976). The dehydrated samples were given four pretreatments and it was observed that the treatments had significant influence on the final moisture content of the sample when subjected to a uniform dehydration process. In the three treatments kept for sundrying there was no significant difference with respect to moisture content. This means that steam blanching and hot water blanching did not accelarate the drying proces. Blanching is generally considered as a pretreatment that accelarates the drying process (Pawar et al., 1985). In the present study also there was a reduction in the final moisture content in the hot water and steam blanched samples though they were not statistically significant. This may be due to the soft textured succulent nature of bittergourd whose tissues are weak enough to loose moisture as rapidly even without blanching treatments. Among the dehydrated samples the lowest moisture content was noticed in the brine treated product which was on par with the dehydrated product without any pretreatments. This indicates that brine soaking helped exclusion of water from tissue probably due to the osmotic process during soaking (Vehgani and Chundawat, 1986). The pattern of moisture loss was similar in the hot water blanched and dehydrated (T_5) product. The steam blanched and dehydrated (T_6) and sulphited (T_7) products were more comparable with that of the sundried product. This can be explained on the ground that steam blanching was not as efficient as hot water blanching and probably the osmotic pressure of 0.1 per cent KMS solution was lesser than that of 5 per cent NaCl, ultimately resulting in a higher moisture content in the product.

Ascorbic acid content of the dried samples were significantly influenced by the method of drying as well as the pretreatments given. Highest ascorbic acid content was recorded in T_9 (intermediate moisture bittergourd). The other treatments with higher retention of ascorbic acid was T_4 (dehydrated) and T_1 (sundried). The maximum retention of ascorbic acid in the intermediate moisture product was expected as the processes involved was minimum as compared to other treatments. Ascorbic acid being a water soluble vitamin, treatments like hot water, steam blanching, soaking in KMS and brine solutions cause its leaching loss. In a detailed review on the effect of processing on vitamins and minerals in fruits and vegetables Ratnatunga et al. (1978) have reported that ascorbic acid loss is an unavoidable event in processing since it is highly soluble in water and easily extracted from tissues. They have also stated that retention of ascorbic acid is taken as an index of quality deterioration and nutritive value. Chaudhary and Roy (1979) have reported that in fenugreek the retention of ascorbic acid was 41.8, 29.4, 18.1, 24.3 mg/100 g in the fresh, unblanched, blanched and sulphite treated samples respectively. Reviewing the reasons for the loss of colour and vitamins on dehydration of vegetables, Ranganathan and Dubash (1981) stated that ascorbic acid is the most difficult of vitamins to preserve during blanching and dehydration. Pawar et al. (1985) reported that in pumpkin sulphiting reduced the loss of ascorbic acid content, when sulphiting was done prior to blanching. So sulphiting prior to blanching reduces the loss of ascorbic acid through heat, light and oxidation. However, in the present study sulphiting was done after blanching and hence the treatment could not help retain the initial quantity of ascorbic acid, a part of which was already lost through leaching in the blanching process. Further detailed studies are required onthe specific effect of blanching before and after sulphiting with respect to the retention of ascorbic acid and the preservative property of SO_2. Among the dehydration treatments bittergourd sample without any pretreatment retained the maximum amount of ascorbic acid. This was followed by the steam blanched sample and the other treatments were on par. The factors causing leaching of ascorbic acid was not allowed to act in the dehydration treatment by eliminating the pretreatments which resulted in the maximum retention of ascorbic acid. Ratnatunga et al. (1978) have reported that steam blanching caused smaller losses of vitamins than hot water blanching as leaching is minimised. This explains the better retention of ascorbic acid in steam blanched samples in the present study. This also explains the reasons for the better retention of ascorbic acid in the sundried samples pretreated with steam blanching as compared to hot water blanching of samples.

As far as the retention of phenol is concerned maximum retention was in the dehydrated sample (T_4) and minimum was observed in T_2 (hot water blanched and sundried). This reveals that phenols are also subject to loss during the pretreatments and processes employed for dehydration. Salunkhe et al. (1976) have reported that the phenol content of the fresh material is contributing to the browning of the final product. In the dehydrated samples better colour retention was observed in the samples with higher retention of phenol. Thus the present study indicates that phenol retention during the dehydration process may help to retain the green colour of the final product in a better way.

The drying processes significantly influenced the retention of iron in the final product. Retention of iron in processing of bittergourd is important because it is considered as an important vegetable due to its iron content which is essential for the maintenance of haemoglobin level in blood. Hence in product development with bittergourd retention of iron content forms an important consideration. In the present study it was observed that the brine treated sample retained the maximum amount of iron in the product. This was on par with the hot water blanched + sundried (T_2) and hot water blanched + dehydrated (T_5). Iron content was minimum in the dehydrated sample without any pretreatment. This indicates that the pretreatments did not influence loss of iron from the sample. Tap water was used for the hot water, steam, sulphiting and brine preparation in the present study. May be there was some amount of iron present as an impurity in the tap water and the NaCl used for the experiment, that might have influenced the final iron content of the product. This aspect needs further detailed studies. However, it is worth mentioning here that in the traditional drying method followed by the people of South India the bittergourd rings are soaked in brine prior to sundrying. May be, the capacity of the brine to retain the iron present in the bittergourd was noticed by our fore-fathers. The intermediate moisture product in the present study had lesser iron compared to other dehydrated product. This was mainly due to the increased amount of moisture forming major portion of the final product.

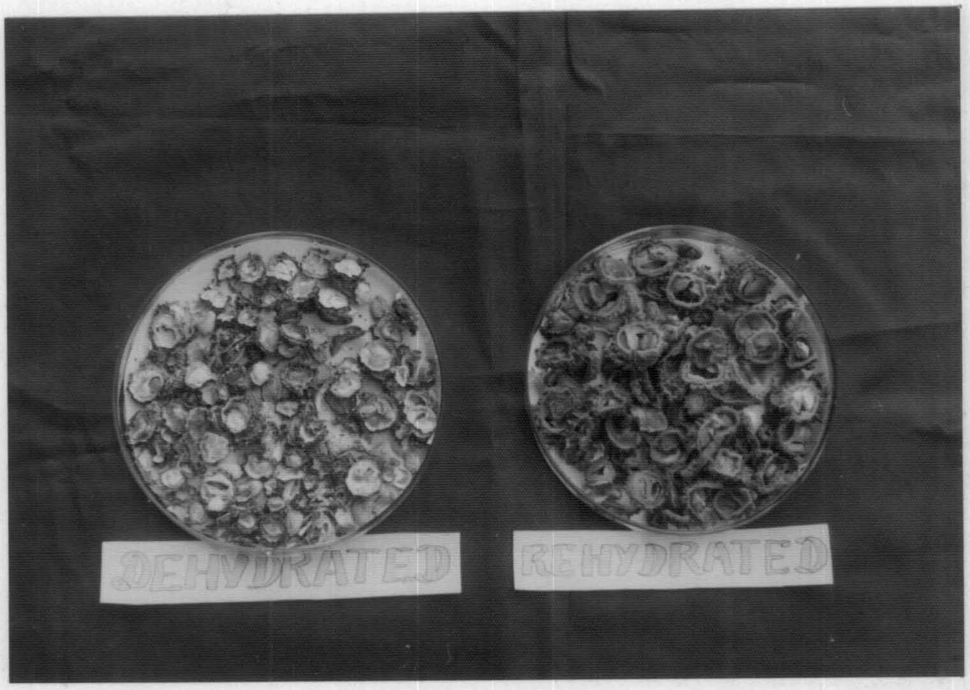
The ash content of the dehydrated samples is an indication of the mineral content of the product. In the present investigation maximum amount of total ash was noticed in the sundried and in T_7 (sulphited and dehydrated) samples. The minimum amount of total ash was noticed in the IM bittergourd and also in T_6 (steam blanched and dehydrated). The lower total ash content of IM bittergourd was due to the higher amount of moisture present in the final product. The total ash content was generally lower in all the dehydration treatments. This indicates that a higher total ash content is related with a lower process temperature. In the sulphited samples the total ash content was high. KMS itself might have contributed to the total ash content of the produce to cause this effect. Similar findings were reported by Vehgani and Chundawat (1986).

There was significant variation in chlorophyll content of different products. Maximum chlorophyll was recorded in the dehydrated sample (T_4) and minimum content was in the brine treated and the IM bittergourd (T_9). Reason for the poor retention of chlorophyll in IM bittergourd may be due to the pretreatments of blanching and subsequent sulphiting. The blanching treatment might have caused the conversion of some of the chlorophyll to phaeophytin resulting in loss of green colour. Similar findings have been reported by Kalra (1990). Sulphite treatment also recorded comparatively less chlorophyll. Similar findings have been reported by Kumar et al. (1991) in bittergourd.

In the present study sulphiting was done after hot water blanching. In hot water blanching treatment alone chlorophyll reduction has been recorded. Hence sulphiting as such did not significantly influence chlorophyll degradation in dehydrated product.

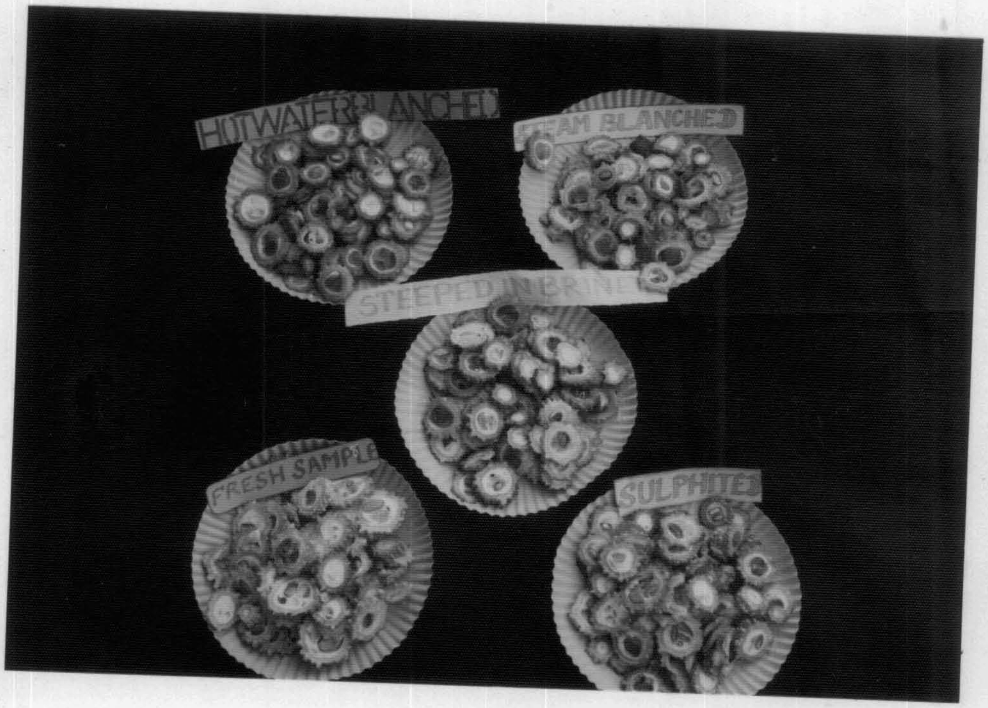
Data on the dehydration ratio revealed that the IM bittergourd (T_9) was significantly superior to all other treatments with respect to the recovery of final product. This is obvious as it contains 30 per cent moisture in the final product as compared to 4 to 8 per cent moisture in other treatments. Among the other treatments there was no significant difference between the dehydration ratios. This indicates that any suitable method of drying can be employed where the value addition due to the various processes become the deciding factor rather than the process as far as the dehydration ratio is concerned. The IM bittergourd proves its superiority with respect to dehydration ratio also and therefore holds potential as a strong competitor to the traditional dehydrated material and also to some extent to the fresh vegetables in the coming years provided a suitable packaging technique is standardised for the same. Between the sundrying and dehydration treatments; the final decision of choice has to be on the overall merits of the long duration of drying, requirement of open space, availability of labour, suitability of weather in sundrying as against high capital investment, saving of time and space, freedom from risk of weather fluctuation in case in the dehydration treatments. However, provided the capital cost of setting up the dehydration unit is made available the choice goes in favour of the same as the quality factors are well within the control of the manufacturer rather than when he goes for the sundrying process.

Rehydration of the dried products (Plate 12) were conducted to assess the ability of the product to reconstitute to the original form of the fresh material so that the product can be recommended for use in curry preparations. The results indicated that the rehydration ratio was more in sundried, brine treated and dehydrated samples. The minimum rehydration ratio was observed in the steam blanched treatments, besides the IM product. Hence it can be concluded that as far as rehydration requirement is concerned brine treatment can be suggested as a pretreatment provided the salty taste is acceptable. Steam blanching will work out as a costlier process of value addition as compared to hot water blanching and brine treatment and the results with respect to the rehydration ratio also indicates that it is not very desirable. Variation in the rehydration


DEHYDRATED
REHYDRATED

ratio between the different processes might be due to its effect on the disruption of cellular structure of the slices as reported by Teotia *et al*. (1987) in mango.

For the purposes of evaluation of sensory qualities suitable Hedonic scales were formulated for scoring with positive scores showing undesirable characters in the ascending order. Hence the product with minimum score can be rated as best. The appearance of the produce after different pretreatments and after the completion of drying are presented in Plates 13 and 14. The results revealed that T_4 was the best treatment with respect to colour and overall appearance and T_7 recorded the lowest score for texture. With respect to colour retention the better treatments were T_1, T_2, T_7 and T_8 i.e., sundried hot water blanched + sundried, sulphited + dehydrated, brine treated and dehydrated. The colour retention may be an indication of the lesser browning taking place during drying. Phenols are found to contribute to the browning process during drying (Salunkhe, 1976). In the present study wherever colour retention was adjudged better, retention of phenol content was higher. This indicates that the process employed in such cases did not favour conversion of phenol to brown pigmented polymers resulting in the darkening of the product. High temperature processes are reported to favour browning and enhanced chlorophyll degradation (Kalra, 1990). In this experiment also better colour retention was recorded in treatments receiving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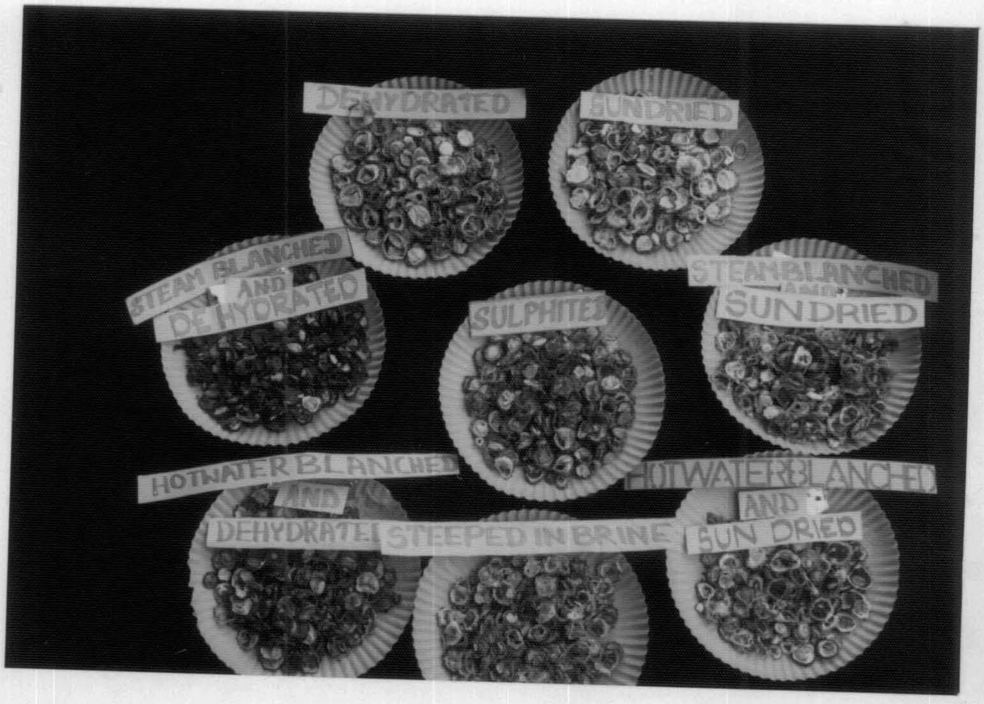
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STEAM BLANCHED AND DE HYDRATED
SULPHITED
STEAMBLANCHED AND SUNDRIED
HOTWATER BLANCHED AND DEHYDRATED
STEEPED IN BRINE
HOTWATERBLANCHED AND SUN DRIED

lower process temperature like sundrying, dehydration without steam or hot water blanching. As far as the IM bittergourd is concerned the product had a light colour, probably due to the bleaching action of KMS as the fresh slices were subjected to overnight steeping in 0.2 per cent KMS.

As far as texture of dried product is concerned T_7 (sulphited and dehydrated) resulted in a product with desirable texture. This probably may be due to the combined effect of sulphiting and dehydration process. Here sundried products were of poor texture. Primarily this may be due to the higher moisture content of the product resulting in a slightly flaccid texture. Besides the slight variation in the moisture content between slices in sundried product as compared to the dehydrated product also might have contributed to the poor texture.

The overall appearance was adjudged best for treatment T_4 (dehydrated). This indicates that where the material subjected to a minimum process it resulted in a better product with desirable appearance. The pretreatments namely hot water/ steam blanching, brine and KMS soaking did not contribute considerably to the overall appearance. Hence inclusion of such pretreatments arises only if such treatments have any specific contribution to the dehydration/rehydration ratio, storage stability and retention of the nutritive quality. The IM bittergourd was rated second with respect to overall appearance of the product. Once again the IM bittergourd has revealed its potential as a value added product of bittergourd for the consumer market.

5.4.1 Economics of dehydration

In each case of product development, the value addition on account of various treatments were worked out (Table 23). In product development, the adoption of the technology occurs only if it is economically viable despite the quality of the end product. Hence the analysis of value addition due to standardisation of dehydration technique becomes important. For the purpose, effort was made, to work out the total cost of production of various products. The raw material cost of fresh bittergourd was considered as Rs.3.06 per kg based on the investigation on cost of cultivation of bittergourd conducted at the Department of Agricultural Economics, College of Horticulture (Sandhya, 1992). The following assumptions were also considered for working out the total value addition.

1. Labour cost was fixed as 40 per cent of total input cost for sundrying treatments and 20 per cent for other dehydration treatments.

Table 23. Economics of drying techniques in bittergourd

Treatments	Raw material	Blanching Rs.0.2/kg	Sulphiting / brine treatment	Cost of electrical energy	Labour charges	Total cost per kg of dried product
T_1	37.94	--	--	--	15.18	53.12
T_2	36.10	2.36	--	--	15.39	53.86
T_3	38.25	5.00	--	--	17.30	60.55
T_4	39.17	--	--	7.47	9.33	55.99
T_5	41.31	2.70	--	7.88	10.38	62.27
T_6	39.17	5.12	--	7.47	10.35	62.11
T_7	37.33	2.40	3.42	7.12	10.05	60.32
T_8	41.92	2.74	0.27	7.99	10.59	63.51
T_9	16.21	1.06	8.02	2.33	5.52	33.14

2. The capacity of the dehydrator was 24 kg of fresh bittergourd slices per batch, and the drying duration of 14 h consumed 28 KW units of electrical energy.

3. The cost of citric acid was taken as Rs.238/- per kg and cost of KMS was taken as Rs.140/- per kg which was the prevalent market price at the time of experimentation.

4. The raw material requirement for one kg of product was worked out based on the dehydration ratio in each case.

5. For blanching treatments the cost of steam blanching was considered as twice as that of hot water blanching.

6. The capital costs as cost of cabinet drier, and other items have not been considered in working out the value addition.

The cumulative total of value addition in the various treatments as given in Table 23 reveals that the minimum value addition occurred in the IM bittergourd i.e., Rs.33.14 per kg of product followed by T_1 (sundried) and T_2 (hot water blanched + sundried) with a product cost of Rs.53.12/-and Rs.53.86/-per kg respectively. The treatment T_4 (dehydrated) recorded a cost of Rs.55.99/-per kg. Maximum value addition Rs.63.51/-per kg was noted in T_8 (brine treated). The lowest value addition in IM bittergourd is obvious since the dehydration process is only partial as compared to the other treatments. Among the other

5.5 Comparison of different packaging materials for storage of dehydrated bittergourd

The moisture content of dehydrated food usually lies in the range of 5 to 10 per cent. Such foods are extremely hygroscopic and on contact with an atmosphere of high RH, it will absorb moisture quickly (Pruthi, 1978). This necessitates the dehydrated product to be kept in isolation as efficiently as possible from the atmosphere to prevent moisture uptake. The shelf life of a dehydrated food, like any other food product, depends upon a number of factors and some of these are influenced by packaging. These factors are (1) moisture uptake, (2) oxygen, (3) flavour contamination and (4) mechanical damage. The maintenance of the low moisture level is of two fold importance. Firstly, the major deteriorative chemical reaction in dehydrated food (notably non enzymatic browning) is retarded at very low moisture levels. Secondly, the fundamental function of drying as a method of food preservation is to inhibit the growth of microorganisms through the reduction of moisture level. But in an unsatisfactory package it is possible that during storage, moisture content increases to such an extend that microorganisms can again establish and grow on the dehydrated food (Murthi, 1982).

Packaging of food is usually utilitarian and protective in function and the primary object of a food packer is to preserve the flavour and to keep the product in good condition until it reaches the consumer. The journey from primary producer to ultimate consumer is often long. In nutshell, the package should fulfil two important functions, (1) it must sell its contents as well as (2) protect them. The protective function includes compatability with the product, protection against climatic conditions, microorganisms, insect, filth and flavour gain or loss (Pruthi, 1978).

Studies on the packaging and storage behaviour of dehydrated bittergourd products was undertaken to gather some preliminary information about the facts mentioned above. Four different dehydrated products and nine packages were employed to observe the storage behaviour of these products with respect to certain sensory qualities viz., colour, texture, overall appearance and consumer acceptability and also moisture uptake.

The samples were subjected to Hedonic scale scoring by a panel of semitrained judges at monthly intervals and the cumulative scores of the panel was used for arriving at the best package. Every time the mean scores for each treatment was worked out and subjected to statistical analysis which revealed that the preferences for packages differed significantly for the various attributes studied. At the time of commencement of the study the initial scoring of the products revealed that the treatments T_4 (600 gauge LDPE packaging) followed by T_2 (300 gauge LDPE packaging) and T_6 (polypropylene) in that order was preferred by the panel for all the characters studied. The preference for T_4 may be due to the relatively thicker nature of the polythene sheet used for making the package which produced an almost rigid and safe appearance about the package (Plate 15). The treatment T_2 where polythene packages of half the thickness of T_4 was used, was adjudged as the second best because of similar qualities as T_4. The third best treatment T_6 made out of 100 gauge polypropylene sheet was flexible but had a glossy appearance and silky feel with good transparency resulted in a comparatively higher level of preference by the judging panel.

At the end of the first month of storage the maximum preference was for T_4 closely followed by T_6 and T_3. At end of first month's storage only difference in preference was with respect to the T_3 in place of T_2 which was preferred at the time of initial storage. This is justificable because of the thicker nature of the polythene film used for making the package.

At the end of two months of storage the same trend was followed with the difference that the preference for T_4 and T_6 were equal, closely followed by T_3.

At the end of the three months of storage the treatment T_4 again stood first with T_6 and T_3 having equal preference.


600 Gauge
Packages and containers for d-hydrted Bittergourd
150 Gauge
300 Gauge
450 Gauge

When the cumulative total of the preference over the entire storage period was considered the treatment T_4 retained the first position followed by T_6 and T_3. It is worth mentioning here that even though the thickness of film of T_6 and T_1 are almost similar the preference was defenitely in favour of T_6, indicating that the glossy appearance and the silky feel of the polypropylene film has a definite influence on the consumer preference. Peleg (1985) has reported these relative advantage of polypropylene as compared to polyethylene.

The preference for the treatments T_8 (opaque plastic container) and T_5 (black polythene) were generally low throughout the study. This underline the relevance of transparency of the packaging film for the consumer acceptance of packaged product. In the present study the treatments T_8 (opaque plastic jar) and T_9 (transparent plastic jar) were deliberately included to assess the relative preference between these two so as to recommend a suitable container for household use with repeated opening and closing facility. The preference was clearly in favour of the treatment T_9 i.e. the transparent plastic jar, indicating that even for household storage the preference is for a transparent container that discloses its internal contents without having to open the container.

The treatment T_2 had an additional provision of an inpackage desiccant (silicagel) in a cloth bag kept inside the

Table 24. Economics of different packaging methods for dried bittergourd

Treatments	Dehydrated product (Rs.)			Sundried product (Rs.)			Brine treated product (Rs.)			Intermediate bittergourd(Rs		
	Cost of package	Cost of labour	Total cost	Cost of package	Cost of labour	Total cost	Cost of package	Cost of labour	Total cost	Cost of package	Cost of labour	Total cost
T_1	1.14	2.86	59.99	1.14	2.71	56.97	1.14	3.23	67.88	2.28	1.77	34.91
T_2	2.20	2.89	61.08	2.20	2.77	58.09	2.20	3.29	69.00	4.40	1.88	55.0[illegible]
T_3	3.40	2.95	62.34	3.40	2.83	59.35	3.40	3.35	70.26	6.80	2.00	35.14
T_4	5.80	3.07	64.86	5.80	2.95	61.87	5.80	3.47	72.78	11.60	2.24	35.38
T_5	1.40	2.85	60.24	1.40	2.73	57.25	1.40	3.25	68.16	2.80	1.80	34.94
T_6	1.02	2.83	59.84	1.02	2.71	56.85	1.02	3.23	67.76	2.04	1.78	34.90
T_7	3.50	2.95	62.44	3.50	2.83	59.45	3.50	3.35	70.36	4.50	1.[illegible]8	35.02
T_8	30.00	2.78	88.77	30.00	2.66	85.78	30.00	3.18	96.69	60.00	1.66	94.80
T_9	40.00	2.78	98.77	40.00	2.66	95.78	40.00	3.18	106.69	80.00	1.66	104.80

* 5 per cent of the cost of product + package is taken as the cost of filling and sealing (labour)

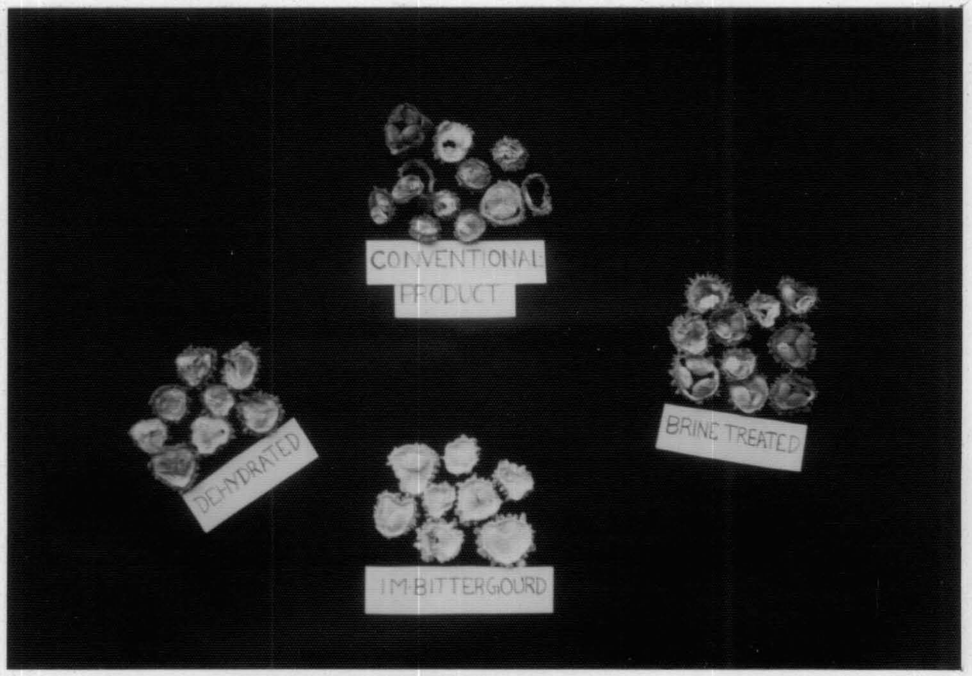
Cost of sundried Rs.53.12; Cost of dehydrated Rs.55.99; Cost of brine treated Rs.63.52; Cost of 1MB · - Rs.33.10

T_6 (polypropylene) was the cheapest packaging material in the present study. It may be considered here that T_4 was adjudged as the best packaging at the end of three months storage. But cost wise it has recorded maximum in the present case. When the moisture transmission potential of the package as given in Table 22 is considered, it is clear that the weight gain due to moisture uptake was not significant between the nine treatments after a period of three months of storage. Under such a circumstance there is no necessity for choosing 600 gauge LDPE whereas it can be easily substituted by the polypropylene which will make a difference of Rs.5.02 in the cost of 1 kg packaged product. If at all LDPE is to be used for packaging the same effect can be obtained by treatments T_1, T_2 and T_3 i.e., 150, 300 and 450 gauge film which were also the cheaper packaging alternatives. This study clearly revealed that cost of packaging can be an important marketing consideration for dehydrated foods. Eventhough treatment T_5 (black polythene) was also a cheaper packaging, its consumer acceptability was very poor (Table 18).

Plate 16 Comparison of conventional and standardised products of dehydrated bittergourd

Plate 17 Comparison of conventional and standardised products of dehydrated bittergourd


CONVENTIONAL PRODUCT
DEHYDRATED
BRINE TREATED
IM BITTERGOURD


CONVENTIONAL PRODUCT
DEHYDRATED
BRINE TREATED
IM BITTERGOURD

Summary

SUMMARY

The present study on "Effect of pre and postharvest treatments on storage life and quality of fresh and dried bittergourd (*Momordica charantia* L.)" was conducted in the vegetable research plots of Department of Olericulture and Processing Unit of Department of Processing Technology, Kerala Agricultural University, Vellanikkara during June, 1991 to September, 1992. The study consisted of the following experiments.

1. Effect of organic and inorganic sources of nitrogen on the shelf life of fresh bittergourd fruits.

2. Effect of preharvest sprays on the shelf life of fruits of bittergourd.

3. Effect of postharvest treatments on the shelf life of fruits of bittergourd.

4. Standardisation of drying technique(s) for bittergourd.

5. Comparison of different packaging materials for storage of dehydrated bittergourd.

The experiment on the effect of sources and quantities of nitrogen on the storage life of bittergourd revealed that the treatments significantly influenced ascorbic acid, iron content,

shelf life and the change of colour of fruits during storage. Ascorbic acid content was maximum when KAU recommedations were followed and shelf life and colour retention was superior in the treatments with higher dose of organic manure.

Preharvest growth regulator sprays with GA (200 and 300 ppm), CCC (250 and 500 ppm) and MH (500 and 1000 ppm) significantly influenced fruit length, fruit girth, yield per plot, moisture content, ascorbic acid content and shelf life of fruits. GA 300 ppm gave maximum fruit length, girth and yield per plot. Moisture retention was maximum in CCC 250 ppm treated fruits. Maximum ascorbic acid content was obtained with GA 200 ppm. Better shelf life was exhibited by sprays of MH 500 ppm. Maximum colour retention was recorded in MH 500 ppm. Fruit malformation was maximum in MH 1000 ppm.

Postharvest dip treatment with CCC, GA and $CaCl_2$, and storing in village model cooling chamber and refrigerators indicated maximum storage life for CCC treated refrigerated fruits. The micro environment inside the village model cooling chamber registered a reduction of 3°C in the maximum temperature as compared to the outside environment. The refrigerated storage and village model cooling chamber registered minimum weight loss of the stored bittergourd.

Out of the nine dehydration treatments tried in bittergourd, four methods were found promising viz., sundrying, dehydration in a cabinet drier, treatment with 4 per cent brine + dehydration and intermediate moisture bittergourd. Drying treatments significantly influenced ascorbic acid, total ash, chlorophyll and phenol content of bittergourd. Ascorbic acid content was maximum in intermediate moisture bittergourd. Total ash content was highest in KMS treated sample. Iron content was maximum in brine treated and dehydrated bittergourd rings. Chlorophyll retention and phenol content was highest in samples dehydrated without any pretreatments. Maximum dehydration ratio was recorded in intermediate moisture bittergourd. Rehydration ratio was better in sundried sample without any pretreatment and in brine treated and cabinet dried sample. Sensory evaluation of colour showed best preference for dehydrated sample and when scores for texture were considered sulphited + dehydrated and brine treated + dehydrated were preferred by the panel of judges. Overall appearance was best in dehydrated samples without any pretreatment followed by intermediate moisture bittergourd, and brine treated + dehydrated bittergourd. When the value addition by the different dehydration techniques was worked out, it was found that lowest value addition was for intermediate moisture bittergourd followed by sundried product.

The storage study of dehydrated packaged bittergourd packaged in different types of packages revealed that 600 gauge LDPE and 100 gauge polypropylene packages were efficient upto three months of storage. When the cost of packaging was considered, polypropylene 100 gauge was found to be the cheapest package for dehydrated bittergourd. For household use transparent plastic jars with screw type lids were found to be effective for the storage of dehydrated bittergourd.

The intermediate moisture bittergourd standardised in the present study was found to have a higher dehydration ratio, soft texture and overall appearance. The product was more or less like the fresh vegetable except for colour. It was stored well for a period of three months in the conventional packaging systems using polythene films and plastic jars.

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* Originals not seen

Appendices

Appendix I

Meteorological data during the experimental period

Month	Week number	Temperature (°C) Maximum	Minimum	Mean	R.H. (%)	R.F. (mm)	Sunshine hours (mean)	Wind velocity kmph (mean)
August 1991	32	29.5	23.1	26.30	89.0	65.2	2.3	3.1
	33	27.8	22.0	24.90	89.5			
	34	29.1	22.3	25.70	87.5	53.0	3.5	3.9
	35	30.4	23.3	26.85	80.0	12.5	6.5	4.4
September 1991	36	31.4	23.2	27.30	74.5	0.0	9.1	4.5
	37	31.6	24.6	28.10	77.5	4.0	6.1	4.4
	38	31.4	22.4	26.90	75.5	18.3	6.8	3.7
	39	31.7	24.0	27.85	80.0	8.0	6.5	3.8
October 1991	40	31.2	23.5	27.35	84.5	11.4	4.1	2.9
	41	30.6	23.2	26.90	83.0	97.3	4.3	3.2
	42	32.1	23.0	27.45	76.5	57.6	6.4	4.7
	43	30.8	23.1	26.95	79.5	40.0	3.9	4.0
	44	29.8	23.0	26.40	76.9	107.8	3.0	3.0
November 1991	45	32.1	22.5	27.30	75.5	105.0	7.4	3.8
	46	31.4	22.8	27.10	81.5	53.4	5.0	3.6
	47	31.0	24.4	27.70	67.0	0.5	7.7	12.1
	48	31.9	20.9	26.40	68.5	0.0	8.6	6.8
December 1991	49	31.3	21.4	26.35	61.5	0.0	9.7	11.5
	50	30.9	23.5	27.20	62.5	0.0	8.0	15.6
	51	31.9	23.2	27.55	62.0	0.0	7.9	9.3
	52	33.2	19.9	26.55	68.0	0.0	8.0	4.0
May 1992	18	35.9	25.5	30.70	66.0	0.0	9.3	5.3
	19	35.0	24.2	29.60	74.0	28.4	8.8	4.6
	20	30.9	24.1	27.50	80.5	58.0	3.7	3.8
	21	33.6	25.3	29.45	72.5	3.0	9.1	4.2
	22	34.0	24.9	29.45	72.5	11.4	6.3	4.6
June 1992	23	30.2	23.6	26.90	84.0	307.9	3.6	4.7
	24	30.0	23.6	26.80	86.0	239.3	2.7	5.5
	25	29.0	23.6	26.30	87.5	232.8	0.7	6.9
	26	29.7	23.5	26.60	83.0	244.6	4.2	4.3
July 1992	27	29.7	23.3	26.50	88.0	171.9	4.3	2.5
	28	29.4	22.7	26.05	81.0	52.0	4.6	5.4
	29	28.1	22.1	25.10	91.0	302.5	4.1	0.7
	30	28.8	22.6	25.70	89.5	247.1	4.7	0.5
	31	27.7	22.5	25.10	89.5	207.9	3.3	0.4
August 1992	32	28.4	23.6	16.00	89.0	116.0	2.1	3.8
	33	29.1	23.8	26.45	88.0	125.1	3.1	5.4
	34	29.9	23.5	26.70	83.0	45.2	5.2	4.1
	35	28.8	22.8	25.80	89.0	157.3	1.5	4.1
September 1992	36	28.6	22.6	25.60	87.0	115.4	1.8	4.7
	37	30.5	22.8	26.65	80.5	20.8	6.7	3.7
	38	31.6	23.8	27.70	79.0	6.2	6.2	4.0
	39	30.3	23.1	26.70	84.0	117.9	3.0	3.3

Source: Department of Agrometeorology, College of Horticulture, Vellanikkara, Thrissur

Appendix IV

Abstract of ANOVA for the influence of preharvest application of growth regulators on the yield attributes, and qualitative characters

Source of variation	d.f	M.S.										
		Number of harvests	Number of fruits	Yield per plot (kg)	Fruit length (cm)	Fruit girth (cm)	Moisture content (%)	Ash content (%)	Ascorbic acid (mg/100g)	Chlorophyll a (mg/100g)	Chlorophyll b (mg/100g)	Total Chlorophyll (mg/100g)
Treatments	6	0.651	61.036*	25.335*	13.96*	5.98*	9.409*	2.360	1303.58*	0.000200	0.00019	0.000360
Replication	3	0.785	3.653	1.647	6.02	0.540	0.035	0.86	39.26	0.000067	0.00045	0.000217
Error	18	0.537	7.480	1.063	2.09	0.364	0.054	3.047	28.04	0.000180	0.00029	0.001989

Source of variation	d.f	M.S.									
		Total phenol (mg/100g)	Iron (mg/100g)	Shelf life (days)	Weight loss during storage			Rotting			Fruit malformation (%)
					After 48 h (%)	After 96 h (%)	Cumulative loss(%)	After 48 h (%)	After 96 h (%)	After 144 h (%)	
Treatments	6	10.22	0.063	2.805*	7.065	11.95	11.167	646.38*	625.09*	17.83	91.73*
Replication	3	2.41	0.086	2.468	1.623	10.396	15.63	46.77	249.32	12.32	0.34
Error	18	4.47	0.05	0.5676	11.21	8.195	11.65	204.3	207.04	6.96	2.18

* Statistical significance at 5 per cent probability level (P = 0.05)

Appendix II

Nutrient content of the soil of the experimental plot and of the manures and fertilisers applied

Material	N	P_2O_5	K_2O
Farm yard manure	1.5%	0.25%	0.8%
Urea	45.0%	--	--
Superphosphate	--	16.00%	--
Muriate of potash	--	--	60.0%
Soil	0.186%	5.08 ppm	201.66 ppm

Appendix III

Abstract of ANOVA for the effect of organic and inorganic sources and quantities of nitrogen on days to first female flower opening, number of harvests, number of fruits, fruit length, fruit girth and qualitative characters

Sources of variation	d.f	M.S.										
		Days to the opening of first female flower	Number of harvests	Number of fruits	Yield per plot (kg)	Fruit length (cm)	Fruit girth (cm)	Moisture content (%)	Ash content (%)	Ascorbic acid (mg/100g)	Total chlro-phyll (mg/100g)	Chloro-phyll a (mg/100g)
Replication	2	3.433	0.700	24.233	7.045	0.598	0.295	0.665	2.97	14.690	0.006	0.001
Factor T	1	0.533	2.133	45.623	2.070	161.472*	69.312*	4.720	3.20	384.234	0.046*	0.009*
Factor V	4	4.283	0.383	11.883	5.038	5.396	1.840	0.656	5.61	1163.644*	0.003	0.001
T x V	4	1.117	0.050	15.217	3.145	3.329	0.673	1.555	10.24	102.257	0.003	0.000
Error	8	1.915	0.663	15.826	2.321	3.654	0.757	1.888	3.95	388.818	0.003	0.000

Sources of variation	d.f	M.S.									
		Chloro-phyll b (mg/100g)	Total phenol (mg/100g)	Iron (mg/100g)	Shelf life (days)	Weight loss during storage			Rotting		
						After 48 h (%)	After 96 h (%)	Cumulative loss (%)	After 48 h (%)	After 96 h (%)	After 144 h (%)
Replication	2	0.002	6.940	0.019	0.075	23.130	11.819	83.279	774.666	37.813	2.044
Factor T	1	0.014*	157.566*	0.682*	0.008	21.421	1.640	4.989	461.070	211.630	15.265
Factor V	4	0.002	40.505	0.102	14.508*	23.427*	8.311*	65.994*	1878.364*	1121.734*	51.367
T x V	4	0.002	14.503	0.187*	0.508	5.360	11.622*	49.345*	733.175	162.480	45.632
Error	8	0.001	22.135	0.049	0.853	7.788	2.305	17.167	487.352	249.052	71.503

* Statistical significance at 5 per cent probability level (P = 0.05)

Appendix IV

Abstract of ANOVA for the influence of preharvest application of growth regulators on the yield attributes, and qualitative characters

Source of variation	d.f	M.S.										
		Number of harvests	Number of fruits	Yield per plot (kg)	Fruit length (cm)	Fruit girth (cm)	Moisture content (%)	Ash content (%)	Ascorbic acid (mg/100g)	Chlorophyll a (mg/100g)	Chlorophyll b (mg/100g)	Total Chlorophyll (mg/100g)
Treatments	6	0.651	61.036*	25.335*	13.96*	5.98*	9.409*	2.360	1303.58*	0.000200	0.00019	0.000360
Replication	3	0.785	3.653	1.647	6.02	0.540	0.035	0.86	39.26	0.000067	0.00045	0.000217
Error	18	0.937	7.480	1.063	2.09	0.364	0.054	3.047	28.04	0.000180	0.00029	0.001989

Source of variation	d.f	M.S.									
		Total phenol (mg/100g)	Iron (mg/100g)	Shelf life (days)	Weight loss during storage			Rotting			Fruit malformation (%)
					After 48 h (%)	After 96 h (%)	Cumulative loss(%)	After 48 h (%)	After 96 h (%)	After 144 h (%)	
Treatments	6	10.22	0.063	2.805*	7.065	11.95	11.167	646.38*	625.09*	17.83	91.73*
Replication	3	2.41	0.086	2.468	1.623	10.396	15.63	46.77	249.32	12.32	0.34
Error	18	4.47	0.05	0.5676	11.21	8.195	11.65	204.3	207.04	6.96	2.18

* Statistical significance at 5 per cent probability level (P = 0.05)

Appendix V

Abstract of ANOVA for the influence of postharvest application of growth regulators and calcium chloride on the shelf life, weight loss and rotting percentage of bittergourd fruits during storage

Source	d.f	M.S.						
		Shelf life	Weight loss (%)			Rotting (%)		
			After 2 days	2-4 days	1-4 days	After 2 days	After 4 days	After 6 days
Treatment	5	12.6*	298.58*	89.622*	679.61*	328.002*	3215.33*	3272.52*
Error	18	0.5	99.58	18.310	192.05	12.720	51.57	16.26

* Statistical significance at 5 per cent probability level

Appendix VI

Abstract of ANOVA for the influence of drying methods on qualitative characters, dehydration and rehydration ratio of bittergourd fruits

Source	d.f.	M.S.									
		Moisture (%)	Ash (%)	Ascorbic acid (mg/100g)	Chloro-phyll a (mg/100g)	Chloro-phyll b (mg/100g)	Total chloro-phyll (mg/100g)	Total phenol (mg/100g)	Iron (mg/100g)	Dehydration ratio	Rehydration ratio
Treatment	8	189.27*	14.970*	340.656*	0.006875*	0.00725*	0.023400*	111.370*	39.735*	41.600*	2.750*
Error	18	1.196	0.611	0.0251	0.000110	0.00017	0.000166	2.156	8.510	0.406	0.205

* Statistical significance at 5 per cent probability level (P = 0.05)

Appendix VII

Abstract of ANOVA for the weight gain of dried product during storage in different packages

Source	d.f	Sundried			Dehydrated			Brine treated			IM bittergourd		
		Weight gain after			Weight gain after			Weight gain after			Weight gain after		
		One month	Two months	Three months	One month	Two months	Three months	One month	Two months	Three months	One month	Two months	Three months
Treatment	8	3.80	14.20	6.80	3.925	7.59	5.16	5.89	77.60	90.00	6.77	15.34	61.96
Error	18	0.22	0.20	0.12	0.184	0.28	0.35	0.05	1.57	1.53	0.14	0.35	4.38

PRE AND POSTHARVEST TREATMENTS ON STORAGE LIFE AND QUALITY OF FRESH AND DRIED BITTERGOURD
(*Momordica charantia* L.)

By

VEENAKUMARI D.

ABSTRACT OF A THESIS

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ABSTRACT

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The present study on "Effect of pre and postharvest treatments on storage life and quality of fresh and dried bittergourd (Momordica charantia L.)" was conducted in the research plots of Department of Olericulture and Processing Unit of Department of Processing Technology, Kerala Agricultural University, Vellanikkara, during June 1991 to September 1992. The study revealed that FYM significantly increased the storage life of bittergourd fruits. Quality with respect to ascorbic acid and iron content were better in treatments T_1 (20 t FYM and 70:25:25 kg NPK ha^{-1} through fertilisers), and T_5 (30 t FYM and 70:25:25 kg NPK ha^{-1} through fertilisers).

The study on the effect of preharvest sprays of growth regulators revealed that MH 500 ppm enhanced storage life of bittergourd. GA 200 and 300 ppm was found to improve yield and quality in terms of ascorbic acid content.

Refrigeration after treating the fruits with CCC 4000 ppm was found superior to all other treatments with respect to shelf life of bittergourd. Fresh vegetable stored in village model cooling chamber had more storage life compared to open air storage.

Study of dehydration techniques in bittergourd revealed that sundrying, dehydration in cabinet drier, brine treatment and dehydration in cabinet drier, and intermediate moisture (IM) bittergourd were promising. In terms of texture and overall appearance IM bittergourd nearly retained the fresh fruit characteristics with a higher dehydration ratio.

Storage study of dehydrated bittergourd showed that 600 gauge LDPE and 100 gauge polypropylene were suitable packaging materials. Costwise, polypropylene was cheaper compared to 600 gauge LDPE. For household use transparent jars with screw type lid was preferable. IM bittergourd stored well without any apparent symptoms of spoilage for three months in packaged condition.