CONSUMER PACKAGING OF SELECTED VEGETABLES

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Horticulture

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Department of Processing Technology
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DECLARATION

I hereby declare that this thesis entitled "Consumer Packaging of Selected Vegetables" 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 University or Society.

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CERTIFICATE

Certified that this thesis entitled "**Consumer Packaging of Selected Vegetables**" is a record of research work done independently by **Mr. Sunil Kumar, G.,** 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 him.

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CERTIFICATE

We, the undersigned members of the Advisory Committee of **Mr. Sunil Kumar, G.**, a candidate for the degree of Master of Science in Horticulture with Major in Processing Technology, agree that the thesis entitled **"Consumer Packaging of Selected Vegetables"** may be submitted by Mr. Sunil Kumar, G. in partial fulfilment of the requirement for the degree.

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ABBREVIATIONS

LDPE	-	Low Density Polyethylene
LDPP	-	Low Density Polypropylene
PP	-	Polypropylne
PE	-	Polyethylene
RH	-	Relative humidity
MAP	-	Modified Atmospheric Packaging
PLW	-	Physiological Loss in Weight
g	-	gram
cm	-	centimetre
%	-	Per cent

Introduction

INTRODUCTION

Vegetables play an important role in human nutrition. Vegetables and fruits are considered as protective foods which supply the required vitamins and minerals. Vegetables are the cheapest and richest sources of natural protective foods. Besides they also contribute carbohydrates, proteins, lipids and the roughage.

India is the second largest producer of vegetables in the world next to China (Majeed and Gowda, 1992). The range of vegetable production in India is unique, consisting of diverse kinds of vegetables produced from nearly 60 species. They are eaten raw as well as in the cooked form. Vegetables are harvested in the immature, mature or ripe stage depending on the commodity. Most of the leaf and fruit vegetables are highly perishable, while those like potatoes and onions have fairly large storage life.

During recent years, the interest in vegetable production has increased as a result of greater appreciation of their food value. The commercial vegetable grower is now looking for the F_1 hybrid vegetable seeds which yields two to three times than the popular commercial variety. The estimated area under vegetables in India at present is 4.0

million hectares with an annual production of about 45.0 million tonnes (Swarup, 1994). With the present production, per capita consumption of vegetables per day in India is 125 to 135 grams. According to the Diet Advisory Committee of the Indian Council of Medical Research, an adult requires 284 grams of vegetables a day. Thus the present vegetable production enables to provide hardly one-half of the daily requirement (Singh, 1991).

Out of the 45 million tonnes produced nearly 20 to 40 per cent goes as waste after harvest due to various factors (Pandey, 1990). Therefore increase in production and productivity along with reduction in postharvest losses must be the strategy for increasing the availability of vegetables in the country. Otherwise an increased production may result in a proportionate increase in postharvest losses owing to various inadequacies at the postharvest levels. In the case of vegetables, losses both in terms of quality and quantity can occur at all stages from harvesting to consumption.

Almost the entire quantity of vegetable production is utilized by the fresh market. The processing industry utilizes only 0.5 to 1.0 per cent. The inherent character of vegetables make their storage life very short. Spoilage to the extend of 20 to 40 per cent can occur due to mechanical injuries, microbial infection and accelerated senescence.

Postharvest handling of vegetables has not yet received the attention that it deserves. As a result, the consumers are provided with vegetables often in a partly damaged and unhygienic condition. In the marketing chain of vegetables scientific postharvest handling techniques are seldom employed. Many a times vegetables are harvested at the wrong maturity stage, at the wrong time of the day and sent to the wholesale or retail market without any grading, precooling or packaging. The commodities are handled in a very careless manner. The only packaging usually used is a gunny bag which is most unsuitable for a tender commodity like vegetables. So there is an urgent need to provide technologies for postharvest handling of vegetables.

The present study was formulated to evaluate the effect of precooling, packaging and low temperature storage on the shelf life and marketability of certain selected vegetables. Besides the study was also intended to evaluate the effect of portion packaging of vegetables like pumpkin, ashgourd, snakegourd, elephant foot yam and oriental pickling melon to suit the requirements of a small family.

By standardising suitable consumer packaging systems, farmers as well as consumers will be benefited through reduction of postharvest losses and ensuring better quality. The value addition for packaging will be nullified by the extra income on account of the additional quantity made available for sale through the extended market life and reduction of losses. The consumers are assured of quality of vegetables in a hygienic form in the required quantity at a reasonable price. Developing this type of scientific, handling and packaging techniques will help to raise standard of vegetable marketing and to promote commercial vegetable cultivation.

In supermarkets in Kerala state a scientifically laid out fruit and vegetable section is lacking at the moment. This will be possible only if the packaging and storage requirements of vegetables are standardised. It will also open up a new area in employment generation. Thus the present study has a lot of contemporary relevance.

The objectives of the study were:

1. To study the effect of precooling of vegetables on postharvest loss reduction and storage life.

2. To study the effect of consumer packages on vegetables with respect to their shelf life and acceptability under ambient and low temperature storage conditions.

3. To assess the suitability of portion packaging of certain large sized vegetables under ambient and low temperature storage conditions.

Review of Literature

REVIEW OF LITERATURE

Fresh vegetables are highly perishable commodities. The postharvest life of the harvested vegetable extent from few hours to few days. Within this short span of time, about 20-40 per cent of the produce is spoiled due to inadequacies in postharvest operations. Several methods have been tried to reduce these postharvest losses. Some of the methods include giving suitable precooling treatments to the produce immediately after the harvest, prepackaging the produce in suitable packages and storage under low temperature conditions. Most of the studies on these aspects were related to vegetables grown in temperate conditions and hence literature on storage of tropical vegetables is limited. A review of literature on the related works done in different places is presented here under in the following titles.

2.1 Effect of precooling treatments on postharvest loss reduction in vegetables

2.2 Effect of packaging and low temperature storage on post-harvest loss reduction and shelf life of vegetables

2.1 Effect of precooling treatments on postharvest loss reduction in vegetables

The beneficial effects of precooling in reducing weight loss and retaining the quality and marketability of vegetables and fruits have been reported by many workers.

2.1.1 Importance of precooling fresh vegetables

The beneficial effects of precooling horticultural produce in retarding the rate of respiration and transpiration was reported by Stewart and Couey (1963).

Precooling of vegetables prior to storage reduced the weight loss (Verbeek, 1986).

2.1.1.1 Amaranth and other leafy vegetables

In celery, hydrocooling was found to be the best among various precooling methods, as it retained the turgidity of the produce for longer period (Stewart and Barger, 1962).

Sozzi and Petronella (1981) reported that hydrocooling of spinach prior to packing retained the freshness during storage.

Kraker (1991) emphasized the need for lowering the temperature of the spinach immediately after the harvest to reduce the postharvest losses.

2.1.1.2 Brinjal

Ryall and Lipton (1979) questioned the usefulness of hydrocooling in egg plants. They observed that due to low surface to volume ratio, the cooling process will be slow and moreover, the risk of 'water-spotting' of the fruit due to hydrocooling is high.

Mohammed and Sealy (1988) reported that the melongenes subjected to hydrocooling were of excellent quality even after eight days of storage at 28-30°C. A delay in the appearance of chilling injury symptom was observed for the hydrocooled samples even after 24 days at 5°C.

2.1.1.3 Chillies and bell peppers

Henry et al. (1980) studied the effect of certain precooling and storage conditions on the quality of bell peppers. Precooled green bell peppers were stored at three humidity levels viz. 92 per cent, 94 per cent and 97 per cent RH. It was observed that weight loss, shrivelling and surface defects were affected by storage conditions but not by cooling treatment.

Seymour et al. (1980) found that hydrocooling capsicums before packing in plastic lined boxes increased rotting and could not be used commercially.

Sherman *et al*. (1982) concluded that precooling of bell peppers to 10°C soon after harvest delayed but did not prevent softrot decay caused by *Erwinia caratovora*. Lingaiah *et al*. (1983a) reported that non-precooled capsicums kept better in polyethylene bags as compared to precooled ones kept in the same bag. Hardenburg *et al*. (1986) found that precooling of sweet peppers immediately after the harvest reduces the market losses.

2.1.1.4 Cowpea and other legumes

According to Stewart and Barger (1960) peas and sweet corn subjected to precooling had better quality as compared to those not subjected to precooling.

Zerbini *et al*. (1978) found that hydrocooling of snap beans immediately after harvest reduced the weight loss and were of satisfactory quality if stored at lower temperatures.

2.1.1.5 Cucurbitaceous crops

Pentzer *et al*. (1940) observed that musk melons harvested in the morning were precooled in much less time and the quantity of ice used in precooling was less than that required for melons harvested during the hottest part of the days. Lipton and Stewart (1961) observed slight reduction in weight loss in cantaloupes subjected to hydrocooling. However no significant difference in market quality was observed between hydrocooled cantaloupes and control samples.

Fellers and Pflug (1967) reported that hydrocooling is essential for pickling cucumbers harvested during hot weather. In musk melons immediate cooling of the produce after harvest maintained the quality over a week (Vaulx and Aubert, 1976).

2.1.1.6 Okra

Woodroof and Shelor (1958) reported high incidence of water spotting in okra subjected to hydrocooling.

Fontenot et al. (1987) studied the effect of hydrocooling in okra pods. Pods were subjected to hydrocooling immediately after harvest. It was observed that the quality of hydrocooled pods were inferior to that of non hydrocooled pods.

2.1.1.7 Tomato

In tomatoes precooling followed by refrigerated storage helps in better retention of moisture and ascorbic acid, less wastage and more uniform development of colour (Srivastava et al., 1962).

Marcellin and Baccaunaud (1979) found significant reduction in the incidence of internal browning in tomatoes subjected to precooling. They also observed that precooling had no significant influence on ripening quality in tomatoes.

Lingaiah et al. (1983b) observed that precooling has no beneficial effect on the shelf life of tomatoes packed in polyethylene bags held at ambient temperature.

2.1.1.8 Other crops

In asparagus and cauliflower precooling the produce after harvest significantly reduced the weight loss during subsequent storage (Stewart and Barger, 1961). Stewart and Barger (1963) studied the effect of various precooling methods on the quality and storage life of brussels sprouts. Sprouts subjected to hydrocooling had the lowest weight loss and wilting percentage and were rated highest in salability. High incidence of decay was observed in sprouts subjected to topicing method.

Lentz and van den Berg (1977) observed that in carrot both precooling rate and temperature gradient are important for the long term storage because of its sensitivity to temperatures above the optimum. Adamicki (1979) studied the effect of water cooling on the storability and commercial quality of asparagus and reported that cooling significantly reduced the losses and quality reduction during storage. It was also observed that the duration of cooling after harvest had no appreciable effect on quality.

Precooling asparagus before storage reduced the rate of deterioration during storage period (Lill, 1980).

According to Damen (1980) cooling cauliflowers prior to storage reduced weight loss and incidence of black discolouration of the head. Precooling of brussels sprouts prior to packaging not only extended the shelf life but also reduced the weight loss (Harrison et al., 1984). Sozzi and Retino (1985) observed high quality retention in cauliflower subjected to precooling.

Hackert et al. (1987) observed no significant difference among precooling treatments on weight loss in broccoli. Gariepy et al. (1991) studied the effect of forced air precooling and hydrocooling on the storability of green asparagus spears. It was observed that precooling the spears prior to storage reduced the losses by more than 20 per cent. However no significant differences was observed between two methods. Precooling of carrots prior to packaging did not have any beneficial effect on the shelf life (Lingaiah and Huddar, 1991).

Tan et al. (1992) observed high incidence of microbial rotting on topiced broccoli which was held in sealed polyethylene bags. The reason attributed to this is the presence of free water in the package after the melting of the ice. The spread of cottony soft rot in stored carrots could be controlled most effectively by precooling the produce immediately after the harvest (Pritchard et al., 1992).

2.2 Effect of packaging and low temperature storage on postharvest loss reduction and shelf life of vegetables

The beneficial effects of packaging in reducing postharvest loss and retaining the quality and marketability of various horticultural produces have been reported by several workers.

2.2.1 Role of polymeric films in packaging of horticultural produce

The importance of packaging of fruits and vegetables in enhancing the shelf life was reported from USA by (Scott and Tewfik, 1947). Hardenburg (1949) reported that prepackaging vegetables in transparent polymeric films were effective for lengthening shelf life and reducing moisture loss. Hardenburg (1954) observed that though the produce maintained good appearance in non ventilated than in ventilated film packages, the development of off odour and off flavour are faster in non ventilated ones.

Roy (1966) reported higher shelf life for prepackaged fruits and vegetables both at room temperature and refrigerated conditions. He has attributed this to the slowing down of the physiological processes like respiration, transpiration and biochemical changes that is taking place in the produce after the harvest. The advantages and disadvantages of prepackaging fresh fruit and vegetables in plastic films was reported by Tomkins (1967).

Hardenburg (1971) observed that packaging the produce with protective films creates a high relative humidity within the package and makes the relative humidity of the storage room less critical as a factor determining moisture loss from the fruit or vegetable. Hall (1973) studied the permeability properties of plastic packaging materials. Plastic packages for respiring product must provide movement of gases in appropriate quantities and direction i.e. O_2 into the package environment from the outside atmosphere, CO_2 from the package environment to the outside atmosphere, but with sufficient moisture retained in the package to prevent excessive loss of moisture from the produce.

Kumar et al. (1976) evaluated some flexible packaging materials used in food packaging for their physico-chemical properties such as water vapour transmission rate (WVTR), tensile and bursting strengths, tearing resistance and elongation.

According to Harvey (1978) proper packaging of a product can reduce not only browning and crushing but also reduce the moisture loss, prevent recontamination of the produce with spoilage organisms, reduce pilferage, maintain a sanitary environment during marketing.

Salunkhe and Desai (1984) reported the usefulness of packaging vegetables in reducing postharvest loss retaining the quality and enhancing the storage life of the vegetables. Ben-Yehoshua (1985) reported the beneficial effects of individual seal packaging of fruits and vegetables. The beneficial effects attributed are extended shelf life, reduced shrinkage, weight loss, occurrence of various blemishes and refrigeration costs. Peleg (1985) reported some typical properties of most popular plastic films for retail produce packaging.

Maaker (1986) studied the effect of perforations in polymeric films on weight loss in vegetables. It was observed that perforations had a direct influence on weight loss. The biochemical and physiological basis for the effects of controlled and modified atmospheres on fruits and vegetables was reported by Kader (1986). Zagory and Kader (1988) reported the beneficial effects of modified atmosphere packaging of fresh produce.

Wills et al. (1989) reported that packaging not only provides convenient units for marketing and distribution but also protects the fruits and vegetables from undue damage thereby reducing the postharvest losses.

Risse (1989) observed that film wrapping of vegetables retarded the weight loss, colour development, chilling injury and maintained the firmness and internal quality, some of the disadvantages reported are enhancement of decay and development of off-flavours.

Khan et al. (1990) reported that polyethylene bags could be advantageously used for consumer packaging of fruits as they are fully transparent, convenient to handle during storage and marketing and retain the produce in good condition for a considerable long period. It was observed that packaging of fruits in polyethylene bags reduced the weight loss and the percentage of fruits ripened. Adak (1990) reported the usefulness of low density polyethylene (LDPE) as an effective packaging material for fresh produce. Usefulness of polypropylene films in packaging of fresh produce was reported by Chowdhary (1990).

Rao (1993) reported that the shelf life of vegetables could be greatly enhanced if packaging is combined with low temperature storage. Roy and Pal (1993) reported that use of plastics in packaging of horticultural produce helps in minimizing the cost of packaging materials and makes the whole process less dependent on scarce materials like wood thereby resulting in conservation of environment.

2.2.1.1 Amaranth and other leafy vegetables

Parsons (1960) reported that celery packaged in polyethylene bags had lower weight loss and better appearance as compared to celery stored in other polybags. He has attributed this to the better permeability of the polyethylene film to CO_2, O_2 and moisture. Stewart and Barger (1962) observed very little deterioration even after 8 days in celery pre packaged with ventilated polyethylene bags stored at 34°F. Aharoni and Ben-Yehoshua (1973) observed lower incidence of yellowing and decay in Romaine lettuce prepackaged in closed polyethylene bags.. The efficacy of PE bags in delaying deterioration was related to reduction of O_2 and accumulation of CO_2 in the ambient atmosphere in the package.

Basak (1980) observed a higher shelf life for amaranth, bittergourd, longmelon packaged in perforated polyethylene bags, compared to non-perforated bags, both under refrigerated and non-refrigerated conditions. Risse (1981) observed that the losses due to decay in lettuce could be reduced greatly if harvested and packed carefully and held at temperatures ranging from 0-2°C.

Midon and Lam (1982) observed that lettuces stored in polyethylene bags with perforations ranging from 0.50 to 0.75 per cent and at temperatures of 5°C, 10°C and 15°C retained the quality even after 21 days, 14 days and 7 days respectively. Maaker (1984) studied the effect of individual packaging on shelf life quality in iceberg lettuces, broccoli and cauliflowers. With all the packed vegetables, weight loss was reduced and quality was better after several days both at room temperature as well as low temperature.

Zavgorodnyaya et al. (1985) studied the effect of polymeric film packaging on storage of parsley and celery. Untrimmed parsley and celery plants were packaged in polyethylene films, sealed and stored for $\leq$ 120 days at 0-2°C and 85-93 per cent RH. The plastic bags extended the storage life of parsley to 2.5-3.0 months and of celery to 2.0-2.5 months. It was also reported that storage of these vegetables in small bags facilitated the sale of the produce all the year around.

Kim (1985) found that spinach leaves in packages remained acceptable for 3 days at 20°C when compared to leaves kept without packaging. It was also observed that weight loss in prepackaged spinach was closely related to temperature and packaging conditions.

Lazan et al. (1987) observed that wrapping leaves of *Amaranthus caudatus* in LDPE film retained the turgidity for longer periods both at ambient and low temperatures. The unwrapped leaves lost water more rapidly under both the situations.

Ballantyne et al. (1988) reported a shelf life of 14 days, almost double that of the controls, for shredded lettuce held in polyethylene films at 5°C.

Stanley (1989) stressed the importance of quality of lettuces prior to packaging. For best results high quality lettuces are to be packaged.

Chikkasubbana et al. (1991) reported that prepackaging of lettuce heads in sealed and perforated polyethylene bags reduced physiological loss in weight (PLW), ascorbic acid content and extended the storage life.

Bittenbender (1992) studied the effect of packaging on shelf life of cowpea as a leafy vegetable. It was observed that irrespective of storage temperatures (15-30°C) and package ventilation the leaves packaged in 2 mil polyethylene bag retained moisture content similar to that of freshly harvested leaves.

Bracy et al. (1992) determined the effect of packaging and storage temperature on postharvest life and quality of mustard leaf. Packaging mustard leaves in perforated bags significantly reduced weight loss and had a high keeping quality even after 12 days at either 1°C or 4°C. The non-bagged mustard leaves were unacceptable after 5 days. It was also observed that bagging significantly increased the incidence of decay and yellow discolouration when stored at 15°C.

2.2.1.2 Brinjal

Viraktamath et al. (1963) reported a shelf life of 8-10 days and 30-32 days for brinjal prepackaged in ventilated 200 gauge PE and stored at 24-26°C, 72-75 per cent RH and 8-10°C, 85-90 per cent RH respectively. It was also observed that fruits prepackaged in ventilated bags had higher consumer acceptability as compared to fruits prepackaged in unventilated polybags. The keeping quality of brinjal fruits in perforated bags was higher than in open boxes (Uncini et al., 1977a).

Abe et al. (1980) observed that in brinjal smaller fruits deteriorated more rapidly than the larger one's stored in polyethylene bags.

Risse and Miller (1983) compared the wrapping of eggplant fruits in ventilated and non-ventilated polymeric films. Wrapping in non-ventilated films reduced the weight loss, maintained the firmness but significantly increased the decay.

Seal packaging of melongenes in polyethylene film appears to be useful and beneficial supplement to refrigeration for delaying deterioration and thereby enhancing the marketable life (Mohammed and Sealy, 1986).

Badgujar et al. (1987) reported that packing of brinjal fruits in 200 gauge polyethylene bags with 1 per cent vent prolonged the shelf life compared with unpacked fruit.

Esteban et al. (1989) studied the physical alterations in egg plant fruits placed in trays covered with perforated plastic sheet, during storage at different temperatures. Results obtained that preservation of these fruits during 18 days at 10°C produced less variation in their physical characteristics compared with the other conditions studied (5° and 20°C).

Gadakh et al. (1990) observed maximum weight loss in unpacked brinjal (23-53%) when compared to brinjal held in 200 gauge polyethylene bags with 1 per cent ventilation at ambient storage (29.6°C and 69.6% RH).

2.2.1.3 Chillies and bell peppers

Anandaswamy et al. (1959) observed that the shelf life of sweet peppers and green chillies could be greatly enhanced both under normal and low temperature storage by prepackaging the produce in 150 gauge polyethylene film with adequate ventilation.

Prepackaging green bell peppers in polyethylene film supplemented with low temperature storage not only reduced moisture loss but also retarded the colour development of the produce (Bussel and Kenigsberger, 1975).

Uncini et al. (1977b) found that the weight loss, shrivelling and disease incidence in hot peppers could be greatly reduced by keeping it in polyethylene bags and storing at 8-9°C.

Mikhailov (1979) compared the shelf life of various pepper varieties stored in wooden boxes and polyethylene bags and showed that the peppers stored in wooden boxes had the greater weight loss, but losses due to moulds were greater in those stored in polyethylene bags.

Hughes et al. (1981) observed significant increase in shelf life for capsicums wrapped in polymeric films and stored at 8.8 ± 0.2°C and 86 ± 4 per cent RH.

Individual seal packaging in high density polyethylene (HDPE) film prolonged the storage life of bell peppers (Ben-Yehoshua et al., 1983). It markedly inhibited weight loss, delayed softening and membrane disintegration. These effects were related to the water saturated atmosphere in the sealed enclosure around the fruit.

Miller et al. (1986) found that the rate of weight loss were 0.06 per cent for capsicums wrapped in plastic film and for nonwrapped fruits it was 0.74 per cent per week. Both wrapped and nonwrapped fruits were stored at 15.5°C. Wrapping significantly reduced the rate of fruit softening during storage. The rate of yellow or red colour development were not significantly reduced. Wrapping of bell peppers, broccoli, cucumbers, aubergines, lettuces, sweetpotatoes and tomatoes in polymeric films reduced moisture loss, softening were retarded and the characteristic freshness and colour were maintained during extended periods of storage and marketing (Miller and Risse, 1988).

Brackett (1990) studied the influence of modified atmosphere packaging on the microflora on quality of fresh bell peppers. High population of microflora was observed in shrink wrapped bell peppers. The shrink wrapped bell peppers remained unspoiled for about 6 weeks as compared to 3 weeks in the control.

High incidence of decay due to Erwinia carotovora was reported in hot pepper (Capsicum frutescens L.) fruits packed in LDPE film. It was also observed that hot peppers prepackaged in paper bags had lower shelf life compared to fruits in LDPE bags. This was attributed to the delay in fungal decay which started 4 days later for fruits in LDPE bags (Mohammed, 1990).

2.2.1.4 Cowpea and other legumes

Prepackaged snap beans in polyethylene bags with 1.2 per cent ventilation had a shelf life of 7 days and 16 days held at 75-80°F, 50-75 per cent R.H and 47-50°F, 80-95 per cent RH respectively (Anandaswamy and Iyengar, 1961). Increased weight loss was reported in snap beans stored in perforated polybags (Buescher and Adams, 1979).

Matsui et al. (1980) studied the effect of temperature and packaging on weight loss and marketing quality in soybeans. Green immature soybeans for vegetable use were

Palilov et al. (1979) reported that the weight loss in cucumbers packaged in sealed polyethylene film were insignificant when compared to fruits kept in open condition.

Atwa et al. (1980) studied the effect of some packaging methods and storage conditions on cucumber fruits. Cucumbers were either packaged in perforated polyethylene bags or left unpackaged for storage under ambient (31 ± 2°C, 65% RH) or refrigerated (7°C, 85% RH) condition. Though both packaging and refrigeration reduced the weight loss, the incidence of decay was high in packaged fruits, especially under ambient conditions.

Elkashif et al. (1983) reported that cucumber and broccoli stored in perforated polyethylene film at low temperature maintained their freshness and firmness for longer periods. It was also observed that film thickness had no effect on weight loss, but significantly affected Co_2 and O_2 concentration within the package.

Wrapping of cucumbers in polymeric film significantly reduced the weight loss. It was also observed that 60 per cent of the decay in all fruits was due to bacterial soft rot (Risse et al., 1985a).

Adamicki (1985) studied the effect of storage temperatures and wrapping on keeping quality of cucumber fruits. Fruits were wrapped in plastic film and held at 5, 12.5 or 15°C. A significant decrease in weight loss of fruits wrapped in plastic film, compared with non-wrapped fruits was observed under all conditions. Weight loss in fruits wrapped in plastic film did not exceed even 0.5 per cent after 9 days of storage whereas without wrapping weight loss increased to 6.2-8.4 per cent. Wrapping extended the fruit life by over 2 days. The incidence of chilling injury and surface break down was observed only in nonwrapped fruits held at 5°C.

According to Lester and Burton (1986) wrapping musk melon fruits in polymeric films exhibited no significant change in percentage dry weight, firmness or loss of membrane integrity throughout 40 days of storage. Though wrapped fruits had a decline in appearance rating the fruits were generally rated as excellent to good quality.

Cucumber Cv. Corona were shrink wrapped in perforated polyethylene and kept at 13°C and 80-85 per cent RH. Weight loss with wrapped cucumbers was only 1.3 per cent after 19 days, whereas unwrapped fruits were soft after 12-15 days, with weight loss amounting to 4.5-6.3 per cent. The rate of colour loss in fruits wrapped in perforated polyethylene was similar to that in unwrapped fruits (Otma, 1988). Rij and Ross (1988) reported that the quality of honeydew melons could be maintained for longer periods by individually wrapping the honeydew melons with a PVC film. It was attributed to the alteration of the internal atmosphere by elevating CO_2 and reducing O_2 levels which resulted in slowing down the process of ripening, reduced the danger of development of chilling injury and retained the desired turgidity.

Rock melon and honeydew melon were shrink wrapped and stored at 6° and 3°C. The rock melons stored at 6° and 3°C kept for 22 and 29 days respectively. Honeydew melons stored at 6°C kept well for 28 days but those stored at 3° showed chilling damage after 12 days (Salvestrin and Jones, 1988).

Collins _et al_. (1990) observed that shrink wrapping of musk melons in polyethylene film enhanced undesirable flavour changes resulting in an inferior quality produce.

Venkatesha _et al_. (1993) found that coccinia packed in different gauge of polyethylene bags with different levels of ventilation showed least physiological loss in weight, retained more firmness as compared to the control.

2.2.1.6 Okra

Anandaswamy _et al_. (1963) conducted prepackaging studies in okra and reported that prepackaging okra in unventilated 100 gauge polyethylene enhanced the shelf life to 7-8 days and 16-18 days respectively under room temperature

(24-26°C and 72-75% RH) and cold storage (11-13°C and 85-90% RH) conditions.

Singh and Dhankhar (1980) viewed that packaging of okra in polyethylene bags delayed the blackening of fruit by 8-9 days at room temperature (32 ± 2°C) and 12 days at chilled temperature (10 ± 1°C) when compared to 2-3 days in control.

Singh et al. (1980) studied the effect of prepackaging on storage life of fresh okra. The storage life of okra could be increased to 9 days at room temperature (32 ± 2°C) when packed in 400 gauge polyethylene bags whereas the control fruits kept for only 2-3 days.

Saimbhi and Randhawa (1983) reported that perforated polyethylene bags of 400 or 200 gauge thickness were better than unperforated bags for prepackaging of okra fruits as it enhanced the shelf life upto 10 days at 42°C and 77.5 per cent RH.

Joshi et al. (1984) reported a shelf life of 7 and 15 days for okra cultivar 'Pusa Sawani' packed in perforated and nonperforated polyethylene packs held at 16 to 30°C and 44-100 per cent RH compared to two days in control. Tamura and Minamide (1984) reported that okra's kept best at 12°C in a perforated plastic bags when compared to nonperforated bags. Use of polythene bags in conjunction with low temperature storage (4.4°C) reduced weight loss and prevented colour changes without causing chilling injury in okra (Fontenot, _et al_., 1987).

Kalra _et al_. (1988) reported that okra could be stored upto 6 days and 15 days respectively in 200 gauge polypropylene bags held at room temperature (26-34°C, RH 65-90%) and refrigerated (8-10°C, RH 85-90%) conditions.

2.2.1.7 Tomato

Ben-Yehoshua _et al_. (1979) studied the effect of seal packaging on tomato in LDPE film. The packaging induced the following effects. The storage life of the fruits was doubled, maintained its fresh appearance and normal flavour for a much longer period. Shrinkage was practically nil, weight loss was reduced by five fold, chilling injury was markedly inhibited.

Risch and Watson (1980) observed a linearity in weight loss with time for tomatoes wrapped in PVC film after two days of storage and correlated well with temperature and humidity of the storage atmosphere.

Hobson (1981) reported that the modified atmosphere developed within the package extended the ripening time, improved firmness and maintained the quality in tomatoes.

According to Geeson and Browne (1983) tomato fruits kept in ventilated packs ripened more faster when compared to those fruits kept in non-ventilated packs. Rotting was observed in certain packs which was associated with low O_2 or high Co_2 concentration and high relative humidity. It was also observed that ripening could be further delayed by keeping tomatoes in low temperature.

Anderson and Poapst (1983) studied the effect of cultivar and modified atmosphere on ripening and decay of mature green tomatoes. Mature green fruit of tomato were stored at 13°C in air or in a modified atmosphere formed by sealing the fruits in a LDPE bag. Modified atmosphere fruit ripened more slowly and decayed less than those in air. It was also observed that the marketing period could be extended by modified atmosphere storage.

In another study tomato fruits held at 10-12°C and 87-89 per cent relative humidity in polyethylene bags enhanced the storage life and maintained the quality compared to those fruits kept at 24-25°C and 75-77 per cent RH (Collazos et al., 1984).

Risse et al. (1985b) observed that mature green tomatoes wrapped in heat shrinkable plastic films retained the firmness for longer periods. Decay development observed to be similar for both nonwrapped and wrapped tomatoes.

Polymeric films with less than 2 per cent perforations drastically reduced the weight loss and tissue softening resulting in tomatoes of good eating quality and bright red colour (Floros et al., 1987).

Hall (1989) observed 35 per cent decay in packed tomatoes after 3 weeks of storage in ambient conditions. Tomato, capsicum and aubergines harvested at fully ripe stage were wrapped in different plastic films and stored at 5°C and 10°C (Mencarelli et al., 1989). Aubergine fruits maintained good quality when wrapped in perforated or non-perforated plastic film regardless of the storage temperature. Capsicum and tomato fruits remained attractive when stored at 5°C.

According to Casas et al. (1990) tomatoes packaged in cellophane film and held at 25°C and 85-90 per cent RH had a shelf life of 35 days whereas spinach packed in LDPE and held at 0 or 2°C and 85-90 per cent RH had a shelf life of 26 days.

Marangoni and Stanley (1991) reported a storage life of 10-30 days for field grown mature green tomatoes stored at 12°C in modified atmosphere. A study was carried out by Nakhasi et al. (1991) to investigate potential benefits of modified atmospheric packaging (MAP) on shelf life of tomatoes at breaker stage. It was reported that storage life could be substantially increased by MAP without much reduction in weight.

The shelf life of tomatoes could be increased by four times, compared with control by packaging the breaker stage tomatoes in 300 gauge polyethylene bags with 3 vents (Naik *et al.*, 1993; Jayanthi *et al.*, 1993).

2.2.1.8 Other crops

Carrots prepackaged in perforated bags had a longer shelf life than unpackaged bunched carrots (Hardenburg *et al.*, 1953).

Hardenburg (1955) studied the effect of perforations on the storability of onions within package and observed that about 71 per cent of the onion rooted in bags without ventilation whereas only 4 per cent rooting was observed in onions stored in ventilated bags. Parsons (1959) studied the effect of perforated and non perforated polyethylene films on quality of cabbage stored at 32°, 38° and 45°F. It was observed that cabbage stored in perforated polyethylene bags had higher acceptability after eight weeks of storage. Moreover no significant difference was observed between losses occurring at 32°, 38° and 45°F. Stewart and Barger (1963) observed significant reduction in decay percentage in brussels sprouts prepackaged in polymeric films.

Zisman and Temkin-Gorodeiski (1978) observed a delay in leaf sprouting and rootlet growth in radishes packaged in polyethylene bags. Wu and Salunkhe (1978) reported that packaging of broccoli in polythene bags not only extended the storage life but also improved the colour of buds, leaves and stalks.

Freshly harvested leeks prepackaged in sealed nonperforated polyethylene bags stored well for ten weeks at 0°C. No off odours, off flavours or tissue injury from CO_2 build up or O_2 depletion were observed in leeks in the sealed packages (Hruschka, 1978). Hovadik et al. (1980) studied the effect of packaging on weight loss, chemical composition and microbial growth on savoy cabbage heads. The external and internal qualities were maintained best by wrapping in perforated polyethylene film and storing it at low temperature, high relative humidity. Microbial growth was inhibited by low temperature storage. Lill (1980) reported that fresh asparagus spears kept in perforated polyethylene bags had lower weight loss. The packaged asparagus spears had better appearances. It is also reported that asparagus packed in perforated bags could be stored upto 4 weeks at a temperature of 2 to 4°C.

High degree of Botrytis porri infection was observed on leeks stored in perforated plastic bags kept in a refrigerated store at 0° to 1°C and RH ranging from 96-98 per cent (Tahvonen, 1980). Andre et al. (1980) reported that storage life of artichoke could be extended to two months when individual wrapping of artichoke in polyethylene bags was combined with refrigerated storage. Carrots packaged in perforated polyethylene bags with 0.8 per cent recorded lowest weight loss and spoilage percentage (Ram et al., 1981).

Experiments were performed by Umiecka (1981) to determine the best conditions for the storage of carrots in plastic bags in order to prolong the availability of the vegetables beyond the time provided. It was observed that storage times of 8-9 months were achieved for some varieties, the best results were obtained by storage in perforated polyethylene film at temperatures of 0°-1°C. For shorter periods, i.e., for 3-4 weeks, carrots could be stored at 4-5°C in unperforated polyethylene bags.

Iwase et al. (1982) observed that onions stored in plastic film bags are of poor quality when compared to those stored in plastic mesh containers. Song et al. (1982) reported that eight month storage of garlic in polyethylene bags resulted in 23 per cent weight loss and 17 per cent decay when compared to 92 per cent and 77 per cent respectively in the control.

It was observed that in Colocassia and Xanthosoma spp. though the weight loss was reduced by packaging in polyethylene film, the incidence of decay was very high under ambient storage (Passam, 1982). Radishes kept in polyethylene bags at 0° to 1°C recorded the lowest weight loss (Dyachenko and Kravtsov, 1982).

Potatoes were packed in polyethylene film and stored at 5°C and 20°C for 27 weeks (Woo, 1983). Germination was observed from 12th and 6th week onwards for variety "May Queen" and "Namjak" during storage at 5°C. A steady increase in respiration rate was observed for both varieties after germination during storage at 20°C. However quality changes were very little throughout the storage. Saimbhi (1983) reported a loss of 31 to 37 per cent fresh weight after four days in carrots left unwrapped. Whereas packaging in polyethylene bags resulted only 5 to 11 per cent of fresh weight after 20 days of storage.

Akhundov et al. (1983) reported a storage life of 10-30 days for beetroots stored in polythene packages in a cold store when compared to 3 days in a cold store without packaging.

Shredded cabbages were stored in low density poly ethylene (LDPE) pouches for five days. Wilting, browning, off-flavour and spoilage were evaluated. Significant differences were found in browning and off-flavour. Degree of browning was higher in thinner pouches and at high temperature. After five days of storage, ethanol was detected in some pouches resulting in off-flavour to the produce. Higher accumulation and consumption rate of CO_2 and O_2 respectively were observed in thicker pouches at higher temperature (Kawano et al., 1984).

The influence of several plastic films combined with low temperature to prolong the marketability of sprouting broccoli and turnip greens was studied by Anelli et al. (1985). It was observed that plastic films prevented the development of unpleasant volatile compounds and reduced excessive loss of water.

Shrink wrapping of fresh sweet corn with polymeric films eliminated moisture loss and resulted in elevated CO_2 and decreased O_2 concentrations within packages. These effects, together with refrigeration markedly reduced the changes associated with senescence and postharvest deterioration resulting in three fold extension in shelf life (Deak et al., 1987). Mencarelli (1987) studied the storage of globe artichokes in polymeric films of varying permeability.

Best results were obtained in films which are sufficiently permeable to gaseous exchange while maintaining high humidity. Packaging of asparagus spear in sealed polyethylene bags not only reduced the percentage weight loss but also reduced the incidence of fungal rotting and browning (Saliuus *et al*., 1987).

Ceausescu *et al*. (1988) reported a storage life of 60 days for cauliflower held in polyethylene bags whereas for non-packaged cauliflowers it was only 30 days. Tomkins and Cumming (1988) observed that the development of modified atmosphere within the package reduced the moisture loss, retained the growth of pathogen and maintained the quality of asparagus.

Kawashima *et al*. (1989) detected a strong odour in broccoli wrapped in low gas permeable film while those wrapped with high gas permeable films developed yellowing.

Maharaj and Sankat (1990) reported storage life of 2-3 days and 14-15 days respectively for prepackaged bread fruits held at low and ambient conditions. At high temperatures packaging induced browning. Schowbe and Parkin (1990) studied the effect of low temperature and modified atmosphere storage on sugar accumulation in potatoes. A larger delay in sugar accumulation was observed in tubers held under modified atmospheres.

Packaging of 'ready-to-use' grated carrots were studied in different polymeric films and stored at 2, 6 or 10°C for 10 days (Carlin et al., 1990). At low temperature (2°C) physiological activity and microbial growth were reduced sufficiently to delay spoilage, even with the least permeable film. But above 6°C the use of high permeability films is perfectly justified.

Asparagus stored in modified atmosphere had better colour, fresh appearance, firm texture and a weight loss of less than 12 per cent after 28 days of storage (Gariepy et al., 1991). Prepackaging of carrots in 100 and 200 gauge polyethylene bags with 18 vents extended shelf life by 6 days over control samples at ambient conditions of temperature 22.8-25.5°C and relative humidity ranging from 61.0-79.0 per cent (Lingaiah and Huddar, 1991).

According to Sankat and Maharaj (1993) the ripening process in bread fruits could be delayed if low temperature storage is coupled with packaging in polyethylene bags thereby enhancing the storage life. The influence of maturity levels and prepackaging treatments on shelf life and quality in two varieties of carrot was studied by Lingaiah and Reddy (1993). It was observed that the shelf life varies with maturity of the produce as well as between the varieties. Highest shelf life was obtained with polythene bags having 0.5 per cent ventilation irrespective of the thickness.

Materials and Methods

MATERIALS AND METHODS

Investigations on enhancing the shelf life of selected vegetables through certain postharvest technologies were conducted in the Department of Processing Technology, College of Horticulture, Vellanikkara, Thrissur, Kerala from June 1992 to October, 1993. Vellanikkara enjoys a warm humid climate throughout the year with minor fluctuations in daily temperature. The area is situated between 10° 32' N latitude, and 76° 16' E longitude and at an altitude of 23 M above MSL.

Fresh vegetables are highly perishable. Due to inadequate harvesting, handling, packaging, transport, storage and marketing practices large quantities of these vegetables are lost. In the present study an effort was made to extend the storage life and also to reduce postharvest losses of certain vegetables by testing different precooling, packaging and storage systems.

The study was conducted in three experiments as indicated below:

3.1 Standardisation of precooling treatments to improve the postharvest life of fresh vegetables, 3.2 Effect of precooling and packaging on shelf life of vegetables under ambient and refrigerated storage environment,

3.3 Effect of portion packaging of large sized vegetables.

The fresh vegetables except elephant foot yam required for the study were produced in the research plots of the Department of Olericulture, College of Horticulture as per Kerala Agricultural University package of practices (1989). The produce after harvest were taken immediately to the laboratories of the Processing Technology Department for conducting the experiments. The elephant yam corms required for the study was procured from a nearby farmers' field.

3.1 Experimental 1: Standardisation of precooling treatments to improve the postharvest life of fresh vegetables

Details of the experiment are given below.

3.1.1 Vegetables used for the experiment

Vegetable	Variety	Maturity at harvest in no. of days after fruitset
Amaranth	Kannara Local	Tender fully grown leaves*
Brinjal	Surya	21
Chilli	Jwala Sakhi	30

Plate 1. Precooling by contact icing

Plate 1. Precooling by contact icing

Cowpea	Kanakamony	14
Okra	Arka Anamika	7
Tomato	PKM-1	30

* Duration changes from harvest to harvest

3.1.2 Treatments

C_1 - Hydrocooling in tap water for 20 minutes at the rate of 5 litre/kg of the vegetables.

C_2 - Hydrocooling with cold water (15°C) for 20 minutes at the rate of 5 litre/kg of vegetables.

C_3 - Top icing with crushed ice.

Crushed ice was spread all over the produce to be precooled in alternate layers at the rate of 1 kg of ice per kg of vegetables (Plate 1). A contact time of twenty minutes was allowed.

C_4 - Control (No precooling treatment)

The experiment was conducted at the laboratory both under ambient temperature and refrigerated storage environments. For refrigerated storage, Voltas refrigerator of 3B-07378 model of capacity 305 litres was used. The temperture inside the refrigerator was maintained at 11 $\pm$ 1°C with RH ranging between 60 to 65 per cent; by adjusting the control knob of the refrigerator to the 6th position.

3.1.3 Preparation of vegetables for precooling treatment

Fresh vegetables harvested before 10.00 A.M. were taken to the laboratory. Malformed and bruised vegetables were removed. In the case of amaranthus only tender stem cuttings with leaves of 20-25 cm length were taken. After sorting, the vegetables with uniform maturity were selected visually and these vegetables were subjected to precooling treatments. For all treatments, samples weighing 500 ± 10 g of vegetables were used except in the case of chillies where the sample weight was 250 ± 10 g. The samples were placed on paper plates and one set of treatments were kept in the open and the other set inside the refrigerator. Each treatment were replicated five times, both under ambient refrigerated environments.

3.1.4 Observations

3.1.4.1 Physiological loss in weight (PLW)

The fresh weight of the vegetables were taken immediately after precooling and draining and subsequently the cumulative weight loss during storage were found out at intervals of 24 hours and expressed as percentage.

3.1.4.2 Environmental conditions

Environmental parameters such as maximum temperature, minimum temperature, relative humidity were recorded daily at 2 P.M. during the experimental period. The mean figures for the above parameters are presented below on respective tables. For measuring maximum and minimum temperatures, maximum-minimum thermometers were used. For relative humidity measurements, dial type hygrometers were used.

For the measurement of temperature and relative humidity inside the refrigerator; the refrigerator was adjusted to work at a temperature of 11 $\pm$ 1°C after keeping the precooled vegetable. Maximum-minimum thermometers, dial type hygrometers were placed inside the refrigerator for monitoring the temperature and humidity inside the refrigerator.

3.1.4.3 Unmarketability

The percentage of unmarketability was determined based on visual observation. Once the sample showed apparent visual symptoms of wilting or withering or decay the sample was treated as unmarketable. Unmarketability was assessed at intervals of 24 hours from the beginning of the experiment.

3.2 Experiment II. Effect of precooling and packaging on shelf life of vegetables under ambient and refrigerated storage environments

3.2.1 Vegetables used for the experiment

The same six vegetables used for the first experiment, (under 3.1.1) were used in this case also.

3.2.2 Treatments

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

P_5 - Polypropylene bags of 100 gauge without ventilation

P_6 - Polypropylene bags of 200 gauge without ventilation

P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

The experiment was conducted under the following conditions.

1. P_1 to P_8 kept under ambient temperature storage
2. P_1 to P_8 kept under refrigerated storage
3. P_1 to P_8 treatments were subjected to precooling treatments as in experiment (1) and kept under ambient temperature storage.

4. P_1 to P_8 treatments subjected to precooling treatments as in experiment (1) and kept under refrigerated storage.

3.2.3 Preparation of vegetables

Vegetables immediately after the harvest were subjected to precooling treatments as described in 3.1.2 and 3.1.3. The precooled vegetables were then wiped using tissue paper and then subjected to prepackaging.

3.2.4 Prepackaging of vegetables

3.2.4.1 Packaging materials

Polyethylene and polypropylene bags of 100 and 200 gauge thickness were used for prepackaging. Bags measuring 25 cm x 20 cm to hold 500 ± 10 gm of material were used except in the case of amaranthus and chillies where bags measuring 30 cm x 25 cm and 15 cm x 20 cm were respectively used.

3.2.4.2 Ventilation

The ventilation in polybags were provided by making holes with the help of single punch which makes a hole of area 0.25 cm^2. For bags measuring 25 cm x 20 cm a total of 20 holes were provided with 10 holes each on both sides. For bags of size 30 cm x 25 cm and 15 cm x 20 cm, a total of 30

Plate 2. Packaged vegetables stored inside the refrigerator

and 12 holes were given respectively for providing the necessary ventilation.

3.2.4.3 Packaging

The prepared vegetables were filled in polybags, weighed and then sealed using quick seal heat-sealers. The sealing was air tight. Each bag was then labelled, weighed and kept for storage under two storage environments.

The samples for testing under ambient temperature storage were kept on the raised platforms inside the laboratory. For refrigerated storage the samples were kept inside 3B-07378 model voltas refrigerator of 305 litres capacity (Plate 2). The temperature and relative humidity inside the refrigerator was maintained as explained in the experiment under 3.1.2. Both under ambient and refrigerated environments for each treatment there were five samples each representing a replication.

3.2.5 Observations

3.2.5.1 Physiological loss in weight during storage

P.L.W. was measured as described in 3.1.4.1.

3.2.5.2 Unmarketability

Unmarketability was estimated as described in 3.1.4.3.

3.2.5.3 Length of storage life

The storage life or shelf life was measured interms of number of days upto which produce was held in a marketable condition. The produce was treated unmarketable once an apparent mould growth or decay or shrivelling was observed on the produce kept inside the package. The period was expressed as days.

3.2.5.4 Consumer acceptability

The consumer acceptability was evaluated by scoring technique on a 5 point hedonic scale as given below Veenakumari (1992). The acceptability was scored at intervals of 24 hours.

Description	Score
Acceptable fully	1
Acceptable somewhat	2
Neither acceptable nor unacceptable	3
Unacceptable somewhat	4
Not acceptable	5

For the assessment of acceptability, one additional replication of the samples were used and these packets were kept separately. While other observations on the treatment vegetables were taken, this replication was given to a group of three semitrained persons to score for acceptability.

The causal organism for microbial spoilage was also identified by microscopic examination.

3.2.5.5 Environmental parameters

Environmental parameters were recorded as described in 3.1.4.2.

3.3.1 Experiment III

Effect of portion packaging techniques of large sized vegetables.

3.3.2 Vegetables used for the experiment

Vegetable	Variety	Maturity at harvest in no. of days after fruitset
Ashgourd	KAU local	25
Elephant foot yam	Local	9 months**
Oriental pickling melon	Mudicode local	30
Pumpkin	Ambili	35
Snakegourd	TA-19	18

** after planting

3.3.3 Treatment details

T_1 - Packaging portioned vegetable slice in polyethylene sheet

T_2 - Packaging portioned vegetable slice in polypropylene sheet

T_3 - Packaging precooled portioned vegetable slice in polyethylene sheet

T_4 - Packaging precooled portioned vegetable slice in polypropylene sheet

T_5 - Portioned vegetable slice, unpacked

T_6 - Portioned slice of precooled vegetable unpacked

The experiment was conducted at the laboratory both under refrigerated and ambient storage environment. For refrigerated storage voltas refrigerator as specified in the experiment (1) under 3.1.2 was used. The inside temperature of the refrigerator was maintained at 11 $\pm$ 1°C with RH ranging from 60-65 per cent.

3.3.4 Preparation of vegetables

Vegetables , after the harvest were subjected to hydrocooling in cold water (15°C) for 20 min. After hydrocooling the vegetables were wiped using tissue paper and then cut into slices each weighing 500 $\pm$ 10 g. Elephant foot yam used for the experiment was thoroughly cleaned and all the soil particles and root growths were removed before precooling

Plate 3. Portion packaging of elephant foot yam

and slicing. Another set of samples were prepared in the same way without the precooling treatment.

3.3.5 Prepackaging of vegetables

3.3.5.1 Packaging materials

Polyethylene and polypropylene sheets of 100 gauge thickness were used for prepackaging of the vegetables.

3.3.5.2 Packaging

Polyethylene and polypropylene sheets of required size were cut. The sliced vegetables were then wrapped with the sheet. The ends were heat sealed using heat sealer to get air tight sealing after removing the trapped air as far as possible (Plate 3).

The samples for ambient temperature storage were kept in the laboratory. For refrigerated storage voltas refrigerator as specified in the experiment (1) under 3.1.2 was used. The temperature and relative humidity inside the refrigerator was maintained as explained under 3.1.2. Each treatment were replicated five times both under ambient and refrigerated storage environments.

3.3.6 Observations

3.3.6.1 Physiological loss in weight

PLW was measured as described in 3.1.4.1

3.3.6.2 Unmarketability

Unmarketability was estimated as described in 3.1.4.1.

3.3.6.3 Consumer acceptability

Consumer acceptability was assessed as described in 3.2.5.4

3.3.6.4 Environmental parameters

Environmental parameters were recorded as described in 3.1.4.2.

3.4 Statistical analysis

The data generated from the three experiments were subjected to statistical analysis suggested by Panse and Sukhatme (1954). In the case of experiment 3.1 the analysis was done as a factorial CRD with two factors viz. precooling and days after storage; for the variables PLW and unmarketability. For the experiment 3.2 the analysis was done using Split - Split plot design for the variables PLW, unmarketability and consumer acceptability. Precooling was taken as the main plot treatments and packaging and days after storage were taken as sub plot treatments. For the variable, length of storage life the analysis done was factorial CRD with two factors viz. precooling and packaging. In all the cases the levels of precooling and packaging treatments were four and eight respectively. The levels for days after storage varied with crops. For the experiment 3.3 the analysis was done as a factorial CRD with two factors viz. packaging and days after storage for the variables PLW, Unmarketability and Consumer acceptability. The level of packaging treatments are four and two (total six). Here the control samples are analysed separately. The levels for the days after storage varied with crops.

In the case of Experiment 1 values of daily observations were used. In the case of Experiments 2 and 3 mean values observation of two days and three days interval respectively were used under both the storage environments. Statistical analysis of the data of the experiments collected as mentioned above was done and interpreted for drawing conclusion.

Results

RESULTS

4.1 Standardisation of precooling treatments to improve the postharvest life of fresh vegetables

Effect of various precooling treatments were studied in amaranth, brinjal, chilli, cowpea, okra and tomato. Daily observations were taken on PLW and unmarketability for all vegetables except in the case of tomato. In the case of tomato, for the convenience of statistical analysis mean values of the observations for two days and three days interval were used respectively under ambient and refrigerated storage environments in various treatments. Salient results of the experiments are described below.

4.1.1 Amaranth (<u>Amaranthus</u> <u>tricolor</u> L.)

Data on PLW and unmarketability as influenced by precooling treatments are presented in Table 1.

4.1.1.1 Physiological loss in weight

The influence of precooling treatments on PLW was significant only under refrigerated storage.

Perusal of data in Table 1 showed that under refrigerated storage, the PLW was minimum in C_2 (cold water),

Table 1. Effect of precooling treatments on PLW and unmarketability in amaranth

Treatments	Physiological loss in weight (%)							Unmarketability (%)					
	Ambient temperature storage			Refrigerated storage				Ambient temperature storage			Refrigerated storage		
	D_1	D_2	Mean	D_1	D_2	D_3	Mean	D_1	D_2	Mean	D_2	D_3	Mean
C_1-Tap water	31.13	54.05	42.59	7.25	10.47	19.38	12.37[a]	84.00 (66.63)	100.00 (89.99)	92.00[b] (78.31)	1.00 (2.69)	18.00 (22.67)	9.50 (12.68)
C_2-Cold water	32.26	49.06	40.66	6.52	11.72	16.40	11.55[a]	84.00 (66.63)	100.00 (89.99)	92.00[b] (78.22)	1.00 (2.69)	11.00 (16.49)	6.00 (9.59)
C_3-Contact icing	30.44	47.16	38.80	7.05	13.35	18.73	13.38[a]	74.00 (59.54)	96.00 (85.82)	85.00[a] (72.18)	1.00 (2.69)	9.00 (13.56)	5.00 (8.13)
C_4-Control	33.60	50.43	42.01	8.90	16.61	21.48	15.66[b]	81.00 (64.25)	100.00 (89.99)	90.50[b] (77.12)	1.00 (2.69)	18.50 (23.43)	9.75 (13.06)
CD													
Precooling(c)		N.S			1.83*				3.16*			N.S	

* Significant at 5 per cent level

Mean temperature during experiment period		
Maximum temperature	33.4°C	10.9°C
Minimum temperature	27.2°C	8.9°C
Mean relative humidity during experiment period	78.5%	60.1%

D_1, D_2, ... D_n - 'n' Days after storage

Figures in bracket indicates transformed values

followed by C_1 (tap water) and C_3 (contact icing). Treatments C_2, C_1 and C_3 were on par with each other. Maximum PLW was recorded in C_4 (control).

4.1.1.2 Unmarketability

Precooling treatments had significant influence on unmarketability only under ambient temperature storage.

Minimum unmarketability under ambient temperature storage was recorded in C_3 (contact icing). Maximum unmarketability was recorded in C_2 (cold water) and C_1 (tap water) which were on par with C_4 (control).

4.1.2 Brinjal (Solanum melongena L.)

PLW and unmaketability as influenced by precooling treatments are presented in Table 2.

4.1.2.1 Physiological loss in weight

Precooling treatments showed significant influence on PLW both under ambient and refrigerated storage environments.

Minimum PLW under ambient temperature storage was recorded in C_3 (contact icing) which was followed by C_2 (cold water). Treatments C_3 and C_2 were on par with each other.

Table 2. Effect of precooling treatments on PLW and unmarketability in brinjal

Treatments	Physiological loss in weight (%)													Unmarketability (%)					
	Ambient temperature storage						Refrigerated storage							Ambient temperature storate			Refrigerated storage		
	D_1	D_2	D_3	D_4	D_5	Mean	D_1	D_2	D_3	D_4	D_5	D_6	Mean	D_4	D_5	Mean	D_5	D_6	Mean
C_1-Tap water	5.74	8.43	9.32	11.42	13.59	9.70[b]	1.29	2.45	3.18	5.28	6.07	8.88	4.53[b]	13.00 (21.04)	34.00 (35.64)	23.50[c] (28.34)	5.00 (8.24)	17.00 (21.27)	11.00[b] (14.76)
C_2-Cold water	4.17	7.61	9.33	10.81	12.15	8.81[a]	1.10	2.63	3.09	5.13	6.12	8.38	4.41[b]	6.00 (9.11)	23.00 (28.32)	14.50[b] (18.72)	1.00 (2.69)	4.00 (7.37)	2.50[a] (5.03)
C_3-Contact-icing	3.88	6.39	8.01	9.96	11.70	7.99[a]	1.06	2.25	3.05	3.99	5.43	7.84	3.94[a]	1.00 (2.69)	11.00 (17.36)	6.00[a] (10.03)	1.00 (2.69)	1.00 (2.69)	1.00[a] (2.69)
C_4-Control	4.94	7.58	9.50	11.31	13.56	9.38[b]	1.62	3.01	4.41	5.89	6.69	8.70	5.05[c]	10.00 (16.49)	32.50 (34.81)	21.25[c] (25.65)	1.50 (3.69)	12.50 (18.80)	7.00[b] (11.25)
CD																			
Precooling(c)			1.38*						0.17*							6.59*			5.91*

Significant at 5 per cent level

Mean temperature during experiment period		
Maximum temperature	31.8°C	12.2°C
Minimum temperature	28.6°C	9.4°C
Mean relative humidity during experiment period	82.5%	62.2%

D_1, D_2 .... D_n - 'n' Days after storage

Figures in bracket indicates transformed values

The PLW was maximum in C_1 (tap water) which was on par with C_4 (control).

Minimum PLW under refrigerated storage was recorded in C_3 (contact icing). This treatment was significantly superior to all other treatments. Maximum PLW was recorded in C_4 (control).

4.1.2.2 Unmarketability

Data on unmarketability showed significant variation among precooling treatments both under ambient and refrigerated storage environment.

Under ambient temperature storage the minimum unmarketability was recorded in C_3 (contact icing) which was significantly lower than all other treatments. It was followed by C_2 (cold water). Maximum unmarketability was recorded in C_1 (tap water) which was on par with C_4 (control).

Contact icing (C_3) and cold water (C_2) treatments recorded the minimum unmarketability under refrigerated storage. The effect of these two treatments were on par. Maximum unmarketability was recorded in C_1 (tap water) which was on par with C_4 (control).

4.1.3 Chilli (*Capsicum annum* L.)

The influence of precooling treatments on PLW and unmarketability are presented in Table 3.

4.1.3.1 Physiological loss in weight

Precooling treatments had significant influence both under ambient and refrigerated storage environment.

Minimum PLW under ambient temperature storage was recorded in C_2 (cold water) which was on par with C_3 (contact icing). Maximum PLW was recorded in C_1 (tap water). C_1 was followed by C_4 (control). Treatments C_1 and C_4 were on par with each other.

Perusal of data in Table 3 showed that minimum PLW under refrigerated storage was in C_3 (contact icing) which was on par with C_2 (cold water). Maximum PLW was recorded in C_1 (tap water) which was on par with C_4 (control).

4.1.3.2 Unmarketability

Precooling treatments had significant effect on unmarketability only under refrigerated storage.

Among the treatments, minimum unmarketability under refrigerated storage was recorded in contact icing (C_3). This was followed by cold water (C_2). C_3 and C_2 were on par with

Table 3. Effect of precooling treatments on PLW and unmarketability in chilli

Treatments	Physiological loss in weight (%)												Unmarketability (%)					
	Ambient temperature storage					Refrigerated storage							Ambient temperature storage			Refrigerated storage		
	D_1	D_2	D_3	D_4	Mean	D_1	D_2	D_3	D_4	D_5	D_6	Mean	D_4	D_5	Mean	D_5	D_6	Mean
C_1-Tap water	13.00	24.92	31.28	36.84	26.51[b]	4.00	8.46	12.69	15.96	19.43	23.28	13.98[b]	21.00 (26.70)	50.00 (45.10)	35.00 (35.90)	4.50 (7.37)	18.50 (24.83)	11.50[b] (16.10)
C_2-Cold water	11.00	19.75	26.75	34.52	23.00[a]	3.46	8.08	10.77	13.85	17.69	21.54	12.56[a]	19.00 (25.21)	47.00 (43.25)	33.00 (34.23)	5.00 (8.24)	13.00 (19.41)	9.00[a] (13.83)
C_3-Contact-icing	14.17	24.17	28.58	34.00	25.23[a]	3.02	5.66	9.06	13.97	18.36	21.49	11.93[a]	21.00 (26.70)	44.00 (41.47)	32.50 (34.08)	1.00 (2.68)	8.50 (15.13)	4.75[a] (8.91)
C_4-Control	13.02	22.93	31.18	37.55	26.17[b]	4.42	7.68	10.39	14.24	18.85	23.29	13.14[b]	24.00 (28.78)	52.00 (44.34)	38.00 (36.57)	9.00 (15.38)	17.50 (21.45)	13.25[b] (18.42)
CD																		
Precooling(c)			2.23*					0.89*						N.S			6.51*	

* Significant at 5 per cent level

Mean temperature during experiment period

Maximum temperature	32.4°C	11.6°C
Minimum temperature	28.1°C	8.9°C
Mean relative humidity during experiment period	80.2%	61.4%

D_1, D_2 .... D_n - 'n' Days after storage

Figures in bracket indicates transformed values

each other. Maximum unmarketability was recorded in C_4 (control) which was on par with C_1 (tap water).

4.1.4 Cowpea (*Vigna unguiculata* (L.) Walp.)

Data on the effect of precooling treatments on PLW and unmarketability are presented in Table 4.

4.1.4.1 Physiological loss in weight

Precooling treatments differed significantly both under ambient and refrigerated storage environment.

Minimum PLW under ambient temperature storage was recorded in C_2 (cold water). This was followed by C_3 (contact icing) and C_1 (tap water). C_3 and C_1 were on par with each other. Maximum PLW was recorded in C_4 (control).

Under refrigerated storage minimum PLW was recorded in C_3 (contact icing) which was followed by C_2 (cold water). The effect of C_3 and C_2 were on par. PLW was maximum in C_1 (tap water) which was on par with C_4 (control).

4.1.3.2 Unmarketability

Data on unmarketability indicated that there was no significant difference between precooling treatments on unmarketability both under ambient and refrigerated storage environments.

Table 4. Effect of precooling treatments on PLW and unmarketability in cowpea

Treatments	Physiological loss in weight (%)							Unmarketability (%)					
	Ambient temperature storage			Refrigerated storage				Ambient temperature storage			Refrigerated storage		
	D_1	D_2	Mean	D_1	D_2	D_3	Mean	D_1	D_2	Mean	D_2	D_3	Mean
C_1-Tap water	12.57	20.77	16.67[b]	6.28	13.69	22.54	14.17[b]	36.00 (36.80)	78.00 (62.12)	57.00 (49.49)	5.00 (8.24)	19.00 (25.44)	12.00 (16.84)
C_2-Cold water	10.55	19.11	14.83[a]	6.11	12.21	21.16	13.16[a]	36.00 (36.86)	79.00 (62.18)	57.50 (49.84)	6.00 (9.11)	21.00 (27.07)	13.50 (18.09)
C_3-Contact-icing	12.83	20.45	16.64[b]	4.98	11.00	20.99	12.32[a]	31.50 (33.79)	76.50 (61.44)	54.00 (47.61)	3.00 (4.56)	18.00 (23.16)	10.50 (13.84)
C_4-Control	14.63	22.05	18.34[c]	6.51	12.79	21.24	13.51[b]	35.00 (36.25)	77.00 (61.63)	56.00 (48.94)	10.00 (14.24)	26.00 (30.36)	18.00 (22.30)
CD													
Precooling(c)		0.53*			0.86*				N.S			N.S	

* Significant at 5 per cent level

Mean temperature during experiment period

Maximum temperature	32.8°C	11.2°C
Minimum temperature	27.8°C	9.1°C
Mean relative humidity during experiment period	79.6%	60.3%

D_1, D_2 .... D_n - 'n' Days after storage

Figures in bracket indicates transformed values

4.1.5 Okra (*Abelmoschus esculentus* L. Moench)

Data on PLW and unmarketability as influenced by precooling treatments are presented in Table 5.

4.1.5.1 Physiological loss in weight

Significant difference between precooling treatments on PLW were observed both under ambient and refrigerated storage environments.

Minimum PLW under ambient temperature storage was recorded in C_1 (tap water). It was followed by C_3 (contact icing) and C_2 (cold water). C_3 and C_2 were on par with each other. Maximum PLW was recorded in C_4 (control).

Minimum PLW under refrigerated storage was recorded in C_2 (cold water) which was on par with C_3 (contact icing). PLW was maximum in C_1 (tap water) which was on par with C_4 (control).

4.1.5.2 Unmarketability

Perusal of data on Table 5 showed that the precooling treatments had significant effect only under ambient temperature storage.

Minimum unmarketability under ambient temperature storage was recorded in C_3 (contact icing). This treatment

Table 5. Effect of precooling treatments on PLW and unmarketability in okra

Treatments	Physiological loss in weight (%)										Unmarketability (%)					
	Ambient temperature storage					Refrigerated storage					Ambient temperature storage			Refrigerated storage		
	D_1	D_2	D_3	D_4	Mean	D_1	D_2	D_3	D_4	Mean	D_3	D_4	Mean	D_3	D_4	Mean
C_1-Tap water	5.31	16.42	23.99	28.67	18.60[a]	4.86	8.34	12.58	17.75	10.68[b]	28.00 (31.47)	52.00 (46.15)	40.00[a] (38.81)	9.00 (13.56)	21.00 (26.81)	15.00 (20.18)
C_2-Cold water	5.87	19.03	28.41	32.87	21.53[b]	3.47	6.50	10.63	14.77	8.84[a]	21.00 (26.44)	49.00 (44.42)	35.00[a] (35.43)	5.00 (8.24)	18.00 (23.24)	11.50 (15.74)
C_3-Contact-icing	6.09	19.45	26.45	33.79	21.44[b]	3.03	6.21	11.85	16.71	9.45[a]	21.00 (26.92)	46.00 (42.67)	33.50[a] (34.80)	7.00 (11.94)	19.00 (25.37)	13.00 (18.65)
C_4-Control	7.63	20.02	29.18	37.43	23.56[c]	4.04	7.25	11.79	17.48	10.14[b]	40.00 (38.81)	72.00 (59.45)	56.00[b] (49.13)	13.00 (18.80)	27.00 (31.21)	20.00 (25.00)
CD																
Precooling(c)			0.92*					0.86*				7.98*			N.S	

* Significant at 5 per cent level

Mean temperature during experiment period

Maximum temperature	31.4°C	11.6°C
Minimum temperature	28.8°C	8.8°C
Mean relative humidity during experiment period	83.4%	59.7%

D_1, D_2 .... D_n - 'n' Days after storage

Figures in bracket indicates transformed values

was followed by C_2 (cold water) and C_1 (tap water). C_3, C_2 and C_1 were on par with each other. Maximum unmarketability was recorded in C_4 (control).

4.1.6 Tomato (Lycopersicon esculentum Mill.)

Data on the effect of precooling treatments on PLW and unmarketability in tomato are presented in Table 6.

4.1.6.1 Physiological loss in weight

Data on PLW showed significant difference among precooling treatments both under ambient and refrigerated storage environment.

PLW under ambient temperature storage was minimum in C_3 (contact icing) which was on par with C_1 (tap water). Treatments C_3 and C_1 were followed by C_4 (control). Maximum PLW was recorded in C_2 (cold water).

Minimum PLW under refrigerated storage was recorded in C_3 (contact icing) which was on par with C_1 (tap water). C_3 and C_1 were followed by C_2 (cold water). Maximum PLW was recorded in C_4 (control).

4.1.6.2 Unmarketability

Significant difference in unmarketability among

Table 6. Effect of precooling treatments on PLW and unmarketability in tomato

Treatments	Physiological loss in weight (%)											Unmarketability (%)					
	Ambient temperature storage					Refrigerated storage						Ambient temperature storage			Refrigerated storate		
	D_2	D_4	D_6	D_8	Mean	D_3	D_6	D_9	D_{12}	D_{15}	Mean	D_6	D_8	Mean	D_{12}	D_{15}	Mean
C_1-Tap water	2.69	5.38	8.93	12.28	7.32[a]	1.97	2.46	4.82	6.58	9.79	5.13[a]	15.00 (22.67)	38.00 (36.32)	26.50[a] (29.49)	11.80 (17.36)	30.00 (33.10)	20.90 (25.23)
C_2-Cold water	4.01	7.22	12.34	15.41	9.74[c]	2.31	3.19	5.92	6.98	9.96	5.67[b]	29.00 (32.38)	63.00 (52.95)	46.00[b] (42.66)	5.00 (8.71)	25.00 (29.91)	15.00 (19.51)
C_3-Contact-icing	2.61	5.42	8.08	11.47	6.89[a]	1.69	2.74	4.86	5.62	9.41	4.87[a]	10.00 (15.18)	36.00 (37.14)	23.00[a] (26.16)	10.00 (14.43)	24.80 (29.27)	17.40 (21.85)
C_4-Control	3.14	6.61	9.12	12.35	7.80[b]	2.80	4.18	6.85	9.95	14.23	7.60[c]	25.00 (29.95)	53.00 (46.72)	39.00[b] (38.34)	6.00 (9.11)	31.50 (35.49)	18.30 (22.30)
CD																	
Precooling(c)			0.88*				0.38*							7.98*			N.S

* Significant at 5 per cent level

Mean temperature during experiment period

	Ambient	Refrigerated
Maximum temperature	32.1°C	12.4°C
Minimum temperature	28.4°C	8.9°C
Mean relative humidity during experiment period	82.8%	60.5%

D_2, D_3 .... D_n - 'n' Days after storage

Figures in bracket indicates transformed values

various precooling treatments was observed only under ambient temperature storage.

Minimum unmarketability under ambient temperature storage was recorded in C_3 (contact icing) which was followed by C_1 (tap water). Treatments C_3 and C_1 were on par with each other. Maximum unmarketability was recorded in C_2 (cold water) which was on par with C_4 (control).

4.2 Effect of precooling and packaging on shelf life of vegetables under ambient and refrigerated storage environments

Effect of various packaging treatments on precooled vegetables were studied in amaranth, brinjal, chilli, cowpea, okra and tomato. Daily observations were taken on PLW, unmarketability and consumer acceptability. For the convenience of statistical analysis mean values of the observations of two days and three days interval were used respectively under ambient and refrigerated storage environment in various treatments. In the case of cowpea and okra kept under ambient temperature storage mean values of the daily observations were taken. For tomatoes kept under refrigerated storage, mean values of the observations of six days interval were used. Salient results of the experiments are given below.

4.2.1 Amaranth (*Amaranthus tricolor* L.)

A view of amaranth packaged in polymeric films is presented in Plate 4.

4.2.1.1 Physiological loss in weight

Data on PLW as influenced by precooling and packaging treatments are presented in Table 7. Treatments differed significantly both under ambient and refrigerated storage environments.

Among precooling treatments, under ambient temperature storage, minimum PLW was recorded in C_3 (contact icing). Maximum PLW was recorded in C_2 (cold water) which was on par with C_1 (tap water). These treatments were followed by C_4 (control).

Among packaging treatments, under ambient temperature storage, minimum PLW was recorded in P_1 (100 gauge PE, unventilated) followed by P_2 (200 gauge PE, unventilated). Treatments P_1 and P_2 were on par. Maximum PLW was recorded in P_3 (100 gauge PE, ventilated).

With respect to refrigerated storage minimum PLW, among precooling treatments was recorded in C_3 (contact icing). Maximum PLW was recorded in C_2 (cold water) which was on par with C_1 (tap water).

Table 7. Influence of precooling and packaging treatments on PLW (%) in amaranth

7a. Main effects

Treatments	Days after storage										
	Ambient temperature storage					Refrigerated storage					
	D_2	D_4	D_6	D_8	Mean	D_3	D_6	D_9	D_{12}	D_{15}	Mean
Precooling											
C_1	2.75	4.49	6.18	7.86	5.32[c]	3.14	4.98	6.53	8.69	10.26	6.72[c]
C_2	3.22	4.88	6.52	7.89	5.62[c]	2.67	5.45	6.82	8.65	10.48	6.82[c]
C_3	2.19	3.35	4.77	5.66	3.98[a]	1.98	3.33	4.86	7.60	9.10	5.37[a]
C_4	2.38	3.65	5.33	6.96	4.58[b]	1.70	3.74	5.19	8.60	10.14	5.89[b]
Packaging											
P_1	0.26	0.34	0.46	0.56	0.41[a]	0.34	0.53	0.75	0.89	1.46	0.79[a]
P_2	0.44	0.67	0.74	1.36	0.80[a]	1.21	2.21	2.54	3.25	3.56	2.55[c]
P_3	4.71	8.22	12.51	15.46	10.23[e]	3.17	5.60	7.95	11.38	15.09	8.64[d]
P_4	4.37	6.66	9.59	12.57	8.30[c]	5.17	9.47	11.45	14.68	16.87	11.58[e]
P_5	0.87	1.07	1.47	1.57	1.25[b]	0.63	0.96	1.33	2.17	2.83	1.59[b]
P_6	1.04	1.31	1.63	2.29	1.57[b]	1.42	2.58	3.01	3.30	3.58	2.78[c]
P_7	4.58	7.64	8.96	10.20	7.84[c]	2.15	5.88	10.54	16.46	20.86	11.18[e]
P_8	5.05	7.01	10.67	14.01	9.18[d]	5.79	8.81	10.09	13.60	16.79	11.02[e]

Contd.

Table 7b. Interaction effects

Treatments	Days after storage								
	Ambient temperature storage				Refrigerated storage				
	D_2	D_4	D_6	D_8	D_3	D_6	D_9	D_{12}	D_{15}
Precooling x Packaging									
C_1P_1	0.18	0.24	0.37	0.39	0.55	0.95	1.43	1.67	2.96
C_2P_1	0.21	0.38	0.62	0.90	0.16	0.22	0.54	0.59	0.19
C_3P_1	0.17	0.18	0.23	0.24	0.16	0.19	0.29	0.48	0.82
C_4P_1	0.46	0.51	0.70	0.72	0.47	0.75	0.76	0.81	0.86
C_1P_2	0.16	0.29	0.36	1.51	0.98	1.42	1.53	1.63	1.98
C_2P_2	0.73	0.97	1.24	1.65	0.92	2.31	3.08	3.69	4.15
C_3P_2	0.62	0.75	0.76	0.90	1.28	1.48	1.62	2.03	2.45
C_4P_2	0.25	0.54	0.66	1.54	1.64	3.61	3.94	6.67	6.85
C_1P_3	4.78	9.82	14.51	17.51	7.08	8.83	10.33	14.50	16.23
C_2P_3	6.14	10.77	15.34	18.14	2.65	6.62	8.63	11.73	15.22
C_3P_3	3.79	5.92	12.48	15.48	1.79	3.58	5.81	9.99	13.96
C_4P_3	4.14	6.38	7.72	10.70	1.16	3.38	7.04	9.26	14.94
C_1P_4	2.98	5.65	7.99	9.98	4.88	8.03	12.14	16.00	17.02
C_2P_4	4.46	7.37	9.33	11.93	7.58	14.12	15.01	15.45	16.76
C_3P_4	4.11	6.25	10.95	16.80	4.88	7.48	9.28	13.61	18.23
C_4P_4	4.84	7.37	10.09	11.52	3.35	8.24	9.36	13.65	15.46
C_1P_5	0.57	0.83	1.29	1.46	0.61	0.62	1.23	2.15	2.54
C_2P_5	0.27	0.38	0.73	0.74	0.44	0.69	1.14	2.17	3.26
C_3P_5	0.90	1.24	1.31	1.32	0.58	0.70	0.85	1.39	2.01
C_4P_5	0.94	1.05	1.74	1.75	0.91	1.81	2.12	2.98	3.51
C_1P_6	0.79	1.14	1.77	3.11	2.31	4.11	4.61	4.62	4.62
C_2P_6	1.90	1.91	2.57	3.23	1.22	2.43	2.44	2.44	2.45
C_3P_6	0.28	0.53	0.63	0.67	0.39	0.58	0.91	1.22	2.24
C_4P_6	0.97	1.57	1.61	2.10	0.78	1.79	3.07	3.94	3.95
C_1P_7	6.19	9.86	10.84	11.75	2.82	6.72	11.16	16.46	21.99
C_2P_7	6.83	10.54	12.31	13.94	2.92	6.75	11.70	16.13	21.35
C_3P_7	2.47	5.31	6.24	6.99	0.89	4.72	9.21	15.66	19.16

Contd.

Table 7b (Contd.)

Treatments	Days after storage								
	Ambient temperature storage				Refrigerated storage				
	D_2	D_4	D_6	D_8	D_3	D_6	D_9	D_{12}	D_{15}
C_4P_7	2.82	4.83	6.44	8.14	1.92	5.83	10.19	17.62	20.92
C_1P_8	6.37	8.09	12.35	17.14	5.91	9.20	9.77	12.56	14.75
C_2P_8	4.24	6.70	10.02	11.83	5.50	11.00	12.15	17.00	19.50
C_3P_8	4.72	6.28	10.14	13.44	8.45	10.52	13.43	19.01	24.53
C_4P_8	4.84	6.95	10.26	13.63	3.33	4.53	5.03	5.83	8.38
CD for									
Precooling (C)	0.58*					0.49*			
Packaging (P)	0.80*					0.72*			
C x P	NS					NS			

* Significant at 5 per cent level

Mean temperature during experiment period

	Ambient	Refrigerated
Maximum temperature	33.4°C	10.9°C
Minimum temperature	27.2°C	8.9°C
Mean relative humidity during experiment period	78.5%	60.1%

C_1 - Precooling with tap water

C_2 - Precooling with cold water

C_3 - Precooling by contact icing

C_4 - Control

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

P_5 - Polypropylene bags of 100 gauge without ventilation

P_6 - Polypropylene bags of 200 gauge without ventilation

P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

D_2, D_3, ... D_n - 'n' Days after storage

Plate 4. Amaranth packaged in polymeric films

Plate 5. Type of spoilage in amaranth

In the case of packaging treatments under refrigerated storage, minimum PLW was recorded in P_1 (100 gauge PE, unventilated). Maximum PLW was recorded in P_4 (200 gauge PE ventilated) followed by P_7 (100 gauge PP, ventilated) and P_8 (200 gauge PP, ventilated). Treatments P_4, P_7 and P_8 were on par with each other.

The interaction of precooling and packaging had no significant effect on PLW both under ambient and refrigerated storage environments.

4.2.1.2 Unmarketability

The influence of precooling and packaging treatments on unmarketability are presented in Table 8. The type of spoilage leading to unmarketability of the packaged produce is presented in Plate 5.

In the case of unmarketability, precooling and packaging treatments had significant effect only under refrigerated storage. In this case, among precooling treatments, minimum unmarketability was recorded in C_1 (tap water) which was on par with C_3 (contact icing). Maximum unmarketability was recorded in C_2 (cold water) which was followed by C_4 (control). With respect to packaging treatments minimum unmarketability was recorded in P_1 (100 gauge PE, unventilated) which was on par with P_5 (100 gauge

Table 8. Influence of precooling and packaging treatments on unmarketability (%) in amaranth

8a. Main effects

Treatments	Days after storage					
	Ambient temperature storage			Refrigerated storage		
	D_6	D_8	Mean	D_{12}	D_{15}	Mean
Precooling						
C_1	6.25 (10.60)	18.75 (25.29)	12.50 (17.95)	12.13 15.83)	35.13 (34.49)	23.63[a] (25.16)
C_2	5.50 (8.75)	18.25 (24.86)	11.88 (16.80)	22.75 (25.16)	48.75 (44.53)	35.75[c] (34.85)
C_3	4.75 (7.84)	17.38 (24.23)	11.06 (16.04)	12.63 (16.12)	37.63 (36.32)	25.16[a] (26.22)
C_4	8.13 (12.60)	22.38 (27.83)	15.25 (20.22)	15.25 (19.49)	39.75 (38.84)	27.50[b] (29.16)
Packaging						
P_1	8.50 (13.69)	21.25 (27.06)	14.88 (20.38)	2.75 (5.71)	21.00 (27.12)	11.88[a] (16.42)
P_2	9.00 (13.54)	23.00 (27.95)	16.00 (20.75)	12.50 (17.27)	34.00 (34.29)	23.25[b] (25.78)
P_3	7.75 (12.66)	20.75 (26.73)	14.25 (19.69)	26.50 (30.77)	53.75 (47.21)	40.13[d] (38.99)
P_4	5.25 (8.54)	18.25 (24.91)	11.75 (16.73)	34.00 (35.20)	61.25 (52.34)	47.63[e] (43.77)
P_5	3.25 (5.36)	16.00 (23.30)	9.63 (14.88)	4.00 (7.28)	27.75 (31.68)	15.88[a] (19.48)
P_6	5.75 (9.50)	18.75 (25.28)	12.25 (17.37)	6.25 (9.54)	21.50 (22.59)	13.88[a] (16.07)
P_7	6.25 (10.32)	19.50 (25.88)	12.88 (18.10)	16.25 (20.73)	42.00 (40.26)	29.13[c] (30.49)
P_8	3.50 (6.00)	16.20 (23.33)	9.80 (14.87)	25.25 (29.04)	53.25 (46.99)	39.25[d] (38.02)

Table 8b. Interaction effects

Treatments	Days after storage			
	Ambient temperature storage		Refrigerated storage	
	D_6	D_8	D_{12}	D_{15}
Precooling x Packaging				
C_1P_1	11.00 (19.08)	25.00 (29.86)	3.00 (6.35)	19.00 (25.75)
C_2P_1	7.00 (9.95)	18.00 (24.59)	3.00 (6.35)	24.00 (29.17)
C_3P_1	5.00 (8.33)	18.00 (24.59)	2.00 (3.79)	19.00 (25.69)
C_4P_1	11.00 (17.39)	24.00 (29.21)	3.00 (6.35)	22.00 (27.88)
C_1P_2	6.00 (9.19)	20.00 (25.99)	1.00 (2.69)	9.00 (15.65)
C_2P_2	6.00 (9.19)	18.00 (24.59)	15.00 (20.46)	39.00 (38.45)
C_3P_2	6.00 (9.19)	18.00 (24.59)	11.00 (17.39)	39.00 (38.61)
C_4P_2	18.00 (24.59)	36.00 (36.66)	21.00 (28.53)	49.00 (44.43)
C_1P_3	7.00 (12.04)	18.00 (24.70)	30.00 (33.07)	59.00 (50.26)
C_2P_3	2.00 (3.79)	16.00 (23.37)	29.00 (32.46)	54.00 (47.35)
C_3P_3	8.00 (12.86)	21.00 (26.90)	18.00 (24.99)	44.00 (41.56)
C_4P_3	14.00 (21.93)	28.00 (31.94)	29.00 (32.56)	58.00 (49.65)
C_1P_4	5.00 (8.33)	16.00 (23.26)	30.00 (33.07)	57.00 (49.09)
C_2P_4	8.00 (12.86)	22.00 (27.77)	62.00 (52.06)	88.00 (70.21)
C_3P_4	3.00 (4.66)	16.00 (23.14)	20.00 (26.44)	49.00 (44.44)
C_4P_4	5.00 (8.33)	19.00 (25.46)	24.00 (29.21)	51.00 (45.60)
C_1P_5	5.00 (8.33)	17.00 (24.13)	3.00 (6.35)	24.00 (29.28)
C_2P_5	3.00 (4.66)	16.00 (23.14)	4.00 (7.22)	30.00 (33.15)
C_3P_5	2.00 (3.79)	15.00 (22.68)	3.00 (6.35)	27.00 (31.23)
C_4P_5	3.00 (4.66)	18.00 (24.88)	6.00 (9.20)	30.00 (33.07)
C_1P_6	5.00 (8.33)	18.00 (24.81)	1.00 (2.69)	8.00 (10.66)
C_2P_6	8.00 (12.86)	20.00 (26.03)	20.00 (26.44)	49.00 (44.44)
C_3P_6	5.00 (8.33)	19.00 (25.46)	1.00 (2.69)	3.00 (4.64)
C_4P_6	5.00 (8.33)	18.00 (24.81)	3.00 (6.35)	26.00 (30.60)
C_1P_7	6.00 (9.19)	19.00 (25.46)	15.00 (20.53)	39.00 (38.56)
C_2P_7	7.00 (11.99)	21.00 (26.90)	17.00 (21.91)	44.00 (41.44)
C_3P_7	6.00 (9.19)	19.00 (25.46)	16.00 (18.70)	46.00 (42.56)
C_4P_7	6.00 (10.89)	19.00 (25.69)	17.00 (21.79)	39.00 (38.49)

Contd.

Table 8b (Contd.)

Treatments	Days after storage			
	Ambient temperature storage		Refrigerated storage	
	D_6	D_8	D_{12}	D_{15}
C_1P_8	5.00 (8.33)	17.00 (24.13)	14.00 (21.81)	39.00 (38.65)
C_2P_8	3.00 (4.66)	15.00 (22.50)	32.00 (34.40)	62.00 (52.03)
C_3P_8	3.00 (6.35)	13.00 (21.06)	38.00 (38.02)	69.00 (56.36)
C_4P_8	3.00 (4.66)	17.00 (24.01)	17.00 (21.91)	43.00 (40.99)
CD for				
Precooling (C)	N.S		2.88*	
Packaging (P)	N.S		4.08*	
C x P	N.S		N.S	

* Significant at 5 per cent level

	Ambient	Refrigerated
Mean temperature during experiment period		
Maximum temperature	33.4°C	10.9°C
Minimum temperature	27.2°C	8.9°C
Mean relative humidity during experiment period	78.5%	60.1%

C_1 - Precooling with tap water

C_2 - Precooling with cold water

C_3 - Precooling by contact icing

C_4 - Control

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

P_5 - Polypropylene bags of 100 gauge without ventilation

P_6 - Polypropylene bags of 200 gauge without ventilation

P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

D_6, D_8, ... D_n - 'n' Days after storage

* Figures in bracket indicates transformed values

PP, unventilated) and P_6 (200 gauge PP, unventilated). Maximum unmarketability was recorded in P_4 (200 gauge PE, ventilated).

The interaction had no significant effect both under ambient and refrigerated storage environments.

4.2.1.3 Length of storage life

Data on storage life as influenced by precooling and packaging treatments are presented in Table 9. Precooling and packaging treatments had significant effect both under ambient and refrigerated storage environments on the shelf life of amaranth.

Among precooling treatments, maximum shelf life was recorded in C_3 (contact icing) followed by C_2 (cold water) and C_1 (tap water) under ambient temperature storage. Treatments C_3, C_2 and C_1 were on par. Lowest shelf life was recorded in C_4 (Control).

With respect to packaging treatments under ambient temperature storage, maximum shelf life was recorded in P_8 (200 gauge PP, ventilated) and P_4 (200 gauge PE, ventilated). Treatments P_8 and P_4 were on par. Minimum shelf life was recorded in P_2 (200 gauge PE, unventilated).

Table 9. Storage life (days) amaranth as influenced by precooling and packaging treatments

Precooling x Packaging	Ambient temperature storage					Refrigerated storage				
	C_1	C_2	C_3	C_4	Mean	C_1	C_2	C_3	C_4	Mean
P_1	4.20	4.60	4.60	4.20	4.40[b]	11.40	11.40	14.60	12.20	11.90[a]
P_2	4.40	4.60	4.60	3.40	4.25[c]	13.00	10.00	10.20	9.20	10.60[c]
P_3	4.40	4.80	4.40	3.80	4.35[b]	8.40	8.00	9.60	8.60	8.40[e]
P_4	4.60	4.80	5.10	4.80	4.80[a]	7.80	4.80	9.40	9.20	7.80[f]
P_5	4.48	4.40	4.80	4.60	4.57[b]	11.20	11.00	11.40	11.00	11.15[b]
P_6	4.60	4.40	4.60	4.60	4.55[b]	13.70	9.30	13.70	11.30	12.00[a]
P_7	4.60	4.40	4.60	4.60	4.55[b]	9.40	9.60	9.80	9.80	9.65[d]
P_8	4.60	4.80	5.00	4.80	4.83[a]	9.80	7.80	7.80	9.80	8.75[e]
Mean	4.50[a]	4.60[a]	4.70[a]	4.35[b]		10.32[a]	9.00[c]	10.50[a]	10.15[b]	

CD for	Ambient temperature storage	Refrigerated storage
Precooling (C)	0.20*	0.29*
Packaging (P)	0.25*	0.42*
C x P	N.S	N.S

* Significant at 5 per cent level

	Ambient	Refrigerated
Mean storage life of control samples	<1 day	1.5 days
Mean temperature during experiment period		
Maximum temperature	33.4°C	10.9°C
Minimum temperature	27.2°C	8.9°C
Mean relative humidity during experiment period	78.5%	60.1%

C_1 - C_4 - Precooling treatments

P_1 - P_8 - Packaging treatments

C_3 (contact icing) and C_1 (tap water) had the maximum shelf life among precooling treatments, under refrigerated storage. The effect of treatments C_3 and C_1 were on par. Minimum shelf life was recorded in C_2 (cold water) which was on par with C_4 (control).

Among packaging treatments, under refrigerated storage, maximum shelf life was recorded in P_6 (200 gauge PP, unventilated) and P_1 (100 gauge PE, unventilated) and were at par. Minimum shelf life was recorded in P_4 (200 gauge PE, ventilated).

The interaction had no significant effect both under ambient and refrigerated storage environment.

4.2.1.4 Consumer acceptability

Results of the consumer acceptability rating of the precooled produce in different packages are presented in Table 10.

In the case of ambient temperature storage, significant difference in acceptability was observed only among packaging treatments with best acceptability for P_8 (200 gauge PP, ventilated).

With respect to refrigerated storage significant difference in acceptability was observed among precooling and

Table 10. Consumer acceptability of amaranth as influenced by precooling and packaging treatments

10a. Main effects

Treatments	Days after storage										
	Ambient temperature storage					Refrigerated storage					
	D_2	D_4	D_6	D_8	Mean	D_3	D_6	D_9	D_{12}	D_{15}	Mean
Precooling											
C_1	1.98	2.63	3.58	4.48	3.16	1.30	1.88	2.60	3.53	4.40	2.75[a]
C_2	1.93	2.45	3.60	4.63	3.15	1.60	2.38	3.08	4.10	4.75	3.18[c]
C_3	1.98	2.53	3.43	4.53	3.11	1.40	2.10	2.63	3.58	4.53	2.85[a]
C_4	2.05	2.65	3.85	4.70	3.31	1.98	2.23	2.78	3.73	4.65	3.01[b]
Packaging											
P_1	1.95	2.70	3.90	4.60	3.29[c]	1.10	1.80	2.25	3.00	4.10	2.44[a]
P_2	2.15	2.90	3.85	4.65	3.39[c]	1.35	2.10	2.65	3.65	4.50	2.85[c]
P_3	1.90	2.50	3.50	4.60	3.12[b]	1.65	2.40	3.15	4.50	5.00	3.34[e]
P_4	1.95	2.45	3.65	4.50	3.12[b]	1.95	2.65	3.30	4.45	4.95	3.46[f]
P_5	1.85	2.45	3.35	4.55	3.05[b]	1.35	1.85	2.55	3.00	4.45	2.64[b]
P_6	2.05	2.65	3.75	4.55	3.25[b]	1.25	1.70	2.30	3.10	3.90	2.45[a]
P_7	2.20	2.60	3.75	4.60	3.29[c]	1.50	2.10	2.85	3.90	4.80	3.03[d]
P_8	1.70	2.15	3.10	4.20	2.78[a]	1.70	2.50	3.00	4.25	-4.85	3.26[e]

Contd.

Table 10.b. Interaction effects

Treatments	Days after storage								
	Ambient temperature storage				Refrigerated storage				
	D_2	D_4	D_6	D_8	D_3	D_6	D_9	D_{12}	D_{15}
Precooling x Packaging									
C_1P_1	2.20	3.40	4.40	4.80	1.00	1.80	2.00	3.00	4.20
C_2P_1	1.80	2.40	3.60	4.40	1.00	1.80	2.40	3.00	4.20
C_3P_1	1.80	2.40	3.60	4.60	1.00	1.60	2.00	2.80	3.80
C_4P_1	2.00	2.60	4.00	4.60	1.40	2.20	2.60	3.00	4.20
C_1P_2	2.00	2.80	3.60	4.60	1.00	1.40	2.00	2.60	3.80
C_2P_2	2.00	2.40	3.80	4.60	1.20	2.20	2.80	4.00	4.40
C_3P_2	2.00	2.60	3.60	4.40	1.40	2.20	2.80	3.80	4.80
C_4P_2	2.60	3.80	4.40	5.00	1.80	2.60	3.00	4.20	5.00
C_1P_3	2.00	2.60	3.40	4.60	1.40	2.40	3.60	4.80	5.00
C_2P_3	1.60	2.20	3.20	4.60	1.80	2.40	3.20	4.80	5.00
C_3P_3	2.20	2.60	3.80	4.60	1.60	2.20	2.80	4.00	5.00
C_4P_3	1.80	2.60	3.60	4.60	1.80	2.60	3.00	4.40	5.00
C_1P_4	2.00	2.40	3.40	4.40	1.60	2.40	3.00	4.20	4.80
C_2P_4	2.20	2.60	3.80	4.80	2.80	3.40	4.40	5.00	5.00
C_3P_4	1.80	2.40	3.40	4.40	1.60	2.40	2.80	4.20	5.00
C_4P_4	1.80	2.40	3.80	4.60	1.80	2.40	3.00	4.40	5.00
C_1P_5	1.80	2.40	3.40	4.40	1.40	1.60	2.20	3.00	4.00
C_2P_5	1.80	2.40	3.20	4.60	1.40	2.00	2.80	3.00	4.80
C_3P_5	1.80	2.60	3.00	4.00	1.20	2.00	2.40	3.00	4.60
C_4P_5	2.00	2.40	3.80	4.80	1.40	1.80	2.80	3.00	4.40
C_1P_6	1.80	2.60	3.40	4.40	1.00	1.20	1.80	2.40	3.40
C_2P_6	2.00	2.60	4.00	4.80	1.40	2.40	2.80	4.40	5.00
C_3P_6	2.20	2.80	3.80	4.60	1.00	1.40	2.20	2.60	3.20
C_4P_6	2.20	2.60	3.80	4.60	1.60	1.80	2.40	3.00	4.20
C_1P_7	2.20	2.60	3.60	4.40	1.40	2.20	3.00	4.00	4.80
C_2P_7	2.20	2.60	3.80	4.60	1.40	2.20	2.80	4.00	4.80
C_3P_7	2.20	2.80	3.60	4.60	1.80	2.00	2.80	3.60	4.80

Contd

Table 10b. (Contd.)

Treatments	Days after storage								
	Ambient temperature storage				Refrigerated storage				
	D_2	D_4	D_6	D_8	D_3	D_6	D_9	D_{12}	D_5
C_4P_7	2.20	2.40	4.00	4.80	1.80	2.00	2.80	4.00	4.80
C_1P_8	1.80	2.20	3.40	4.60	1.20	2.00	2.80	4.00	5.00
C_2P_8	1.80	2.40	3.40	4.60	1.80	2.60	3.40	4.60	4.80
C_3P_8	1.80	2.00	2.60	3.60	2.00	3.00	3.20	4.60	5.00
C_4P_8	1.80	2.40	3.40	4.60	1.80	2.40	2.60	3.80	4.60
CD for									
Procooling (C)			N.S				0.10*		
Packaging (P)			0.22*				0.11*		
C x P			N.S				N.S		

* Significant at 5 per cent level

Five point scale for consumer acceptability

1. Acceptable fully
2. Acceptable somewhat,
3. Neither acceptable non unacceptable
4. Unacceptable somewhat
5. Not acceptable

C_1 - Precooling with tap water

C_2 - Precooling with cold water

C_3 - Precooling by contact icing

C_4 - Control

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

P_5 - Polypropylene bags of 100 gauge without ventilation

P_6 - Polypropylene bags of 200 gauge without ventilation

P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

D_2, D_3, ... D_n - 'n' Days after storage

packaging treatments. Among precooling treatments, C_1 (tap water) and C_3 (contact icing) were rated as best and equally acceptable. Among packaging treatments, P_6 (200 gauge PP, unventilated) and P_1 (100 gauge PE, unventilated) were rated as best and equally acceptable.

Interaction of precooling and packaging treatments indicated no significant effects under two storage regimes.

4.2.2 Brinjal Solanum melongena L.)

A view of brinjal packaged in polymeric film is presented in Plate 6.

4.2.2.1 Physiological loss in weight

The influence of precooling and packaging treatments on PLW in brinjal are presented in Table 11 and Fig.1. Precooling and packaging treatments differed significantly both under ambient and refrigerated storage environments.

In the case of precooling treatments, under ambient temperature storage, minimum PLW was recorded in C_2 (cold water). Maximum PLW was recorded in C_4 (control) which was on par with C_1 (tap water).

Among packaging treatments, under ambient temperature storage, minimum PLW was recorded in P_2 (200 gauge PE,

Table 11. Influence of precooling and packaging treatments on PLW (%) in brinjal

11a. Main effects

Treatments	Days after storage											
	Ambient temperature storage					Refrigerated storage							
	D_2	D_4	D_6	D_8	Mean	D_3	D_6	D_9	D_{12}	D_{15}	D_{18}	D_{21}	Mean
Precooling													
C_1	1.26	1.66	2.02	2.58	1.90[c]	0.74	1.16	1.58	2.01	2.48	2.95	3.46	2.07[c]
C_2	0.73	1.28	1.89	2.39	1.58[a]	0.64	1.02	1.51	1.91	2.28	2.69	3.16	1.89[b]
C_3	0.96	1.45	2.01	2.54	1.74[b]	0.33	0.68	1.06	1.46	1.88	2.32	2.88	1.52[a]
C_4	1.07	1.53	2.27	2.82	1.92[c]	0.77	1.19	1.59	1.97	2.33	2.77	3.30	1.99[c]
Packaging													
P_1	0.27	0.56	0.84	1.18	0.71[b]	0.23	0.34	0.47	0.56	0.65	0.70	0.85	0.54[a]
P_2	0.39	0.45	0.56	0.67	0.52[a]	0.22	0.27	0.35	0.42	0.47	0.58	0.67	0.40[a]
P_3	0.96	1.80	3.22	3.92	2.48[d]	0.86	1.65	2.52	3.28	3.94	4.72	5.50	3.28[c]
P_4	1.59	2.07	2.89	3.53	2.52[d]	0.95	1.76	2.63	3.33	4.14	4.98	5.87	3.38[c]
P_5	0.85	1.42	2.05	2.60	1.73[c]	0.22	0.26	0.32	0.43	0.46	0.59	0.83	0.44[a]
P_6	0.49	0.65	0.78	1.36	0.82[b]	0.19	0.31	0.41	0.51	0.60	0.70	1.10	0.55[a]
P_7	1.39	2.26	2.85	4.03	2.63[e]	0.84	1.85	2.98	3.47	4.08	4.65	5.33	3.26[c]
P_8	1.54	2.11	2.74	3.63	2.50[d]	1.04	1.29	1.73	2.31	3.25	4.15	5.06	2.69[b]

Contd.

Table 11b. Interaction effects

Treatments	Days after storage: Ambient temperature storage D_2	D_4	D_6	D_8	Refrigerated storage D_3	D_6	D_9	D_{12}	D_{15}	D_{18}	D_{21}
Precooling x Packaging											
C_1P_1	0.32	0.69	0.41	1.14	0.33	0.43	0.67	0.76	1.05	1.14	1.33
C_2P_1	0.14	0.17	0.21	0.59	0.16	0.31	0.46	0.55	0.56	0.56	0.71
C_3P_1	0.25	0.49	1.14	1.40	0.14	0.23	0.24	0.33	0.35	0.36	0.42
C_4P_1	0.38	0.89	1.58	1.58	0.35	0.45	0.60	0.68	0.69	0.82	0.92
C_1P_2	0.16	0.20	0.21	0.30	0.45	0.46	0.47	0.48	0.49	0.59	0.63
C_2P_2	0.21	0.36	0.53	0.56	0.16	0.24	0.34	0.41	0.49	0.54	0.54
C_3P_2	0.96	0.98	1.05	1.37	0.12	0.18	0.22	0.31	0.32	0.47	0.59
C_4P_2	0.23	0.24	0.45	0.46	0.18	0.23	0.42	0.51	0.65	0.71	0.90
C_1P_3	1.06	1.76	2.47	3.31	0.62	1.22	2.03	2.67	3.49	3.76	4.48
C_2P_3	0.83	1.70	3.45	4.21	1.28	1.58	3.17	3.96	4.75	5.54	5.79
C_3P_3	0.78	1.93	3.61	3.83	0.48	1.86	2.55	2.84	3.55	4.67	6.04
C_4P_3	1.18	1.82	3.37	4.35	1.09	1.93	2.71	3.67	3.96	4.92	5.70
C_1P_4	2.04	2.22	2.60	3.17	1.41	2.44	3.70	4.44	4.96	6.09	6.93
C_2P_4	1.08	2.14	3.14	3.48	0.72	1.59	2.36	2.99	4.13	4.74	5.55
C_3P_4	1.38	1.64	2.18	3.03	0.67	1.24	1.85	2.83	3.68	4.53	5.50
C_4P_4	1.87	2.28	3.63	4.44	1.01	1.78	2.62	3.06	3.80	4.58	5.48
C_1P_5	1.10	1.81	2.26	3.21	0.27	0.28	0.35	0.36	0.45	0.69	0.95
C_2P_5	0.47	0.83	1.42	1.75	0.35	0.47	0.51	0.68	0.69	0.80	1.04
C_3P_5	0.95	1.44	2.10	2.44	0.14	0.15	0.23	0.45	0.46	0.47	0.71
C_4P_5	0.88	1.59	2.43	2.95	0.08	0.14	0.16	0.20	0.23	0.40	0.60
C_1P_6	0.92	1.04	1.27	2.02	0.19	0.39	0.49	0.50	0.57	0.77	1.44
C_2P_6	0.70	0.90	0.94	1.35	0.13	0.31	0.45	0.66	0.81	0.85	1.39
C_3P_6	0.95	1.38	1.66	2.25	0.19	0.24	0.25	0.44	0.43	0.51	0.73
C_4P_6	0.70	0.85	0.90	1.30	0.12	0.17	0.30	0.31	0.40	0.49	0.83
C_1P_7	2.27	2.60	2.86	4.22	1.18	2.15	3.18	3.69	4.50	5.15	5.66
C_2P_7	1.27	2.15	2.80	3.88	1.13	2.50	3.63	4.31	4.53	4.98	5.89
C_3P_7	0.64	2.08	2.50	3.72	0.18	0.87	1.89	2.63	3.35	3.86	4.49

Contd.

Table 11b (Contd.)

Treatments	Days after storage										
	Ambient temperature storage				Refrigerated storage						
	D_2	D_4	D_6	D_8	D_3	D_6	D_9	D_{12}	D_{15}	D_{18}	D_{21}
C_4P_7	1.39	2.23	3.22	4.29	0.87	1.09	2.42	3.25	3.92	4.80	5.28
C_1P_8	1.98	2.72	3.65	4.68	1.44	1.98	2.55	3.16	4.37	5.35	6.25
C_2P_8	0.99	1.97	2.70	3.59	1.15	1.36	1.16	1.74	2.32	3.49	4.34
C_3P_8	1.43	1.45	2.06	2.80	0.68	0.69	1.27	1.87	2.88	3.72	4.56
C_4P_8	1.76	2.29	2.57	3.45	0.87	1.40	1.93	2.45	3.41	4.03	5.08
CD for											
Precooling (C)	0.08*				0.09*						
Packaging (P)	0.14*				0.17*						
C x P	NS				NS						

* Significant at 5 per cent level

Mean temperature during experiment period

	Ambient	Refrigerated
Maximum temperature	31.8°C	12.2°C
Minimum temperature	28.6°C	9.4°C
Mean relative humidity during experiment period	82.5%	62.2%

C_1 - Precooling with tap water

C_2 - Precooling with cold water

C_3 - Precooling by contact icing

C_4 - Control

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

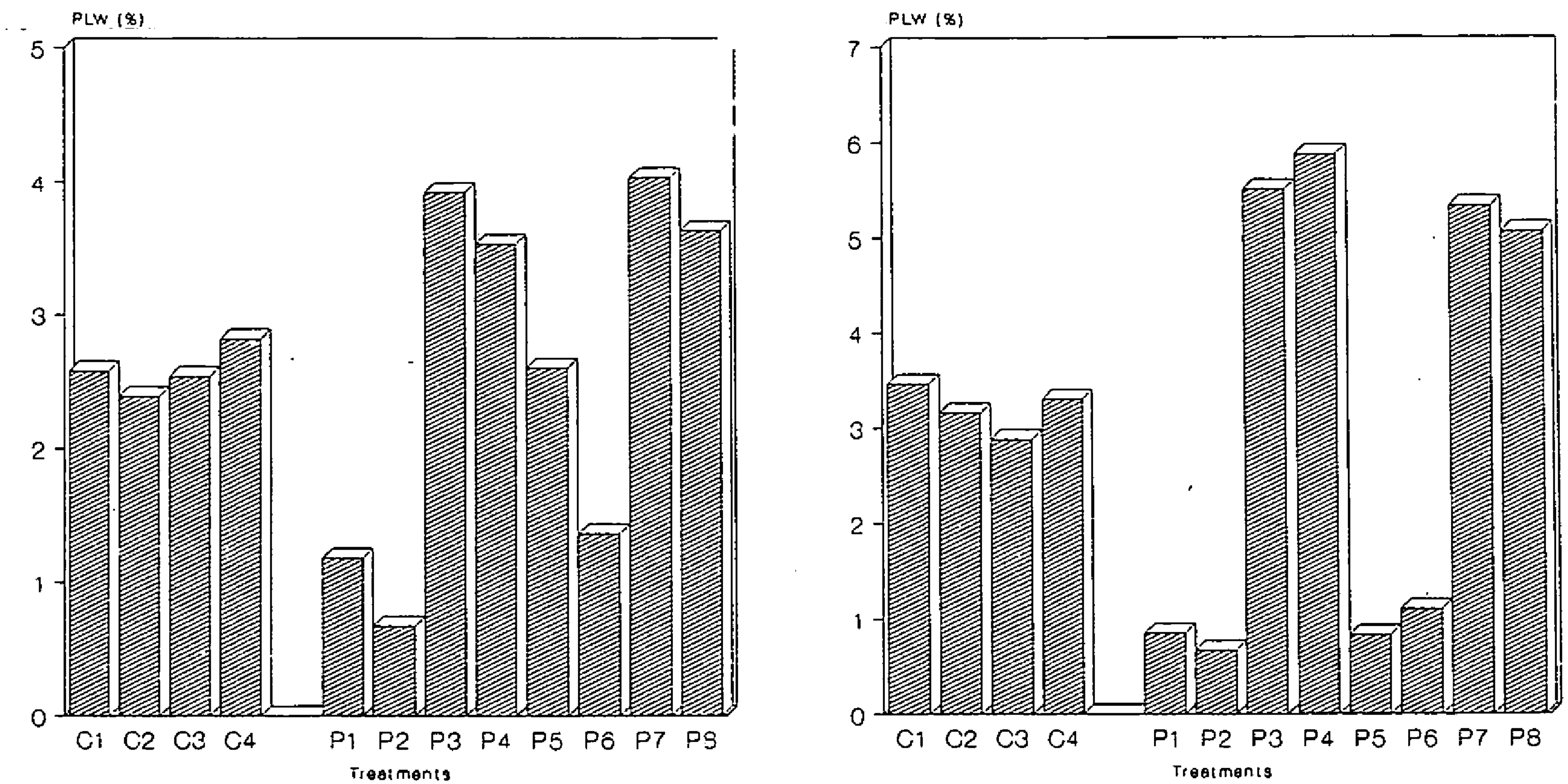
P_5 - Polypropylene bags of 100 gauge without ventilation

P_6 - Polypropylene bags of 200 gauge without ventilation

P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

D_2, D_3, ... D_n - 'n' Days after storage



(a) Ambient temperature storage
(After eight days of storage)

(b) Refrigerated storage
(After twenty one days of storage)

Fig. 1 Effect of precooling and packaging on physiological loss in weight in Brinjal.

unventilated) which was significantly superior to all other treatments. Maximum PLW was recorded in P_7 (100 gauge PP ventilated).

With respect to refrigerated storage, among precooling treatments, C_3 (contact icing) recorded the minimum PLW. Maximum PLW was recorded in C_1 (tap water) which was on par with C_4 (control).

Minimum PLW, among packaging treatments under refrigerated storage was recorded in P_2 (200 gauge PE, unventilated) followed by P_5 (100 gauge PP, unventilated), P_1 (100 gauge PE, unventilated) and P_6 (200 gauge PP, unventilated). Treatments P_2, P_5, P_1 and P_6 were on par with each other. Maximum PLW was recorded in P_4 (200 gauge PE, ventilated) which was on par with P_3 (100 gauge PE, ventilated) and P_7 (100 gauge PP, ventilated).

The interaction between precooling and packaging had no significant effect under the two storage regimes studied.

4.2.2.2 Unmarketability

Unmarketability as influenced by precooling and packaging treatments are presented in Table 12 and Fig.2. Type of spoilage leading to unmarketability of the packaged brinjal are presented in Plate 7. Data presented in Table 12

Table 12. Influence of precooling and packaging treatments on unmarketability (%) in brinjal

12a. Main effects

Treatments	Days after storage					
	Ambient temperature storage			Refrigerated storage		
	D_6	D_8	Mean	D_{18}	D_{21}	Mean
Precooling						
C_1	7.88 (12.39)	31.63 (32.76)	19.76^{b} (22.58)	22.25 (27.16)	51.00 (45.66)	36.63^{c} (36.41)
C_2	2.38 (4.72)	22.75 (27.81)	12.56^{a} (16.27)	12.00 (17.30)	39.25 (38.64)	25.63^{b} 27.97)
C_3	7.75 (11.74)	30.50 (32.40)	19.13^{b} (22.10)	8.00 (12.42)	32.38 (34.49)	20.19^{a} 23.46)
C_4	8.50 (12.46)	36.38 (35.93)	22.44^{c} (24.19)	27.00 (29.84)	60.13 (51.21)	43.56^{d} (40.53)
Packaging						
P_1	9.25 (15.43)	40.25 (39.23)	24.75^{c} (27.33)	24.25 (27.01)	54.50 (47.96)	39.38^{d} (37.48)
P_2	8.25 (13.16)	37.50 (36.69)	22.88^{c} (24.93)	18.00 (22.75)	47.25 (43.46)	32.63^{c} (33.10)
P_3	2.25 (4.43)	17.25 (23.77)	9.75^{a} (14.10)	15.25 (20.40)	39.00 (38.54)	27.13^{b} (29.47)
P_4	1.75 (3.88)	12.00 (18.67)	6.88^{a} (11.28)	5.00 (8.66)	31.00 (33.61)	18.00^{a} (21.14)
P_5	17.00 (20.73)	46.59 (42.18)	31.75^{d} (31.45)	26.00 (30.27)	55.75 (48.42)	40.88^{e} (39.34)
P_6	8.50 (13.85)	35.50 (35.92)	22.00^{c} (24.89)	21.75 (25.34)	51.75 (46.25)	36.75^{d} (35.79)
P_7	3.25 (15.84)	28.50 (31.75)	15.88^{b} (18.82)	13.25 (18.79)	43.00 (40.84)	28.13^{b} (29.82)
P_8	2.75 (5.29)	25.00 (29.60)	13.87^{b} (17.44)	15.00 (20.23)	43.25 (40.94)	29.13^{b} (30.59)

Table 12b. Interaction effects

Treatments	Days after storage			
	Ambient temperature storage		Refrigerated storage	
	D_6	D_8	D_{18}	D_{21}
Precooling x Packaging				
C_1P_1	10.00 (16.41)	38.00 (37.88)	34.00 (35.88)	73.00 (59.09)
C_2P_1	3.00 (6.35)	33.00 (34.83)	17.00 (24.13)	42.00 (40.39)
C_3P_1	12.00 (19.49)	45.00 (42.12)	6.00 (9.08)	29.00 (32.51)
C_4P_1	12.00 (19.49)	45.00 (42.12)	40.00 (39.22)	74.00 (59.86)
C_1P_2	1.00 (2.69)	11.00 (18.55)	19.00 (25.57)	45.00 (42.07)
C_2P_2	3.00 (6.35)	25.00 (29.97)	4.00 (7.22)	30.00 (33.20)
C_3P_2	15.00 (22.15)	56.00 (48.52)	16.00 (23.26)	42.00 (40.34)
C_4P_2	14.00 (21.47)	58.00 (49.71)	33.00 (34.93)	72.00 (58.23)
C_1P_3	2.00 (3.79)	15.00 (22.34)	17.00 (24.13)	36.00 (36.83)
C_2P_3	2.00 (3.79)	27.00 (31.27)	15.00 (22.68)	38.00 (38.07)
C_3P_3	3.00 (6.35)	13.00 (20.18)	2.00 (3.79)	25.00 (30.10)
C_4P_3	2.00 (3.79)	14.00 (21.28)	27.00 (30.99)	56.00 (48.66)
C_1P_4	2.00 (3.79)	11.00 (18.74)	9.00 (13.62)	36.00 (36.60)
C_2P_4	2.00 (5.25)	18.00 (24.47)	3.00 (6.353)	26.00 (30.61)
C_3P_4	2.00 (3.79)	9.00 (15.78)	5.00 (8.33)	32.00 (34.07)
C_4P_4	1.00 (2.69)	10.00 (16.31)	3.00 (6.353)	30.00 (33.15)
C_1P_5	23.00 (27.65)	58.00 (49.86)	28.00 (31.70)	62.00 (52.11)
C_2P_5	2.00 (3.79)	10.00 (17.86)	27.00 (31.23)	60.00 (50.86)
C_3P_5	14.00 (19.41)	48.00 (43.82)	15.00 (22.50)	35.00 (36.22)
C_4P_5	29.00 (32.07)	70.00 (57.14)	34.00 (35.64)	66.00 (54.49)
C_1P_6	15.00 (22.34)	49.00 (44.44)	27.00 (31.11)	57.00 (49.09)
C_2P_6	2.00 (3.79)	14.00 (21.58)	14.00 (19.41)	40.00 (39.08)
C_3P_6	13.00 (20.36)	44.00 (41.50)	10.00 (14.30)	36.00 (36.76)
C_4P_6	4.00 (8.91)	35.00 (36.19)	36.00 (36.53)	74.00 (60.08)
C_1P_7	5.00 (8.33)	37.00 (37.41)	21.00 (27.08)	51.00 (45.62)
C_2P_7	2.00 (3.79)	28.00 (31.82)	8.00 (14.54)	40.00 (39.03)
C_3P_7	2.00 (3.79)	15.00 (22.27)	3.00 (6.35)	28.00 (31.94)
C_4P_7	4.00 (7.46)	34.00 (35.51)	21.00 (27.19)	53.00 (46.75)

Contd.

Table 12b (Contd.)

Treatments	Days after storage			
	Ambient temperature storage		Refrigerated storage	
	D_6	D_8	D_{18}	D_{21}
C_1P_8	4.00 (8.91)	25.00 (29.97)	23.00 (28.48)	48.00 (43.87)
C_2P_8	3.00 (4.66)	27.00 (30.69)	8.00 (12.86)	38.00 (37.92)
C_3P_8	2.00 (3.79)	22.00 (27.54)	7.00 (11.76)	31.00 (33.49)
C_4P_8	2.00 (3.79)	26.00 (30.19)	22.00 (27.84)	56.00 (48.50)
CD for				
Precooling (C)	3.05*		2.83*	
Packaging (P)	4.32*		4.02*	
C x P	N.S		N.S	

Significant at 5 per cent level

	Ambient	Refrigerated
Mean temperature during experiment period		
Maximum temperature	31.8°C	12.2°C
Minimum temperature	28.6°C	9.4°C
Mean relative humidity during experiment period	82.5%	62.2%

C_1 - Precooling with tap water

C_2 - Precooling with cold water

C_3 - Precooling by contact icing

C_4 - Control

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

P_5 - Polypropylene bags of 100 gauge without ventilati

P_6 - Polypropylene bags of 200 gauge without ventilation

P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

D_6, D_8, ... D_n - 'n' Days after storage

* Figures in bracket indicates transformed values

showed significant difference between precooling and packaging treatments under the two storage regimes.

Among precooling treatments, under ambient temperature storage, minimum unmarketability was recorded in C_2 (cold water) which was significantly superior to all other treatments. Maximum unmarketability was recorded in C_4 (control).

With respect to packaging treatments, under ambient temperature storage, minimum unmarketability was obtained in P_4 (200 gauge PE, ventilated) which was on par with P_3 (100 gauge PE, ventilated). Maximum unmarketability was recorded in P_5 (100 gauge PP, unventilated).

Minimum unmarketability, among precooling treatments under refrigerated storage was recorded in C_3 (contact icing) which was significantly superior to all other treatments. Maximum unmarketability was recorded in C_4 (control).

With regard to packaging treatments under refrigerated storage, treatment P_4 (200 gauge PE, ventilated) recorded the minimum unmarketability whereas treatment P_5 (100 gauge PP, unventilated) recorded the maximum unmarketability.

The interaction had no significant effect both under ambient and refrigerated storage environments.

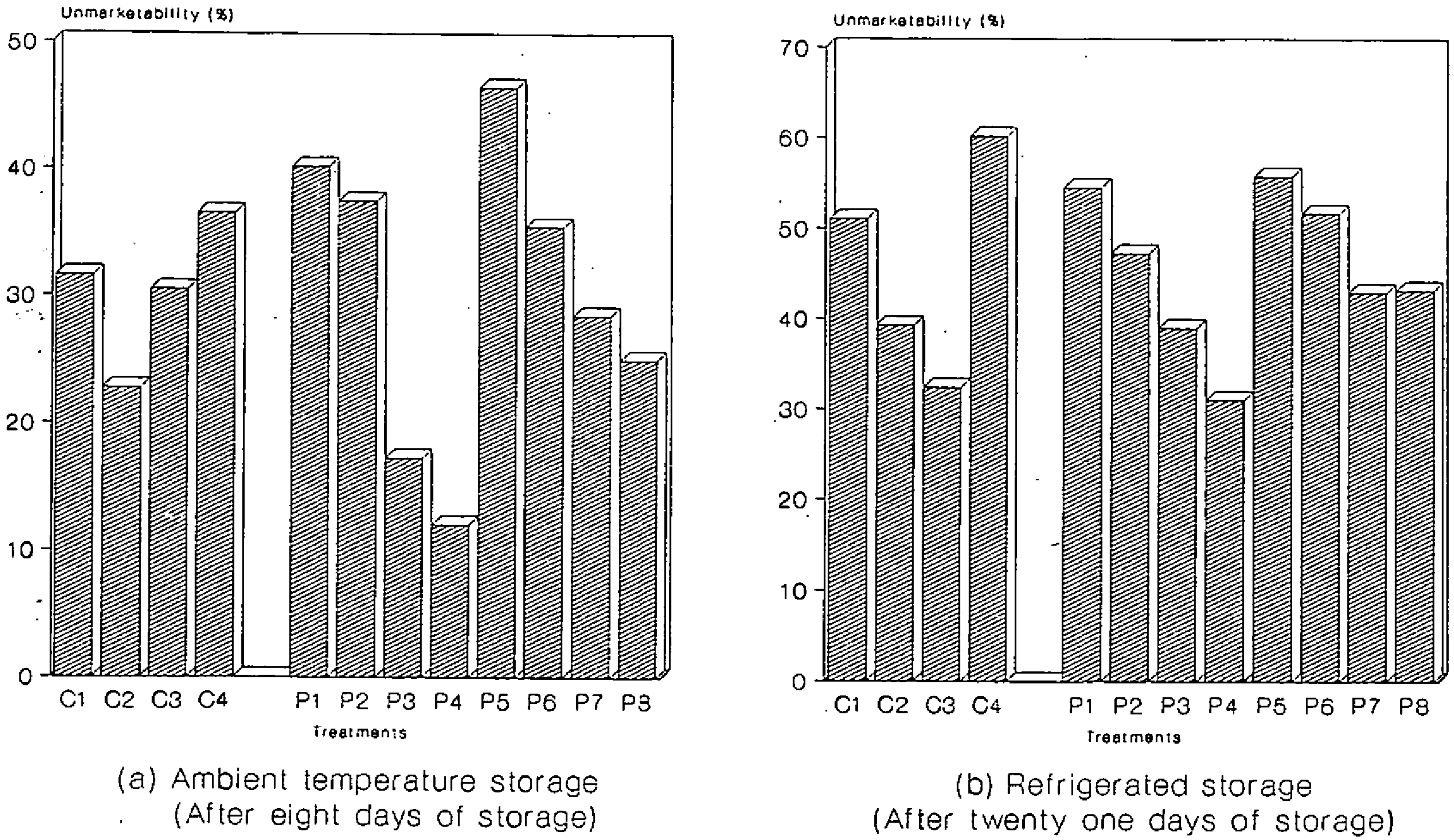


Fig. 2 Effect of precooling and packaging on unmarketabilityin Brinjal.

Plate 6. Brinjal packaged in polymeric films

Plate 7. Type of spoilage in brinjal

4.2.2.3 Length of storage life

Data on storage life as influenced by precooling and packaging treatments are presented in Table 13. The effects of packaging on shelf life is presented in Plate 8. Significant differences were observed among precooling and packaging treatments both under ambient and refrigerated storage environments.

Maximum shelf life, among precooling treatments, under ambient temperature storage was recorded in C_2 (cold water). minimum shelf life was recorded in C_4 (control).

Among packaging treatments, under ambient temperature storage, maximum shelf life was recorded in P_4 (200 gauge PE, ventilated) which was on par with P_3 (100 gauge PE, ventilated) and P_8 (200 gauge PP, ventilated). Minimum shelf life was recorded in P_5 (100 gauge PP, unventilated) which was on par with P_1 (100 gauge PE, unventilated), P_2 (200 gauge PE, unventilated) and P_6 (200 gauge PP, unventilated).

With respect to refrigerated storage, among precooling treatments, maximum shelf life was recorded in C_3 (contact icing). Minimum shelf life was recorded in C_4 (control) and C_1 (tap water). Treatments C_4 and C_1 were on par.

Table 13. Storage life (days) of brinjal as influenced by precooling and packaging treatments

Precooling x Packaging	Ambient temperature storage					Refrigerated storage				
	C_1	C_2	C_3	C_4	Mean	C_1	C_2	C_3	C_4	Mean
P_1	5.00	5.60	4.40	4.40	4.90[c]	14.60	15.80	17.00	13.60	15.25[d]
P_2	6.00	5.60	4.20	4.20	5.00[c]	16.20	17.80	16.60	14.80	16.35[b]
P_3	6.05	5.85	6.45	5.25	5.90[a]	15.60	16.60	18.40	15.20	16.45[b]
P_4	6.65	5.65	6.85	4.65	5.95[a]	17.20	18.00	18.20	17.60	17.75[a]
P_5	4.20	7.00	4.05	4.00	4.80[c]	15.00	14.80	16.60	15.20	15.40[d]
P_6	4.20	6.20	4.40	5.40	5.05[c]	14.80	16.60	17.20	14.80	15.85[c]
P_7	5.40	5.80	5.40	5.40	5.50[b]	15.60	16.80	18.00	16.00	16.60[b]
P_8	5.75	5.85	6.25	5.90	5.90[a]	15.60	17.20	17.80	16.00	16.65[b]
Mean	5.40[b]	5.95[a]	5.28[b]	4.90[c]		15.58[c]	16.70[b]	17.48[a]	15.40[c]	

CD for	Ambient temperature storage	Refrigerated storage
Precooling (C)	0.25*	0.28*
Packaging (P)	0.36*	0.42*
C x P	N.S	N.S

* Significant at 5 per cent level

	Ambient temperature storage	Refrigerated storage
Mean storage life of control samples	3.5 days	4.8 days
Mean temperature during experiment period		
Maximum temperature	31.8°C	12.2°C
Minimum temperature	28.6°C	9.4°C
Mean relative humidity during experiment period	82.5%	62.2%

C_1 - C_4 - Precooling treatments

P_1 - P_8 - Packaging treatments

Plate 8. Effect of packaging on storage life of brinjal

Among packaging treatments, under refrigerated storage, maximum shelf life was recorded in P_4 (200 gauge PE, ventilated) which was significantly superior to all other treatments. Minimum shelf life was recorded in P_1 (100 gauge PE, unventilated) which was on par with P_5 (100 gauge PP, unventilated).

The interaction had no significant effect both under ambient and refrigerated storage environment.

4.2.2.4 Consumer acceptability

Results of the consumer acceptability rating of the precooled produce in different packages are presented in Table 14. In all the treatments significant difference in acceptability was observed both under ambient and refrigerated storage environments.

Among precooling treatments, under ambient temperature storage, best acceptability was obtained for C_2 (cold water). Among packaging treatments, best acceptability was obtained for P_8 (200 gauge PP, ventilated), P_3 (100 gauge PE, ventilated), P_7 (100 gauge PP, ventilated) and P_4 (200 gauge PE, ventilated). Treatments P_8, P_3, P_7 and P_4 were equally acceptable.

Table 14. Consumer acceptability of brinjal as influenced by precooling and packaging treatments

14a. Main effects

Treatments	Days after storage: Ambient temperature storage D_2	D_4	D_6	D_8	Mean	Refrigerated storage D_3	D_6	D_9	D_{12}	D_{15}	D_{18}	D_{21}	Mean
Precooling													
C_1	2.05	2.65	3.58	4.55	3.22^b	1.00	1.95	2.33	2.90	3.10	4.23	4.95	2.93^c
C_2	2.03	2.58	3.25	4.43	3.07^a	1.00	1.90	2.33	2.93	3.05	3.70	4.70	2.80^b
C_3	2.20	2.65	3.83	4.68	3.34^c	1.03	1.93	2.28	2.78	3.10	3.45	4.50	2.71^a
C_4	2.33	2.93	3.98	4.78	3.50^d	1.00	2.03	2.70	2.93	3.35	4.35	4.93	3.04^d
Packaging													
P_1	2.20	2.90	4.00	4.80	3.48^b	1.00	2.00	2.45	2.95	3.45	4.35	4.95	3.02^d
P_2	2.30	2.85	3.95	4.70	3.45^b	1.00	2.00	2.40	2.75	3.10	4.05	4.80	2.87^b
P_3	2.05	2.55	3.35	4.40	3.09^a	1.00	1.95	2.50	2.95	3.05	3.95	4.85	2.89^c
P_4	2.05	2.45	3.51	4.55	3.14^a	1.00	1.85	2.25	2.70	3.10	3.25	4.25	2.62^a
P_5	2.40	3.00	4.20	4.70	3.58^b	1.10	2.15	2.55	3.00	3.30	4.30	4.95	3.04^d
P_6	2.15	2.65	4.30	4.80	3.48^b	1.00	2.00	2.35	2.95	3.10	4.00	4.80	2.89^c
P_7	2.05	2.60	3.25	4.50	3.10^a	1.00	1.65	2.30	2.85	3.05	3.80	4.85	2.78^b
P_8	2.00	2.60	3.15	4.50	3.04^a	1.00	2.00	2.45	2.90	3.10	3.85	4.70	2.84^b

Contd.

Table 14b. Interaction effects

Treatments	Days after storage										
	Ambient temperature storage				Refrigerated storage						
	D_2	D_4	D_6	D_8	D_3	D_6	D_9	D_{12}	D_{15}	D_{18}	D_{21}
Precooling x Packaging											
C_1P_1	2.00	2.80	3.80	4.80	1.00	2.00	2.60	3.00	3.40	4.60	5.00
C_2P_1	2.00	2.60	3.40	4.40	1.00	2.00	2.40	3.00	3.00	4.20	5.00
C_3P_1	2.20	3.20	4.40	5.00	1.00	2.00	2.00	2.80	3.00	3.60	4.80
C_4P_1	2.60	3.00	4.40	5.00	1.00	2.00	2.80	3.00	4.40	5.00	5.00
C_1P_2	1.80	2.60	3.20	4.40	1.00	2.00	2.00	2.40	3.00	4.20	5.00
C_2P_2	2.00	2.80	3.40	4.40	1.00	2.00	2.20	2.60	3.00	3.20	4.20
C_3P_2	2.60	3.00	4.60	5.00	1.00	2.00	2.60	3.00	3.00	4.00	5.00
C_4P_2	2.80	3.00	4.60	5.00	1.00	2.00	2.80	3.00	3.40	4.80	5.00
C_1P_3	2.00	2.40	3.00	4.40	1.00	1.80	2.20	3.00	3.00	4.40	5.00
C_2P_3	2.00	2.60	3.20	4.20	1.00	2.00	2.60	3.00	3.00	4.00	5.00
C_3P_3	2.00	2.40	3.40	4.40	1.00	2.00	2.40	2.80	3.00	3.00	4.00
C_4P_3	2.20	2.80	3.80	4.60	1.00	2.00	2.80	3.00	3.20	4.40	5.00
C_1P_4	2.00	2.40	3.00	4.60	1.00	2.00	2.40	2.80	3.00	3.60	4.60
C_2P_4	2.00	2.40	3.20	4.60	1.00	1.60	2.20	3.00	3.00	3.00	4.40
C_3P_4	2.00	2.00	3.20	3.80	1.00	1.80	2.00	2.60	3.00	3.20	3.60
C_4P_4	2.20	3.00	4.40	5.00	1.00	2.00	2.40	2.40	3.00	3.20	4.40
C_1P_5	2.60	3.00	4.60	4.80	1.00	2.00	2.40	3.00	3.40	4.40	5.00
C_2P_5	2.20	2.80	3.20	4.20	1.00	2.00	2.40	3.00	3.40	4.20	4.80
C_3P_5	2.20	3.00	4.40	4.80	1.20	2.00	2.40	3.00	3.00	4.00	5.00
C_4P_5	2.60	3.20	4.60	5.00	1.00	2.60	[illegible].00	3.00	3.40	4.60	5.00
C_1P_6	2.00	2.60	4.40	5.00	1.00	2.00	2.20	3.00	3.00	4.60	5.00
C_2P_6	2.00	2.40	3.20	4.60	1.00	2.00	2.40	3.00	3.00	3.80	4.80
C_3P_6	2.60	3.00	4.60	5.00	1.00	2.00	2.20	2.80	3.00	3.60	4.40
C_4P_6	2.00	2.60	3.40	2.60	1.00	2.00	2.60	3.00	3.40	4.00	5.00
C_1P_7	2.00	2.80	3.40	4.00	1.00	1.80	2.40	3.00	3.00	4.00	5.00
C_2P_7	2.00	2.40	3.20	4.40	1.00	1.60	2.00	2.80	3.00	3.60	4.80
C_3P_7	2.00	2.20	3.00	4.60	1.00	1.60	2.20	2.60	3.00	3.00	4.60

Contd.

Table 14b. (Contd.)

Treatments	Days after storage										
	Ambient temperature storage				Refrigerated storage						
	D_2	D_4	D_6	D_8	D_3	D_6	D_9	D_{12}	D_{15}	D_{18}	D_{21}
C_4P_7	2.20	3.00	3.40	5.00	1.00	1.60	2.60	3.00	3.00	4.60	5.00
C_1P_8	2.00	2.60	3.20	4.40	1.00	2.00	2.40	3.00	3.00	4.40	5.00
C_2P_8	2.00	2.60	3.20	4.60	1.00	2.00	2.40	3.00	3.00	3.60	4.60
C_3P_8	2.00	2.40	3.00	4.60	1.00	2.00	2.40	2.60	3.00	3.20	4.00
C_4P_8	2.00	2.80	3.20	4.20	1.00	2.00	2.60	3.00	3.00	4.20	5.00
CD for											
Precooling (C)	0.10*				0.08*						
Packaging (P)	0.14*				0.10*						
C x P	N.S				N.S						

Significant at 5 per cent level

Five point scale for consumer acceptability

1. Acceptable fully
2. Acceptable somewhat,
3. Neither acceptable non unacceptable
4. Unacceptable somewhat
5. Not acceptable

C_1 - Precooling with tap water

C_2 - Precooling with cold water

C_3 - Precooling by contact icing

C_4 - Control

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

P_5 - Polypropylene bags of 100 gauge without ventilation

P_6 - Polypropylene bags of 200 gauge without ventilation

P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

D_2, D_3, ... D_n - 'n' Days after storage

With respect to refrigerated storage, among precooling treatments, contact icing (C_3) was rated as the best. For packaging treatments, best acceptability was obtained for P_4 (200 gauge PE, ventilated).

No significant difference in consumer acceptability was observed for the interaction effect of precooling and packaging both under ambient and refrigerated storage environments.

4.2.3 Chilli (Capsicum annum L.)

A view of chilli packaged in polymeric films are presented in Plate 9.

4.2.3.1 Physiological loss in weight

The data on the effect of precooling and packaging treatments on PLW are presented in Table 15. Significant influence for precooling and packaging treatments on PLW were observed both under ambient and refrigerated storage environments.

Minimum PLW, among precooling treatments, under ambient temperature storage was recorded in C_3 (contact icing). Maximum PLW was recorded in C_1 (tap water) which was on par with C_2 (cold water). Treatments C_1 and C_2 was followed by C_4 (control).

Table 15. Influence of precooling and packaging treatments on PLW (%) in chilli

15a. Main effects

Treatments	Days after storage													
	Ambient temperature storage					Refrigerated storage								
	D_2	D_4	D_6	D_8	Mean	D_3	D_6	D_9	D_{12}	D_{15}	D_{18}	D_{21}	D_{24}	Mean
Precooling														
C_1	0.96	1.89	2.53	3.67	2.19[c]	1.03	1.97	3.18	4.67	5.68	6.54	7.60	8.29	4.87[d]
C_2	1.03	1.47	2.33	3.61	2.11[c]	0.92	1.77	2.64	3.48	4.14	5.07	6.17	7.13	3.91[c]
C_3	0.74	1.06	1.55	2.41	1.44[a]	0.79	1.46	1.90	2.37	2.82	3.58	3.76	4.18	2.60[a]
C_4	0.87	1.28	1.77	2.84	1.69[b]	0.80	1.36	2.04	2.86	3.39	3.78	4.02	4.53	2.85[b]
Packaging														
P_1	0.52	0.82	1.05	1.89	1.07[a]	0.63	0.99	1.52	1.81	2.15	2.62	3.03	3.38	2.02[a]
P_2	0.57	1.02	1.18	1.78	1.14[a]	0.68	1.18	1.70	2.45	3.09	3.38	3.85	3.89	2.53[b]
P_3	1.65	2.19	2.91	4.21	2.74[d]	1.07	1.97	2.81	3.89	4.66	5.32	6.07	6.95	4.09[c]
P_4	0.95	1.39	2.56	3.97	2.22[b]	0.98	1.89	3.47	4.75	5.77	7.66	8.77	9.84	5.39[e]
P_5	0.44	0.69	1.36	2.15	1.16[a]	0.56	1.05	1.59	2.36	2.62	2.80	3.14	3.71	2.23[a]
P_6	0.37	0.91	1.02	2.14	1.11[a]	0.51	1.09	1.61	2.22	2.62	2.93	3.64	3.85	2.31[a]
P_7	1.02	1.97	2.88	4.08	2.49[c]	1.48	2.74	3.49	4.69	5.60	6.62	7.45	8.89	5.12[d]
P_8	1.66	2.01	3.38	4.83	2.97[e]	0.88	2.01	3.3[illegible]	4.62	5.55	6.56	7.14	7.76	4.73[d]

Contd.

Table 15b. Interaction effects

Treatments	Days after storage											
	Ambient temperature storage				Refrigerated storage							
	D_2	D_4	D_6	D_8	D_3	D_6	D_9	D_{12}	D_{15}	D_{18}	D_{21}	D_{24}
Precooling x Packaging												
C_1P_1	0.51	0.82	1.47	1.51	0.61	0.93	2.57	3.59	4.62	5.60	5.39	6.15
C_2P_1	0.50	0.92	1.27	2.54	1.25	1.87	1.88	1.88	2.09	2.81	4.37	4.37
C_3P_1	0.39	0.50	0.53	1.30	0.28	0.33	0.35	0.45	0.56	0.63	0.85	1.38
C_4P_1	0.68	0.91	1.05	1.82	0.50	0.84	1.28	1.31	1.36	1.45	1.52	1.60
C_1P_2	0.43	1.42	2.84	3.46	0.76	1.52	2.86	4.34	5.11	5.31	5.43	5.57
C_2P_2	0.60	0.62	1.01	1.58	0.95	1.87	1.87	3.10	3.16	3.82	5.58	5.58
C_3P_2	0.51	0.61	0.62	0.76	0.38	0.51	0.63	0.92	1.81	1.93	1.93	1.93
C_4P_2	0.62	0.72	0.90	1.46	0.62	0.81	1.42	1.44	2.27	2.47	2.49	2.51
C_1P_3	1.91	2.87	3.51	4.48	1.30	2.92	3.88	5.17	6.65	7.39	8.81	9.93
C_2P_3	2.45	2.46	3.68	4.91	1.22	2.52	3.19	4.28	4.91	5.53	6.77	8.87
C_3P_3	0.76	1.51	2.20	3.77	0.82	0.90	1.94	3.21	3.87	4.50	4.50	4.51
C_4P_3	1.47	1.92	2.24	3.65	0.94	1.52	2.24	2.89	3.21	3.85	4.18	4.49
C_1P_4	0.60	1.21	2.47	4.99	1.22	2.56	4.48	6.41	7.18	9.28	11.50	12.17
C_2P_4	1.07	1.84	3.07	4.29	1.22	2.47	4.32	4.94	6.67	9.24	10.26	11.85
C_3P_4	0.81	0.97	1.91	3.17	0.65	1.27	2.54	3.81	4.45	5.74	6.72	7.37
C_4P_4	1.33	1.55	2.80	3.43	0.83	1.27	2.55	3.82	4.78	6.37	6.58	7.96
C_1P_5	0.39	0.83	1.28	2.24	0.56	1.26	1.95	3.89	4.10	4.49	4.97	5.46
C_2P_5	0.61	0.83	1.91	3.18	0.39	0.72	1.44	1.44	1.83	2.18	2.56	3.32
C_3P_5	0.65	0.68	0.98	1.34	0.64	0.74	1.51	2.60	2.61	2.62	3.11	4.10
C_4P_5	0.13	0.44	1.26	1.85	0.72	1.47	1.48	1.48	1.94	1.95	1.95	1.95
C_1P_6	0.31	1.90	1.91	1.92	0.73	1.51	2.16	2.44	3.28	3.47	5.48	5.86
C_2P_6	0.35	0.55	0.63	2.52	0.52	0.79	1.90	2.54	3.30	3.59	4.25	4.64
C_3P_6	0.31	0.48	0.97	1.94	0.36	0.65	0.96	1.99	2.00	2.12	2.32	2.34
C_4P_6	0.49	0.70	0.88	2.19	0.43	1.43	1.44	1.89	1.90	2.53	2.55	2.55
C_1P_7	1.60	2.24	3.21	4.49	1.91	2.55	3.82	5.73	7.64	8.79	10.32	11.85
C_2P_7	0.94	2.21	3.46	4.42	0.82	2.01	2.75	4.04	5.12	6.14	7.52	9.57
C_3P_7	0.98	1.96	2.62	3.60	1.29	2.60	3.60	4.55	5.20	5.86	6.25	7.95

Contd.

Table 15b. (Contd.)

Treatments	Days after storage											
	Ambient temperature storage				Refrigerated storage							
	D_2	D_4	D_6	D_8	D_3	D_6	D_9	D_{12}	D_{15}	D_{18}	D_{21}	D_{24}
C_4P_7	0.57	1.45	2.23	3.82	1.90	3.80	3.83	4.44	4.45	5.69	5.70	6.21
C_1P_8	1.92	2.22	3.48	5.36	1.26	2.53	3.74	5.73	6.88	7.96	8.90	9.33
C_2P_8	1.65	2.00	3.94	5.93	1.01	1.83	3.74	5.63	6.07	7.32	8.07	8.83
C_3P_8	1.48	1.62	2.58	3.55	0.63	2.58	3.97	4.51	5.80	5.81	5.82	6.45
C_4P_8	1.60	2.21	3.51	4.46	0.62	1.06	1.94	2.59	3.47	5.17	5.81	6.45

CD for	Ambient temperature storage	Refrigerated storage
Preccoling (C)	0.16*	0.23*
Packaging (P)	0.20*	0.39*
C x P	NS	NS

* Significant at 5 per cent level

Mean temperature during experiment period	Ambient temperature storage	Refrigerated storage
Maximum temperature	32.4°C	11.6°C
Minimum temperature	28.1°C	8.9°C
Mean relative humidity during experiment period	80.2%	61.4%

C_1 - Precooling with tap water

C_2 - Precooling with cold water

C_3 - Precooling by contact icing

C_4 - Control

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

P_5 - Polypropylene bags of 100 gauge without ventilation

P_6 - Polypropylene bags of 200 gauge without ventilation

P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

D_2, D_3, ... D_n - 'n' Days after storage

Plate 9. Chilli packaged in polymeric films

Plate 10. Type of spoilage in chilli

With respect to packaging treatments, under ambient temperature storage, minimum PLW was recorded in P_1 (100 gauge PE, unventilated) which was on par with P_6 (200 gauge PP, unventilated), P_2 (200 gauge PE, unventilated) and P_5 (100 gauge PP, unventilated). Maximum PLW was recorded in P_8 (200 gauge PP, ventilated).

In the case of refrigerated storage, minimum and maximum PLW, among precooling treatments, was recorded in C_3 (contact icing) and C_1 (tap water) respectively.

Among packaging treatments, under refrigerated storage, minimum PLW was recorded in P_1 (100 gauge PE, unventilated) which was on par with P_5 (100 gauge PP, unventilated) and P_6 (200 gauge PP, unventilated). Maximum PLW was recorded in P_4 (200 gauge PE, ventilated).

The interaction had no significant effect both under ambient and refrigerated storage environments.

4.2.3.2 Unmarketability

Data on unmarketability as influenced by different precooling and packaging treatments are presented in Table 16. Type of spoilage leading to unmarketability of packaged chilli is presented in Plate 10.

Table 16. Influence of precooling and packaging treatments on unmarketability (%) in chilli

16a. Main effects

Treatments	Days after storage: Ambient temperature storage D_6	D_8	Mean	Refrigerated storage D_{18}	D_{21}	Mean
Precooling						
C_1	18.38 (24.12)	49.88 (45.02)	34.13^d (34.57)	90.13 (74.18)	96.25 (81.86)	93.19^d (78.03)
C_2	12.00 (17.49)	42.38 (40.46)	27.19^c (28.98)	82.50 (66.81)	92.00 (76.47)	87.25^c (71.64)
C_3	2.25 (4.41)	16.50 (21.38)	9.38^a (12.90)	21.38 (25.26)	41.00 (39.53)	31.18^a (32.40)
C_4	3.13 (5.53)	22.50 (27.24)	12.81^b (16.38)	23.13 (27.48)	44.50 (43.62)	33.82^b (35.55)
Packaging						
P_1	12.75 (17.48)	40.25 (39.15)	26.50^b (28.31)	52.75 (48.36)	62.00 (57.95)	57.38^c (53.16)
P_2	15.25 (18.49)	40.00 (37.84)	27.63^c (28.16)	59.50 (53.72)	73.25 (63.81)	66.38^e (58.78)
P_3	7.25 (11.20)	30.25 (32.10)	18.75^a (21.64)	45.75 (39.71)	60.75 (55.25)	53.25^b (47.48)
P_4	7.75 (11.37)	28.51 (29.51)	18.13^a (20.44)	55.75 (49.83)	70.00 (61.23)	62.88^d (55.53)
P_5	8.25 (12.50)	35.50 (36.16)	21.88^b (24.26)	51.00 (44.40)	68.00 (58.13)	59.50^c (51.27)
P_6	7.75 (11.60)	36.25 (36.67)	22.00^b (24.14)	55.25 (49.73)	68.25 (59.77)	61.75^d (54.76)
P_7	5.50 (9.14)	27.50 (29.67)	16.50^a (19.40)	53.50 (46.49)	68.75 (59.50)	61.13^d (52.99)
P_8	8.50 (13.05)	25.25 (26.57)	16.88^a (19.82)	40.75 (35.22)	56.50 (31.32)	48.63^a (43.27)

Table 16b. Interaction effects

Treatments	Days after storage			
	Ambient temperature storage		Refrigerated storage	
	D_6	D_8	D_{18}	D_{21}
Precooling x Packaging				
C_1P_1	21.00 (27.13)	50.00 (45.02)	97.00 (83.77)	98.80 (86.55)
C_2P_1	20.00 (26.33)	51.00 (45.62)	95.00 (78.60)	98.00 (84.88)
C_3P_1	4.00 (7.25)	25.00 (29.86)	13.00 (20.18)	31.00 (33.49)
C_4P_1	6.00 (9.23)	35.00 (36.09)	6.00 (10.89)	21.00 (27.08)
C_1P_2	33.00 (34.87)	72.00 (58.56)	96.00 (81.19)	95.00 (80.32)
C_2P_2	22.00 (27.77)	56.00 (48.55)	92.00 (73.81)	98.00 (84.88)
C_3P_2	4.00 (7.49)	15.00 (20.29)	22.00 (27.95)	44.00 (41.57)
C_4P_2	2.00 (3.833)	17.00 (23.94)	28.00 (31.94)	56.00 (48.50)
C_1P_3	14.00 (19.72)	45.00 (42.02)	81.00 (64.41)	95.00 (78.60)
C_2P_3	11.00 (17.40)	43.00 (40.87)	90.00 (72.41)	96.00 (81.19)
C_3P_3	2.00 (3.83)	14.00 (19.72)	8.00 (14.55)	26.00 (30.61)
C_4P_3	2.00 (3.83)	19.00 (25.69)	4.00 (7.46)	26.00 (30.58)
C_1P_4	21.00 (26.90)	48.00 (43.78)	89.00 (72.79)	97.00 (83.77)
C_2P_4	7.00 (12.01)	28.00 (31.64)	87.00 (68.99)	94.00 (77.49)
C_3P_4	1.00 (2.73)	9.00 (13.75)	20.00 (26.33)	42.00 (40.36)
C_4P_4	2.00 (3.83)	13.00 (19.03)	27.00 (31.23)	47.00 (43.29)
C_1P_5	13.00 (18.85)	44.00 (41.52)	90.00 (73.89)	96.00 (81.19)
C_2P_5	10.00 (16.53)	42.00 (40.36)	62.00 (52.06)	80.00 (63.83)
C_3P_5	2.00 (3.83)	24.00 (29.21)	47.00 (43.28)	69.00 (56.29)
C_4P_5	2.00 (3.83)	28.00 (31.94)	5.00 (8.38)	29.00 (31.23)
C_1P_6	18.00 (24.99)	50.00 (45.02)	91.00 (74.42)	97.00 (82.29)
C_2P_6	5.00 (8.36)	33.00 (34.93)	90.00 (71.83)	94.00 (77.49)
C_3P_6	3.00 (4.71)	77.00 (30.70)	15.00 (22.68)	32.00 (34.34)
C_4P_6	5.00 (8.36)	35.00 (36.02)	25.00 (29.97)	50.00 (45.02)
C_1P_7	12.00 (17.97)	45.00 (42.09)	91.00 (74.77)	95.00 (80.08)
C_2P_7	7.00 (12.01)	38.00 (37.94)	75.00 (60.45)	91.00 (74.65)
C_3P_7	1.00 (2.73)	12.00 (18.28)	43.00 (40.76)	64.00 (53.28)
C_4P_7	2.00 (3.83)	15.00 (20.36)	5.00 (10.01)	25.00 (29.97)

Contd.

Table 16b. (Contd.)

Treatments	Days after storage			
	Ambient temperature storage		Refrigerated storage	
	D_6	D_8	D_{18}	D_{21}
C_1P_8	15.00 (22.50)	45.00 (42.14)	86.00 (68.23)	97.00 (82.29)
C_2P_8	14.00 (19.49)	48.00 (43.77)	69.00 (56.29)	85.00 (67.36)
C_3P_8	1.00 (2.73)	6.00 (9.23)	3.00 (6.35)	20.00 (26.33)
C_4P_8	4.00 (7.49)	18.00 (24.81)	5.00 (10.01)	24.00 (29.28)
CD for				
Precooling (C)	3.29*		2.62*	
Packaging (P)	4.66*		3.71*	
C x P	N.S		N.S	

* Significant at 5 per cent level

Mean temperature during experiment period

	Ambient	Refrigerated
Maximum temperature	32.4°C	11.6°C
Minimum temperature	28.1°C	8.9°C
Mean relative humidity during experiment period	80.2%	61.4%

C_1 - Precooling with tap water

C_2 - Precooling with cold water

C_3 - Precooling by contact icing

C_4 - Control

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

P_5 - Polypropylene bags of 100 gauge without ventilation

P_6 - Polypropylene bags of 200 gauge without ventilation

P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

D_6, D_8, ... D_n - 'n' Days after storage

* Figures in bracket indicates transformed values.

Significant differences were observed among various precooling and packaging treatments both under ambient and refrigerated storage environments.

In the case of ambient temperature storage, among precooling treatments minimum unmarketability was recorded in C_3 (contact icing). Maximum unmarketability was recorded in C_1 (tap water).

Among packaging treatments, under ambient temperature storage, minimum unmarketability was recorded in P_7 (100 gauge PP, ventilated) which was followed by P_8 (200 gauge PP, ventilated), P_4 (200 gauge PE, ventilated) and P_3 (100 gauge PE, ventilated). Treatments P_7, P_8, P_4 and P_3 were on par with each other. Maximum unmarketability was recorded in P_2 (200 gauge PE, unventilated).

With regard to refrigerated storage, minimum unmarketability, among precooling treatments was recorded in C_3 (contact icing) which was significantly superior to all other treatments. Maximum unmarketability was recorded in C_1 (tap water).

In the case of packaging treatments, under refrigerated storage, minimum unmarketability was recorded in P_8 (200 gauge PP, ventilated). Maximum unmarketability was recorded in P_2 (200 gauge, PE, unventilated).

The interaction of precooling and packaging had no significant effect under both the storage environments.

4.2.3.3 Length of storage life

Data on storage life as influenced by precooling and packaging treatments are presented in Table 17. Precooling and packaging treatments had significant effect both under ambient and refrigerated environments.

Among precooling treatments maximum shelf life under ambient temperature storage, was recorded in C_3 (contact icing). Minimum shelf life was recorded in C_1 (tap water).

Maximum shelf life among packaging treatments, under ambient temperature storage, was recorded in P_4 (200 gauge PE, ventilated) followed by P_7 (100 gauge PP, ventilated), P_8 (200 gauge PP, ventilated) and P_3 (100 gauge PE, ventilated). Treatments P_4, P_7, P_8 and P_3 were on par. Minimum shelf life was recorded in P_1 (100 gauge PE, unventilated) which was on par with P_2 (200 gauge PE, unventilated), P_5 (100 gauge PP, unventilated) and P_6 (200 gauge PP, unventilated).

With respect to refrigerated storage, maximum shelf life among precooling treatments was recorded in C_3 (contact icing). Minimum shelf life was recorded in C_1 (tap water).

Table 17. Storage life (days) of chilli as influenced by precooling and packaging treatments

Precooling x Packaging	Ambient temperature storage					Refrigerated storage				
	C_1	C_2	C_3	C_4	Mean	C_1	C_2	C_3	C_4	Mean
P_1	4.40	4.60	6.00	5.50	5.13[b]	6.80	10.60	21.20	20.20	14.65[b]
P_2	3.60	4.60	6.60	6.10	5.23[b]	7.80	6.80	17.80	18.40	14.70[b]
P_3	5.00	5.40	6.60	6.10	5.78[a]	7.60	10.20	21.20	20.20	14.80[b]
P_4	4.40	6.00	7.20	6.90	6.13[a]	8.40	7.80	18.40	19.20	13.45[c]
P_5	4.80	5.20	6.00	5.70	5.43[b]	8.[illegible]0	14.20	20.80	15.20	14.65[b]
P_6	4.60	5.60	6.00	5.50	5.43[b]	6.[illegible]0	8.20	18.60	19.80	13.38[c]
P_7	5.00	5.40	6.80	6.70	5.98[a]	8.60	11.60	22.20	17.00	14.85[b]
P_8	4.80	5.00	7.20	6.90	5.98[a]	10.[illegible]0	8.40	22.35	22.10	15.81[a]
Mean	4.58[d]	5.24[c]	6.56[a]	6.18[b]		8.11[d]	9.73[c]	20.30[a]	19.01[b]	

CD for	Ambient temperature storage	Refrigerated storage
Precooling (C)	0.35*	0.30*
Packaging (P)	0.46*	0.47*
C x P	N.S	N.S

* Significant at 5 per cent level

	Ambient temperature storage	Refrigerated storage
Mean storage life of control samples	3.4 days	4.8 days
Mean temperature during experiment period		
Maximum temperature	32.4°C	11.6°C
Minimum temperature	28.1°C	8.9°C
Mean relative humidity during experiment period	80.2%	61.4%

C_1 - C_4 - Precooling treatments

P_1 - P_8 - Packaging treatments

Among packaging treatments, under refrigerated storage, maximum shelf life was recorded in P_8 (200 gauge PP, ventilated). Minimum shelf life was recorded in P_6 (200 gauge PP, unventilated) which was on par with P_4 (200 gauge PE, ventilated).

The interaction of precooling and packaging had no significant influence under the two storage regimes.

4.2.3.4 Consumer acceptability

Results of the consumer acceptability rating of the precooled produce in different packages are presented in Table 18. Significant difference in acceptability was observed among precooling and packaging treatments both under ambient and refrigerated storage environments.

Among precooling treatments, under ambient temperature storage, best acceptability was obtained for C_3 (contact icing). Among packaging treatments, treatments P_7 (100 gauge PP, ventilated), P_8 (200 gauge PP, ventilated), P_3 (100 gauge PE, ventilated), P_4 (200 gauge PE, ventilated) were rated as best and equally acceptable.

With respect to refrigerated storage, best acceptability, among precooling treatments was obtained for C_3

Table 18. Consumer acceptability of chilli as influenced by precooling and packaging treatments

18a. Main effects

Treatments	Days after storage													
	Ambient temperature storage					Refrigerated storage								
	D_2	D_4	D_6	D_8	Mean	D_3	D_6	D_9	D_{12}	D_{15}	D_{18}	D_{21}	D_{24}	Mean
Precooling														
C_1	2.63	3.05	4.13	4.98	3.69[d]	1.88	2.83	3.88	4.80	5.00	5.00	5.00	5.00	4.17[d]
C_2	2.50	2.98	3.80	4.80	3.52[c]	1.80	2.60	3.48	4.30	4.75	4.95	5.00	5.00	3.98[c]
C_3	2.13	2.65	3.05	3.98	2.94[a]	1.08	1.40	2.10	2.30	2.90	3.28	3.73	4.41	2.65[a]
C_4	2.20	2.73	3.08	4.23	3.06[b]	1.05	1.53	2.05	2.38	2.93	3.00	4.15	4.70	2.72[b]
Packaging														
P_1	2.60	3.00	3.85	4.70	3.54[c]	1.45	2.10	2.85	3.35	3.85	4.00	4.20	4.75	3.32[b]
P_2	2.30	2.90	3.75	4.45	3.35[b]	1.65	2.25	3.15	3.55	4.00	4.00	4.85	5.00	3.56[d]
P_3	2.35	2.90	3.35	4.50	3.28[a]	1.45	2.00	2.75	3.25	3.80	4.00	4.35	4.85	3.31[b]
P_4	2.20	2.50	3.30	4.85	3.21[a]	1.25	1.85	2.85	3.55	4.00	4.00	4.85	5.00	3.42[c]
P_5	2.50	3.00	3.50	4.80	3.45[b]	1.65	2.30	2.85	3.35	3.70	4.25	4.55	4.80	3.43[c]
P_6	2.45	3.00	3.55	4.65	3.41[b]	1.50	2.40	3.25	3.85	4.00	4.00	4.50	5.00	3.56[d]
P_7	2.35	2.75	3.30	4.35	3.19[a]	1.40	1.95	2.65	3.30	3.90	4.20	4.45	4.80	3.33[b]
P_8	2.15	2.75	3.50	4.40	3.20[a]	1.25	1.85	2.65	3.35	3.90	4.00	4.00	4.75	3.22[a]

Contd.

Table 18b. Interaction effects

Treatments	Ambient temperature storage				Refrigerated storage							
	D_2	D_4	D_6	D_8	D_3	D_6	D_9	D_{12}	D_{15}	D_{18}	D_{21}	D_{24}
Precooling x Packaging												
C_1P_1	2.80	3.00	4.40	5.00	2.00	3.00	4.40	5.00	5.00	5.00	5.00	5.00
C_2P_1	2.60	3.00	4.40	5.00	1.80	2.60	3.00	4.40	5.00	5.00	5.00	5.00
C_3P_1	2.40	3.00	3.20	4.20	1.00	1.40	2.00	2.00	2.80	3.00	3.40	4.40
C_4P_1	2.60	3.00	3.40	4.60	1.00	1.40	2.00	2.00	2.60	3.00	3.40	4.60
C_1P_2	2.60	3.40	4.60	5.00	2.20	3.00	4.20	5.00	5.00	5.00	5.00	5.00
C_2P_2	2.60	3.00	4.40	5.00	2.40	3.00	4.40	5.00	5.00	5.00	5.00	5.00
C_3P_2	2.00	2.60	3.00	3.80	1.00	1.40	2.00	2.00	3.00	3.00	4.60	5.00
C_4P_2	2.00	2.60	3.00	4.00	1.00	1.60	2.00	2.20	3.00	3.00	4.80	5.00
C_1P_3	2.60	3.00	3.80	5.00	2.00	3.00	4.00	5.00	5.00	5.00	5.00	5.00
C_2P_3	2.60	3.00	3.60	5.00	1.80	2.60	3.00	3.80	4.80	5.00	5.00	5.00
C_3P_3	2.00	2.60	3.00	3.80	1.00	1.00	2.00	2.00	2.60	3.00	3.80	4.60
C_4P_3	2.00	3.00	3.00	4.20	1.00	1.40	2.00	2.20	2.80	3.00	3.60	4.80
C_1P_4	2.80	3.00	4.20	5.00	1.40	2.40	3.40	5.00	5.00	5.00	5.00	5.00
C_2P_4	2.00	2.80	3.20	4.20	1.60	2.60	4.00	5.00	5.00	5.00	5.00	5.00
C_3P_4	2.00	2.20	3.00	3.60	1.00	1.20	2.00	2.00	3.00	3.00	4.60	5.00
C_4P_4	2.00	2.00	3.00	3.60	1.00	1.20	2.00	2.20	3.00	3.00	4.80	5.00
C_1P_5	2.60	3.00	4.20	4.80	2.00	3.00	3.80	4.80	5.00	5.00	5.00	5.00
C_2P_5	2.60	3.00	3.80	4.80	1.60	2.20	3.00	3.00	3.60	4.60	5.00	5.00
C_3P_5	2.40	3.00	3.00	4.80	1.60	2.00	2 60	3.00	3.20	4.40	5.00	5.00
C_4P_5	2.40	3.00	3.00	4.80	1.40	2.00	2 00	2.60	3.00	3.00	3.20	4.20
C_1P_6	2.80	3.00	4.40	5.50	2.00	3.00	4.80	5.00	5.00	5.00	5.00	5.00
C_2P_6	2.60	3.00	3.40	5.00	2.00	3.00	3.80	5.00	5.00	5.00	5.00	5.00
C_3P_6	2.20	3.00	3.20	4.40	1.00	1.60	2.00	2.40	3.00	3.00	4.00	5.00
C_4P_6	2.20	3.00	3.20	4.20	1.00	2.00	2.40	3.00	3.00	3.00	4.00	5.00
C_1P_7	2.60	3.00	3.60	5.00	2.00	2.80	3.40	4.60	5.00	5.00	5.00	5.00
C_2P_7	2.60	3.00	3.60	4.60	1.60	2.20	3.00	3.20	4.60	5.00	5.00	5.00
C_3P_7	2.00	2.40	3.00	3.80	1.00	1.60	2.20	3.00	3.00	3.80	4.80	5.00

Contd.

Table 18b. (Contd.)

Treatments	Days after storage											
	Ambient temperature storage				Refrigerated storage							
	D_2	D_4	D_6	D_8	D_3	D_6	D_9	D_{12}	D_{15}	D_{18}	D_{21}	D_{24}
C_4P_7	2.20	2.60	3.00	4.00	1.00	1.20	2.00	2.40	3.00	3.00	3.00	4.20
C_1P_8	2.20	3.00	4.00	5.00	1.40	2.40	3.00	4.00	5.00	5.00	5.00	5.00
C_2P_8	2.40	3.00	4.00	4.80	1.60	2.60	3.60	5.00	5.00	5.00	5.00	5.00
C_3P_8	2.00	2.40	3.00	3.40	1.00	1.00	2.00	2.00	2.60	3.00	3.00	4.00
C_4P_8	2.00	2.60	3.00	4.40	1.00	1.40	2.00	2.40	3.00	3.00	3.00	4.80
CD for												
Precooling (C)			0.11*					0.06*				
Packaging (P)			0.14*					0.08*				
C x P			N.S					N.S				

* Significant at 5 per cent level

Five point scale for consumer acceptability

1. Acceptable fully
2. Acceptable somewhat,
3. Neither acceptable non unacceptable
4. Unacceptable somewhat
5. Not acceptable

C_1 - Precooling with tap water

C_2 - Precooling with cold water

C_3 - Precooling by contact icing

C_4 - Control

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

P_5 - Polypropylene bags of 100 gauge without ventilation

P_6 - Polypropylene bags of 200 gauge without ventilation

P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

D_2, D_3, ... D_n - 'n' Days after storage

(contact icing). Among packaging treatments, chillies packaged in ventliated 200 gauge PP (P_8) had the highest acceptability.

The interaction of precooling and packaging had no significant effect both under ambient and refrigerated storage environments.

4.2.4 Cowpea (Vigna unquiculata (L.) Walp.)

A view of cowpea packaged in polymeric films are presented in Plate 11.

4.2.4.1 Physiological loss in weight

Data on PLW as influenced by precooling and packaging treatments are presented in Table 19. Precooling and packaging treatments differed significantly both under ambient and refrigerated storage environments.

Among precooling treatments, under ambient temperature storage, minimum PLW was recorded in C_3 (contact icing). Maximum PLW was recorded in C_2 (cold water) which was on par with C_1 (tap water).

Among packaging treatments, under ambient temperature storage, minimum PLW was recorded in P_5 (100 gauge PP, unventilated) which was followed by P_1 (100 gauge PE, unventilated) and P_6 (200 gauge PP, unventilated). Treatments

Table 19. Influence of precooling and packaging treatments on PLW (%) in cowpea 19a. Main effects

Treatments	Days after storage								
	Ambient temperature storage				Refrigerated storage				
	D_1	D_2	D_3	Mean	D_3	D_6	D_9	D_{12}	Mean
Precooling									
C_1	1.47	2.20	3.22	2.30[c]	1.58	3.28	4.70	6.03	3.89[c]
C_2	1.34	2.26	3.41	2.43[c]	0.80	1.87	3.30	4.07	2.50[a]
C_3	0.64	0.87	1.79	1.11[a]	1.24	2.52	3.54	4.59	2.99[b]
C_4	0.91	1.83	2.68	1.81[b]	1.33	2.10	3.47	4.49	2.85[b]
Packaging									
P_1	0.76	0.78	1.14	0.89[a]	0.58	0.95	1.51	1.62	1.16[a]
P_2	0.78	1.27	1.62	1.22[b]	0.43	0.64	0.96	1.21	0.81[a]
P_3	0.17	2.78	4.51	2.82[d]	1.71	3.84	5.97	7.89	4.85[c]
P_4	2.08	3.33	4.46	3.29[e]	2.29	4.49	6.88	9.25	5.73[d]
P_5	0.62	0.74	1.29	0.88[a]	0.63	0.98	1.77	2.08	1.37[b]
P_6	0.63	0.81	1.57	1.01[a]	0.59	0.90	1.39	1.48	1.09[a]
P_7	1.29	2.15	3.58	2.34[c]	1.48	3.50	5.72	7.24	4.49[c]
P_8	1.55	3.02	4.15	2.91[d]	1.67	3.69	5.30	7.22	4.47[c]

Contd.

Table 19b. Interaction effects

Treatments	Days after storage						
	Ambient temperature storage			Refrigerated storage			
	D_1	D_2	D_3	D_3	D_6	D_9	D_{12}
Precooling x Packaging							
C_1P_1	1.09	1.13	1.18	0.79	1.60	1.61	1.62
C_2P_1	0.36	0.47	0.70	0.68	1.01	2.01	2.10
C_3P_1	0.10	0.39	0.48	0.52	0.56	0.86	0.98
C_4P_1	0.66	1.02	1.86	0.32	0.62	1.59	1.78
C_1P_2	1.36	1.91	1.92	0.54	0.73	1.03	1.20
C_2P_2	0.45	0.67	1.32	0.48	0.62	1.10	1.18
C_3P_2	0.36	0.53	1.09	0.53	0.49	0.50	0.55
C_4P_2	0.98	1.96	2.15	0.36	0.73	1.23	1.89
C_1P_3	2.05	3.29	4.68	2.02	5.32	7.29	10.05
C_2P_3	1.03	2.99	4.44	1.33	3.36	5.40	6.72
C_3P_3	0.89	1.82	3.60	1.97	3.64	5.96	7.93
C_4P_3	0.72	2.99	5.34	1.52	3.04	5.25	6.86
C_1P_4	2.45	4.15	5.39	3.62	7.24	9.39	11.46
C_2P_4	2.91	4.59	5.75	0.89	1.36	4.24	5.54
C_3P_4	1.55	2.32	3.35	2.71	6.44	9.19	12.81
C_4P_4	1.41	2.24	3.36	1.95	2.92	4.71	7.20
C_1P_5	0.62	0.77	1.84	0.76	1.43	2.77	3.03
C_2P_5	0.71	0.72	1.32	0.53	0.99	1.54	2.09
C_3P_5	0.10	0.18	0.37	0.53	0.80	0.95	0.99
C_4P_5	0.80	1.63	1.63	0.72	0.78	1.82	2.82
C_1P_6	0.65	0.94	1.88	0.78	0.84	1.93	2.02
C_2P_6	0.19	0.55	1.32	0.51	1.06	1.11	1.19
C_3P_6	0.54	0.74	1.16	0.48	0.54	0.88	0.89
C_4P_6	0.79	1.38	1.95	0.60	1.18	1.67	1.81
C_1P_7	2.17	2.78	4.09	2.09	4.84	7.76	10.25
C_2P_7	1.31	3.23	5.65	0.71	2.96	5.42	6.23
C_3P_7	0.63	0.86	1.76	1.33	2.94	4.60	6.03

Contd.

Table 19b. (Contd.)

Treatments	Days after storage						
	Ambient temperature storage			Refrigerated storage			
	D_1	D_2	D_3	D_3	D_6	D_9	D_{12}
C_4P_7	1.07	1.74	2.81	1.70	3.23	5.10	6.46
C_1P_8	2.44	4.41	4.89	2.03	4.25	5.83	8.64
C_2P_8	2.33	5.24	6.98	1.53	3.82	5.99	7.63
C_3P_8	0.59	0.74	2.36	2.05	4.72	5.37	7.29
C_4P_8	83	1.89	2.37	[illegible]	1.99	4.02	5.32
CD for							
Precccling (C)	0.22*				0.33*		
Packaging (P)	0.30*				0.50*		
C x P	N.S				N.S		

* Significant at 5 per cent level

Mean temperature during experiment period

	Ambient temperature storage	Refrigerated storage
Maximum temperature	32.8°C	11.2°C
Minimum temperature	27.8°C	9.1°C
Mean relative humidity during experiment period	79.6%	60.3%

C_1 - Precooling with tap water

C_2 - Precooling with cold water

C_3 - Precooling by contact icing

C_4 - Control

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

P_5 - Polypropylene bags of 100 gauge without ventilation

P_6 - Polypropylene bags of 200 gauge without ventilation

P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

D_1, D_2, ... D_n - 'n' Days after storage

Plate 11. Cowpea packaged in polymeric films

P_5, P_1 and P_6 were on par. Maximum PLW was recorded in P_4 (200 gauge PE, ventilated).

In the case of refrigerated storage, C_2 (cold water) recorded the minimum PLW among precooling treatments. Maximum PLW was recorded in C_1 (tap water).

Minimum PLW among packaging treatments, under refrigerated storage was recorded in P_2 (200 gauge PE, unventilated) which was on par with P_6 (200 gauge PP, unventilated) and P_1 (100 gauge PE, unventilated). Maximum PLW was recorded in P_4 (200 gauge PE, ventilated).

The interaction of precooling and packaging had no significant effect both under ambient and refrigerated storage environments.

4.2.4.2 Unmarketability

Data on unmarketability as influenced by precooling and packaging treatments are presented in Table 20. Type of spoilage leading to unmarketability of the packaged produce under ambient and refrigerated storage environments are presented in Plates 12 and 13.

In the case of ambient temperature storage significant difference in unmarketability was observed only in the case of packaging treatments. Minimum unmarketability, among

Table 20. Influence of precooling and packaging treatments on unmarketability (%) in cowpea

20a. Main effects

Treatments	Days after storage					
	Ambient temperature storage			Refrigerated storage		
	D_2	D_3	Mean	D_9	D_{12}	Mean
Precooling						
C_1	18.88 (21.89)	53.88 (46.99)	36.13 (34.44)	21.00 (24.39)	47.75 43.61)	34.38^{c} (33.99)
C_2	27.38 (31.16)	65.88 (54.42)	46.63 (42.79)	18.25 (22.90)	42.00 40.23)	30.13^{b} (31.57)
C_3	6.25 (8.78)	33.38 (35.11)	19.81 (21.94)	13.00 (16.42)	36.38 (36.43)	24.69^{a} (26.43)
C_4	25.13 (28.34)	61.38 (51.73)	43.25 (40.04)	18.75 (23.58)	44.75 (41.91)	31.75^{b} (32.74)
Packaging						
P_1	25.75 (28.39)	62.75 (52.61)	44.25^{c} (40.50)	15.00 (18.17)	38.25 (37.07)	26.63^{c} (27.62)
P_2	18.00 (23.02)	59.75 (50.89)	38.88^{b} (36.95)	2.25 (4.43)	27.50 (31.58)	14.88^{a} (18.01)
P_3	22.00 (25.22)	55.00 (47.89)	38.50^{b} (36.56)	27.25 (31.37)	54.25 (47.48)	40.75^{f} (39.42)
P_4	16.50 (20.28)	47.50 (43.40)	32.00^{a} (31.84)	24.00 (29.14)	49.50 (44.73)	36.75^{e} (36.43)
P_5	20.70 (23.23)	50.70 (45.65)	35.70^{b} (34.44)	19.00 (23.18)	44.50 (41.74)	31.75^{d} (32.46)
P_6	20.25 (23.40)	55.25 (48.12)	37.75^{b} (35.76)	8.00 (11.79)	32.50 (34.61)	20.25^{b} (23.20)
P_7	15.25 (17.91)	46.50 (42.89)	30.88^{a} (30.40)	23.50 (28.05)	47.75 (43.58)	35.63^{e} (35.81)
P_8	18.00 (19.86)	51.75 (46.05)	34.38^{a} (32.96)	23.00 (28.46)	47.60 (43.55)	35.25^{e} (36.00)

Table 20b. Interaction effects

Treatments	Days after storage			
	Ambient temperature storage		Refrigerated storage	
	D_2	D_3	D_9	D_{12}
Precooling x Packaging				
C_1P_1	23.00 (25.94)	61.00 (51.54)	3.00 (6.35)	25.00 (29.97)
C_2P_1	32.00 (34.45)	75.00 (60.19)	30.00 (33.17)	57.00 (49.07)
C_3P_1	17.00 (19.35)	48.00 (43.73)	3.00 (2.69)	17.00 (21.91)
C_4P_1	31.00 (33.84)	67.00 (54.98)	26.00 (30.47)	54.00 (47.34)
C_1P_2	21.00 (27.19)	71.00 (57.57)	2.00 (3.79)	29.00 (35.56)
C_2P_2	22.00 (27.88)	68.00 (55.77)	3.00 (6.35)	26.00 (30.66)
C_3P_2	3.00 (6.35)	27.00 (31.27)	2.00 (3.79)	26.00 (30.66)
C_4P_2	26.00 (30.66)	73.00 (58.93)	2.00 (3.79)	29.00 (32.56)
C_1P_3	24.00 (26.58)	59.00 (50.32)	31.00 (33.81)	57.00 (49.05)
C_2P_3	27.00 (31.30)	63.00 (52.57)	26.00 (30.61)	53.00 (46.75)
C_3P_3	8.00 (10.41)	36.00 (36.69)	26.00 (30.47)	55.00 (47.92)
C_4P_3	29.00 (32.58)	62.00 (51.99)	26.00 (30.58)	52.00 (46.18)
C_1P_4	14.00 (17.37)	39.00 (38.39)	29.00 (32.48)	57.00 (49.10)
C_2P_4	27.00 (31.30)	65.00 (53.91)	28.00 (25.07)	39.00 (38.61)
C_3P_4	2.00 (3.79)	24.00 (29.33)	29.00 (32.56)	59.00 (50.53)
C_4P_4	23.00 (28.64)	62.00 (51.98)	20.00 (26.44)	47.00 (43.29)
C_1P_5	17.00 (19.35)	44.00 (41.41)	30.00 (33.20)	58.00 (50.10)
C_2P_5	23.00 (25.97)	57.00 (49.09)	14.00 (19.78)	34.00 (35.58)
C_3P_5	8.00 (10.41)	36.00 (36.69)	7.00 (9.95)	31.00 (33.81)
C_4P_5	30.00 (33.20)	61.00 (51.42)	25.00 (29.78)	54.00 (47.34)
C_1P_6	16.00 (18.70)	51.00 (45.63)	15.00 (20.46)	42.00 (40.36)
C_2P_6	28.00 (31.94)	65.00 (53.91)	6.00 (9.19)	28.00 (31.74)
C_3P_6	7.00 (9.77)	37.00 (37.39)	2.00 (3.79)	28.00 (31.94)
C_4P_6	30.00 (33.20)	58.00 (55.68)	9.00 (13.73)	32.00 (34.40)
C_1P_7	18.00 (19.95)	50.00 (44.99)	31.00 (33.81)	55.00 (47.91)
C_2P_7	28.00 (31.94)	64.00 (53.18)	25.00 (29.78)	50.00 (45.01)
C_3P_7	3.00 (6.35)	28.00 (31.94)	12.00 (18.15)	30.00 (32.90)
C_4P_7	12.00 (13.36)	48.00 (44.03)	26.00 (30.47)	52.00 (46.17)

Contd.

Table 20b. (Contd.)

Treatments	Days after storage			
	Ambient temperature storage		Refrigerated storage	
	D_2	D_3	D_9	D_{12}
C_1P_8	18.00 (19.98)	52.00 (46.13)	27.00 (31.23)	54.00 (47.33)
C_2P_8	32.00 (34.45)	70.00 (56.85)	24.00 (29.28)	49.00 (44.44)
C_3P_8	2.00 (3.79)	31.00 (33.81)	25.00 (29.97)	49.00 (44.44)
C_4P_8	20.00 (21.21)	54.00 (47.41)	16.00 (23.37)	38.00 (37.97)
CD for				
Precooling (C)	N.S		2.32*	
Packaging (P)	4.71*		3.29*	
C x P	N.S		N.S	

* Significant at 5 per cent level

	Ambient	Refrigerated
Mean temperature during experiment period		
Maximum temperature	32.8°C	11.2°C
Minimum temperature	27.8°C	9.1°C
Mean relative humidity during experiment period	79.6%	60.3%

C_1 - Precooling with tap water

C_2 - Precooling with cold water

C_3 - Precooling by contact icing

C_4 - Control

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

P_5 - Polypropylene bags of 100 gauge without ventilation

P_6 - Polypropylene bags of 200 gauge without ventilation

P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

D_2, D_3, ... D_n - 'n' Days after storage

* Figures in bracket indicates transformed values

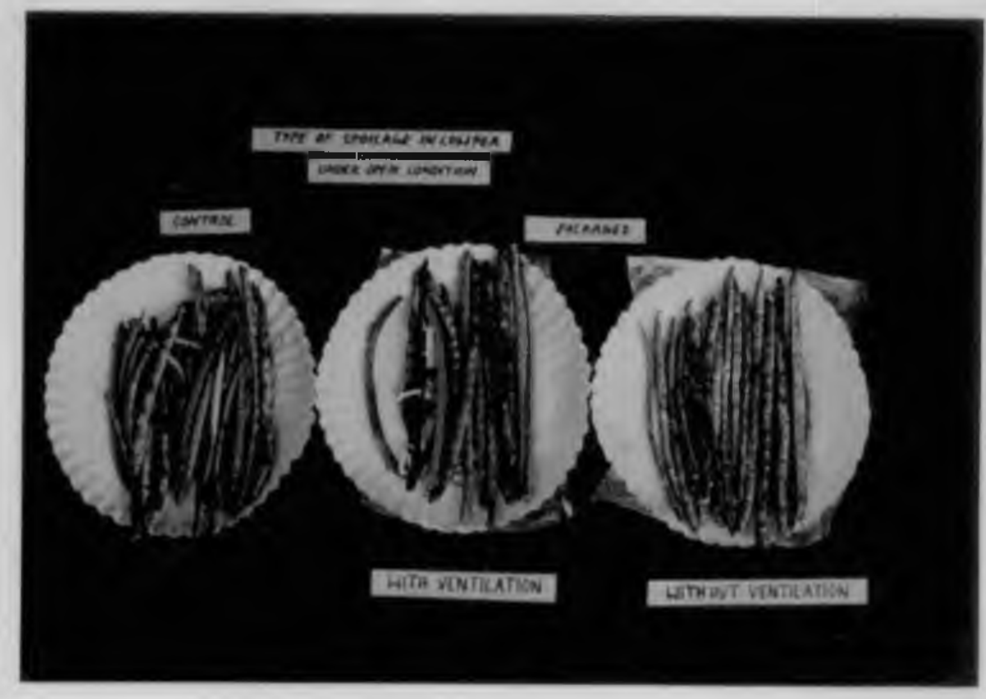


Plate 12. Type of spoilage in cowpea under ambient temperature storage

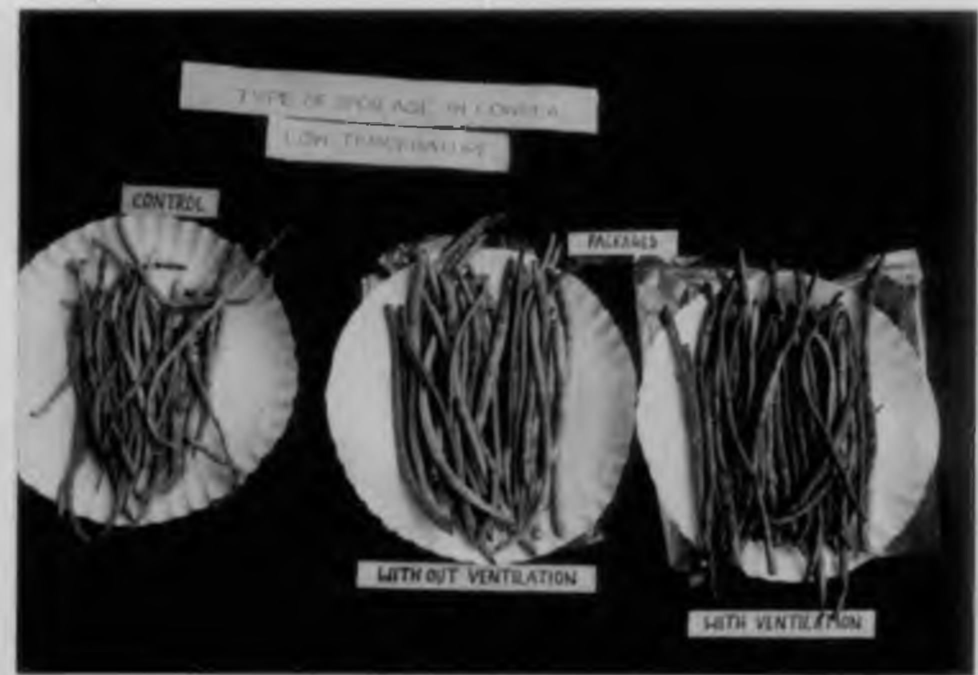


Plate 13. Type of spoilage in cowpea under refrigerated storage

packaging treatments, was recorded in P_7 (100 gauge PE, ventilated) followed by P_4 (200 gauge PE, ventilated) and P_8 (200 gauge PP, ventilated). Treatments P_7, P_4 and P_8 were on par with each other. Maximum unmarketability was recorded in P_1 (100 gauge PE, unventilated).

With respect to refrigerated storage, significant difference in unmarketability was observed among precooling and packaging treatments. In the case of precooling treatments, minimum unmarketability was recorded in C_3 (contact icing). Maximum unmarketability was recorded in C_1 (tap water). Among packaging treatments, minimum unmarketability was recorded in P_2 (200 gauge PE, unventilated) which was significantly superior to all other treatments. Maximum unmarketability was recorded in P_3 (100 gauge PE, ventilated).

The interaction of precooling and packaging had no significant effect on unmarketability both under ambient and refrigerated storage environments.

4.2.4.3 Length of storage life

Data on storage life as influenced by precooling and packaging treatments are presented in Table 21.

Table 21. Storage life (days) of cowpea as influenced by precooling and packaging treatments

Precooling x Packaging	Ambient temperature storage					Refrigerated storage				
	C_1	C_2	C_3	C_4	Mean	C_1	C_2	C_3	C_4	Mean
P_1	1.20	.00	1.60	1.00	1.20	9.60	6.60	11.00	6.80	8.50^{b}
P_2	1.40	.00	2.00	1.00	1.35	8.90	8.50	9.50	8.70	8.90^{a}
P_3	1.20	.00	1.80	1.00	1.20	5.80	6.60	7.00	6.80	6.55^{e}
P_4	1.60	.20	2.10	1.00	1.45	6.40	7.80	5.60	7.40	6.80^{d}
P_5	1.40	.20	1.80	1.00	1.35	6.60	8.20	8.60	6.80	7.55^{c}
P_6	1.40	.00	1.80	1.00	1.30	7.82	8.62	9.42	8.22	8.52^{b}
P_7	1.40	.00	2.00	1.60	1.50	6.00	7.00	8.20	6.80	7.00^{d}
P_8	1.60	1.40	2.00	1.00	1.50	6.40	6.60	6.60	7.80	6.85^{d}
Mean	1.40^{b}	1.10^{c}	1.88^{a}	1.05^{c}		7.20^{c}	7.50^{b}	8.24^{a}	7.42^{b}	

CD for	Ambient temperature storage	Refrigerated storage
Precooling (C)	0.16*	0.25*
Packaging (P)	N.S	0.36*
C x P	N.S	N.S

* Significant at 5 per cent level

	Ambient temperature storage	Refrigerated storage
Mean storage life of control samples	1 day	1.7 days
Mean temperature during experiment period		
Maximum temperature	32.8°C	11.2°C
Minimum temperature	27.8°C	9.1°C
Mean relative humidity during experiment period	79.6%	60.3%

C_1 - C_4 - Precooling treatments

P_1 - P_8 - Packaging treatments

Perusal of data in Table 21 indicates that under ambient temperature storage, significant differences in shelf life was observed only among precooling treatments, with maximum shelf life being recorded in C_3 (contact icing). Minimum shelf life was recorded in C_4 (control) which was on par with C_2 (cold water).

With respect to refrigerated storage, shelf life varied significantly among precooling and packaging treatments. Among precooling treatments maximum shelf life was recorded in C_3 (contact icing). Minimum shelf life was recorded in C_1 (tap water). Among packaging treatments maximum shelf life was recorded in P_2 (200 gauge PE, unventilated). Minimum shelf life was recorded in P_3 (100 gauge PE, ventilated).

The interaction had no significant effect both under ambient and refrigerated storage environments.

4.2.4.4 Consumer acceptability

Results of the consumer acceptability rating of the precooled cowpea in different packages are presented in Table 22. Significant difference in consumer acceptability among precooling and packaging treatments was observed only under refrigerated storage with best acceptability being recorded for C_3 (contact icing) and P_2 (200 gauge PE,

Table 22. Consumer acceptability of cowpea as influenced by precooling and packaging treatments

22a. Main effects

Treatments	Days after storage								
	Ambient temperature storage				Refrigerated storage				
	D_1	D_2	D_3	Mean	D_3	D_6	D_9	D_{12}	Mean
Precooling									
C_1	3.00	4.20	5.00	4.07	1.85	2.85	4.03	4.80	3.38^b
C_2	3.00	4.38	5.00	4.12	1.95	2.83	3.90	4.75	3.36^b
C_3	3.00	3.68	4.48	3.72	1.80	2.55	3.53	4.53	3.10^a
C_4	3.00	4.25	5.00	4.10	2.08	2.78	4.00	4.75	3.40^b
Packaging									
P_1	3.00	4.15	4.80	3.98	1.70	2.55	3.45	4.55	3.06^b
P_2	3.00	4.20	4.80	4.00	1.60	2.40	3.00	4.20	2.80^a
P_3	3.00	4.05	4.75	3.93	2.10	2.95	4.30	5.00	3.59^d
P_4	3.00	4.15	4.70	3.95	2.00	2.95	4.10	4.90	3.48^d
P_5	3.00	4.10	4.80	3.97	1.85	2.80	3.80	4.80	3.31^c
P_6	3.00	4.20	4.75	3.98	1.75	2.55	3.30	4.35	2.98^b
P_7	3.00	4.05	4.65	3.90	2.15	2.85	4.10	4.90	3.50^d
P_8	3.00	4.10	4.70	3.93	2.20	2.95	4.45	4.95	3.64^e

Contd.

Table 22b. Interaction effects

Treatments	Days after storage						
	Ambient temperature storage			Refrigerated storage			
	D_1	D_2	D_3	D_3	D_6	D_9	D_{12}
Precooling x Packaging							
C_1P_1	3.00	4.00	5.00	1.60	2.40	3.00	4.40
C_2P_1	3.00	4.20	4.80	2.20	3.00	4.40	5.00
C_3P_1	3.00	4.00	4.60	1.00	2.00	2.40	3.80
C_4P_1	3.00	4.40	4.80	2.00	2.80	4.00	5.00
C_1P_2	3.00	4.40	5.00	1.60	2.60	3.00	4.40
C_2P_2	3.00	4.20	4.80	1.60	2.40	3.00	4.40
C_3P_2	3.00	3.80	4.60	2.40	2.20	3.00	4.00
C_4P_2	3.00	4.40	4.80	1.80	2.40	3.00	4.00
C_1P_3	3.00	3.80	5.00	2.00	3.00	4.40	5.00
C_2P_3	3.00	4.40	4.80	2.20	3.00	4.60	5.00
C_3P_3	3.00	3.60	4.40	2.00	2.80	4.00	5.00
C_4P_3	3.00	4.40	4.80	2.20	3.00	4.20	5.00
C_1P_4	3.00	4.20	5.00	1.80	3.00	4.40	5.00
C_2P_4	3.00	4.40	4.80	1.80	3.00	3.80	4.80
C_3P_4	3.00	3.40	4.20	2.40	3.00	4.40	5.00
C_4P_4	3.00	4.60	4.80	2.00	2.80	3.80	4.80
C_1P_5	3.00	4.40	5.00	1.60	3.00	4.40	5.00
C_2P_5	3.00	4.20	4.80	1.80	2.80	3.60	4.60
C_3P_5	3.00	3.60	4.60	1.80	2.40	3.20	4.60
C_4P_5	3.00	4.20	4.80	2.20	3.00	4.00	5.00
C_1P_6	3.00	4.20	5.00	1.80	2.80	3.60	4.60
C_2P_6	3.00	4.60	4.80	1.80	2.60	3.20	4.40
C_3P_6	3.00	3.80	4.60	1.60	2.20	3.00	4.00
C_4P_6	3.00	4.20	4.60	1.80	2.60	3.40	4.40
C_1P_7	3.00	4.20	5.00	2.20	3.00	4.60	5.00
C_2P_7	3.00	4.60	4.80	2.20	2.80	4.00	4.80
C_3P_7	3.00	3.60	4.40	1.80	2.80	3.60	4.80

Contd.

Table 22b. (Contd.)

Treatments	Days after storage						
	Ambient temperature storage			Refrigerated storage			
	D_1	D_2	D_3	D_3	D_6	D_9	D_{12}
C_4P_7	3.00	3.80	4.40	2.40	2.80	4.20	5.00
C_1P_8	3.00	4.40	5.00	2.20	3.00	4.80	5.00
C_2P_8	3.00	4.40	4.80	2.00	3.00	4.60	5.00
C_3P_8	3.00	1.60	4.40	2.40	3.00	4.60	5.00
C_4P_8	3.00	4.00	4.60	2.20	2.80	3.80	4.80
CD for							
Precooling (C)		N.S			0.08*		
Packaging (P)		N.S			0.13*		
C x P		N.S			N.S		

* Significant at 5 per cent level

Five point scale for consumer acceptability

1. Acceptable fully
2. Acceptable somewhat,
3. Neither acceptable non unacceptable
4. Unacceptable somewhat
5. Not acceptable

C_1 - Precooling with tap water

C_2 - Precooling with cold water

C_3 - Precooling by contact icing

C_4 - Control

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

P_5 - Polypropylene bags of 100 gauge without ventilation

P_6 - Polypropylene bags of 200 gauge without ventilation

P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

D_1, D_2, ... D_n - 'n' Days after storage

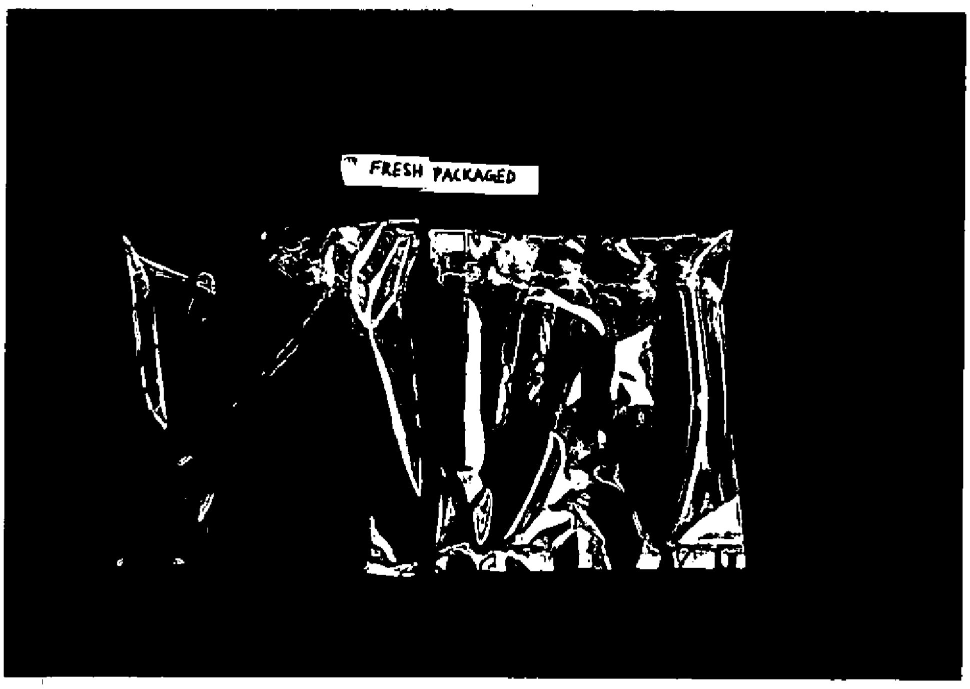


Plate 14. Okra packaged in polymeric films

Plate 14. Okra packaged in polymeric films

unventilated) among precooling and packaging treatments respectively.

The interaction of precooling and packaging had no significant effect on acceptability under both the storage regimes.

4.2.5 Okra (Abelmoschus esculentus L. Moench)

A view of okra packaged in polymeric films are presented in Plate 14.

4.2.5.1 Physiological loss in weight

The influence of precooling and packaging treatments on PLW are presented in Table 23 and Fig.3. Precooling and packaging treatments differed significantly both under ambient and refrigerated storage environments.

Among precooling treatments, under ambient temperature storage, the PLW was minimum in C_2 (cold water) which was significantly superior to all other treatments. Maximum PLW was recorded in C_4 (control).

With regard to packaging treatments, under ambient temperature storage, minimum PLW was recorded in P_1 (100 gauge PE, unventilated) which was followed by P_5 (100 gauge PP, unventilated) and P_2 (200 gauge PE, unventilated). Treatments

Table 23. Influence of precooling and packaging treatments on PLW (%) in okra

23a. Main effects

Treatments	Days after storage											
	Ambient temperature storage							Refrigerated storage				
	D_1	D_2	D_3	D_4	D_5	D_6	Mean	D_3	D_6	D_9	D_{12}	Mean
Precooling												
C_1	1.28	1.89	2.50	3.25	4.02	5.38	3.05[b]	0.53	1.19	1.83	2.61	1.55[b]
C_2	0.92	1.61	2.42	2.96	3.47	4.55	2.65[a]	0.69	1.37	1.95	2.72	1.69[b]
C_3	1.20	1.92	2.66	3.31	3.97	5.20	3.03[b]	0.55	0.97	1.53	2.15	1.30[a]
C_4	1.50	2.24	2.95	3.55	4.14	5.39	3.3[illegible][c]	0.98	1.92	2.73	3.46	2.27[c]
Packaging												
P_1	0.80	0.99	1.24	1.51	1.79	2.04	1.3[illegible][a]	0.11	0.18	0.24	0.31	0.21[a]
P_2	1.23	1.40	1.57	1.73	1.88	2.25	1.6[illegible][a]	0.30	0.39	0.62	0.81	0.53[b]
P_3	1.63	2.71	3.79	4.44	5.09	6.67	4.06[c]	0.88	2.20	3.74	5.34	3.04[e]
P_4	2.10	2.90	3.99	4.79	5.60	7.15	4.4[illegible][c]	1.15	2.01	2.94	4.06	2.54[d]
P_5	1.00	1.23	1.47	1.72	1.92	2.39	1.6[illegible][a]	0.30	0.47	0.65	0.68	0.52[b]
P_6	1.23	1.47	1.67	1.93	2.23	2.87	1.9[illegible][b]	0.35	0.76	0.92	1.05	0.77[c]
P_7	1.87	2.64	3.75	4.75	5.76	7.89	4.4[illegible][c]	1.26	2.24	2.89	3.66	2.52[d]
P_8	2.46	3.39	4.32	5.45	6.57	8.59	5.1[illegible][d]	1.30	2.76	4.17	5.97	3.60[f]

Contd.

Table 23b. Interaction effects

Treatments	Days after storage									
	Ambient temperature storage						Refrigerated storage			
	D_1	D_2	D_3	D_4	D_5	D_6	D_3	D_6	D_9	D_{12}
Precooling x Packaging										
C_1P_1	0.63	0.66	0.68	1.19	1.74	2.06	0.09	0.17	0.22	0.34
C_2P_1	0.40	0.73	1.45	1.45	1.46	1.89	0.09	0.19	0.21	0.32
C_3P_1	1.09	1.40	1.72	1.82	1.92	2.16	0.11	0.14	0.15	0.21
C_4P_1	1.09	1.20	1.20	1.58	2.05	2.06	0.13	0.21	0.35	0.37
C_1P_2	1.01	1.07	1.12	1.19	1.26	1.26	0.32	0.41	0.53	0.63
C_2P_2	1.28	1.64	2.00	2.16	2.33	3 41	0.24	0.43	0.70	0.93
C_3P_2	1.58	1.65	1.71	2.02	2.33	2.49	0.26	0.28	0.66	0.96
C_4P_2	1.05	1.25	1.45	1.54	1.62	1.84	0.30	0.45	0.58	0.69
C_1P_3	1.92	2.81	3.70	4.55	5.40	6.77	0.31	1.76	3.05	4.90
C_2P_3	1.20	2.21	3.23	3.94	4.65	6.66	0.84	2.30	4.02	5.62
C_3P_3	0.85	2.19	3.54	4.24	4.95	6.56	0.44	1.49	2.56	3.57
C_4P_3	2.55	3.63	4.71	5.04	5.36	6 69	1.96	3.27	5.31	7.28
C_1P_4	2.59	3.41	4.29	5.30	6.29	8.40	1.07	1.91	3.04	4.86
C_2P_4	1.69	2.61	3.82	4.76	5.70	7.53	0.93	1.95	2.72	3.75
C_3P_4	1.69	2.44	3.35	3.92	4.49	5.70	0.61	1.24	1.69	2.66
C_4P_4	2.50	3.50	4.48	5.21	5.93	6.96	1.38	2.59	4.00	4.98
C_1P_5	0.35	0.58	0.80	0.99	1.19	1 20	0.25	0.38	0.49	0.50
C_2P_5	0.11	0.16	0.21	0.30	0.31	0.32	0.20	0.27	0.35	0.38
C_3P_5	1.95	2.49	3.03	3.44	3.90	4.58	0.22	0.34	0.48	0.56
C_4P_5	1.59	1.70	1.84	2.12	2.44	3.49	0.55	0.96	1.26	1.29
C_1P_6	0.63	0.88	1.10	1.30	1.40	1.66	0.28	0.52	0.92	1.09
C_2P_6	0.54	0.94	1.55	1.88	1.98	2.10	0.16	0.17	0.17	0.25
C_3P_6	1.58	1.62	1.90	2.10	0.30	2.40	0.21	0.42	0.63	0.93
C_4P_6	1.88	2.22	2.56	2.98	3.49	4.46	0.77	1.95	0.95	1.98
C_1P_7	1.48	2.49	3.50	4.89	6.26	10.34	0.54	1.74	2.29	2.48
C_2P_7	0.57	1.71	3.09	3.93	4.77	6.57	1.54	2.81	3.20	4.50
C_3P_7	1.21	2.11	3.01	3.89	4.77	6.79	1.24	1.65	2.30	2.82

Contd.

Table 23b. (Contd.)

Treatments	Days after storage									
	Ambient temperature storage						Refrigerated storage			
	D_1	D_2	D_3	D_4	D_5	D_6	D_3	D_6	D_9	D_{12}
C_4P_7	1.80	3.00	4.20	5.10	6.00	7.37	1.73	2.79	3.80	4.83
C_1P_8	3.19	4.19	5.20	6.47	7.73	9.53	1.43	2.69	4.13	6.13
C_2P_8	2.22	3.34	4.45	5.29	6.12	7.37	1.54	2.91	4.26	5.97
C_3P_8	2.08	2.73	3.39	4.82	6.26	8.51	1.26	2.28	3.77	5.50
C_4P_8	2.36	3.31	4.25	5.21	6.16	8.94	0.98	3.15	4.54	6.25
CD for										
Precooling (C)	0.25*						0.14*			
Packaging (P)	0.38*						0.19*			
C x P	NS						NS			

Significant at 5 per cent level

Mean temperature during experiment period

	Ambient temperature storage	Refrigerated storage
Maximum temperature	31.4°C	11.6°C
Minimum temperature	28.8°C	8.8°C
Mean relative humidity during experiment period	83.4%	59.7%

C_1 - Precooling with tap water

C_2 - Precooling with cold water

C_3 - Precooling by contact icing

C_4 - Control

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

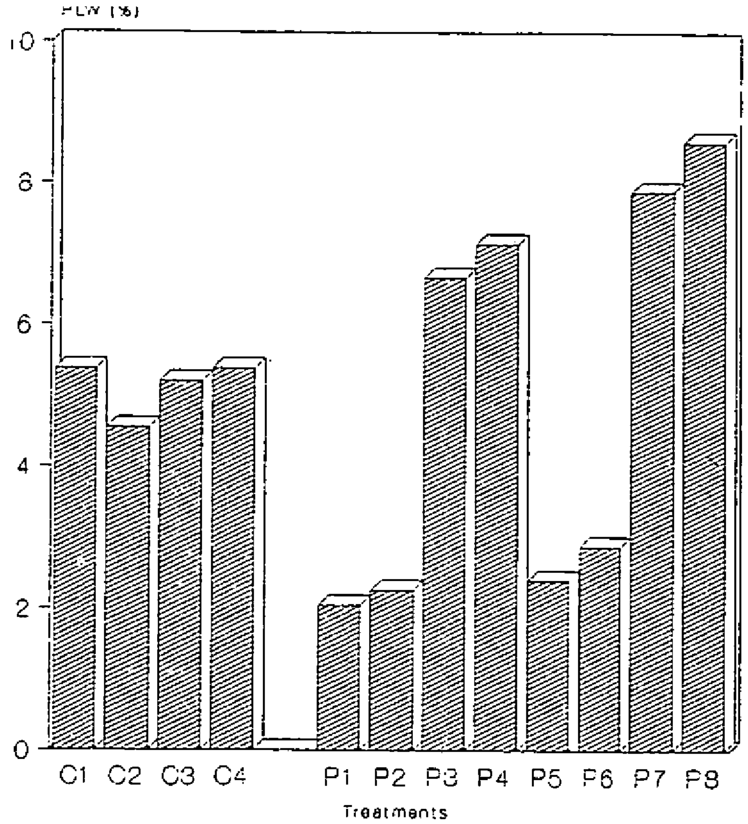
P_5 - Polypropylene bags of 100 gauge without ventilat...

P_6 - Polypropylene bags of 200 gauge without ventilation

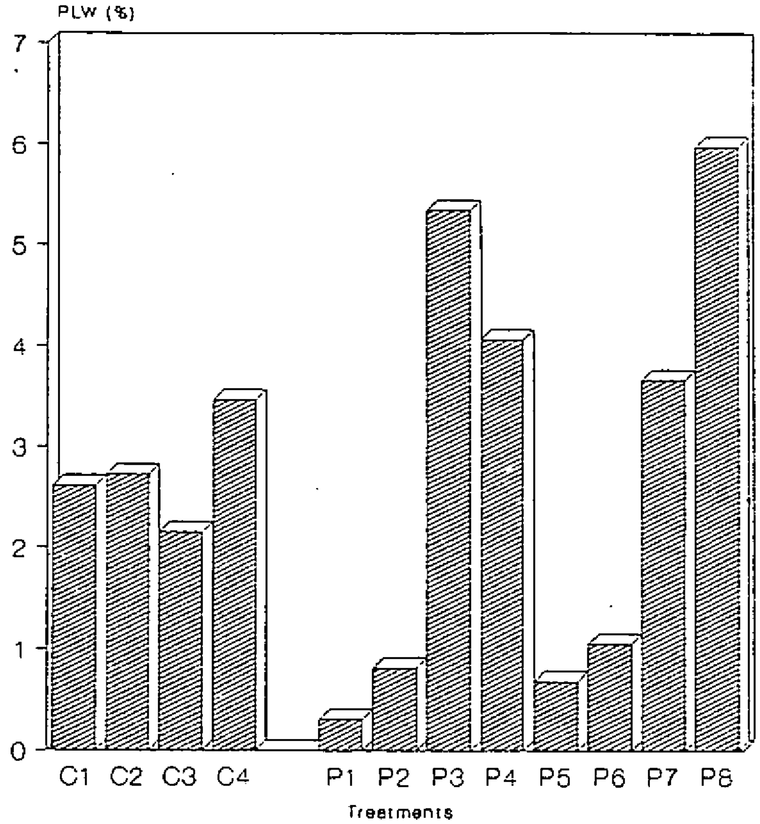
P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

D_1, D_2, ... D_n - 'n' Days after storage



(a) Ambient temperature storage
(After six days of storage)



(b) Refrigerated storage
(After twelve days of storage)

Fig. 3 Effect of precooling and packaging on physiological loss in weight in Okra.

P_1, P_5 and P_2 were on par with each other. Maximum PLW was recorded in P_8 (200 gauge PP, ventilated).

In the case of refrigerated storage, among precooling treatments, minimum PLW was recorded in C_3 (contact icing). Maximum PLW was recorded in C_4 (control).

With respect to packaging treatments, under refrigerated storage, minimum PLW was recorded in P_1 (100 gauge PE, unventilated). PLW was maximum in P_8 (200 gauge PP, ventilated).

The interaction among precooling and packaging treatments had no significant effect under both storage environments.

4.2.5.2 Unmarketability

The influence of precooling and packaging treatments on unmarketability are presented in Table 24 and Fig.4. Type of spoilage leading to unmarketability of the packaged produce under ambient and refrigerated storage environments are presented in Plates 15 and 16. Precooling and packaging treatments differed significantly both under ambient and refrigerated storage environments.

With respect to ambient temperature storage, minimum unmarketability, among precooling treatments was recorded in

Table 24. Influence of precooling and packaging treatments on unmarketability (%) in okra

24a. Main effects

Treatments	Days after storage					
	Ambient temperature storage			Refrigerated storage		
	D_5	D_6	Mean	D_9	D_{12}	Mean
Precooling						
C_1	17.88 (20.51)	41.50 (37.43)	29.69[b] (28.97)	16.50 (22.38)	40.63 (38.86)	28.56[b] (30.62)
C_2	10.51 (12.77)	29.26 (29.04)	19.88[a] (20.90)	17.00 (21.74)	41.25 (39.81)	29.13[b] (30.78)
C_3	23.00 (27.57)	48.38 (45.33)	35.69[c] (36.45)	14.63 (19.83)	36.38 (36.90)	25.50[a] (28.36)
C_4	28.04 (29.57)	48.55 (44.63)	36.18[c] (37.10)	27.38 (31.22)	54.50 (47.67)	40.94[c] (39.44)
Packaging						
P_1	13.25 (20.62)	35.50 (36.33)	24.38[b] (28.48)	8.50 (12.64)	30.25 (33.06)	19.38[a] (22.85)
P_2	28.00 (31.01)	55.25 (48.42)	41.63[c] (39.71)	12.25 (17.18)	35.25 (36.26)	23.75[b] (26.92)
P_3	37.00 (37.08)	68.75 (57.61)	52.88[d] (47.35)	25.50 (29.95)	50.50 (45.37)	38.26[e] (37.66)
P_4	28.00 (31.68)	55.00 (48.24)	41.75[c] (39.97)	24.00 (29.18)	48.75 (44.28)	36.38[d] (34.73)
P_5	8.50 (13.04)	25.25 (28.73)	16.88[a] (20.87)	13.75 (18.27)	35.75 (36.42)	24.75[b] (27.35)
P_6	11.25 (17.19)	31.25 (31.91)	21.25[a] (24.55)	17.50 (22.83)	40.00 (39.14)	28.75[c] (31.48)
P_7	12.50 (18.39)	32.00 (33.85)	22.25[b] (26.12)	24.00 (29.24)	46.25 (42.86)	35.10[d] (36.05)
P_8	12.75 (18.51)	33.00 (34.60)	22.88[b] (26.55)	25.06 (30.05)	50.75 (45.48)	38.37[e] (37.76)

Table 24b. Interaction effects

Treatments	Days after storage			
	Ambient temperature storage		Refrigerated storage	
	D_5	D_6	D_9	D_{12}
Precooling x Packaging				
C_1P_1	13.00 (20.71)	42.00 (40.28)	6.00 (9.19)	25.00 (29.78)
C_2P_1	11.00 (17.28)	30.00 (32.67)	8.00 (12.86)	30.00 (33.17)
C_3P_1	14.00 (21.81)	36.00 (36.78)	2.00 (3.79)	22.00 (27.83)
C_4P_1	15.00 (22.68)	34.00 (35.59)	18.00 (24.70)	44.00 (41.45)
C_1P_2	17.00 (23.64)	45.00 (42.14)	18.00 (24.99)	38.00 (38.02)
C_2P_2	13.00 (20.94)	31.00 (33.76)	10.00 (14.49)	36.00 (36.77)
C_3P_2	49.00 (44.45)	79.00 (63.22)	2.00 (3.79)	25.00 (29.94)
C_4P_2	33.00 (34.98)	66.00 (54.56)	19.00 (25.46)	42.00 (40.33)
C_1P_3	35.00 (36.01)	67.00 (55.36)	18.00 (24.99)	38.00 (38.03)
C_2P_3	25.00 (29.78)	53.00 (46.77)	27.00 (31.30)	55.00 (57.92)
C_3P_3	29.00 (32.28)	64.00 (53.54)	17.00 (24.31)	38.00 (38.03)
C_4P_3	59.00 (50.24)	91.00 (74.77)	40.00 (39.19)	71.00 (57.49)
C_1P_4	34.00 (35.60)	66.00 (54.45)	21.00 (27.19)	42.00 (40.36)
C_2P_4	18.00 (25.07)	40.00 (39.23)	27.00 (31.30)	45.00 (47.90)
C_3P_4	26.00 (30.66)	59.00 (50.23)	18.00 (25.07)	39.00 (38.61)
C_4P_4	34.00 (35.43)	57.00 (49.07)	30.00 (33.17)	59.00 (50.25)
C_1P_5	4.00 (7.51)	22.00 (27.32)	8.00 (12.86)	25.00 (29.78)
C_2P_5	1.00 (2.74)	10.00 (16.18)	3.00 (4.66)	25.00 (29.97)
C_3P_5	18.00 (24.51)	41.00 (39.68)	19.00 (25.69)	41.00 (39.76)
C_4P_5	11.00 (17.39)	28.00 (31.72)	25.00 (29.86)	52.00 (56.17)
C_1P_6	5.00 (8.33)	27.00 (30.85)	17.00 (24.13)	38.00 (38.00)
C_2P_6	3.00 (5.42)	17.00 (24.42)	14.00 (21.81)	34.00 (35.61)
C_3P_6	20.00 (26.12)	44.00 (41.16)	12.00 (18.15)	33.00 (35.02)
C_4P_6	13.00 (20.90)	40.00 (39.16)	27.00 (31.23)	55.00 (47.92)
C_1P_7	10.00 (16.52)	27.00 (30.85)	20.00 (26.44)	42.00 (40.39)
C_2P_7	5.00 (8.33)	19.00 (25.20)	26.00 (30.61)	47.00 (43.29)
C_3P_7	16.00 (23.14)	32.00 (40.32)	24.00 (29.28)	46.00 (42.72)

Contd.

Table 24b. (Contd.)

Treatments	Days after storage			
	Ambient temperature storage		Refrigerated storage	
	D_5	D_6	D_9	D_{12}
C_4P_7	20.00 (26.07)	40.00 (39.03)	26.00 (30.61)	50.00 (45.02)
C_1P_8	17.00 (23.89)	44.00 (41.55)	24.00 (29.21)	45.00 (42.08)
C_2P_8	11.00 (17.28)	31.00 (33.13)	21.00 (26.90)	48.43.854.44)
C_3P_8	11.00 (17.28)	33.00 (32.62)	23.00 (28.53)	47.00 (43.28)
C_4P_8	11.00 (17.28)	27.00 (31.11)	34.00 (35.55)	63.00 (52.70)

CD for

	Ambient	Refrigerated
Precooling (C)	3.19*	2.21*
Packaging (P)	4.51*	3.10*
C x P	N.S	N.S

* Significant at 5 per cent level

Mean temperature during experiment period

	Ambient	Refrigerated
Maximum temperature	31.4°C	11.6°C
Minimum temperature	28.8°C	8.8°C
Mean relative humidity during experiment period	83.4%	59.7%

C_1 - Precooling with tap water

C_2 - Precooling with cold water

C_3 - Precooling by contact icing

C_4 - Control

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

P_5 - Polypropylene bags of 100 gauge without ventilation

P_6 - Polypropylene bags of 200 gauge without ventilation

P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

D_5, D_6, ... D_n - 'n' Days after storage

* Figures in bracket indicates transformed values

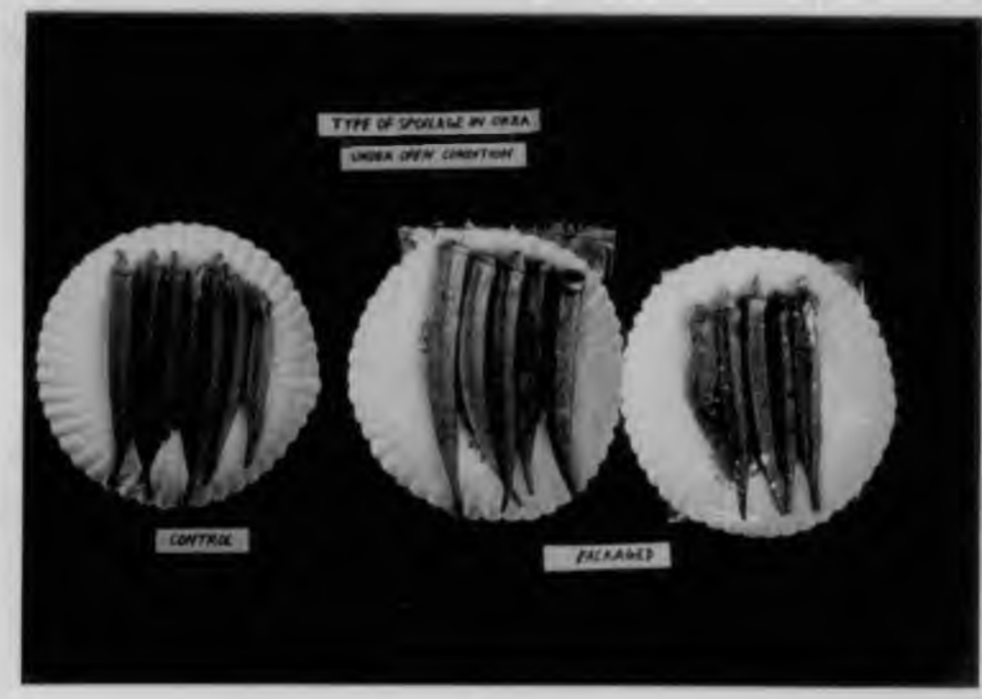


Plate 15. Type of spoilage in okra under ambient temperature storage

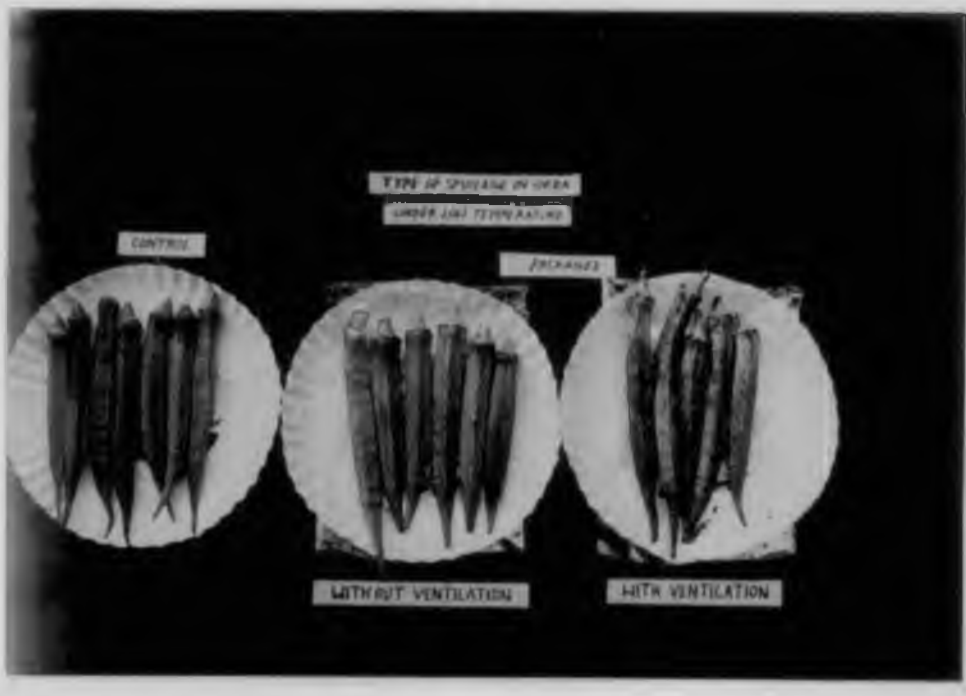


Plate 16. Type of spoilage in okra under low temperature storage

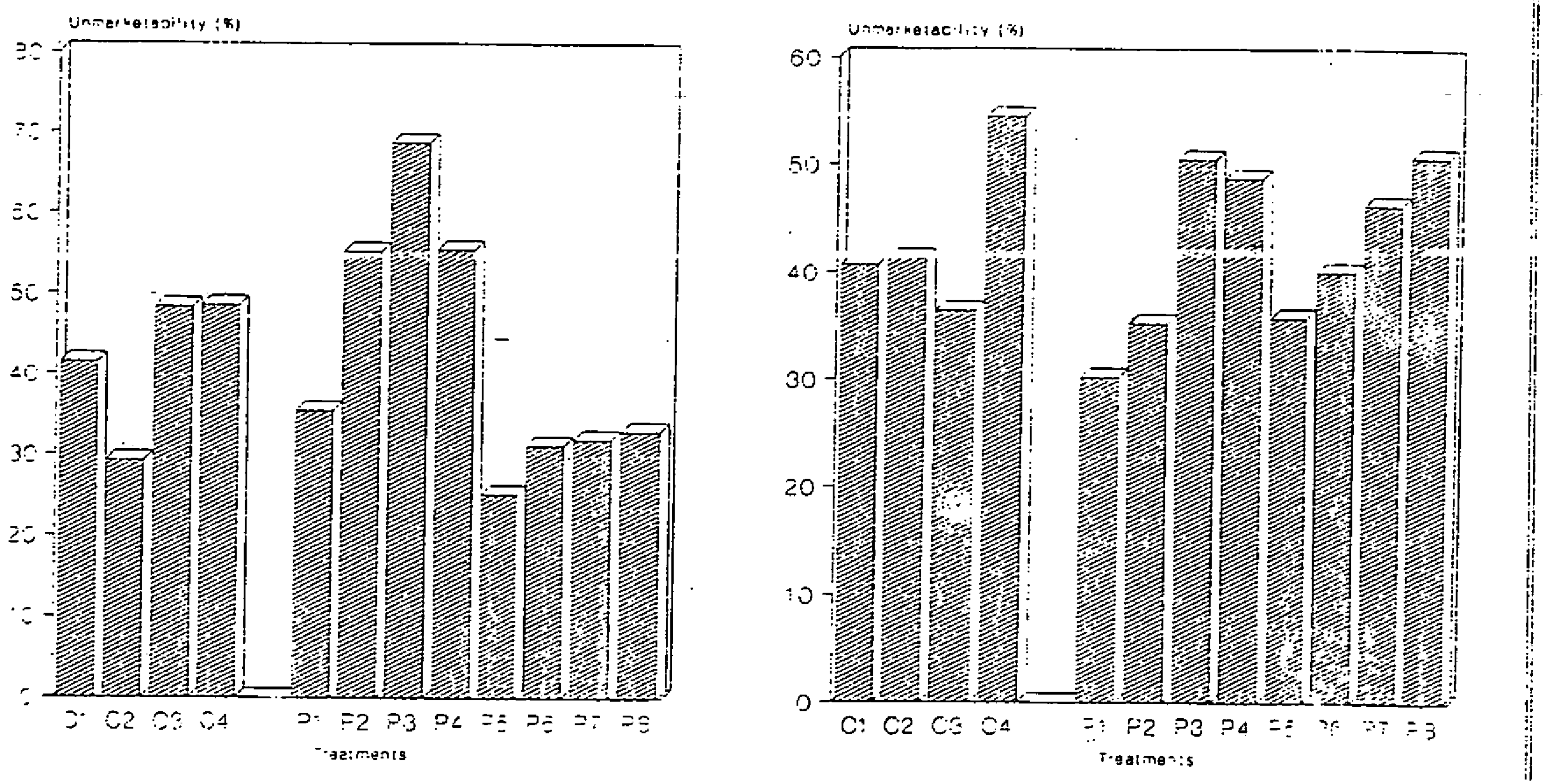
C_2 (cold water). Maximum unmarketability was recorded in C_4 (control) which was on par with C_3 (contact icing).

Among packaging treatments, under ambient temperature storage, minimum unmarketability was recorded in P_5 (100 gauge PP, unventilated) which was on par with P_6 (200 gauge PP, unventilated). Maximum unmarketability was recorded in P_3 (100 gauge PE, ventilated).

With regard to refrigerated storage, minimum unmarketability among precooling treatments was recorded in C_3 (contact icing). Maximum unmarketability was recorded in C_4 (control).

Among packaging treatments, under refrigerated storage, minimum unkarketability was recorded in P_1 (100 gauge PE, unventilated). Maximum unmarketability was recorded in P_3 (100 gauge PE, ventilated) followed by P_8 (200 gauge PP, ventilated). Treatments P_3 and P_8 were on par with each other.

The interaction of precooling and packaging had no significant effect both under ambient and refrigerated storage environments.



(a) Ambient temperature storage
(After six days of storage)

(b) Refrigerated storage
(After twelve days of storage)

Fig. 4 Effect of precooling and packaging on unmarketability in Okra.

4.2.5.3 Length of storage life

Effect of precooling and packaging treatments on storage life are presented in Table 25. Precooling and packaging treatments differed significantly both under ambient and refrigerated storage environments.

Among precooling treatments, under ambient temperature storage, maximum shelf life was recorded in C_2 (cold water). Minimum shelf life was recorded in C_4 (control) which was on par with C_3 (contact icing).

Among packaging treatments, under ambient temperature storage, maximum shelf life was recorded in P_5 (100 gauge PP, unventilated) which was on par with P_6 (200 gauge PP, unventilated). Minimum shelf life was recorded in P_3 (100 gauge PE, ventilated) which was followed by P_4 (200 gauge PE, ventilated) and P_2 (100 gauge PE, unventilated). Treatments P_3, P_4 and P_2 were on par with each other.

With respect to refrigerated storage, among precooling treatments, maximum shelf life was recorded in C_3 (contact icing) which was followed by C_1 (tap water). Minimum shelf life was recorded in C_4 (control).

Among packaging treatments, under refrigerated storage, maximum shelf life was recorded in P_1 (100 gauge PE,

Table 25. Storage life (days) of okra as influenced by precooling and packaging treatments

Precooling x Packaging	Ambient temperature storage					Refrigerated storage				
	C_1	C_2	C_3	C_4	Mean	C_1	C_2	C_3	C_4	Mean
P_1	4.25	4.65	4.25	4.05	4.30[b]	8.80	8.40	9.20	7.40	8.45[a]
P_2	4.70	5.50	2.50	3.50	4.05[c]	7.60	8.40	9.00	7.60	8.15[a]
P_3	4.20	4.60	4.40	2.40	3.90[c]	7.20	6.40	7.60	5.40	6.65[d]
P_4	3.35	4.95	3.95	3.75	4.00[c]	6.10	6.40	7.80	6.40	6.85[d]
P_5	5.10	6.30	3.50	4.30	4.80[a]	8.40	9.00	7.60	6.80	7.95[b]
P_6	4.40	4.60	4.80	4.20	4.50[a]	7.80	8.00	8.00	5.60	7.35[c]
P_7	4.70	5.30	3.90	3.70	4.40[b]	7.40	6.20	6.60	6.00	6.54[e]
P_8	4.09	4.49	4.69	4.55	4.44[b]	7.10	6.80	7.00	5.20	6.54[e]
Mean	4.35[b]	5.05[a]	4.00[c]	3.80[c]		7.65[b]	7.45[c]	7.85[a]	6.35[d]	

CD for	Ambient temperature storage	Refrigerated storage
Precooling (C)	0.34*	0.19*
Packaging (P)	0.30*	0.30*
C x P	N.S	N.S

* Significant at 5 per cent level

	Ambient temperature storage	Refrigerated storage
Mean storage life of control samples	1.8 days	2.8 days
Mean temperature during experiment period		
Maximum temperature	31.4°C	11.6°C
Minimum temperature	28.8°C	8.8°C
Mean relative humidity during experiment period	83.4%	59.7%

C_1 - C_4 - Precooling treatments

P_1 - P_8 - Packaging treatments

unventilated) which was on par with P_2 (200 gauge PE, unventilated). Minimum shelf life was recorded in P_7 (100 gauge PP, ventilated) and P_8 (200 gauge PP, ventilated). Treatments P_7 and P_8 were on par with each other.

The interaction of precooling and packaging had no significant effect both under ambient and refrigerated storage environments.

4.2.5.4 Consumer acceptability

Results of the consumer acceptability rating of the precooled produce in different packages are presented in Table 26. Significant difference in consumer acceptability among precooled and packaged produce was observed both under ambient and refrigerated storage environments.

Among precooling treatments, under ambient temperature storage, best acceptability was obtained for C_2 (cold water). With respect to packaging treatments best acceptability was obtained for P_5 (100 gauge PP, unventilated) which was followed by P_6 (200 gauge PP, unventilated). Treatments P_5 and P_6 were equally acceptable.

With respect to refrigerated storage, among precooling treatments best acceptability was obtained for C_3 (contact icing). Among packaging treatments, best acceptability was

Table 26. Consumer acceptability of okra as influenced by precooling and packaging treatments

26a. Main effects

Treatments	Days after storage											
	Ambient temperature storage							Refrigerated storage				
	D_1	D_2	D_3	D_4	D_5	D_6	Mean	D_3	D_6	D_9	D_{12}	Mean
Precooling												
C_1	1.57	2.47	2.87	3.39	4.29	4.54	3.19[b]	2.00	2.90	4.08	4.90	3.47[c]
C_2	1.58	2.38	2.73	3.15	3.90	4.55	3.05[a]	1.88	2.75	4.03	4.78	3.36[b]
C_3	1.69	2.49	2.86	3.64	4.36	4.79	3.30[c]	1.78	2.68	3.83	4.75	3.26[a]
C_4	1.89	2.59	3.11	3.69	4.42	4.67	3.40[d]	2.30	3.10	4.45	4.95	3.70[d]
Packaging												
P_1	1.65	2.40	2.70	3.10	4.30	4.95	3.19[b]	1.65	2.60	3.55	4.65	3.11[a]
P_2	1.80	2.45	2.95	3.80	4.55	4.95	3.43[c]	1.75	2.55	3.75	4.75	3.20[a]
P_3	2.00	2.65	3.35	4.15	4.65	5.00	3.63[d]	2.20	3.10	4.45	4.95	3.68[c]
P_4	1.80	2.50	3.00	3.85	4.75	5.00	3.48[c]	2.20	2.90	4.30	4.95	3.58[c]
P_5	1.50	2.25	2.55	3.05	3.85	4.55	2.96[a]	1.70	2.70	3.80	4.60	3.20[a]
P_6	1.55	2.05	2.60	3.00	4.20	4.95	3.06[a]	1.90	2.90	4.00	4.85	3.41[b]
P_7	1.60	2.45	2.70	3.10	4.10	4.85	3.13[b]	2.20	3.05	4.50	5.00	3.69[c]
P_8	1.65	2.35	2.65	3.15	4.20	4.63	3.11[b]	2.30	3.10	4.40	5.00	3.70[c]

Contd.

Table 26b. Interaction effects

Treatments	Days after storage									
	Ambient temperature storage						Refrigerated storage			
	D_1	D_2	D_3	D_4	D_5	D_6	D_3	D_6	D_9	D_{12}
Precooling x Packaging										
C_1P_1	1.60	2.40	2.60	3.20	4.20	4.60	1.60	2.60	3.40	4.60
C_2P_1	1.80	2.40	2.60	3.00	4.20	4.80	1.60	2.60	3.60	4.60
C_3P_1	1.60	2.40	2.80	3.00	4.60	5.00	1.20	2.20	3.00	4.20
C_4P_1	1.60	2.40	2.80	3.20	4.20	4.60	2.20	3.00	4.20	5.00
C_1P_2	1.60	2.40	2.60	3.40	4.20	4.80	1.80	2.80	4.00	5.00
C_2P_2	1.60	2.20	2.60	3.00	4.40	5.00	1.60	2.60	3.80	4.60
C_3P_2	2.20	2.60	3.60	4.60	4.80	5.00	1.40	2.20	3.00	4.60
C_4P_2	1.80	2.60	3.20	4.20	4.80	5.00	2.20	2.60	4.20	4.80
C_1P_3	1.60	2.60	3.20	4.20	4.60	5.00	2.00	3.00	4.20	5.00
C_2P_3	1.80	2.40	3.20	3.80	4.60	5.00	2.40	3.00	4.60	5.00
C_3P_3	1.80	2.60	2.80	4.00	4.40	5.00	2.00	3.00	4.20	4.80
C_4P_3	2.80	3.00	4.20	4.60	5.00	5.00	2.00	3.40	4.80	5.00
C_1P_4	1.60	2.40	3.00	4.00	5.00	5.00	2.20	3.00	4.40	5.00
C_2P_4	1.60	2.40	2.80	3.00	4.00	5.00	2.60	3.00	4.40	5.00
C_3P_4	1.80	2.40	2.80	4.00	4.60	5.00	1.80	2.60	4.00	4.80
C_4P_4	2.20	2.80	3.20	4.40	5.00	5.00	2.20	3.00	4.40	5.00
C_1P_5	1.40	2.00	2.40	2.80	3.60	4.40	1.80	2.80	3.60	4.60
C_2P_5	1.40	2.20	2.60	2.80	3.00	4.20	1.40	2.40	3.00	4.40
C_3P_5	1.60	2.40	2.60	3.40	4.60	5.00	1.80	2.80	4.20	4.80
C_4P_5	1.60	2.40	2.60	3.20	4.20	4.60	1.80	2.80	4.40	4.80
C_1P_6	1.80	2.20	3.00	3.00	4.60	5.00	2.00	3.00	4.00	5.00
C_2P_6	1.40	2.00	2.60	3.00	4.00	4.80	1.60	2.60	3.80	4.80
C_3P_6	1.40	2.00	2.20	3.00	4.00	5.00	1.60	2.60	3.60	4.60
C_4P_6	1.40	2.00	2.60	3.00	4.20	5.00	2.40	3.40	4.60	5.00
C_1P_7	1.60	2.40	2.80	2.80	4.40	4.80	2.20	3.00	4.60	5.00
C_2P_7	1.40	2.40	2.60	2.80	3.40	4.60	2.00	3.00	4.60	5.00
C_3P_7	1.60	2.40	2.60	3.40	4.20	5.00	2.20	3.00	4.40	5.00

Contd.

Table 26b. (Contd.)

Treatments	Days after storage									
	Ambient temperature storage						Refrigerated storage			
	D_1	D_2	D_3	D_4	D_5	D_6	D_3	D_6	D_9	D_{12}
C_4P_7	1.80	2.60	2.80	3.40	4.40	5.00	2.40	3.00	4.40	5.00
C_1P_8	1.60	2.60	2.80	3.00	4.00	4.60	2.40	3.00	4.40	5.00
C_2P_8	1.60	2.20	2.40	3.40	3.80	4.40	2.80	2.80	4.40	5.00
C_3P_8	1.60	2.40	2.60	3.20	4.20	4.80	2.20	3.00	4.20	5.00
C_4P_8	1.80	2.20	2.80	3.00	4.20	4.60	2.80	3.60	4.60	5.00
CD for										
Precooling (C)			0.08*				0.07*			
Packaging (P)			0.14*				0.12*			
C x P			N.S				N.S			

* Significant at 5 per cent level

Five point scale for consumer acceptability

1. Acceptable fully
2. Acceptable somewhat,
3. Neither acceptable non unacceptable
4. Unacceptable somewhat
5. Not acceptable

C_1 - Precooling with tap water

C_2 - Precooling with cold water

C_3 - Precooling by contact icing

C_4 - Control

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

P_5 - Polypropylene bags of 100 gauge without ventilation

P_6 - Polypropylene bags of 200 gauge without ventilation

P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

D_1, D_2, ... D_n - 'n' Days after storage obtained for P_1 (100 gauge PE, unventilated) followed by P_2 (200 gauge PE, unventilated) and P_5 (100 gauge PP, unventilated). Treatments P_1, P_2, P_5 were equally acceptable.

With respect to interaction effects, no significant difference in consumer acceptability was observed both under ambient and refrigerated storage environments.

4.2.6 Tomato (<u>Lycopersion</u> <u>esculentum</u> Mill)

A view of tomato packaged in polymeric film is presented in Plate 17.

4.2.6.1 Physiological loss in weight

The data on the influence of precooling and packaging treatments on PLW are presented in Table 27. Among various precooling and packaging treatments significant differences were observed both under ambient and refrigerated storage environments.

With respect to ambient temperature storage, among precooling treatments, minimum PLW was recorded in C_3 (contact icing) which was significantly superior to all other treatments. Maximum PLW was recorded in C_1 (tap water).

Among packaging treatments, under ambient temperature storage, minimum PLW was recorded in P_1 (100 gauge PE,

Table 27. Influence of precooling and packaging treatments on PLW (%) in tomato

27a. Main effects

Treatments	Days after storage														
	Ambient temperature storage								Refrigerated storage						
	D_2	D_4	D_6	D_8	D_{10}	D_{12}	D_{14}	Mean	D_6	D_{12}	D_{18}	D_{24}	D_{30}	D_{36}	Mean
Precooling															
C_1	0.57	1.12	1.69	2.39	2.89	3.48	3.96	2.30^d	0.86	1.43	1.95	2.42	2.96	3.68	2.21^b
C_2	0.52	0.92	1.55	2.04	2.56	3.13	3.74	2.07^c	0.63	1.14	1.77	2.28	2.73	3.30	1.98^a
C_3	0.42	0.71	0.96	1.28	1.64	1.88	2.32	1.20^a	0.64	1.18	1.77	2.48	3.15	3.58	2.14^a
C_4	0.52	0.75	1.03	1.50	1.61	1.90	2.40	1.40^b	0.91	1.28	1.86	2.44	2.88	3.61	2.16^b
Packaging															
P_1	0.27	0.53	0.82	0.99	1.06	1.09	1.19	0.85^a	0.25	0.29	0.42	0.51	0.52	0.56	0.43^a
P_2	0.47	0.65	0.80	1.01	1.24	1.53	1.76	1.06^a	0.37	0.47	0.70	0.80	0.80	1.04	0.70^b
P_3	0.56	1.01	1.61	2.19	2.80	3.36	4.39	2.28^c	0.93	1.36	2.32	3.32	4.36	5.23	2.90^c
P_4	0.81	1.29	1.88	2.58	3.24	4.06	4.99	2.69^d	0.92	1.70	2.64	3.59	4.48	5.62	3.16^d
P_5	0.53	0.63	0.85	0.98	1.19	1.34	1.44	0.99^a	0.29	0.43	0.51	0.66	0.78	0.97	0.60^a
P_6	0.49	0.70	0.88	1.22	1.43	1.63	1.73	1.15^b	0.39	0.64	0.68	0.80	0.91	1.05	0.75^b
P_7	0.76	1.36	2.23	3.14	3.69	4.29	4.85	2.90^e	1.27	2.47	3.59	4.89	5.77	6.86	4.14^e
P_8	0.59	1.25	1.78	2.66	3.12	3.91	4.85	2.59^d	1.58	2.71	3.80	4.69	5.81	6.99	4.26^e

Contd.

Table 27b. Interaction effects

Treatments	Days after storage												
	Ambient temperature storage							Refrigerated storage					
	D_2	D_4	D_6	D_8	D_{10}	D_{12}	D_{14}	D_6	D_{12}	D_{18}	D_{24}	D_{30}	D_{36}
Precooling x Packaging													
C_1P_1	0.38	0.57	0.97	1.04	1.32	1.51	1.89	0.19	0.29	0.33	0.41	0.44	0.56
C_2P_1	0.43	0.75	1.08	1.38	1.47	1.75	2.12	0.32	0.35	0.40	0.45	0.47	0.48
C_3P_1	0.25	0.35	0.36	0.46	0.61	0.84	0.89	0.16	0.19	0.36	0.40	0.42	0.45
C_4P_1	0.02	0.32	0.37	0.39	0.62	0.69	0.99	0.32	0.39	0.58	0.76	0.76	0.76
C_1P_2	0.84	1.15	1.25	1.57	1.77	1.97	2.28	0.38	0.58	0.63	0.66	0.68	1.07
C_2P_2	0.34	0.58	0.87	1.14	1.39	1.74	1.99	0.36	0.48	0.51	0.57	0.61	0.62
C_3P_2	0.13	0.20	0.33	0.39	0.53	0.87	1.16	0.24	0.31	0.39	0.63	0.73	0.87
C_4P_2	0.59	0.67	0.76	0.92	1.27	1.52	1.60	0.70	0.71	1.42	1.44	1.46	1.82
C_1P_3	0.62	1.21	2.09	2.80	3.59	4.17	4.99	1.22	1.99	2.84	3.34	4.49	5.63
C_2P_3	0.54	0.99	1.58	2.28	3.12	4.11	5.24	5.47	3.98	2.26	3.30	4.14	4.98
C_3P_3	0.64	1.31	2.00	2.02	2.83	2.84	4.26	0.88	1.35	2.64	3.93	5.32	5.85
C_4P_3	0.43	0.55	0.76	1.64	1.66	2.34	3.11	1.16	1.18	1.55	2.72	3.49	4.46
C_1P_4	0.77	1.41	2.17	3.49	4.16	5.55	6.44	1.28	2.05	2.81	4.07	5.17	6.28
C_2P_4	0.58	1.18	2.17	2.83	3.80	4.57	5.98	5.84	3.66	3.68	3.52	4.34	5.47
C_3P_4	0.95	1.27	1.57	2.07	2.55	3.33	4.13	0.52	1.17	2.09	3.03	3.95	5.17
C_4P_4	0.94	1.28	1.80	1.92	2.46	2.78	3.43	1.07	1.92	2.99	3.75	4.48	5.58
C_1P_5	0.36	0.59	0.92	1.19	1.48	1.55	1.56	0.41	0.47	0.49	0.73	0.81	1.19
C_2P_5	0.33	0.38	0.69	0.85	1.06	1.38	1.59	0.16	0.29	0.41	0.62	0.81	1.08
C_3P_5	0.77	0.89	1.07	1.16	1.28	1.38	1.48	0.27	0.46	0.52	0.61	0.73	0.82
C_4P_5	0.64	0.65	0.72	0.73	0.97	1.05	1.11	0.31	0.55	0.62	0.70	0.72	0.78
C_1P_6	0.36	0.51	0.62	1.20	1.46	1.79	2.12	0.25	0.28	0.35	0.37	0.41	0.42
C_2P_6	0.53	0.76	1.17	1.31	1.69	1.95	1.96	0.38	0.56	0.58	0.60	0.62	0.63
C_3P_6	0.59	0.97	1.04	1.41	1.60	1.61	1.68	0.59	1.08	1.08	1.44	1.72	2.03
C_4P_6	0.49	0.58	0.68	0.96	0.97	1.15	1.16	0.25	0.42	0.57	0.59	0.65	0.90
C_1P_7	0.75	1.99	3.58	4.77	5.59	6.53	7.04	1.58	2.39	3.79	4.89	5.85	7.10
C_2P_7	0.72	1.44	2.81	3.70	4.38	5.21	5.75	1.09	2.41	3.61	4.95	5.91	7.11
C_3P_7	0.98	1.09	1.10	1.59	2.24	2.58	3.07	0.89	2.37	3.59	5.08	6.06	7.06

Contd.

Table 27b. (Contd.)

Treatments	Days after storage												
	Ambient temperature storage							Refrigerated storage					
	D_2	D_4	D_6	D_8	D_{10}	D_{12}	D_{14}	D_6	D_{12}	D_{18}	D_{24}	D_{30}	D_{36}
C_4P_7	0.59	0.91	1.43	2.51	2.55	2.85	3.52	1.53	2.74	3.38	4.62	5.24	6.18
C_1P_8	0.51	1.54	1.95	3.09	3.75	4.72	5.37	1.57	1.42	4.27	4.82	5.82	7.18
C_2P_8	0.72	1.32	2.04	2.88	3.60	4.32	5.28	1.46	2.45	3.75	4.24	4.96	6.00
C_3P_8	2.65	1.07	1.49	2.36	2.79	3.67	4.08	1.40	2.60	3.52	4.73	4.14	7.11
C_4P_8	0.47	1.06	1.85	2.29	2.35	2.93	4.68	1.90	2.37	3.67	5.00	6.30	7.61

CD for	Ambient temperature storage	Refrigerated storage
Precooling (C)	0.17	0.16
Packaging (P)	0.25	0.24
C x P	NS	NS

* Significant at 5 per cent level

	Ambient temperature storage	Refrigerated storage
Mean temperature during experiment period		
Maximum temperature	32.1°C	12.4°C
Minimum temperature	28.4°C	8.9°C
Mean relative humidity during experiment period	82.8%	60.5%

C_1 - Precooling with tap water

C_2 - Precooling with cold water

C_3 - Precooling by contact icing

C_4 - Control

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

P_5 - Polypropylene bags of 100 gauge without ventilation

P_6 - Polypropylene bags of 200 gauge without ventilation

P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

D_2, D_4, ... D_n - 'n' Days after storage unventilated) which was on par with P_5 (100 gauge PP, unventilated) and P_2 (100 gauge PE, unventilated). PLW was maximum in P_7 (100 gauge PP, ventilated).

With regard to refrigerated storage, among precooling treatments, PLW was minimum in C_2 (cold water) and C_3 (contact icing). Treatments C_2 and C_3 were on par. Maximum PLW was recorded in C_1 (tap water) which was on par with C_4 (control).

Among packaging treatments, under refrigerated storage, minimum PLW was recorded in P_1 (100 gauge PE, unventilated) which was on par with P_5 (100 gauge PP, unventilated). PLW was maximum in P_8 (200 gauge PP, ventilated) followed by P_7 (100 gauge PP, ventilated). Treatments P_8 and P_7 were on par with each other.

The interaction of precooling and packaging had no significant effect both under ambient and refrigerated storage environments.

4.2.6.2 Unmarketability

Data on unmarketability as influenced by precooling and packaging treatments are presented in Table 28. Type of spoilage leading to unmarketability of the packaged tomato are presented in Plate 18. Precooling and packaging treatments

Table 28. Influence of precooling and packaging treatments on unmarketability (%) in tomato

28a. Main effects

Treatments	Days after storage					
	Ambient temperature storage			Refrigerated storage		
	D_{12}	D_{14}	Mean	D_{30}	D_{36}	Mean
Precooling						
C_1	34.13 (35.94)	65.50 (54.55)	49.81[c] (45.02)	39.38 (38.73)	71.38 (58.42)	55.38[c] (48.57)
C_2	34.00 (35.32)	62.63 (52.84)	48.31[c] 44.08)	26.80 (30.20)	57.13 (49.37)	41.99[a] (39.79)
C_3	4.63 (7.61)	24.50 (29.33)	14.56[a] 18.47)	26.45 (30.01)	53.60 (47.18)	40.04[a] (38.60)
C_4	10.86 (13.78)	25.26 (29.90)	18.06[b] (21.84)	28.88 (32.35)	57.75 (49.59)	43.31[b] (40.97)
Packaging						
P_1	21.25 (22.39)	49.50 (44.77)	35.40[b] (33.58)	23.50 (28.85)	49.25 (44.59)	36.38[b] (36.72)
P_2	22.25 (24.29)	47.50 (43.63)	34.88[b] (33.96)	37.50 (37.63)	68.50 (56.35)	53.00[e] (46.99)
P_3	16.00 (18.34)	38.25 (36.84)	27.13[a] (27.59)	19.50 (24.75)	47.25 (43.42)	33.38[a] (34.08)
P_4	16.75 (19.79)	39.00 (38.18)	27.88[a] (28.99)	26.25 (30.66)	54.00 (47.37)	40.13[c] (39.02)
P_5	21.50 (23.71)	48.75 (44.64)	35.13[b] (34.17)	37.45 (37.76)	72.45 (58.91)	54.95[f] (48.34)
P_6	21.50 (23.60)	49.25 (44.69)	35.38[b] (33.64)	37.25 (37.46)	67.00 (55.76)	52.13[e] (46.61)
P_7	20.75 (21.88)	46.00 (42.52)	33.38[b] (32.20)	33.50 (35.31)	65.00 (53.92)	49.25[d] (44.61)
P_8	13.50 (17.69)	35.50 (36.01)	24.50[a] (26.85)	28.25 (31.91)	56.50 (49.00)	42.38[c] (40.54)

Table 28b. Interaction effects

Treatments	Days after storage			
	Ambient temperature storage		Refrigerated storage	
	D_{12}	D_{14}	D_{30}	D_{36}
Precooling x Packaging				
C_1P_1	39.00 (38.55)	77.00 (61.93)	30.00 (33.17)	57.00 (49.10)
C_2P_1	38.00 (38.02)	68.00 (55.67)	21.00 (27.20)	49.00 (44.44)
C_3P_1	3.00 (4.66)	22.00 (27.69)	22.00 (27.95)	44.00 (42.54)
C_4P_1	5.00 (8.33)	31.00 (33.76)	21.00 (27.02)	47.00 (43.29)
C_1P_2	46.00 (42.69)	81.00 (64.36)	54.00 (47.33)	85.00 (67.36)
C_2P_2	28.00 (31.64)	55.00 (48.00)	30.00 (33.17)	59.00 (50.25)
C_3P_2	10.00 (14.49)	30.00 (33.01)	33.00 (35.02)	65.00 (53.93)
C_4P_2	5.00 (8.33)	24.00 (29.14)	33.00 (35.01)	65.00 (53.85)
C_1P_3	32.00 (34.34)	64.00 (53.39)	28.00 (31.94)	58.00 (49.67)
C_2P_3	29.00 (32.53)	55.00 (47.92)	8.00 (12.86)	37.00 (37.42)
C_3P_3	1.00 (3.79)	19.00 (20.78)	19.00 (28.45)	45.00 (44.45)
C_4P_3	2.00 (2.69)	15.00 (25.75)	23.00 (25.75)	49.00 (42.12)
C_1P_4	29.00 (32.32)	58.00 (49.88)	33.00 (34.98)	66.00 (54.42)
C_2P_4	32.00 (34.16)	58.00 (50.05)	23.00 (28.53)	51.00 (45.60)
C_3P_4	3.00 (6.35)	20.00 (26.44)	23.00 (28.53)	47.00 (43.28)
C_4P_4	3.00 (6.35)	20.00 (26.33)	26.00 (30.61)	52.00 (46.18)
C_1P_5	23.00 (28.34)	50.00 (45.04)	11.00 (39.76)	76.00 (61.37)
C_2P_5	49.00 (44.45)	86.00 (68.12)	11.00 (39.82)	79.00 (63.22)
C_3P_5	5.00 (8.33)	26.00 (30.42)	32.00 (34.40)	62.00 (52.08)
C_4P_5	9.00 (13.73)	33.00 (34.97)	15.00 (36.27)	72.00 (58.18)
C_1P_6	40.00 (39.01)	71.00 (58.20)	6.00 (48.49)	88.00 (70.44)
C_2P_6	36.00 (36.76)	67.00 (55.19)	29.00 (32.56)	56.00 (48.50)
C_3P_6	7.00 (9.95)	32.00 (34.29)	1.00 (33.72)	61.00 (51.51)
C_4P_6	3.00 (4.66)	27.00 (31.06)	3.00 (35.07)	63.00 (52.60)
C_1P_7	34.00 (35.60)	64.00 (53.34)	37.00 (37.40)	71.00 (57.57)
C_2P_7	43.00 (40.89)	73.00 (59.17)	36.00 (36.86)	71.00 (57.62)
C_3P_7	4.00 (7.22)	26.00 (30.42)	31.00 (33.76)	60.00 (50.86)

Contd.

Table 28b (Contd.)

Treatments	Days after storage			
	Ambient temperature storage		Refrigerated storage	
	D_{12}	D_{14}	D_{30}	D_{36}
C_4P_7	2.00 (3.79)	21.00 (27.13)	30.00 (33.20)	58.00 (49.65)
C_1P_8	30.00 (33.09)	59.00 (50.26)	36.00 (36.74)	70.00 (57.43)
C_2P_8	17.00 (24.13)	39.00 (38.59)	26.00 (30.61)	55.00 (47.92)
C_3P_8	4.00 (7.22)	21.00 (26.64)	21.00 (27.19)	45.00 (43.12)
C_4P_8	3.00 (6.35)	23.00 (28.53)	30.00 (33.07)	56.00 (48.54)
CD for				
Precooling (C)	3.08		1.97	
Packaging (P)	4.32		2.74	
C x P	N.S		N.S	

* Significant at 5 per cent level

	Ambient	Refrigerated
Mean temperature during experiment period		
Maximum temperature	32.1°C	12.4°C
Minimum temperature	28.4°C	8.9°C
Mean relative humidity during experiment period	82.8%	60.5%

C_1 - Precooling with tap water

C_2 - Precooling with cold water

C_3 - Precooling by contact icing

C_4 - Control

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

P_5 - Polypropylene bags of 100 gauge without ventilation

P_6 - Polypropylene bags of 200 gauge without ventilation

P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

D_{12}, D_{14}, ... D_n - 'n' Days after storage

* Figures in bracket indicates transformed values

different significantly both under ambient and refrigerated storage environment.

Minimum unmarketability, among precooling treatments, under ambient temperature storage was recorded in C_3 (contact icing). Maximum unmarketability was recorded in C_1 (tap water) which was on par with C_2 (cold water).

Among packaging treatments, under ambient temperature storage, Minimum unmarketability was recorded in P_8 (200 gauge PP, ventilated) which was on par with P_3 (100 gauge PE, ventilated) and P_4 (200 gauge PE, ventilated). Maximum unmarketability was recorded for the rest of the five treatments viz. P_1, P_2, P_5, P_6, P_7 which were all on par.

With respect to refrigerated storage, minimum unmarketability, among precooling treatments was recorded in C_3 (contact icing) which was on par with C_2 (cold water). Maximum unmarketability was recorded in C_1 (tap water).

Among packaging treatments, under refrigerated storage, minimum unmarketability was recorded in P_3 (100 gauge PE, ventilated). Maximum unmarketability was recorded in P_5 (100 gauge PP, unventilated).

The interaction of precooling and packaging had no

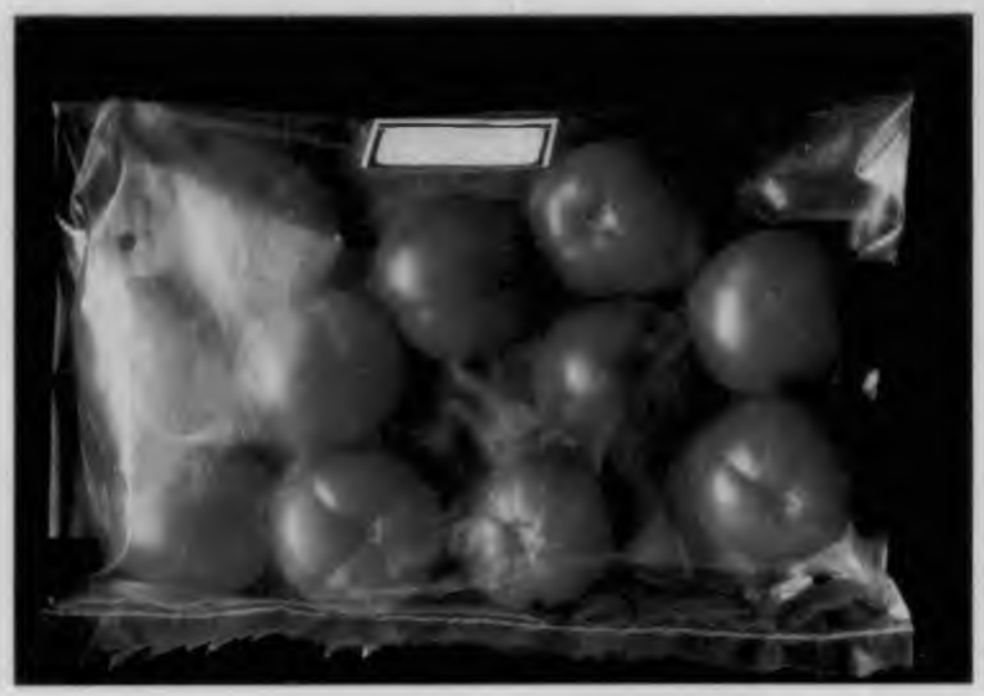


Plate 17. Tomato packaged in polymeric films

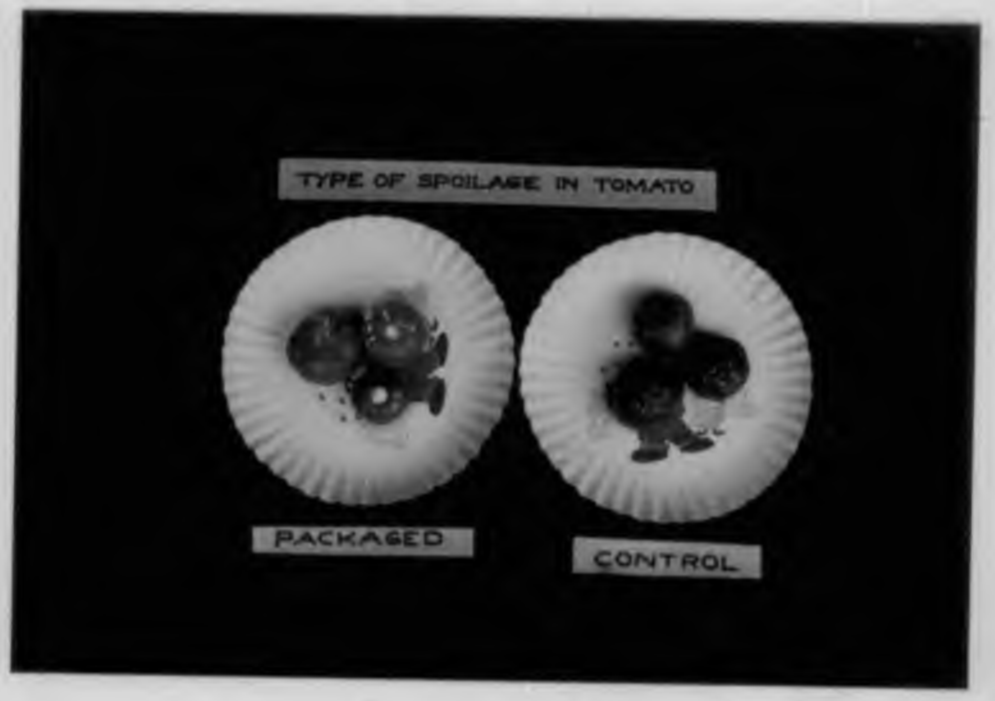


Plate 18. Type of spoilage in tomato

significant effect both under ambient and refrigerated storage environments.

4.2.6.3 Length of storage life

Data on storage life as influenced by precooling and packaging treatments are presented in Table 29. Significant difference in shelf life was observed among precooling and packaging treatments both under ambient and refrigerated storage environments.

Maximum shelf life among precooling treatments, under ambient temperature storage, was obtained for C_3 (contact icing). Minimum shelf life was recorded in C_1 (tap water).

Among packaging treatments, under ambient temperature storage, maximum shelf life was recorded in P_8 (200 gauge PP, ventilated) which was on par with P_3 (100 gauge PE, ventilated) and P_4 (200 gauge PE, ventilated). Minimum shelf life was recorded in P_1 (100 gauge PE, unventilated) followed by P_2 (200 gauge PE, unventilated) and P_6 (200 gauge PP, unventilated). Treatments P_1, P_2 and P_6 were on par with each other.

With respect to refrigerated storage, among precooling treatments, maximum shelf life was recorded in C_3 (contact

Table 29. Storage life (days) of tomato as influenced by precooling and packaging treatments

Precooling x Packaging	Ambient temperature storage					Refrigerated storage				
	C_1	C_2	C_3	C_4	Mean	C_1	C_2	C_3	C_4	Mean
P_1	8.80	8.60	12.20	11.60	10.30[c]	24.40	27.80	27.80	27.00	26.75[b]
P_2	8.60	9.00	12.00	11.60	10.30[c]	21.60	26.00	25.80	25.40	24.70[c]
P_3	9.20	9.60	12.80	12.60	11.05[a]	25.20	29.40	27.80	27.60	27.80[a]
P_4	9.40	9.20	12.60	12.60	10.95[a]	24.20	27.00	27.40	26.80	26.35[b]
P_5	9.60	8.40	12.00	11.40	10.35[b]	23.20	23.40	25.40	25.00	24.25[d]
P_6	8.60	9.40	11.20	12.00	10.30[c]	21.60	26.20	25.80	25.40	24.75[c]
P_7	9.20	9.20	12.40	12.00	10.70[b]	24.60	24.40	25.80	25.80	25.00[c]
P_8	9.40	10.40	12.20	12.40	11.10[a]	24.20	27.00	27.40	26.80	26.35[b]
Mean	9.10[d]	9.23[c]	12.18[a]	12.05[b]		23.62[c]	26.40[a]	26.65[a]	26.23[b]	
CD for										
Precooling (C)			0.10*				0.31*			
Packaging (P)			0.39*				0.44*			
C x P			N.S				N.S			

* Significant at 5 per cent level

	Ambient temperature storage	Refrigerated storage
Mean storage life of control samples	4.8 days	11.0 days
Mean temperature during experiment period		
Maximum temperature	32.1°C	12.4°C
Minimum temperature	28.4°C	8.9°C
Mean relative humidity during experiment period	82.8%	60.5%

C_1 - C_4 - Precooling treatments

P_1 - P_8 - Packaging treatments

icing) which was on par with C_2 (cold water). Minimum shelf life was recorded in C_1 (tap water).

Maximum shelf life among packaging treatments under refrigerated storage was recorded in P_3 (100 gauge PE, ventilated) which was significantly superior to all other treatments. Minimum shelf life was recorded in P_5 (100 gauge PP, unventilated).

The interaction of precooling and packaging treatments had no significant effect both under ambient and refrigerated storage environments.

4.2.6.4 Consumer acceptability

Results of the consumer acceptability rating of the precooled produce in different packages are presented in Table 30. Significant variation in acceptability was observed among various precooling and packaging treatments both under ambient and refrigerated storage environment.

Tomatoes precooled by contact icing method (C_3) and packaged in ventilated 100 gauge PE (P_3) were rated as the best precooling and packaging treatment both under ambient and refrigerated storage environments.

Table 30. Consumer acceptability of tomato as influenced by precooling and packaging treatments

30a. Main effects

Treatments	Days after storage														
	Ambient temperature storage								Refrigerated storage						
	D_2	D_4	D_6	D_8	D_{10}	D_{12}	D_{14}	Mean	D_6	D_{12}	D_{18}	D_{24}	D_{30}	D_{36}	Mean
Precooling															
C_1	1.70	2.08	2.55	2.98	3.88	4.50	4.90	3.23^c	1.50	2.25	2.85	3.35	4.55	5.00	3.32^c
C_2	1.68	2.20	2.60	2.90	3.78	4.40	4.85	3.20^c	1.58	2.15	2.63	3.08	4.10	4.93	3.07^b
C_3	1.63	2.10	2.35	2.63	3.00	3.43	4.35	2.80^a	1.53	2.03	2.45	3.00	4.10	4.88	3.00^a
C_4	1.68	2.28	2.53	2.65	3.03	3.40	4.55	2.88^b	1.68	2.00	2.63	3.05	4.10	5.00	3.08^b
Packaging															
P_1	1.65	2.10	2.45	2.75	3.50	4.05	4.75	3.05^c	1.65	2.05	2.60	3.00	4.20	4.95	3.06^b
P_2	1.55	1.95	2.60	2.90	3.60	4.25	4.75	3.09^c	1.75	2.20	2.80	3.30	4.40	5.00	3.24^d
P_3	1.50	2.00	2.25	2.65	3.30	3.65	4.45	2.82^a	1.55	2.00	2.30	3.00	3.85	4.75	2.90^a
P_4	1.75	2.10	2.50	2.75	3.25	3.70	4.60	2.95^b	1.65	1.95	2.60	3.00	4.10	4.95	3.04^b
P_5	1.75	2.20	2.50	2.80	3.40	4.10	4.75	3.07^c	1.75	2.30	2.90	3.25	4.40	5.00	3.27^d
P_6	1.80	2.20	2.45	2.90	3.45	4.05	4.70	3.08^c	1.30	2.25	2.70	3.25	4.35	4.95	3.22^d
P_7	1.65	2.10	2.40	2.80	3.40	3.85	4.70	2.99^b	1.75	2.10	2.70	3.05	4.20	5.00	3.13^c
P_8	1.70	2.10	2.35	2.75	3.20	3.80	4.60	2.94^b	1.55	2.00	2.50	3.05	4.15	4.95	3.03^b

Contd.

Table 30b. Interaction effects

Treatments	Days after storage												
	Ambient temperature storage							Refrigerated storage					
	D_2	D_4	D_6	D_8	D_{10}	D_{12}	D_{14}	D_6	D_{12}	D_{18}	D_{24}	D_{30}	D_{36}
Precooling x Packaging													
C_1P_1	1.40	2.00	2.40	2.60	4.00	4.40	5.00	1.80	2.20	3.00	3.00	4.60	5.00.
C_2P_1	2.00	2.40	2.80	3.00	4.20	4.60	5.00	1.40	2.00	2.60	3.00	4.00	4.80
C_3P_1	1.60	2.00	2.00	2.40	2.80	3.20	4.20	1.40	2.00	2.20	3.00	4.00	5.00
C_4P_1	1.60	2.00	2.60	3.00	3.00	4.00	4.80	1.60	2.00	2.60	3.00	4.20	5.20
C_1P_2	1.40	1.80	2.80	3.20	4.40	5.00	5.00	2.00	2.40	3.00	4.00	5.00	5.00
C_2P_2	1.60	2.20	2.80	3.00	4.00	4.60	5.00	1.60	2.20	2.80	3.00	4.40	5.00
C_3P_2	1.60	2.00	2.40	2.60	3.00	3.80	4.40	1.60	2.20	2.60	3.00	4.20	5.00
C_4P_2	1.60	1.80	2.40	2.80	3.00	3.60	4.60	1.80	2.00	2.80	3.00	4.00	5.00
C_1P_3	1.60	1.80	2.40	2.80	3.60	4.40	5.00	1.80	2.00	2.40	3.00	4.20	5.00
C_2P_3	1.60	2.20	2.60	3.00	3.80	4.20	4.60	1.40	2.00	2.20	2.80	4.00	4.00
C_3P_3	1.40	2.00	2.00	2.40	2.80	3.00	4.00	1.40	2.00	2.20	2.80	3.80	4.40
C_4P_3	1.40	2.00	2.00	2.40	3.00	3.00	4.20	3.60	2.00	2.40	3.00	4.00	4.80
C_1P_4	1.60	1.80	2.40	2.80	3.60	4.40	4.80	2.20	2.00	2.80	3.00	4.20	5.00
C_2P_4	1.80	2.60	2.80	3.00	3.80	4.40	4.80	1.60	2.00	2.60	3.00	4.20	5.00
C_3P_4	1.60	2.00	2.40	2.60	2.80	3.00	4.20	1.40	1.80	2.40	3.00	4.00	4.80
C_4P_4	2.00	2.00	2.40	2.60	2.80	3.00	4.60	1.60	2.00	2.60	3.00	4.00	5.00
C_1P_5	1.80	2.40	2.40	3.00	3.60	4.40	4.80	1.80	2.40	3.00	3.40	4.10	5.00
C_2P_5	1.60	2.20	2.60	2.80	4.00	4.60	5.00	1.80	2.60	3.00	3.60	4.80	5.00
C_3P_5	1.60	2.00	2.40	2.60	3.00	3.60	4.40	1.60	2.70	2.80	1.00	4.20	5.00
C_4P_5	2.00	2.20	2.60	2.80	3.00	3.80	4.80	1.80	2.00	2.80	3.00	4.20	5.00
C_1P_6	1.80	2.20	2.60	3.20	4.00	4.80	5.00	2.20	2.80	3.00	4.00	5.00	5.00
C_2P_6	1.60	2.20	2.60	3.00	3.80	4.40	5.00	1.60	2.20	2.40	3.00	4.20	5.00
C_3P_6	2.00	2.40	2.60	2.80	3.00	3.60	4.40	1.60	2.00	2.60	3.00	4.20	4.80
C_4P_6	1.80	2.00	2.00	2.60	3.00	3.80	4.40	1.80	2.00	2.80	1.00	4.00	5.00
C_1P_7	2.20	2.40	2.80	3.20	3.80	4.20	4.80	1.80	2.20	2.80	3.20	4.40	5.00
C_2P_7	1.70	2.00	2.40	2.80	3.80	4.40	4.80	1.80	2.20	2.80	3.00	4.20	5.00
C_3P_7	1.40	2.00	2.40	2.80	3.00	3.60	4.80	1.80	2.00	2.60	3.00	4.20	5.00

Contd.

Table 30b. (Contd.)

Treatments	Days after storage												
	Ambient temperature storage							Refrigerated storage					
	D_2	D_4	D_6	D_8	D_{10}	D_{12}	D_{14}	D_6	D_{12}	D_{18}	D_{24}	D_{30}	D_{36}
C_4P_7	1.40	2.00	2.00	2.40	1.00	3.00	4.40	1.60	2.00	2.60	3.00	4.00	5.00
C_1P_8	1.80	2.20	2.60	3.00	4.00	4.60	4.80	1.80	2.00	2.80	3.20	4.60	5.00
C_2P_8	1.60	1.80	2.20	2.60	2.80	4.00	4.60	1.40	2.00	2.60	3.00	4.00	5.00
C_3P_8	1.80	2.40	2.60	2.80	3.00	3.60	4.40	1.40	1.00	2.20	3.00	4.00	4.80
C_4P_8	1.60	2.00	2.00	2.60	3.00	3.00	4.60	1.60	2.00	2.40	3.00	4.00	5.00

CD for	Ambient temperature storage	Refrigerated storage
Precooling (C)	0.06*	0.05*
Packaging (P)	0.10*	0.08*
C x P	N.S	N.S

* Significant at 5 per cent level

Five point scale for consumer acceptability

1. Acceptable fully
2. Acceptable somewhat,
3. Neither acceptable non unacceptable
4. Unacceptable somewhat
5. Not acceptable

C_1 - Precooling with tap water

C_2 - Precooling with cold water

C_3 - Precooling by contact icing

C_4 - Control

P_1 - Polyethylene bags of 100 gauge without ventilation

P_2 - Polyethylene bags of 200 gauge without ventilation

P_3 - P_1 with 0.5 per cent ventilation

P_4 - P_2 with 0.5 per cent ventilation

P_5 - Polypropylene bags of 100 gauge without ventilation

P_6 - Polypropylene bags of 200 gauge without ventilation

P_7 - P_5 with 0.5 per cent ventilation

P_8 - P_6 with 0.5 per cent ventilation

D_2, D_4, ... D_n - 'n' Days after storage

The interaction of precooling and packaging indicated no significant effect on consumer acceptability both under ambient and refrigerated storage environments.

4.3 Effect of portion packaging of large sized vegetables

Effect of various portion packaging treatments on precooled vegetables were studied in ashgourd, elephant foot yam, oriental pickling melon, pumpkin and snakegourd. Daily observations were taken on PLW, unmarketability and consumer acceptability. For the convenience of statistical analysis and mean value of the observations for two days and three days were used respectively under ambient and refrigerated storage environment in various treatments. Salient results of the experiment are given below.

4.3.1 Ashgourd (*Benincasa hispida* (Thunb.) Cogn.)

A view of ashgourd portion packaged in polymeric films are presented in Plate 19.

4.3.1.1 Physiological loss in weight

Data on PLW as influenced by portion packaging treatments are presented in Table 31. Significant difference among treatments were observed both under ambient and refrigerated storage environments.

Table 31. Effect of portion packaging treatments on PLW (%) in ashgourd

Treatments	Days after storage								
	Ambient temperature storage				Refrigerated storage				
	D_2	D_4	D_6	Mean	D_3	D_6	D_9	D_{12}	Mean
T_1	0.43	0.68	1.49	0.87[b]	0.41	0.52	0.96	1.15	0.75[c]
T_2	0.65	0.88	0.93	0.83[b]	0.21	0.29	0.39	0.52	0.35[b]
T_3	0.56	0.68	0.79	0.68[b]	0.05	0.08	0.12	0.13	0.09[a]
T_4	0.39	0.45	0.49	0.45[a]	0.08	0.16	0.27	0.51	0.26[b]
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	D_4	Mean
T_5	8.74	13.83	16.14	12.90	6.32	10.15	15.06	18.13	12.42
T_6	7.90	12.80	16.10	12.27	4.63	9.35	13.84	17.10	11.23
CD									
$T_1 - T_4$			0.22*			0.11*			
$T_5 - T_6$			N.S			N.S			

* Significant at 5 per cent level

	Ambient	Refrigerated
Mean temperature during experiment period		
Maximum temperature	33.4°C	11.6°C
Minimum temperature	27.6°C	8.9°C
Mean relative humidity during experiment period	78.2%	61.4%

T_1 - Portion packaging in PE

T_2 - Portion packaging in PP

T_3 - Precooling + portion packaging in PE

T_4 - Precooling + Portion packaging in PP

T_5 - Portioned but not packaged (control)

T_6 - Precooled and portioned but not packaged (Control)

D_1, D_2 .... D_n - 'n' Days after storage

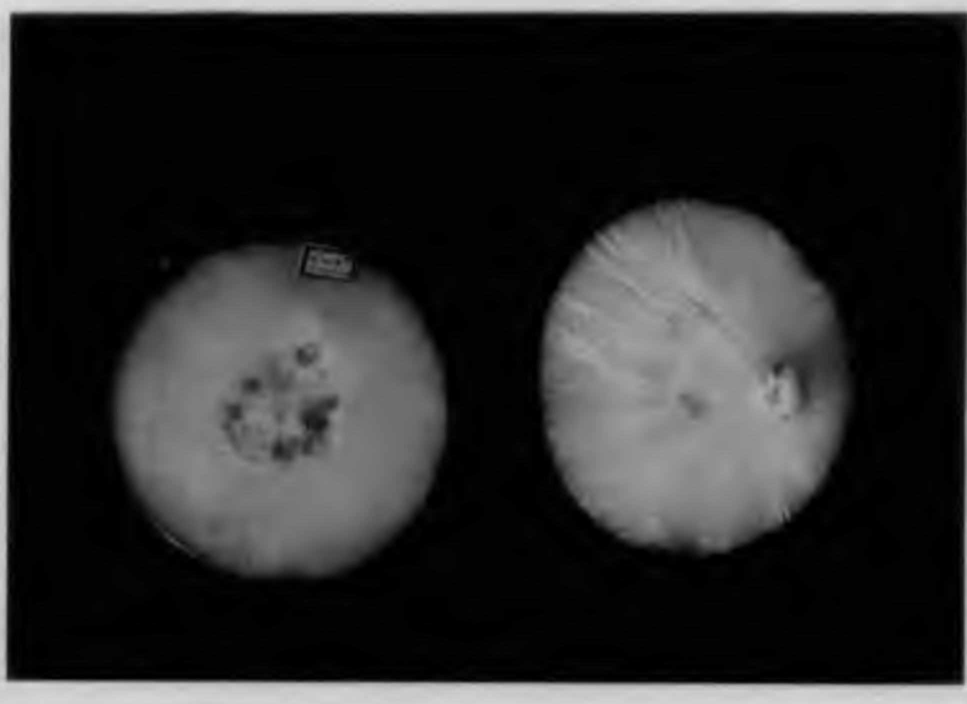


Plate 19. Portioned ashgourd packaged in polymeric films

In the case of ambient temperature storage, minimum PLW was recorded in T_4 (precooled and portion packaged in 100 gauge PP). PLW was maximum in both the control samples (T_5 and T_6) and there was no significant difference between them.

With respect to refrigerated storage, PLW was minimum in T_3 (precooled and portion packaged in PE). Maximum PLW was recorded in control (T_5 and T_6) where no significant difference was observed between them.

4.3.1.2 Unmarketability

Data on unmarketability as influenced by portion packaging treatments are presented in Table 32. Type of spoilage leading to unmarketability of the portion packaged produce are presented in Plates 20 and 21. Significant difference in unmarketability was observed among various treatments both under ambient and refrigerated storage environments.

Among various treatments, under ambient temperature storage, unmarketability was minimum in T_3 (precooled and portion packaged in PE) which was on par with T_4 (precooled and portion packaged in PP). Unmarketability was maximum in both the control samples (T_5 and T_6) where no significant difference was observed between them.

Table 32. Effect of portion packaging treatments on unmarketability (%) in ashgourd

Treatments	Days after storage					
	Ambient temperature storage			Refrigerated storage		
	D_4	D_6	Mean	D_9	D_{12}	Mean
T_1	1.00 (2.58)	21.00 (26.95)	11.00 b (14.78)	1.00 (2.58)	15.00 (22.49)	8.00 b (12.56)
T_2	1.00 (2.58)	20.00 (25.45)	10.50 b (14.02)	1.00 (2.58)	23.00 (28.51)	12.00 c (15.55)
T_3	0.50 (1.29)	10.00 (16.51)	5.30 a (8.90)	0.50 (1.29)	10.00 (16.51)	5.30 a (8.90)
T_4	1.00 (2.58)	11.00 (19.07)	6.00 a (10.83)	1.00 (2.58)	12.00 (19.94)	6.50 a (11.20)
	D_2	D_3	Mean	D_3	D_4	Mean
T_5	20.00 (26.44)	60.00 (50.60)	40.00 (38.52)	15.00 (25.46)	35.00 (36.01)	25.00 (30.74)
T_6	16.00 (23.14)	50.00 (45.02)	33.00 (34.08)	10.00 (17.28)	30.00 (33.17)	20.00 (25.23)
CD						
$T_1 - T_4$		4.29*		2.68*		
$T_5 - T_6$		N.S		N.S		

* Significant at 5 per cent level

Mean temperature during experiment period		
Maximum temperature	33.4°C	11.6°C
Minimum temperature	27.6°C	8.9°C
Mean relative humidity during experiment period	78.2%	61.4%

T_1 - Portion packaging in PE

T_2 - Portion packaging in PP

T_3 - Precooling + portion packaging in PE

T_4 - Precooling + Portion packaging in PP

T_5 - Portioned but not packaged (control)

T_6 - Precooled and portioned but not packaged (Control)

D_2, D_3 .... D_n - 'n' Days after storage

Figures in bracket indicates transformed values

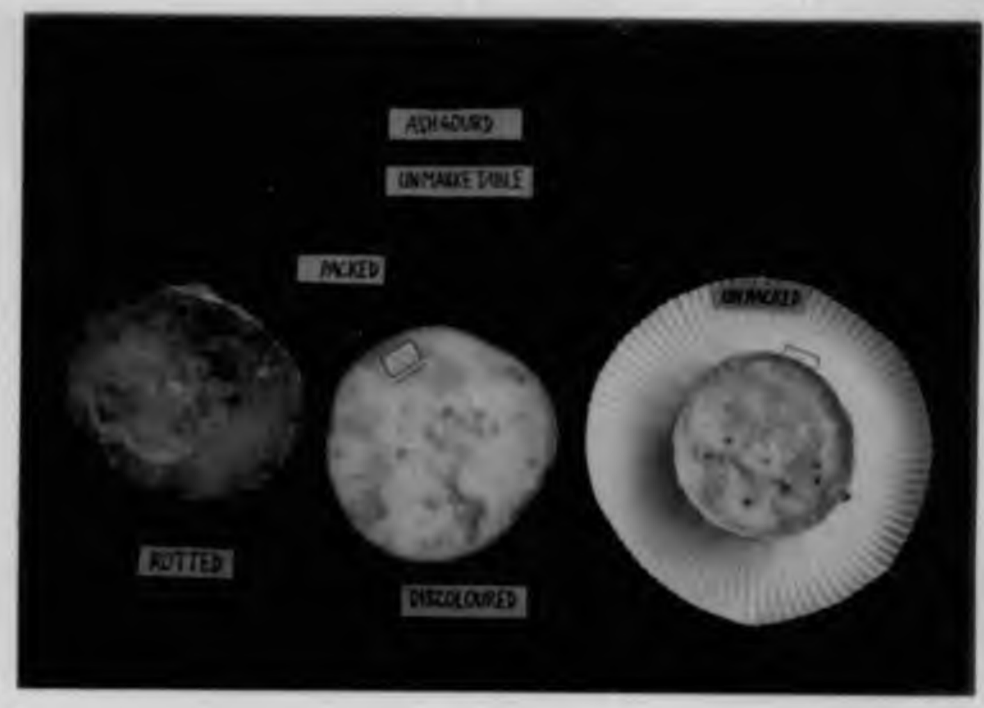


Plate 20. Type of spoilage in portion packaged ashgourd under ambient temperature storage

Plate 21. Type of spoilage in portion packaged ashgourd under refrigerated storage

Table 33. Consumer acceptability of ashgourd as influenced by portion packaging treatments

Treatments	Days after storage								
	Ambient temperature storage				Refrigerated storage				
	D_2	D_4	D_6	Mean	D_3	D_6	D_9	D_{12}	Mean
T_1	3.00	3.00	4.45	3.48	1.50	2.20	3.00	4.60	2.82
T_2	2.80	3.00	4.60	3.40	1.40	2.20	3.00	4.20	2.70
T_3	2.80	3.00	3.80	3.20	1.10	2.00	3.00	4.20	2.60
T_4	2.60	3.00	4.40	3.33	1.20	2.00	3.00	4.40	2.65
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	D_4	Mean
T_5	3.00	4.60	5.00	4.20	2.80	3.60	4.60	5.00	4.00
T_6	3.00	4.40	4.80	4.10	2.60	3.00	4.20	4.80	3.65
CD									
$T_1 - T_4$			N.S			N.S			
$T_5 - T_6$			N.S			N.S			

Five point scale for consumer acceptability

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

T_1 - Portion packaging in PE

T_2 - Portion packaging in PP

T_3 - Precooling + portion packaging in PE

T_4 - Precooling + Portion packaging in PP

T_5 - Portioned but not packaged (control)

T_6 - Precooled and portioned but not packaged (Control)

D_1, D_2 .... D_n - 'n' Days after storage

With respect to refrigerated storage, unmarketability was minimum recorded in T_3 (precooled and portion packaged in PE) which was on par with T_4 (precooled and portion packaged in PP). Maximum unmarketability was recorded in both the control samples (T_5 and T_6) where no significant difference was observed between them.

4.3.1.3 Consumer acceptability

Results of the consumer acceptability rating of the portion packaged produce are presented in Table 33.

Eventhough higher acceptability was recorded for portion packaged samples, no significant difference was observed between packaged and control samples under both the ambient and refrigerated storage environments.

4.3.2 Elephant foot yam (Amorphophallus campanulatus Blume ex Decne)

A view of elephant foot yam portion packaged in polymeric films are presented in Plate 22.

4.3.2.1 Physiological loss in weight

The data on the influence of portion packaging treatments on PLW are presented in Table 34.

Table 34. Effect of portion packaging treatments on PLW (%) in elephant foot yam

Treatments	Days after storage										
	Ambient temperature storage					Refrigerated storage					
	D_2	D_4	D_6	D_8	Mean	D_3	D_6	D_9	D_{12}	D_{15}	Mean
T_1	0.46	0.81	1.32	1.38	0.99	0.38	0.46	0.48	0.49	0.53	0.47[b]
T_2	0.89	0.96	1.10	1.30	1.06	0.55	0.61	0.68	0.76	0.83	0.69[c]
T_3	0.39	0.83	1.22	1.28	0.93	0.36	0.39	0.45	0.47	0.51	0.44[b]
T_4	0.52	0.80	0.86	0.91	0.77	0.26	0.28	0.31	0.33	0.36	0.31[a]
	D_1	D_2	D_3	D_4	Mean	D_1	D_2	D_3	D_4	D_5	Mean
T_5	13.68	18.02	22.92	27.81	20.61	9.42	13.89	16.77	18.56	21.32	15.99
T_6	13.41	15.88	20.94	25.80	19.10	5.37	8.89	12.89	15.81	18.72	12.34
CD											
$T_1 - T_4$				N.S				0.08*			
$T_5 - T_6$				N.S				N.S			

* Significant at 5 per cent level

Mean temperature during experiment period

	Ambient	Refrigerated
Maximum temperature	32.2°C	11.2°C
Minimum temperature	28.6°C	8.9°C
Mean relative humidity during experiment period	82.4%	60.4%

T_1 - Portion packaging in PE

T_2 - Portion packaging in PP

T_3 - Precooling + portion packaging in PE

T_4 - Precooling + Portion packaging in PP

T_5 - Portioned but not packaged (control)

T_6 - Precooled and portioned but not packaged (Control)

D_1, D_2 .... D_n - 'n' Days after storage

Plate 22. Elephant foot yam portioned and packaged in polymeric films

Plate 23. Type of spoilage in portion packaged elephant foot yam

Significant difference between treatments were observed only under refrigerated storage. Minimum PLW was recorded in T_4 (precooled and portion packaged in PP). PLW was maximum in both the control samples (T_5 and T_6) where no significant difference was observed between them.

4.3.2.2 Unmarketability

Data on the effect of portion packaging treatments on unmarketability are presented in Table 35. Type of spoilage leading to unmarketability of the portion packaged produce is presented in Plate 23.

With respect to unmarketability, significant differences between treatments was observed only under refrigerated storage with minimum unmarketability being recorded in T_4 (precooled and portion packaged in PP) and T_3 (precooled and portion packaged in PE). Effect of treatments T_4 and T_3 were on par. Maximum unmarketability was recorded in control samples (T_5 and T_6) where no significant difference was observed between them.

4.3.2.3 Consumer acceptability

Results of the consumer acceptability rating of the portion packaged produce are presented in Table 36.

Table 35. Effect of portion packaging treatments on unmarketability (%) in elephant foot yam

Treat-ments	Days after storage					
	Ambient temperature storage			Refrigerated storage		
	D_6	D_8	Mean	D_{12}	D_{15}	Mean
T_1	0.50 (0.65)	11.00 (15.18)	5.75 (7.92)	17.00 (24.11)	41.00 (39.76)	29.00[c] (31.95)
T_2	0.50 (0.65)	11.50 (17.24)	6.00 (8.95)	2.00 (3.69)	25.00 (29.76)	13.50[b] (16.73)
T_3	0.50 (0.65)	9.00 (13.56)	4.80 (7.11)	0.25 (0.33)	20.00 (26.31)	10.13[a] (13.32)
T_4	0.25 (0.33)	7.00 (9.87)	3.63 (5.10)	2.00 (3.69)	12.00 (15.69)	7.00[a] (9.69)
	D_3	D_4	Mean	D_4	D_5	Mean
T_5	20.50 (26.72)	35.00 (36.02)	27.75 (31.37)	12.00 (19.97)	24.00 (29.21)	18.00 (23.51)
T_6	18.00 (24.99)	33.00 (34.93)	25.50 (29.96)	10.00 (16.53)	20.00 (26.33)	15.00 (21.43)
CD						
$T_1 - T_4$			N.S		6.38*	
$T_5 - T_6$			N.S		N.S	

* Significant at 5 per cent level

Mean temperature during experiment period

	Ambient	Refrigerated
Maximum temperature	32.2°C	11.2°C
Minimum temperature	28.6°C	8.9°C
Mean relative humidity during experiment period	82.4%	60.4%

T_1 - Portion packaging in PE

T_2 - Portion packaging in PP

T_3 - Precooling + portion packaging in PE

T_4 - Precooling + Portion packaging in PP

T_5 - Portioned but not packaged (control)

T_6 - Precooled and portioned but not packaged (Control)

D_3, D_4 .... D_n - 'n' Days after storage

Figures in bracket indicates transformed values

Table 36. Consumer acceptability of elephant foot yam as influenced by portion packaging treatments

Treatments	Days after storage										
	Ambient temperature storage					Refrigerated storage					
	D_2	D_4	D_6	D_8	Mean	D_3	D_6	D_9	D_{12}	D_{15}	Mean
T_1	2.80	3.00	3.00	4.00	3.20	1.80	2.20	3.00	4.20	5.00	3.20[c]
T_2	2.60	3.00	3.00	3.80	3.10	1.60	2.20	2.80	3.40	4.40	2.90[b]
T_3	2.60	3.00	3.00	3.60	3.05	2.60	2.20	2.60	3.00	4.40	2.76[b]
T_4	2.40	3.00	3.00	3.20	2.90	1.40	2.00	2.20	3.00	3.60	2.44[a]
	D_1	D_2	D_3	D_4	Mean	D_1	D_2	D_3	D_4	D_5	Mean
T_5	2.80	3.30	4.80	5.00	3.98	2.30	3.00	3.50	4.80	5.00	3.72
T_6	2.60	3.20	4.50	5.00	3.83	2.30	3.00	3.30	4.60	5.00	3.64
CD											
T_1 - T_4			N.S				0.22*				
T_5 - T_6			N.S				N.S				

Five point scale for consumer acceptability

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

T_1 - Portion packaging in PE

T_2 - Portion packaging in PP

T_3 - Precooling + portion packaging in PE

T_4 - Precooling + Portion packaging in PP

T_5 - Portioned but not packaged (control)

T_6 - Precooled and portioned but not packaged (Control)

D_1, D_2 .... D_n - 'n' Days after storage

Significant difference in consumer acceptability between different treatments were observed only under refrigerated storage with best acceptability being rated for T_4 (precooled and portion packaged in PP).

4.3.3 Oriental pickling melon (*Cucumis melo* var. *conomon* (L.) Makino)

A view of oriential pickling melon portion packaged in polymeric films are presented in Plate 24.

4.3.3.1 Physiological loss in weight

Data on the influence of portion packaging treatments on PLW are presented in Table 37. Portion packaging treatments had significant influence on PLW under both ambient and refrigerated storage environments.

In the case of ambient temperature storage minimum PLW was recorded in T_4 (precooled and portion packaged in PP) which was on par with T_3 (precooled and portion packaged in PE). Maximum PLW was recorded in control samples (T_5 and T_6) where no significant difference was observed between them.

With respect to refrigerated storage, minimum PLW was recorded in T_4 (precooled and portion packaged in PP) which was significantly superior to all other treatments. Maximum

Table 37. Effect of portion packaging treatments on PLW (%) in oriental pickling melon

Treatments	Days after storage								
	Ambient temperature storage				Refrigerated storage				
	D_2	D_4	D_6	Mean	D_3	D_6	D_9	D_{12}	Mean
T_1	0.45	0.61	0.77	0.61^c	0.11	0.19	0.30	0.32	0.23^b
T_2	0.22	0.43	0.62	0.42^b	0.11	0.18	0.48	0.59	0.34^c
T_3	0.11	0.19	0.30	0.20^a	0.12	0.14	0.23	0.28	0.19^b
T_4	0.10	0.13	0.19	0.14^a	0.04	0.08	0.11	0.16	0.09^a
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	D_4	Mean
T_5	7.53	13.88	19.50	13.64	6.29	7.71	13.89	16.48	11.10
T_6	7.24	12.63	18.59	12.82	4.98	6.86	12.15	14.15	9.54
CD									
$T_1 - T_4$			0.11*			0.05*			
$T_5 - T_6$			N.S			N.S			

* Significant at 5 per cent level

Mean temperature during experiment period

	Ambient	Refrigerated
Maximum temperature	33.2°C	12.1°C
Minimum temperature	27.7°C	9.3°C
Mean relative humidity during experiment period	78.9%	60.6%

T_1 - Portion packaging in PE

T_2 - Portion packaging in PP

T_3 - Precooling + portion packaging in PE

T_4 - Precooling + Portion packaging in PP

T_5 - Portioned but not packaged (control)

T_6 - Precooled and portioned but not packaged (Control)

D_1, D_2 .... D_n - 'n' Days after storage

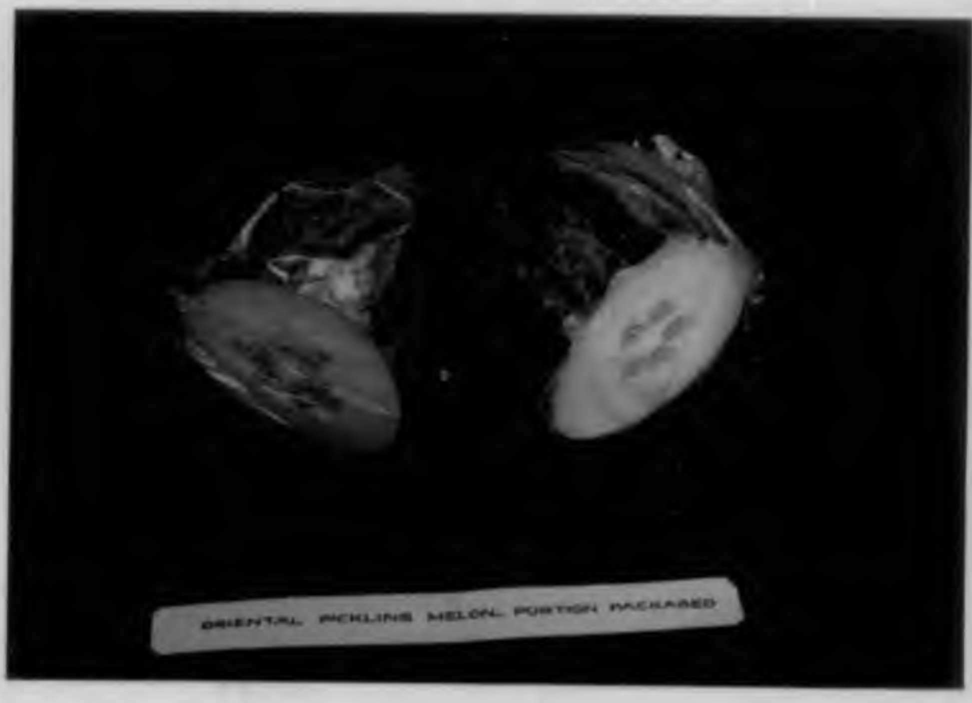


Plate 24. Oriental pickling melon portioned and packaged in polymeric films

PLW was recorded in control samples (T_5 and T_6) where no significant difference was observed between them.

4.3.3.2 Unmarketability

Data on the effect of portion packaging treatments on unmarketability are presented in Table 38. Type of spoilage leading to unmarketability of the portion packaged samples are presented in Plates 25 and 26.

Portion packaging treatments had significant effect only under refrigerated storage with minimum unmarketability being recorded in T_4 (precooled and portion packaged in PP). Maximum unmarketability was recorded for control samples (T_5 and T_6) where no significant difference was observed between them.

4.3.3.3 Consumer acceptability

Results of the consumer acceptability rating of the portion packaged produce are presented in Table 39. Significant difference in acceptability was observed among different treatments both under ambient and refrigerated storage environments.

In the case of ambient temperature storage, treatments T_4 (precooled and portion packaged in PP) and T_3 (precooled

Table 38. Effect of portion packaging treatments on unmarketability (%) in oriental pickling melon

Treatments	Days after storage					
	Ambient temperature storage			Refrigerated storage		
	D_4	D_6	Mean	D_9	D_{12}	Mean
T_1	2.00 (3.68)	11.00 (19.07)	6.50 (11.38)	9.00 (13.37)	35.00 (35.95)	22.00[d] (24.66)
T_2	3.00 (4.56)	16.00 (22.64)	9.50 (13.60)	3.00 (4.56)	19.00 (25.51)	11.00[c] (15.03)
T_3	1.00 (2.58)	10.00 (18.20)	5.50 (10.39)	1.00 (2.58)	14.00 (19.56)	7.50[b] (11.07)
T_4	0.25 (0.33)	10.00 (18.20)	5.13 (9.27)	0.25 (0.33)	3.00 (6.27)	1.63[a] (3.30)
	D_2	D_3	Mean	D_3	D_4	Mean
T_5	18.00 (24.10)	30.00 (32.90)	24.00 (28.50)	18.50 (24.80)	23.00 (28.53)	20.75 (26.67)
T_6	15.00 (22.90)	28.50 (32.10)	21.75 (27.50)	16.00 (23.42)	21.00 (26.80)	18.50 (25.11)
CD						
$T_1 - T_4$			N.S	5.86*		
$T_5 - T_6$			N.S	N.S		

* Significant at 5 per cent level

	Ambient	Refrigerated
Mean temperature during experiment period		
Maximum temperature	33.2°C	12.1°C
Minimum temperature	27.7°C	9.3°C
Mean relative humidity during experiment period	78.9%	60.6%

T_1 - Portion packaging in PE

T_2 - Portion packaging in PP

T_3 - Precooling + portion packaging in PE

T_4 - Precooling + Portion packaging in PP

T_5 - Portioned but not packaged (control)

T_6 - Precooled and portioned but not packaged (Control)

D_2, D_3 .... D_n - 'n' Days after storage

Figures in bracket indicates transformed values

Plate 25. Type of spoilage in portion packaged oriental pickling melon under ambient temperature storage

Plate 26. Type of spoilage in portion packaged oriental pickling melon under refrigerated storage

Table 39. Consumer acceptability of oriental pickling melon as influenced by portion packaging treatments

Treatments	Days after storage								
	Ambient temperature storage				Refrigerated storage				
	D_2	D_4	D_6	Mean	D_3	D_6	D_9	D_{12}	Mean
T_1	3.00	3.40	4.80	3.73^b	1.60	2.40	3.60	4.80	3.10^c
T_2	2.80	3.20	4.60	3.53^b	1.40	2.20	3.20	4.20	2.75^b
T_3	2.80	3.00	4.40	3.40^a	1.20	2.20	3.20	4.20	2.70^b
T_4	2.60	3.00	4.00	3.20^a	1.00	2.00	2.40	3.40	2.20^a
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	D_4	Mean
T_5	2.80	4.40	5.00	4.10	2.40	3.00	4.60	5.00	3.80
T_6	2.80	4.20	4.80	3.93	2.40	2.80	4.40	4.80	3.60
CD									
$T_1 - T_4$			0.27*			0.30*			
$T_5 - T_6$			N.S			N.S			

Five point scale for consumer acceptability

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

T_1 - Portion packaging in PE

T_2 - Portion packaging in PP

T_3 - Precooling + portion packaging in PE

T_4 - Precooling + Portion packaging in PP

T_5 - Portioned but not packaged (control)

T_6 - Precooled and portioned but not packaged (Control)

D_1, D_2 .... D_n - 'n' Days after storage

and portion packaged in PE) were rated as best and equally acceptable.

With respect to refrigerated storage, treatment T_4 (precooled and portion packaged in PP) was rated as the best.

4.3.4 Pumpkin (*Cucurbita moschata* Duchesne)

A view of pumpkin portion packaged in polymeric films are presented in Plate 27.

4.3.4.1 Physiological loss in weight

The data on the influence of portion packaging treatments on PLW are presented in Table 40. Portion packaging treatments had significant effect both under ambient and refrigerated storage environments.

In the case of ambient temperature storage, minimum PLW was recorded in T_4 (precooled and portion packaged in PP) which was on par with T_3 (precooled and portion packaged in PE). PLW was maximum in control samples (T_5 and T_6) where no significant difference was observed between them.

With respect to refrigerated storage, minimum PLW was recorded in T_3 (precooled and portion packaged in PE) which was on par with T_4 (precooled and portion packaged in PP).

Table 40. Effect of portion packaging treatments on PLW (%) in pumpkin

Treatments	Days after storage									
	Ambient temperature storage				Refrigerated storage					
	D_2	D_4	D_6	Mean	D_3	D_6	D_9	D_{12}	D_{15}	Mean
T_1	0.21	0.34	0.41	0.32^b	0.23	0.36	0.51	0.80	0.90	0.56^b
T_2	0.17	0.30	0.38	0.28^b	0.14	0.27	0.42	0.75	0.79	0.47^b
T_3	0.15	0.23	0.34	0.24^a	0.10	0.16	0.28	0.36	0.38	0.26^a
T_4	0.13	0.18	0.33	0.21^a	0.12	0.19	0.25	0.40	0.45	0.28^a
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	D_4	D_5	Mean
T_5	11.47	23.94	36.84	24.10	5.71	10.19	13.49	16.58	19.01	12.99
T_6	9.26	17.25	27.78	18.03	5.47	9.94	12.36	15.26	18.46	12.29
CD										
$T_1 - T_4$			0.06*			0.11*				
$T_5 - T_6$			N.S			N.S				

* Significant at 5 per cent level

Mean temperature during experiment period

	Ambient	Refrigerated
Maximum temperature	33.4°C	11.7°C
Minimum temperature	27.6°C	8.9°C
Mean relative humidity during experiment period	78.7%	60.3%

T_1 - Portion packaging in PE

T_2 - Portion packaging in PP

T_3 - Precooling + portion packaging in PE

T_4 - Precooling + Portion packaging in PP

T_5 - Portioned but not packaged (control)

T_6 - Precooled and portioned but not packaged (Control)

D_1, D_2 .... D_n = 'n' Days after storage

Plate 27. Pumpkin portioned and packaged in polymeric films

Table 41. Effect of portion packaging treatments on unmarketability (%) in pumpkin

Treatments	Days after storage					
	Ambient temperature storage			Refrigerated storage		
	D_4	D_6	Mean	D_{12}	D_{15}	Mean
T_1	6.00 (12.54)	20.00 (25.23)	13.00 (18.85)	18.00 (22.33)	48.00 (43.72)	33.00 (33.03)
T_2	7.00 (11.70)	21.00 (26.17)	14.00 (18.94)	24.00 (29.20)	53.00 (46.72)	38.50 (37.96)
T_3	3.50 (8.27)	16.00 (22.83)	9.80 (13.55)	16.00 (18.64)	43.00 (40.72)	28.50 (29.68)
T_4	3.00 (6.27)	17.00 (23.68)	10.00 (14.98)	9.00 (13.14)	37.00 (37.16)	23.00 (25.15)
	D_2	D_3	Mean	D_4	D_5	Mean
T_5	20.00 (26.31)	50.00 (44.71)	30.00 (35.51)	25.00 (29.80)	40.00 (39.23)	32.50 (34.52)
T_6	15.00 (18.24)	38.00 (37.45)	26.50 (27.85)	18.00 (25.07)	35.00 (35.85)	26.50 (30.46)
CD						
T_1 - T_4			N.S		N.S	
T_5 - T_6			N.S		N.S	

* Significant at 5 per cent level

	Ambient	Refrigerated
Mean temperature during experiment period		
Maximum temperature	33.4°C	11.7°C
Minimum temperature	27.6°C	8.9°C
Mean relative humidity during experiment period	78.7%	60.3%

T_1 - Portion packaging in PE

T_2 - Portion packaging in PP

T_3 - Precooling + portion packaging in PE

T_4 - Precooling + Portion packaging in PP

T_5 - Portioned but not packaged (control)

T_6 - Precooled and portioned but not packaged (Control)

D_2, D_3 .... D_n - 'n' Days after storage

Figures in bracket indicates transformed values

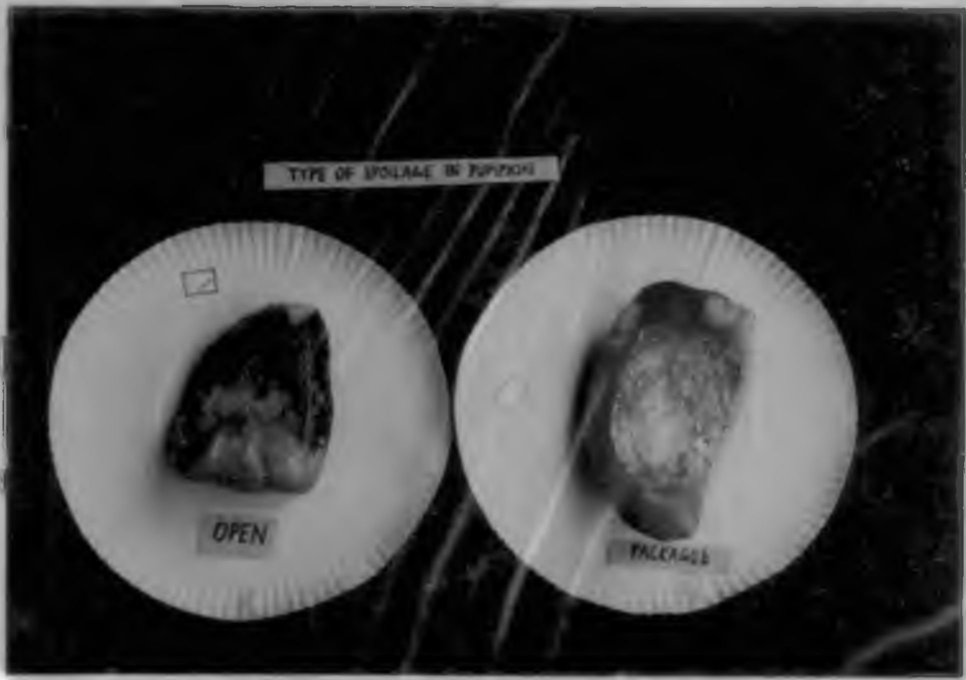


Plate 28. Type of spoilage in portion packaged pumpkin under ambient temperature storage

Plate 29. Type of spoilage in portion packaged pumpkin under refrigerated storage

Table 42. Consumer acceptability of pumpkin as influenced by portion packaging treatments

Treatments	Days after storage									
	Ambient temperature storage				Refrigerated storage					
	D_2	D_4	D_6	Mean	D_3	D_6	D_9	D_{12}	D_{15}	Mean
T_1	2.80	3.60	4.60	3.67	1.20	2.40	3.00	4.20	4.60	3.08
T_2	2.80	3.40	4.40	3.52	1.40	2.40	3.20	3.80	4.40	3.04
T_3	2.60	3.00	4.30	3.30	1.20	2.20	2.80	3.80	4.80	2.96
T_4	2.80	3.00	4.40	3.40	1.00	2.20	3.00	3.60	4.60	2.86
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	D_4	D_5	Mean
T_5	2.80	4.40	5.00	4.10	2.60	3.00	4.20	5.00	5.00	4.00
T_6	2.80	4.20	5.00	4.00	2.40	2.80	4.00	4.80	5.00	3.80
CD										
T_1 - T_4			N.S			N.S				
T_5 - T_6			N.S			N.S				

Five point scale for consumer acceptability

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

T_1 - Portion packaging in PE

T_2 - Portion packaging in PP

T_3 - Precooling + portion packaging in PE

T_4 - Precooling + Portion packaging in PP

T_5 - Portioned but not packaged (control)

T_6 - Precooled and portioned but not packaged (Control)

D_1, D_2 .... D_n - 'n' Days after storage

PLW was maximum for the control samples (T_5 and T_6) where no significant difference was observed between T_5 and T_6.

4.3.4.2 Unmarketability

Data on the effect of portion packaging treatments on unmarketability are presented in Table 41. Type of spoilage leading to unmarketability of the portion packaged produce are presented in Plates 28 and 29.

Portion packaging treatments had no significant effect on unmarketability both under ambient and refrigerated storage environments.

4.3.4.3 Consumer acceptability

Results of the consumer acceptability rating of the portion packaged produce are presented in Table 42.

Portion packaing tretments had no significant effect on consumer acceptability both under ambient and refrigerated storage environments.

4.3.5 Snakegourd (Trichosanthes anguina L.)

A view of snakegourd portion packaged in polymeric films are presented in Plate 30.

4.3.5.1 Physiological loss in weight

Data on the effect of portion packaging treatments on PLW are presented in Table 43. Treatments differed significantly both under ambient and refrigerated storage environments.

Minimum PLW, in the case of ambient temperature storage was recorded in T_4 (precooled and portion packaged in PP) which was on par with T_3 (precooled and portion packaged in PE). PLW was maximum in control samples (T_5 and T_6) where no significant difference was observed between two samples.

In the case of refrigerated storage minimum PLW was recorded in T_4 (precooled and portion packaged in PP) followed by T_3 (precooled and portion packaged in PE). The effect of treatments T_4 and T_3 were on par. As in other cases, maximum PLW was recorded in control (T_5 and T_6) where no significant difference was observed between two samples.

4.3.5.2 Unmarketability

Data on the effect of portion packaging treatments on unmarketability are presented in Table 44. Type of spoilage leading to unmarketability of the portion packaged produce was presented in Plate 31.

Table 43. Effect of portion packaging treatments on PLW (%) in snakegourd

Treatments	Days after storage													
	Ambient temperature storage							Refrigerated storage						
	D_2	D_4	D_6	D_8	D_{10}	D_{12}	Mean	D_3	D_6	D_9	D_{12}	D_{15}	D_{18}	Mean
T_1	0.47	0.50	0.85	0.85	1.13	1.16	0.83[c]	0.58	0.70	0.72	0.74	0.78	0.91	0.74[b]
T_2	0.26	0.45	0.75	0.78	0.89	1.05	0.69[b]	0.72	0.73	0.76	0.78	0.82	0.96	0.80[c]
T_3	0.13	0.20	0.37	0.48	0.74	0.85	0.46[a]	0.33	0.34	0.39	0.46	0.49	0.53	0.42[a]
T_4	0.16	0.26	0.48	0.51	0.53	0.55	0.41[a]	0.29	0.31	0.35	0.39	0.42	0.48	0.37[a]
	D_1	D_2	D_3	D_4	D_5	D_6	Mean	D_1	D_2	D_3	D_4	D_5	D_6	Mean
T_5	8.07	14.17	21.89	28.43	32.48	38.10	23.86	4.89	8.47	11.56	15.17	18.17	22.10	13.39
T_6	7.89	13.91	20.41	26.54	31.51	36.78	22.84	4.37	7.98	11.28	14.58	18.10	22.40	13.12

CD	Ambient temperature storage	Refrigerated storage
$T_1 - T_4$	0.08*	0.05*
$T_5 - T_6$	N.S	N.S

* Significant at 5 per cent level

	Ambient temperature storage	Refrigerated storage
Mean temperature during experiment period		
Maximum temperature	32.2°C	10.9°C
Minimum temperature	28.4°C	8.8°C
Mean relative humidity during experiment period	81.8%	60.4%

T_1 - Portion packaging in PE

T_2 - Portion packaging in PP

T_3 - Precooling + portion packaging in PE

T_4 - Precooling + Portion packaging in PP

T_5 - Portioned but not packaged (control)

T_6 - Precooled and portioned but not packaged (Control)

D_1, D_2 .... D_n - 'n' Days after storage

Table 44. Effect of portion packaging treatments on unmarketability (%) in snakegourd

Treatments	Days after storage					
	Ambient temperature storage			Refrigerated storage		
	D_{10}	D_{12}	Mean	D_{15}	D_{18}	Mean
T_1	4.00 (7.37)	15.00 (21.27)	9.50 (14.32)	41.00 (39.53)	73.00 (59.31)	57.00[d] (49.42)
T_2	2.00 (5.17)	14.00 (20.01)	11.00 (15.89)	25.00 (29.95)	54.00 (47.30)	39.50[c] (38.63)
T_3	5.00 (8.24)	17.00 (23.47)	8.00 (12.59)	0.50 (1.29)	14.00 (19.56)	7.25[b] (10.43)
T_4	0.25 (0.33)	10.00 (13.24)	5.12 (9.29)	0.25 (0.33)	10.00 (13.24)	5.12[a] (9.29)
	D_5	D_6	Mean	D_5	D_6	Mean
T_5	50.00 (45.02)	70.00 (56.85)	60.00 (50.94)	25.00 (29.97)	45.00 (41.71)	35.00 (35.84)
T_6	45.00 (41.71)	65.00 (53.60)	55.00 (47.66)	20.00 (26.90)	40.00 (39.10)	30.00 (33.00)
CD						
$T_1 - T_4$			N.S		6.90*	
$T_5 - T_6$			N.S		N.S	

* Significant at 5 per cent level

Mean temperature during experiment period		
Maximum temperature	32.2°C	10.9°C
Minimum temperature	28.4°C	8.8°C
Mean relative humidity during experiment period	81.8%	60.4%

T_1 - Portion packaging in PE

T_2 - Portion packaging in PP

T_3 - Precooling + portion packaging in PE

T_4 - Precooling + Portion packaging in PP

T_5 - Portioned but not packaged (control)

T_6 - Precooled and portioned but not packaged (Control)

D_5, D_6 .... D_n - 'n' Days after storage

Figures in bracket indicates transformed values

Table 45. Consumer acceptability of snakegourd as influenced by portion packaging treatments

Treatments	Days after storage													
	Ambient temperature storage							Refrigerated storage						
	D_2	D_4	D_6	D_8	D_{10}	D_{12}	Mean	D_3	D_6	D_9	D_{12}	D_{15}	D_{18}	Mean
T_1	1.80	2.20	[illegible].60	3.00	3.40	4.40	2.90	1.20	2.00	2.60	3.80	4.40	4.60	3.10^c
T_2	1.80	2.40	[illegible].00	3.00	3.60	4.60	3.07	1.20	2.00	2.20	3.20	4.40	4.80	2.97^c
T_3	1.80	2.00	[illegible].60	3.00	3.60	4.20	2.87	1.20	2.00	2.40	2.80	3.00	4.40	2.63^b
T_4	1.60	2.00	[illegible].60	3.00	3.00	3.40	2.60	2.00	2.00	2.00	2.40	3.00	3.40	2.30^a
	D_1	D_2	D_3	D_4	D_5	D_6	Mean	D_1	D_2	D_3	D_4	D_5	D_6	Mean
T_5	3.00	4.60	1.80	5.00	5.00	5.00	4.56	2.4[illegible]	2.80	3.00	3.80	4.20	5.00	3.53
T_6	2.80	3.80	1.40	4.80	5.00	5.00	4.30	2.20	2.80	3.00	3.60	4.00	4.80	3.40
CD														
$T_1 - T_4$	N.S							0.22*						
$T_5 - T_6$	N.S							N.S						

Five point scale for consumer acceptability

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

T_1 - Portion packaging in PE

T_2 - Portion packaging in PP

T_3 - Precooling + portion packaging in PE

T_4 - Precooling + Portion packaging in PP

T_5 - Portioned but not packaged (control)

T_6 - Precooled and portioned but not packaged (Control)

D_1, D_2 .... D_n - 'n' Days after storage

Plate 30. Snakegourd portioned and packaged in polymeric films

Plate 31. Type of spoilage in portion packaged snakegourd

Significant difference in unmarketability among treatments were observed only under refrigerated storage. Minimum unmarketability recorded in T_4 (precooled and portion packaged in PP) and T_3 (precooled and portion packaged in PE). Treatments T_4 and T_3 were on par. Maximum unmarketability was recorded for the control samples (T_5 and T_6) where no significant difference was observed between these two samples.

4.3.5.3 Consumer acceptability

Results of the consumer acceptability rating of the portion packaged produce are presented in Table 45.

Significant difference on consumer acceptability among different treatments was observed only under refrigerated storage with best acceptability being recorded for T_4 (precooled and portion packaged in PP).

Discussion

DISCUSSION

Tropical vegetables are highly perishable in nature. There is immense importance for preventing the postharvest losses by adopting appropriate and efficient handling, packaging and storage techniques. Though a large number of tropical vegetables are cultivated in Kerala, both in homesteads and on commercial scale, scientific postharvest handling methods are hardly adopted. Hence investigations were undertaken to assess the effect of precooling and packaging in selected vegetables under ambient and low temperature conditions. The overall aim of the study was to find out efficient precooling and packaging techniques with minimum postharvest losses and value addition. The results of the study conducted under three experiments are discussed in this chapter.

5.1 Standardisation of precooling treatments to improve the postharvest life of fresh vegetables

The precooling technique is mainly recommended for reducing the field heat of the harvested produce. Precooling has to be done as early as possible or atleast within 24 hours of harvest. In the case of vegetables, especially leafy vegetables the time lag between harvesting and precooling should be minimum. Precooling gives best results when supplemented with low temperature storage (Hardenburg, 1971). Precooled vegetables on gradual rewarming under open storage conditions usually do not retain the advantages of precooling in most of the cases (Ryall and Lipton, 1979).

5.1.1 Amaranth (*Amaranthus tricolor* L.)

In the present study precooling of amaranth prior to open storage did not show any significant effect on PLW. The large surface area to volume ratio of leafy vegetables like amaranth quickly losses the effect of precooling thus failing in registering a significant response to precooling with respect to PLW. However, the unmarketability when recorded after 24 hours of treatment, the contact iced leaves were more acceptable. This probably reflects the advantage of better cooling of the contact icing treatment that helps to retain the freshness for a longer period. Stewart and Barger (1963) after conducting studies on the handling of brussels sprouts have reported that contact iced sprouts where rated significantly higher than sprouts not iced.

In the refrigerated storage the precooling treatments indicated distirict superiority over the control for reducing PLW and unmarketability in amaranth. Sozzi and Petronella (1981) reported that hydrocooling of spinach prior to packing retained the freshness during storage. Sherman *et al*. (1982) reported that precooling of bell peppers delayed but did not prevent softrot. Verbeek (1986) has also reported that precooling of vegetables prior to storage reduced the weight loss.

5.1.2 Brinjal (*Solanum melongena* L.)

The effect of precooling in brinjal was significant both under ambient and refrigerated environments. The contact icing treatment was significantly superior in all the situations for reduced moisture loss and better marketability. Eventhough brinjal is a chilling sensitive vegetable (Kader *et al*., 1985) precooling treatments including contact icing for short duration gives beneficial effect for extended storage life. Ryall and Lipton (1979) has reported that brinjal held at 10 to 12.8°C and 95 per cent RH could remain in marketable condition for 10 to 14 days. The results indicate the possibility of recommending precooling treatments for improved shelf life of brinjal.

5.1.3 Chilli (*Capsicum annum* L.)

In the case of chilli also the precooling treatments registered superiority with respect to reduction in PLW and unmarket-ability. Contact icing and cold water treatment were better than the tap water treatment and control. Ryall and

Lipton (1979) stated that pepper fruits remain in better condition if they are hydrocooled rather than if they are cooled slowly, especially if the fruits are 26.7°C or warmer. Hardenburg et al. (1986) have also recommended rapid precooling of sweet peppers to reduce market losses by forced air cooling, hydrocooling or vacuum cooling.

5.1.4 Cowpea [Vigna unguiculata (L.) Walp]

In cowpea cold water and contact icing treatments were superior precooling treatments under the two storage environments. The beneficial effect of hydrocooling for green beans has been reported by Gorini et al. (1974) and Ryall and Lipton (1979). They have stated that the free moisture prevented the wilting or shrivelling of the beans. Zerbini et al. (1978) have reported that hydrocooled snap beans had only lesser PLW and quality deterioration as compared to air cooled treatment. Precooling has an important role in reducing the rate of respiration of cowpea. Smith et al. (1982) have reported that beans stored too long at too high storage temperatures are subjected to various decays including watery softrot, grey mould and the rhizopus rot.

5.1.5 Okra (Abelmoschus esculentus L. Moench.)

In okra tap water treatment was found to be the best precooling treatment for moisture loss reduction under ambient temperature storage. Salunkhe and Desai (1984) reported that high rates of deterioration and of respiration demand rapid cooling of harvested okra. They have also reported that hydrocooling was not generally recommended because water may cause spotting as in prolonged contact with ice or ice water. However in the case of okra, under open conditions the marketability lasted only for two days thus leaving only a shorter span of time to clearly assess the efficiency of precooling.

Under refrigerated condition contact icing and cold water treatments were found to be more beneficial as compared to other treatments. This may be due to the faster reduction in the rate of respiration as already explained.

5.1.6 Tomato (*Lycopersicon esculentum* Mill.)

In tomato contact icing and hydrocooling with tap water treatments proved beneficial under both the storage environments. However, hydrocooling with cold water failed to register any specific advantage. Srivastava *et al*. (1962) reported that precooling of tomatoes followed by refrigerated storage helps in better retention of moisture and ascorbic acid, less wastage and more uniform development of colour. However, Marcellin and Baccaunaud (1979) have observed that precooling had no significant influence on ripening qualities in low temperature. Lingaiah et al. (1983b) did not observe any beneficial effect of precooling in tomato under ambient temperature storage. Wills et al. (1989) have reported that tomato is an extreme case of tolerance to ethylene. Thus the non uniform behaviour of tomato under different precooling treatments may be due to the ethylene effect rather than the effect of precooling.

It can be seen that in most of the cases precooling had beneficial effects in reducing moisture loss and also unmarketablity. The effect of precooling was more pronounced when it was done prior to low temperature storage. Among the precooling treatments, contact icing and cold water hydrocooling were found superior to tap water treatments and control. In amaranth, okra and cowpea where the marketable life was comparatively lesser, the effect of precooling could not be clearly assessed. Thus the feasibility of precooling of vegetables for marketing under open condition needs extensive studies to find out the specific vegetable that responds well to precooling. There is a lot of scope for exploiting the beneficial effects of precooling as a pretreatment to low temperature storage of the vegetables.

5.2 Effect of precooling and packaging on shelf life of vegetables under ambient and refrigerated storage environments

In this experiment the effect of four precooling and eight packaging treatments were studied under ambient and low temperature environments. The salient results are discussed in the following pages.

5.2.1 Amaranth (*Amaranthus tricolor* L.)

With the different packages, precooling treatments showed significant effect for precooling in amaranth. With respect to PLW and shelf life under both situations, the contact icing treatment was found to be the best precooling treatment. When the control gave a shelf life of less than one day, it was above four days with contact icing, cold water and tap water treatments under ambient conditions. In the refrigerated environment, the contact icing and tap water precooling treatments extended the shelf life to more than 10 days with minimum PLW.

Among the packages, 200 gauge PE and PP bags with ventilation proved more beneficial under ambient conditions with respect to shelf life and acceptability whereas PLW was minimum in unventilated 100 and 200 gauge PE. Here again the refrigerated storage considerably enhanced the shelf life with unventilated packages of 100 gauge PE, 100 and 200 gauge PP and 100 gauge PP.

Basak (1980) after studying the effect of packaging, ventilation and low temperature on amaranth and methi found that under unpackaged condition there was rapid moisture loss and the material became unmarketable due to shrivelling. Ventilated packages were found to be superior to unventilated packages with ventilation of 0.24 and 0.48 per cent being ideal. He has also observed that refrigeration extended the shelf life in amaranth considerably.

Lill (1980) reported that precooling and packaging in unperforated PE bags improved the appearance and shelf life of asparagus. Harrison et al. (1984) has reported that brussels sprout precooled and packaged in unperforated PE bags significantly increased the shelf life. Kim (1985) reported that packaging increased the acceptability of spinach at 20°C and at 10°C the acceptability period was doubled. Lazan et al. (1987) reported that in *Amaranthus caudatus* leaves lost water rapidly during storage at 24 to 28°C or 2 to 4°C resulting in accelerated decrease in leaf turgidity. With LDPE packaging the leaves maintained turgidity much better under low temperature conditions. Bittenbender (1992) reported that cowpea leaves stored in 2 mil sealed PE bags at ambient temperature increased storage life compared to open storage.

Cooling further extended the period of storage but cowpea was susceptible to chilling injury below 15°C.

5.2.2 Brinjal (Solanum melongena L.)

In the case of brinjal cold water was found to be efficient precooling under ambient storage whereas contact icing proved to be the efficient under refrigerated storage environment. This may be due to the reason that cold water treatment resulted in contact with 100 per cent skin area whereas in the contact icing treatment the contact area with ice was much less and the resultant precooling was not uniform. However, when the precooled brinjal was kept under refrigerated storage, contact icing performed better than cold water probably due to the reason that the advantage of better cooling with contact icing; though it was not spread over the entire surface area of the fruit, was also utilized in lowering the temperature of the vegetable thus resulting in a better performance as compared to cold water precooling. Regarding the shelf life, it was about three times more than the ambient condition in refrigerated environment. Among the different packages kept under ambient storage, 200 gauge PE, 100 gauge PE, 200 gauge PP and 100 gauge PP gave better results. Eventhough minimum PLW was recorded in unventilated 200 gauge PE, shelf life was maximum in 200 gauge PE, 100 gauge PE and 200 gauge PP all with 0.5 per cent ventilation.

Under refrigerated storage again unventilated packages recorded minimum PLW. However maximum shelf life was recorded in 200 gauge ventilated PE bag.

Viraktamath _et al_. (1963) have reported that ventilated 100 and 200 gauge PE can be used for storage of brinjal under low and ambient storage conditions. 200 gauge PE without ventilation was not suitable for packaging brinjal. In the present study, packaging with 200 gauge PE without ventilation resulted in excessive microbial spoilage and balooning effect due to Co_2 accumulation. Risse and Miller (1983) studied the effect of paper tissue, plastic film and low temperature storage of brinjal and reported that wrapping egg plant fruits in sealed plastic films reduced weight loss, maintained firmness, but significantly increased decay compared with tissue wrapped fruits or fruits wrapped in perforated films. Hardenburg _et al_. (1986) reported that egg plant fruit are chilling sensitive at 10°C and below and deteriorate rapidly at warm temperatures. Badgujar _et al_. (1987) studied the effect of packaging in brinjal and reported that 200 gauge PE with 1 per cent ventilation prolonged the shelf life as compared to unpacked fruit in seven varieties of brinjal.

5.2.3 Chilli (*Capsicum annum* L.)

In chilli contact icing was found to be the efficient precooling method prior to packaging under the two storage environments. The mean shelf life was 3.50 days in control as against 6.56 in precooled packaged samples under ambient temperature storage. Whereas under refrigerated storages, as against a shelf life of 4.80 days in the control samples the mean shelf life for the precooled packaged treatments was 20.36 days. Thus it can be seen that contact icing responds well with chilli under packaged conditions. Ryall and Liption (1979) stated that temperature of harvested peppers should be brought down to a temperature of less than 12.8°C within 3 to 4 hours of harvest for better storage life. Contact icing helps faster cooling of chillies that resulted in the extended storage life. Hardenburg *et al*. (1986) has recommended rapid precooling of harvested sweet peppers in reducing market loss.

Among the packaging treatments under ambient conditions, minimum PLW was recorded in the unventilated polybags. However, with respect to shelf life, ventilated polybags was found more suitable. The best acceptability was for 100 or 200 gauge ventilated PP bags. Under refrigerated storage also, minimum PLW was recorded in the unventilated polybags. But lowest unmarketability, maximum shelf life and acceptability was recorded by 200 gauge PP. The overall performance for the PP bags is probably due to its glossy appearance and silky feel.

Anandaswamy *et al*. (1959) has reported that prepackaging green chilli, in 150 gauge PE is effective at a temperature of 76 to 80°F and 60 to 75 per cent RH and also at 47 to 50°F and 80 to 90 per cent RH. They have also reported that ascorbic acid content of green chilli is not effected by prepackaging. Bussel and Kenigsberger (1975) studied the effect of packaging on green bell peppers in selected permeability films. They have reported that the greatest reduction in weight loss was in the PE film and it did not change significantly between different temperatures. However, moisture condensation occurred inside at all temperatures causing loss of the film transparency. It was also accompanied by a significant increase in decay, compared to other films. The most pronounced benefit of using selective films, according to them was the reduction of water loss which is one of the most important factors in the deterioration of highly perishables. The use of micro plastic films provides an excellent protection against moisture loss especially when they permit adequate gas exchange. So no injury results from insufficient O_2 or excess Co_2 inside the packages. However if condensation occurs as in PE films of low water vapour transmission rate, it provides optimal conditions for microbial decay. Mohammed (1990) compared the performance of two hot pepper cultivars with respect to their storability. He has reported that the variety 'Hot yellow' stored better compared to variety 'Hot Red' at temperature 10, 20 and 30°C. Best storage temperatures was 10°C. Shelf life was restricted in LDPE bags due to decay and extensive shivelling reduced the shelf life in the paper bags. Decay caused by Erwinia carotovora was hastened by the moisture saturated environment caused by the high RH in LDPE bags.

5.2.4 Cowpea [Vigna unguiculata (L.) Walp]

Cowpea is highly perishable under open storage conditions. In the present study, contact icing and cold water precooling treatments were found to be efficient. However, under ambient storage environment, the increase in shelf life on account of precooling and packaging was only just one day revealing that these value additions may not be economical in cowpea for open storage. Anandaswamy and Iyengar (1961) have reported that prepackaging of snapbeans has no beneficial effect for storage under 100°F and 85 to 90 per cent RH. They have also reported that hydrocooling has no beneficial effect for ambient temperature storage. Under refrigerated condition, mean effect of contact icing and packaging treatments increased the shelf life from 1.70 days to 8.26 days. Cowpea pods being harvested in the tender stage is in a state of active respiration. Thus packaging results in accumulation of Co_2 and heat of respiration. Kaufman and Ceponis (1962) have reported that Lima beans are highly perishable and are also susceptible to chilling injury. So they are precooled, preferably by hydrocooling immediately after harvest and kept at low temperature. Thompson (1964) has reported that in consumer packaging of snapbeans when the temperature is above 7°C; decay is likely to be serious within a few days.

Among the packaging treatments tried for cowpea, better ones were 200 gauge PP and 200 and 100 gauge PE without ventilation with respect to PLW under refrigerated storage conditions. For minimum unmarketability, maximum shelf life and acceptability, the best treatment were 200 gauge unventilated PE. Anandaswamy and Iyengar (1961) have reported that 100 and 200 gauge PE bags without ventilation reduced PLW in snapbeans as compared to the control. Bhatnagar et al. (1984) reported that at low temperature, PE packaging proved superior for prolonging the shelf life of pea pods upto 36 days due to restricted metabolic activities and growth of rotting organisms in the packaged environment.

In cowpea it was also observed that, under refrigerated storage ventilated packages showed faster spoilage. The main reason for the spoilage was the disappearance of the green colour much faster as compared to unventilated packages (Plate 13). In the earlier cases of brinjal and chilli, the ventilated packages had better shelf life and acceptability than the unventilated packages. This shows the specificity of the vegetables with respect to moisture and gas permeability requirements. Tomkins (1967) have stated that most films are somewhat too impermeable to Co_2 and to O_2 and it would be generally more convenient if the permeability to O_2 was nearly equal to the permeability of the Co_2. One simple way of changing permeability is to provide holes. This makes the films equally permeable to O_2 and Co_2. The present investigations indicate that the above concept of changing permeability may not always improve the shelf life of vegetables. Hall (1973) has stated that a package for a respiring product must provide movement of gases in appropriate quantities and directions; O_2 into the package environment from the outside atmosphere, Co_2 from the package environment to the outside atmosphere, but with moisture retained in the package to prevent excessive loss of moisture and weight from the product.

5.2.5 Okra (Abelmoschus esculentus L. Moench.)

In okra, cold water was found to be an efficient precooling treatment under packaged condition with a mean shelf life of 5.80 days as against 1.80 days in the control in an open storage condition. Under refrigerated condition, a mean shelf life of 7.85 days with contact icing precooling and packaging was recorded against a shelf life of 2.80 days in the unpackaged okra not subjected to precooling. Hardenburg *et al*. (1986) has reported that okra deteriorates rapidly and is normally stored only briefly to hold for marketing or processing. He has further added that okra has a very high respiration rate at warm temperatures and prompt precooling is essential. Salunkhe and Deasi (1984) has reported that unless okra is cooled below 15.6°C soon after it is packed the heat of respiration causes the temperature of rise quickly and may result in rapid deterioration. They have also reported that hydrocooling is generally not recommended because water may cause spotting as does prolonged contact with ice or ice water. In the present investigation, the contact period was only 20 minutes and therefore spotting symptoms were not noticed in the treated pods. Pentastico *et al*. (1975) have recommended a temperature of 8.9°C and 90 per cent RH to store okra for about 2 weeks in a good marketable condition. In the present study also the packaged okra showed slight yellowing with the advancement of storage (Plate 15) which is in confirmity with the findings of Ryal and Lipton (1979). Ryal and Lipton (1979) have reported that cooled okra has to be held at 7.20 to 10.80°C since at higher temperatures toughening, yellowing and decay were rapid.

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Among the various packaging treatments kept under open conditions, unventilated 100 gauge PE, PP and 200 gauge PE were the better ones with respect to minimum PLW. However with respect to unmarketability, shelf life and acceptability 100 and 200 gauge unventilated PP bags were found to be the best. Thus, it can be presumed that 100 gauge PP unventilated bags are a suitable packaging for okra for open storage provided it is appropriately precooled. Anandaswamy et al. (1963) has observed that untreated okra prepackaged in unventilated 100 gauge PE film bag held under room temperature conditions and 24 to 26°C and 72 to 75 per cent RH had a shelf life of 7 to 8 days as against 2 to 3 days in samples without package. Kalra et al. (1988) has reported that prepackaging of okra in unventilated 200 gauge PP bags and storing at room temperature (26-34°C, RH 65-90%) is advantageous upto 6 days in the case of variety EMS-8.

As far as the refrigerated storage of precooled and prepackaged okra is concerned 100 gauge unventilated PE bags were found to reduce the PLW to the minimum. As far as unmarketability, shelf life and consumer acceptability was concerned, again 100 gauge unventilated PE proved to be the best treatment closely followed by 200 gauge PE (unventilated). Thus it can be concluded that contact icing and 100 gauge unventilated PE bag is the suitable recommendation for the prepackaging of okra under refrigerated storage conditions. Anandaswamy et al. (1963) have reported that 100 gauge unventilated PE extended the shelf life of okra under cold storage condition upto 16 to 18 days as against 10 to 12 days in control. Joshi et al. (1984) has also reported that unperforated PE enhanced the shelf life of okra to 15 days from two days in open tray.

In the case of okra storage in ventilated bags did not improve shelf life or consumer acceptability. A similar trend was observed in the case of cowpea var. Kanakamony in the present study also. It may be noted that both cowpea and okra are harvested at tender immature stages where the rate of respiration is generally high as compared to the mature stages (Wills, 1989). Anandaswamy et al. (1963) have reported that ventilation did not enhance the shelf life of okra. He has also reported that build up of Co_2 in the unventilated film bag provided suitable conditions for extending its shelf life. Thus the results of the effect of ventilation on polybags for the storage of cowpea and okra reveal that ventilation have specific influence on the postharvest behaviour of these vegetables either in the open or in the refrigerated storage.

5.2.6 Tomato (*Lycopersicon esculentum* Mill.)

In the present investigation nature green tomatoes were used for the experiment. Among precooling treatments both under ambient and refrigerated storage conditions; contact icing was found to be the best treatment. In the refrigerated storage, cold water precooling was also found to have a similar beneficial effect. Precooling and packaging extended the mean shelf life from 4.80 days to 12.18 days under open storage whereas under refrigerated condition it went up from 11.0 days to 26.65 days. Srivastava et al. (1962) have reported that precooling of tomatoes helps in better retention of moisture and ascorbic acid, less wastage and more uniform development of colour when kept under a storage condition of 11 to 13°C. Lingaiah et al. (1983b) precooled tomatoes in water of 7 to 10°C for 10 minutes and could not observe any beneficial effect. This indicates that duration of precooling is important and the contact period must be long enough to bring about the required reduction in the temperature of the produce in a rapid manner to retard the physiological process that accelerated the senescence and deterioration of the harvested commodity.

The packaging treatments with the precooled tomatoes revealed that unventilated 100 gauge PE and PP were the suitable packages to minimise the PLW both under open and refrigerated conditions. In the open storage conditions, 200 gauge unventilated PE was equally good for the packaging of tomato. As far as consumer acceptability, shelf life and unmarketability is concerned ventilated bags were found suitable. Under ambient and refrigerated storage conditions, ventilated bags of 100 gauge PE was found to be generally superior. Under ambient storage conditions 200 gauge PP and PE ventilated bags were also found to be better packages. This indicates that for open storage, films of thicker gauge may be necessary for mature green tomato provided the value addition is affordable.

Risch and Watson (1980) studied the rate of weight loss from tomatoes during storage. Their results showed that wrapping individual tomatoes in polymeric films (PVC film) resulted in lowest amount of weight loss. Rate of weight loss were liner with time after 2 days of storage until 14 days and correlated well with temperature and humidity of the storage atmosphere. This results also confirmed that the calyx end region of the tomato accounts for disproportion of large amounts of total weight loss during storage.

Geeson and Brown (1983) conducted an extensive study to compare the permeability properties of about 20 plastic films and to assess the effects of modified atmospheres created by these films on the rate of ripening of tomato fruits during and after storage. They have reported that in packs sealed with K-resin (Butadiene - Styrene co-polymer of

100 gauge thickness) or with PVC films of 60-100 gauge thickness, the concentration of both O_2 and CO_2 equilibrated to 4 to 6 per cent after about 3 days. Fruits in these packs ripened much more slowly than those in ventilated control packs but continued to ripen normally when the packs were opened after 1 to 3 weeks at 10°C and transferred to room temperature. In packs sealed with less permeable films (such as 100 or 200 gauge cellulose acetate or 60 gauge PP) the concentration of O_2 fell to 1-2 per cent and that of Co_2 increased rapidly by 12 to 16 per cent, fruit ripening was inhibited even after the packs were open. Fungal rots were associated with low O_2 or high Co_2 concentration and excessively higher RH in certain bags. Risse et al. (1985b) have reported that wrapped tomatoes stored at 13°C had significantly less weight loss and firmer than nonwrapped tomatoes. They have also added that decay development was similar for nonwrapped and wrapped tomatoes. Marangoni and Stanley (1991) has reported that green house grown mature green tomatoes could be stored for atleast 30 days at 12°C in modified atmosphere with no detectable changes in quality. He has also added that tomato samples kept at 6°C showed marked deterioration after 15 days of storage in both air and modified atmosphere. Jayanthi et al. (1993) reported that tomato fruits stored in low O_2 (2-13%) and enriched Co_2 (10-12%) using 300 gauge PE bags enhanced the shelf life of

fresh tomatoes as compared to storage at normal atmospheres. Naik et al. (1993) have reported that shelf life of tomatoes could be increased almost four times compared with control, by packaging the breaker tomatoes in 300 gauge PE bags with 3 vents (0.25 inch diameter). They have also observed that loss of moisture was directly proportional to thickness and number of vents of the bag.

From the present studies it can be concluded that contact icing and 100 gauge PE film with or without ventilation can be recommended as a suitable package for mature green tomatoes for different storage environments. It is also to be noted that the duration of precooling and the area of the ventilation have significant role in the final shelf life and other attributes of tomato.

5.3. Effect of portion packaging of large sized vegetables

This study was conducted with a view to assess the effect of precooling and packaging on the cut piece of large sized vegetables. Five vegetables viz., ashgourd, elephant foot yam, oriental pickling melon, pumpkin and snakegourd were used for the study. Except elephant foot yam all the other vegetables belonged to the family Cucurbitaceae and had more or less similar fruit characters. The salient results are discussed below.

5.3.1 Ashgourd (<u>Benincasa</u> <u>hispida</u> (Thunb.) Cogn.)

Under ambient temperature conditions precooled ashgourd packaged in 100 gauge PP film was the best treatment with minimum PLW; whereas under refrigerated environment minimum PLW was recorded by precooled ashgourd packaged in 100 gauge PE. Both under ambient and refrigerated environments, packaging significantly reduced PLW and thus reduced unmarketability. The moisture retention was more than 15 per cent as compared to control treatments after 6 and 12 days respectively under ambient and refrigerated conditions for the packaged vegetables. Moisture loss being the primary cause for the unmarketability, packaging can be considered as an efficient barrier for the moisture loss. Also packaging protects the exposed cut surface of the vegetable from contamination (by the atmospheric impurities like dust, dirt and microbial spores). The results revealed that the incidence of unmarketability was faster in the case of ambient storage than in the refrigerated environment which is obvious. The present study revealed that incidence of microbial spoilage could be considerably delayed in the case of packaged ashgourd. Further delaying of the spoilage incidence was noted under refrigerated condition. Symptoms of spoilage could be easily detected so that rejection of sample is quite easy (Plate 20 and 21).

5.3.2 Elephant foot yam (*Amorphophallus campanulatus* Blume ex Decne)

The storage organ of the elephant foot yam is the underground stem which is a corm. The moisture content of the corm is much less as compared to ashgourd, pumpkin or snakegourd and therefore the elephant foot yam has better storability than these vegetables under natural conditions. The cut surface of the corm of elephant foot yam is usually protected by a newly formed layer of callus tissue which is quicker under warmer conditions that at lower temperature. In the present study under ambient temperature conditions, packaging and precooling treatments did not differ significantly among themselves but there was considerable difference in PLW with the control and packaged samples where control samples registered 25.80 per cent to 27.81 per cent weight loss while the precooled, packaged treatments recorded a mean PLW of 0.91 per cent only at the end of storage. Under refrigerated conditions, the packaged treatments registered a PLW of 0.36 per cent whereas in the control samples it was 18.72 to 21.32 per cent. Similar trend was noted in the incidence of unmarketability and also in consumer acceptability. Thus portion packaging of elephant foot yam is good for reducing PLW, unmarketability and extending the consumer acceptability for a longer period of time. In this case also packaging delayed the incidence of microbial spoilage under refrigerated conditions. There was no significant difference between 100 gauge PE and PP films under refrigerated conditions. Whereas for ambient condition 100 gauge PP film was found superior to 100 gauge PE. Thus it can be mentioned here that physical properties of the films became more important at warmer temperature than at lower temperatures.

5.3.3 Oriental pickling melons (Cucumis melo Var. Conomon (L) Makino)

In the case of oriental pickling melon also, precooling and packaging reduced the PLW considerably as in the previous cases. The control samples in open condition registered 18.59 per cent and 19.50 per cent moisture loss three days after storage, whereas the PLW was less than 1 per cent after 6 days in precooled and packaged vegetable kept under open storage and after 12 days under refrigerated storage conditions. Similar beneficial effect of packaging was noticed in the case of unmarketability and consumer acceptability under both the storage environments.

Salunkhe and Desai (1984) have reported that hydrocooling is useful for pickling and slicing cucumbers harvested during hot weather. They have also reported that packaging of cucumbers in ventilated films reduced weight loss considerably. Atwa et al. (1980) reported that packaging and refrigeration reduced weight loss in cucumber. He also reported that decay was greater in packaged fruit especially under ambient conditions. Packaging had only slight effect on chemical composition. Risse et al. (1985a) reported that wrapped cucumber had slightly less weight loss than unwrapped ones.

5.3.4 Pumpkin (Cucurbita moschata Duchesne)

Unlike ashgourd and oriental pickling melon; pumpkin has got a thick skin. However this thickening of the skin takes place in the later stages of maturity and fruits for vegetable use are harvested at an earlier stage when the thickening of the fruit skin is not completed. Salunkhe and Desai (1984) has reported that even under best storage conditions, loss in weight is considerably high in pumpkins owing to loss of water and carbohydrates. Although the percentage of water may not change appreciably during storage, the actual loss by evaporation is masked by the water formed in the respiration and also by the loss of dry matter mainly the carbohydrates. In the present study, precooling and packaging with 100 gauge PP/PE film considerably reduced the PLW in portion packaged pumpkin. When the control slices kept in the open registered a weight loss of 27.78 and 36.84 per cent within three days, packaging brought this down to as low as 0.34 per cent after six days in the open condition. Under refrigerated condition even on the fifteenth day the PLW was only 0.45 per cent. Packaging extended the consumer acceptability and shelf life both under open and refrigerated conditions. Moreover, portion packaging of pumpkin has the added advantage that the consumer will be able to appreciate the internal flesh colour as it is considered that the deeper the yellow colour more is the carotene content. Also it gives a chance to select fruits with more flesh thickness.

5.3.5 Snakegourd (*Trichosanthes anguina* L.)

The vegetable snakegourd fruit is very tender as compared to pumpkin, ashgourd and oriental pickling melon. Therefore it is more perishable. It is long cylindrical in shape and the portioned snakegourd is more or less like a tube with two cut ends (Plate 30). Results of the present study indicate that precooling and packaging with 100 gauge PP or PE film significantly reduced the PLW in snakegourd. The precooled and packaged snakegourd kept under open conditions recorded a PLW of 0.85 per cent after twelve days of storage whereas the PLW of the snakegourd portions kept in open without packaging was 38.1 per cent even at the end of six days of storage. Under refrigerated conditions PLW at the end of sixth day was 22.1 and 22.4 per cent when snakegourd was kept without packaging as against a PLW of only 0.53 per cent for precooled and packaged snakegourd portions after 18 days of storage thereby retaining its acceptability. Thus it can be seen that precooling and packaging improves the shelf life of snakegourd considerably even under open conditions and substantially under refrigerated conditions. Because of the reduced PLW, the incidence of unmarketability was delayed and consumer acceptability was extended. In the case of snakegourd, portion packaging can help mask the curved nature of the fruit to some extent and thereby improve its marketability. Another advantage of portion packaging of snakegourd to the consumer is the convenience in handling.

5.4 Incidence of spoilage in precooled and packaged vegetables

The spoilage associated with precooling and packaging of different vegetables are detailed below:

5.4.1 Amaranth (*Amaranthus tricolor* L.)

In the case of unpackaged amaranth subjected to precooling, the type of spoilage observed was withering of the leaves both under ambient and refrigerated environments (Plate 5). Unpackaged amaranth showed rapid moisture loss due to transpiration. Since there was no barrier to the water vapour, it diffused in quickly into the surrounding atmosphere

(Basak, 1980). With respect to prepackaged samples differences in type of spoilage were observed in unventilated and ventilated polybags. In unventilated polybags, the unmarketability was due to microbial decay whereas in amaranth prepackaged in ventilated polybags the spoilage observed was due to wilting of the leaves (Plate 5). The spoilage observed in unventilated and ventilated polybags were similar under both the storage environments. Hardenburg (1971) reported that microbial decay was more in unventilated bags. The abundance of moisture in unventilated bags favoured microbial growth. He has also added that adequate ventilation should also be provided so that both, life processes viz., respiration and transpiration are kept at the minimum without causing damage to the produce.

5.4.2 Brinjal (Solanum melongena L.)

In the case of precooled samples, the spoilage observed was desiccation of the fruit both under ambient and refrigerated environments (Plate 7). Hardenburg et al. (1986) observed rapid deterioration of eggplants at warm temperatures. Loss of sheen and wilting are symptoms of normal deterioration. A temperature of 8 to 12°C and a relative humidity of 90 to 95 per cent prevented normal deterioration. In unventilated packages microbial decay was the type of spoilage observed (Plate 7). *Phomopsis* sp. and bacteria were found to be associated with the spoilage. In ventilated packages the spoilage observed was shrinkage of the fruit. Both under ambient and refrigerated environment the symptoms of spoilage were similar. Viraktamath *et al*. (1963) observed faster wilting due to higher PLW in brinjal packaged in ventilated polybags. Mohammed and Sealy (1986) reported that the severity of microbial decay in brinjal fruits prepackaged in LDPE may have been aggravated by the high relative humidity and modified atmosphere which resulted in subsequent proliferation of pathogens. Although positive identification of the causal agents was not made symptoms of bacterial soft rot, phomopsis rot and grey mould rot was observed. The above findings supports the results of the present study.

5.4.3 Chilli (*Capsicum annum* L.)

In chillies subjected to precooling, shrivelling of the fruit was the symptom of spoilage observed both under ambient and refrigerated storage (Plate 10). Hardenburg *et al*. (1986) reported that hot peppers must be held in high relative humidity of 90-95 per cent or else will rapidly become wilted. In packaged samples both in unventilated and ventilated, the spoilage observed was microbial decay (Plate 10). *Colletotrichum* sp. was found to be associated with the decay. The spoilage symptoms were similar under both the storage environments. Signs of dehydration, such as dull, shrivelled pericarp were the most obvious defect in unpackaged bell peppers. In contrast, packaged peppers showed microbial rotting which was the major quality defect in packaged peppers (Brackett, 1990). Bussel and Kenigsberger (1975) observed high moisture condensation in PE bags containing bell peppers at all storage temperatures which resulted in providing optimal conditions for decay development. Eckert et al. (1975) stated that anthracnose caused by Colletotrichum sp. causes serious damage during storage.

5.4.4 Cowpea (*Vigna unguiculata* (L.) Walp)

In precooled samples, the spoilage observed was wilting and shrivelling of the pods. The spoilage symptoms were similar both under ambient and refrigerated environment (Plates 12 and 13). Moisture loss of fresh vegetables during storage may lead to serious loss of quality and marked reduction in storage life as a result of shrivelling, wilting and softening (Van den Berg and Lentz, 1971). In packaged samples difference in spoilage symptoms were observed both under ambient and refrigerated environment. Under ambient storage, microbial decay was observed both in unventilated and ventilated polybags (Plate 12). With respect to refrigerated storage, differences were observed in spoilage symptoms among cowpea packaged in ventilated and unventilated polybags. In ventilated bags, the spoilage observed mainly was discolouration of the pod surface where as in unventilated bags softening of the pods followed by microbial decay was observed (Plate 13). Fusarium sp. was found to be associated with the spoilage in both the storage environments. Amandaswamy and Iyengar (1961) observed high amount of wilting, microbial decay and discolouration in prepackaged snapbeans held under different storage temperatures. Bhatnagar et al. (1984) have attributed early microbial infection and deterioration in prepackaged pea pods due to high retention of moisture in the inpackage environment.

5.4.5 Okra (Abelmoschus esculentus L. Moench)

The spoilage observed in precooled produce kept under open conditions were wilting and discolouration of the pods (Plates 15 and 16). Hardenburg et al. (1986) reported rapid toughening, yellowing and shrivelling in okra at high temperatures and low relative humidity. A temperature of 7 to 10°C and a relative humidity of 90 to 95 per cent is desirable to prevent shrivelling. In packaged samples both under ambient and refrigerated conditions differences in spoilage symptoms were observed among okra packaged in ventilated and unventilated bags (Plates 15 and 16). In ventilated packages the type of spoilage manifested was surface discolouration of the pods. In unventilated packages, softening and microbial decay was the main symptoms of spoilage. Anandaswamy _et al._ (1963) reported that the loss of marketability in Okra prepackaged in ventilated plastic films was due to wilting. Saimbhi and Randhawa (1983) reported loss of marketability in okra prepackaged in unventilated PE bags was due to microbial decay. It was also observed that the loss of marketability in unpackaged fruits was due to yellowing, shrivelling and blackening of the edges.

5.4.6 Tomato (_Lycopersicon esculentum_ Mill.)

In the case of precooled samples, the spoilage observed was shrivelling of the fruit skin and shrinkage of the entire fruit both under ambient and refrigerated storage (Plate 18). Loss of moisture with consequent wilting or shrivelling of the tomatoes is the most obvious way in which freshness is lost and affects the appearance, texture and salability under open conditions (Naik _et al._, 1993). In packaged samples under ambient and refrigerated storage, the spoilage observed was microbial rotting (Plate 18). The rotting was seen both in ventilated and unventilated bags. Moreover fruits held under unventilated packages failed to develop the normal red colour under refrigerated storage condition. Hardenburg _et al._

(1986) reported that mature green tomatoes held for 2 weeks or longer at 13°C may develop an abnormal amount of decay and may fail to develop a deep red colour. The optimum temperature for ripening mature green tomatoes ranges from 18 to 21°C.

5.5 Incidence of spoilage associated with portion packaged vegetables

The spoilage resulting in unmarketability of the portion packaged vegetables are given below:

5.5.1 Ashgourd (Benincasa hispida (Thumb.) Cogn.)

The spoilage symptoms associated with portion packaged samples under ambient and refrigerated storage conditions were microbial rotting, softening and brown discolouration of the cut surface (Plates 20 and 21). Rhizopus sp. was found to be associated with the spoilage.

5.5.2 Elephant foot yam (Amorphophallus campanulatus Blume ex Decne)

The spoilage symptoms associated with unmarketability in packaged samples were the brown discolouration and microbial growth of cut surface (Plate 23). The symptoms were similar both under ambient and refrigerated storage.

5.5.3 Oriental pickling melon (*Cucumis melo* var. *conomon* (L.) Makino)

In packaged samples, the spoilage associated with unmarketability both under ambient and refrigerated storage were the discolouration of the cut surface and microbial decay (Plates 25 and 26). In control samples the unmarketability was due to microbial growth and discolouration of the cut surface and shrinkage of the piece of melon. *Fusarium* sp. and *Diplodia* sp. were found to be associated with the spoilage. Walter *et al*. (1990) reported that pickling cucumbers stored at 62 per cent RH exhibited more senescence characteristics and pillowy tissue disorders than fruits stored at 93 per cent RH.

5.5.4 Pumpkin (*Cucurbita moschata* Duchesne)

The spoilage associated with packaged produce both under ambient and refrigerated storage was microbial decay. For the control samples the spoilage associated with unmarketability was microbial rotting and softening (Plates 28 and 29). *Rhizopus* sp. was found to be associated with rotting. In pumpkin higher humidities promote decay and lower humidities causes excess weight loss and tissue deterioration (Ryall and Lipton, 1979).

5.5.5 Snakegourd (*Trichosanthes anguina* L.)

The spoilage associated with unmarketability of the packaged produce was microbial decay and shrinkage (Plate 31). In control samples the spoilage observed were discolouration and shrinkage. *Rhizopus* sp. was found to be associated with the spoiled tissues.

5.6 Economic analysis of the value addition processes

In the present study value addition was done to the fresh vegetable during four stages viz. precooling, packaging, portion packaging and refrigeration. The value addition is always limited by the profitability realized out of the sale of the vegetable. The high perishability of the vegetables offers a lot of risk to the value addition processes.

5.6.1 Precooling treatments

The prevailing market rate of ice blocks were 15 rupees for a block of fifty kilogram. Thus the cost of one kg of ice works out to 0.30 rupees. In the present study, equal quantity of crushed ice was used with every kilogram of the vegetable. Thus the value addition amounted to 0.30 rupees per kilogram of vegetables. The other precooling treatments obviously are the cheaper ones with the tap water treatment being the cheapest. Results revealed that precooling treatments were not very efficient in extending the shelf life of vegetables stored under ambient temperature conditions. Eventhough contact icing improved shelf life of open stored brinjal, chilli, cowpea and tomato; the feasibility for recommending this treatment may be limited to chilli, cowpea and tomato only and not to brinjal because of its lower market price. Precooling with cold water was found beneficial for cowpea and chilli under ambient temperature conditions. Eventhough the extension of shelf life and acceptability due to precooling is about one to two days, it is important as far as the vegetables kept in the open condition are concerned especially when the market prices are high. In the present study the contact time for the precooling is only twenty minutes. Within this period only a part of the ice is melted and also the coldness of the cold water was not completely transferred into the vegetable. This suggest two options; (1) Reuse of the recovered ice and cold water; (2) Extending the contact period of precooling which needs further investigation.

The effect of precooling was more pronounced in the low temperature environment. However, further studies with packages revealed that under low temperature environment precooling alone may not give the desired advantage. Hence the economic analysis is explained for packaged vegetables kept in the low temperature.

5.6.2 Packaging treatments

Under ambient conditions, the packaging nearly doubled the shelf life in most of the cases. However, the performance can vary from season to season due to variations in the temperature and humidity of the environment. This creates some amount of uncertainty to recommend packaging treatments for open displayed vegetables. In situations, where there is some certainty about the minimum daily off take, vegetables can be precooled and packaged in suitable polybags so that the benefit of extended acceptability, reduced spoilage can be made use of. The present study revealed that a 200 gauge PE and PP cover adds value at the rate of 0.40 and 0.19 rupee respectively (The market price of 1 kg PE or PP cover was Rs.70 and Rs.60 respectively). The use of 200 gauge PP covers can be recommended for amaranth, brinjal, chilli, cowpea, okra and tomato. The study has also revealed that 100 gauge PP cover can be used for chilli, cowpea and okra which was the cheapest of the polybags used with a cost of 0.11 rupee per cover. It may be further added that prepackaging eliminates the necessity of subsequent weighing and packaging at the retailer level there by reducing the overhead expenditure. Thus it can be concluded that packaging of fresh vegetables can be undertaken selectively by leading vegetable retailers/supermarkets. This will help the consumers realize the advantages of packaging of vegetables and thus the concept of prepackaging of vegetables will become more popular.

Under refrigerated conditions there is considerable increase in the shelf life of the vegetable. The results of the study indicated that about 50 kg of vegetables packed in units of 500 g can be conveniently stored in a refrigerator which consumed two units of electrical energy per day. At the present rate of Rs.1.98 per unit of electrical energy, the value addition an account of low temperature storage is 0.05 rupee per day per kilogram of vegetable. The capital cost, depreciation value etc. have not been included in this estimate. It is relevant to point out at this juncture that the National Horticulture Board of the Government of India has subsidised schemes for setting up of precooling facilities and cold storages. In the present study the maximum shelf life under refrigerated storage ranged from 8.15 days in okra to 27.80 days in tomato. This gives a lot of convenience to the vegetable merchants to plan the procurement of fresh vegetables depending on market fluctuations. Thus the scope of consumer packaging and low temperature storage is not merely restricted to the extension of shelf life of the vegetable. It has other implications like planning the raw material procurement, better consumer satisfaction and other convenience in the trading process.

5.6.3 Portion packaging

Results of the portion packaging experiments revealed that incidence of unmarketability in vegetable slices kept under ambient temperature conditions can be reduced with the help of precooling and packaging. use of 100 gauge PP and PE was found suitable for the packaging of ashgourd, elephant foot yam, oriental pickling melon, pumpkin and snakegourd through reduction of PLW. With respect to unmarketability and consumer acceptability, the effect of these two types of packaging films were more or less alike. While packaging it is preferable to exclude as much air as possible from within the package for better shelf life and acceptability. PP being lower in density, works out to be the cheaper packaging film as compared to PE film of the same thickness.

In the refrigerated environment also both the films were found efficient for the portion packaging of ashgourd, elephant foot yam, oriental pickling melon, pumpkin and snakegourd. For ashgourd, 100 gauge PE was found to be the best whereas for elephant foot yam and oriental pickling melon 100 gauge PP were found to be the best while in other cases both the films performed in a similar fashion as far as the

PLW was concerned. There was considerably enhancement of shelf life over the open stored samples. Here again the value addition per day an account of the low temperature environment was same as in the other cases i.e., 0.05 rupee per kilogram of vegetable per day as compared to the traditional system of selling vegetables in slices. Keeping the cut vegetables in the open without any packaging results in considerable amount of loss, since every time a new slice is taken from the vegetable a portion of the previous cut surface is rejected to satisfy the customer. In the portion packaging systems this loss can be avoided. Together with the considerably reduced PLW the saleable weight of large sized vegetable will thus be considerably increased. Ultimately the advantage of this type of scientific marketing system will increase the farm gate price of the farmer. Setting up of refrigerated display shelves for packaged and portion packaged vegetables can be tried in the leading supermarkets in the urban area and also in the vegetable retail outlets of agencies like Kerala Horticultural Products Development Corporation (Haritha Stalls). Automatic packing machines with computerized weighing facilities are available in the developed countries. When the prepackaging of the vegetables become popular, such machines can be imported and it will open up a new avenue for generating employment in the state viz. the packing house operations for fruits and vegetables. Such developments will help the development of the overall marketing system in vegetables and make the consumer more quality conscious. Facilities for rapid detection of pesticide residues can also be arranged in such packing houses where by it will be possible to reject vegetable with high amounts of toxic residues. The produce from organic farming can be especially packaged with suitable logo and at present in the developed countries the organically produced fruits and vegetables without residues fetch four times a market price as compared to the traditionally grown produce using a lot of fertilizer and pesticide.

The present study revealed that precooling and packaging can be effectively used for reduction of post harvest losses in vegetables. Even under ambient temperature conditions; precooling and packaging has advantageous effects which can considerably increase the saleable quantity of vegetable as compared to the traditional handling system. Precooling and packaging changes the whole system of vegetable marketing and adds a lot to the commodity status of vegetables. Consumers are provided with vegetables of their choice in convenient packages prepared under hygienic conditions. The supermarkets and the vegetable retail outlets of agencies like the Kerala Horticultural Product Development

Corporation can successfully undertake the prepackaging of vegetables and display for marketing in a refrigerated environment. This will raise the status of the vegetable to that of a stable packaged commodity. Eventually this improved marketing system will fetch the farmer a higher farm gate price on account of the reduced post harvest losses and also the overall improvement of the marketing system which can eliminate the middleman and establish a direct link with the farmers and the supermarket net work.

Further investigations are required on the optimization of the duration of precooling treatments. The exact role of ventilation in providing an extended marketable shelf life for different vegetables needs to be standardized. Use of heat shrinkable polymeric films for packaging with the help of automatic machines may have better results than those used in this study. The study also emphasizes the need for educating the farmer about the importance of post harvest technology similar to that of improved production technology.

Summary

SUMMARY

The present study "Consumer packaging of selected vegetables" was conducted in the Department of Processing Technology, College of Horticulture, Vellanikkara during June 1992 to October 1993. The study consisted of the following experiments.

1. Standardisation of precooling treatments to improve the post harvest life of fresh vegetables.

2. Effect of precooling and packaging on shelf life of vegetables under ambient and refrigerated storage environment.

3. Effect of portion packaging of large sized vegetables.

The experiment on the standardisation of precooling treatments aimed to improve the post harvest life of vegetables revealed that the precooling treatments significantly reduced the physiological loss in weight (PLW) and unmarketability of the vegetables viz., amaranth, brinjal, chilli, cowpea, okra and tomato during storage. In all these vegetables, precooling the produce immediately after harvest reduced the PLW and enhanced the marketability of the produce both under ambient and refrigerated storage environment. The

effect of precooling was more pronounced when it was done prior to low temperature storage. Though the response to different precooling treatments varied with vegetables contact icing and cold water treatments were found to be more efficient in most of the cases.

Combination of the precooling and packaging treatments also significantly influenced PLW, unmarketability, shelf life and consumer acceptability in amaranth, brinjal, chilli, cowpea, okra and tomato both under ambient and refrigerated storage environments. Among precooling treatments, in general, contact icing and cold water treatments were found to be the efficient methods, both under ambient and refrigerated storage and it in reduced PLW, retained the marketability and enhanced the shelf life of packaged vegetables. With respect to packaging treatments, differences in behaviour were observed for PLW, unmarketability, shelf life and consumer acceptability among vegetables stored under ambient and refrigerated environments. Irrespective of packaging materials and storage environments, vegetables packaged in unventilated polybags recorded the lowest PLW. Whereas, the effect of ventilation was very specific for different vegetables with respect to shelf life, unmarketability and spoilage. In the case of amaranth, under ambient temperature storage 200 gauge Polyethylene (PE) or Polypropylene (PP) with

0.5 per cent ventilation was found to be best for reducing PLW, retaining the marketability and enhancing the shelf life and consumer acceptability. In the case of refrigerated storage for amaranth 100 gauge PE and 200 gauge PP without ventilation were found to be the ideal packaging materials. Moreover, the refrigerated storage extended the shelf life of packaged samples by about three times as compared to ambient temperature storage. In brinjal, packaging in 100 or 200 gauge PE with 0.5 per cent ventilation were found to be beneficial both under ambient and refrigerated environments. Prepackaging followed by low temperature storage increased the shelf life almost three times compared to prepackaged brinjal held under ambient temperature storage. In chillies, under ambient temperature storage, prepackaging in ventilated 100 or 200 gauge PE and 100 or 200 gauge PP were found to be effective in reducing the PLW, retaining the marketability and extending the shelf life and consumer acceptability. With respect to refrigerated storage packaging in 200 gauge PP with 0.5 per cent ventilation was found to be beneficial. In refrigerated storage, for prepackaged samples a shelf life of about three times were obtained as compared to ambient temperature storage. In cowpea, prepackaging the pods in 200 gauge PE or PP and 100 gauge PP with 0.5 per cent ventilation were found to be effective under ambient temperature storage. With respect to refrigerated storage, packaging the pods in

200 gauge PE without ventilation reduced PLW, retained the marketability and enhanced the shelf life and consumer acceptability. An increase in shelf life of about four times was obtained for prepackaged samples held under refrigerated storage as compared to ambient temperature storage. In okra, under ambient temperature storage, the efficient packaging material was found to be unventilated 100 or 200 gauge PP whereas under refrigerated storage it was 100 or 200 gauge PE without ventilation. An increase in shelf life of about two times were obtained for prepackaged samples held under refrigerated storage as compared to ambient temperature storage. In the case of tomato, under ambient temperature storage, packaging fruits in ventilated 100 gauge PE and 200 gauge PE or PP were found to be effective in reducing PLW, retaining the marketability and enhancing the shelf life and consumer acceptability. With respect to refrigerated storage, the most efficient packaging material was 100 gauge PE with 0.5 per cent ventilation. Prepackaged samples held under refrigerated storage had a shelf life of about three times higher compared to ambient temperature storage. In all vegetables, irrespective of storage environments, the prepackaged samples had higher shelf life compared to those held without packaging.

The storage study of precooled portioned vegetables viz., ashgourd, elephant foot yam, oriental pickling melon, pumpkin and snakegourd packaged in polymeric films revealed that by portion packaging the PLW could be reduced thereby delaying the incidence of unmarketability both under ambient and refrigerated environments. In ashgourd, elephant foot yam, oriental pickling melon, pumpkin and snakegourd packaging the vegetable pieces in 100 gauge PE or PP coupled with low temperature storage extended the marketability upto 10, 13, 10, 11 and 15 days respectively.

In precooled vegetables kept without packaging, wilting, shrivelling, discolouration and shrinkage were the types of spoilage observed under ambient and refrigerated environments. In packaged samples spoilage due to microbial decay, discolouration and softening were observed under the two storage environments.

Precooling, packaging and refrigeration are value addition processes. Among precooling treatments/cost addition on account of contact icing worked out to 0.30 rupees per kilogram of vegetables. The other precooling treatments are cheaper ones with tap water treatment being the cheapest. When the cast of packaging was considered, polypropylene was found to be the cheapest package with a value addition of 0.11

and 0.19 rupee per cover for 100 and 200 gauge PP respectively. The results of low temperature studies revealed that approximately 50 kilogram of vegetables packaged in units of 500 gram can be conveniently stored in a refrigerator with a value addition of 0.05 rupee per kilogram or vegetable per day. The value addition is always limited by the profit realized out of the sale of the vegetable. Precooling, prepackaging supplemented with low temperature storage not only extends the shelf life but also helps the vegetable merchants to plan the procurement of fresh vegetables depending on market fluctuations.

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* Originals not seen

Appendices

Appendix

Some Typical Properties of Produce Packaging Films

Film name	Specific gravity approx.	Tensile strength, kg/cm^2	Approx. elongation until failure, %	Heat sealing temp. range C°	Approx. heat shrink, %	Heat Shrink tunnel temp. range, C°	Typical thickness range, mm	Water vapor transmission,[a] g 645 mm^2/24 hr.	Gas transmission,[b] cm^3 645 mm^2/24 hr O_2	CO_2
Polyethylene low density	0.90	100-150	200-600	150-260	20-50	150-230	0.025-0.050	1.2-1.4	500	2000
Polyethylene high density	0.95	200-500	20-400	180-310	--	--	0.010-0.015	0.3-0.6	100	450
Polypropylene	0.90	400-600	150-600	160-200	50-70	170-230	0.013-0.040	0.5-0.70	250	900
Polystyrene	1.05	600-850	10-70	120-160	40-70	130-160	0.025-0.040	6-10	330	1100
Poly vinyl chloride) (PVC)	1.25	300-1000	10-500	135-180	5070	120-170	0.010-0.035	2-5	500	3500

CONSUMER PACKAGING OF SELECTED VEGETABLES

By

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ABSTRACT OF A THESIS

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ABSTRACT

The present study on "Consumer packaging of selected vegetables" was conducted in the Department of Processing Technology, Kerala Agricultural University, Vellanikkara during June 1992 to October 1993. The study on standardisation of precooling treatments to improve the postharvest life of the vegetables viz., amaranth, brinjal, chilli, cowpea, okra and tomato revealed that precooling the vegetables immediately after harvest reduced the physiological loss in weight (PLW) and enhanced the marketability both under ambient and refrigerated storage environments. The effect of precooling treatments was more pronounced when precooling was immediately followed by refrigerated storage. Among precooling treatments, contact icing and cold water treatments were found superior to tap water treatment in most of the cases.

The study on precooling and packaging treatments on amaranth, brinjal, chilli, cowpea, okra and tomato revealed that precooling followed by immediate packaging of the vegetables in 100 or 200 gauge polyethylene or polypropylene bags reduced the PLW considerably. Moreover, packaged vegetables had better consumer acceptability and has remained

marketable for longer periods both under ambient and refrigerated storage conditions. In most of the cases, contact icing and cold water treatments gave better results among precooling treatments. With respect to packaging, under ambient temperature storage, 100 or 200 gauge polyethylene or polypropylene bags with 0.5 per cent ventilation was found to be ideal except in okra where unventilated polybags was the best. In refrigerated storage for brinjal, chilli and tomato, polybags with 0.5 per cent ventilation was found to be ideal. For amaranth, cowpea and okra polybags without ventilation was found to be more efficient. Refrigerated storage enhanced the shelf life of packaged vegetables 3-4 times as compared to packaged vegetables kept under ambient temperature storage.

The storage study on precooled portioned vegetables viz., ashgourd, elephant foot yam, oriental pickling melon, pumpkin and snakegourd packaged in polymeric films revealed that portion packaged vegetables had lower PLW and remained marketable for longer periods both under ambient and refrigerated storage environments.

Wilting, shrinkage, shrivelling, discolouration and microbial rotting were the common types of spoilage in packaged vegetables.

Cost-wise, among precooling treatments, tap water treatment was the cheapest followed by cold water and contact icing. Among polybags polypropylene was cheaper compared to polyethylene.