POST HARVEST EVALUATION AND MANAGEMENT OF CHERRY TOMATO [*Solanum lycopersicum* L. var. *cerasiforme* (Dunal) A. Gray] GENOTYPES

By

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(2015-12-011)

THESIS

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DECLARATION

I, hereby declare that this thesis entitled "**Post harvest evaluation and management of cherry tomato [*Solanum lycopersicum* L. var. *cerasiforme* (Dunal) A. Gray] genotypes**" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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Certified that this thesis entitled **"Post harvest evaluation and management of cherry tomato [*Solanum lycopersicum* L. var. *cerasiforme* (Dunal) A. Gray] genotypes"** is a bonafide record of research work done independently by **Ms. Rosemary M. Xavier (2015-12-011)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to her.

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"I am what I am by God's grace"

Holy Bible (1 Corithians 15:10)

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INTRODUCTION

1. INTRODUCTION

Tomato (*Solanum lycopersicum*) is one of the most popular and widely grown Solanaceous vegetable in the world. Among different forms, cherry tomato has recently gained popularity among consumers, because they can be eaten as such, they are deep red in colour and their flavour is intense and pleasant (Bhattarai *et al.*, 2016). Cherry tomato (*Solanum lycopersicum* L. var. *cerasiforme*) is originated from the natural cross between wild type tomato and domesticated garden tomato.

Cherry tomato is considered as a botanical variety of the cultivated tomato with small fruits (1.5 to 3.5 cm in diameter) borne on long panicles. The demand for cherry tomato is increasing steadily due to its high nutritional quality. Fruits are low in calories, packed with fibre and it is rich source of vitamin C, potassium, β carotene, antioxidants like lycopene and several other nutrients.

The average composition profile of cherry tomato is different from other group of tomatoes with high taste index. Cherry tomato is having low acidity, high TSS and sugar content compared to normal sized tomato. Therefore it is ideal for making salads and also called as 'salad tomato'.

America and China are the leading producers of cherry tomato. Though cherry tomato became popular as a cash crop in some Asian countries, it is still new in India. The cultivation of cherry tomato is confined to the private sectors in India. Thus there is a need to increase the production and productivity of cherry tomato in the country.

The cultivation of cherry tomato under protected condition is an emerging field since it is a high value crop performing well under protected conditions in tropical areas. Protected cultivation has specific advantages like high quality produce for export, high productivity and off season vegetable production.

Growing conditions have great influence on physical, biochemical and nutritional qualities of fruits and vegetables. In protected cultivation of fruits and

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vegetables, alternation of light intensity, temperature and relative humidity can affect production and partitioning of photo assimilates in plants, consequently affecting the composition of produced fruits.

Protected cultivation can be used to increase the productivity of cherry tomato. Tomato crops grown under polyhouse condition exhibited early flowering and high yield as compared to open field grown crop (Nagalakshmi *et al.,* 2001).

Cherry tomato is a climacteric fruit and reaches its respiratory peak during ripening process (Sausa *et al.*, 2016). It cannot be stored at ambient temperature beyond a week in tropical conditions when harvested at commercial maturity stage. Ripe cherry tomato is highly perishable, liable to transport damage which leads to loss in quality thus reducing its commercial value.

Packaging and storage in cherry tomato are important because this crop is mainly grown for export purpose and sell at premium prices.

Temperature is the most important factor in maintaining quality and shelf life of fruits and vegetables after harvest. Most of the physiological, biochemical and microbiological activities contributing to the deterioration of the produce quality are largely dependent on temperature.

Modified atmosphere packaging of fresh produce is an option to decrease the respiration rate, softening of fruits, diminishing water loss and shrinkage during the storage of fruits. The effect of different packaging materials, in maintaining physical appearance, chemical constitution and acceptability under different storage conditions of cherry tomato has to be investigated.

Hence the study 'Post harvest evaluation and management of cherry tomato [*Solanum lycopersicum* L. var. *cerasifirme* (Dunal) A. Gray] genotypes', has been laid out with the following objectives;

1. To evaluate the quality attributes of cherry tomato grown under rain shelter and open field condition
2. To standardise the packaging and storage requirements of cherry tomato

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Cherry tomato (*Solanum lycopersicum* L. var. *cerasiforme)* otherwise known as salad tomato, is a cultivated variety of normal sized tomato.

Cherry tomato antioxidants like lycopene, β carotene, total phenols, ascorbic acid and α tocopherol imparts a protective role and are powerful free radicle scavengers (Beecher, 1998 and Sies and Stahl, 1998). The epidemiological studies have revealed that the consumption of tomato reduce the risk of chronic diseases (Wilcox *et al.,* 2003).

Cherry tomato has gained popularity, due to its high nutritional quality. Higher content of soluble solids, dry matter, total phenols and lycopene make cherry tomato unique (Pagliarini *et al*., 2001 and Kuti and Konuru, 2005). These qualities could be affected by both genotypes and harvesting period (Anza *et al.,* 2006 and Raffo *et al*., 2006).

Cherry tomato is enjoying a continuously increasing commercial demand because of several important quality traits such as higher dry matter and higher levels of soluble solids in comparison to normal sized tomato fruits. Moreover, due to their higher levels of sugars and organic acids, cherry tomato exhibit a sweeter taste and rich aroma (Tsaniklidis *et al.,* 2014).

The literature available pertaining to the present study of 'Post harvest evaluation and management of cherry tomato (*Solanum lycopersicum* L. var. *cerasifirme* (Dunal) A. Gray) genotypes' has been reviewed under.

2.1 EVALUATION OF QUALITY ATTRIBUTES OF CHERRY TOMATO GROWN UNDER RAIN SHELTER AND OPEN FIELD CONDITION

2.1.1 Growing condition

Vegetables are well known for their nutritional qualities. Nowadays special attention is being given to improve the quality of the produce along with enhancing production. There are many biotic and abiotic factors that may influence the nutritional quality of the produce. Apart from the inherent factors, growing environment and agro techniques highly influence the same (Rana *et al.*, 2014).

Rain shelter is a less expensive, naturally ventilated tent, similar to the green house, usually made with GI pipes, wooden or bamboo poles. The roofing is provided with a transparent UV stabilized low density polyethylene film of 200 micron thickness, which will create a microclimate inside the tent by regulating temperature, relative humidity and partially filtering UV rays. The technology can be easily adopted by small and marginal farmers (Safia, 2015).

Rain shelter helps to grow off season produce, especially during rainy season, in hilly areas. Cherry tomatoes are richest sources of vitamins and antioxidants like lycopene. In North India, cherry tomatoes are grown both under open field condition and protected structures with shade nets installed for cooling (Rana *et al.*, 2014).

Fruits quality is affected by environmental conditions, besides genotypes. According to Chang *et al.* (1977), Venter (1977) and Davies and Hobson (1981), the nutrients like lycopene and vitamin C are strongly affected by light intensity and temperature.

Cherry tomato cultivation in protected environment had extended the availability of fruits to the off season. Changes in temperature, relative humidity and light intensity inside the protected environment could affect the partitioning of photo assimilates in plants and thereby production. Consequently the physical and chemical composition of the produced fruits may also change (Martinez, 1994. and Bakker, 1995).

Regulation of soil moisture is possible under rain shelter, since the soil is not exposed to rain. Thereby the incidence of fruit cracking and blossom end rot get reduced under rain shelter for tomato. High quality fruits with low occurrence of sun scald and high fruit bearing was observed under rain shelter (Masaki *et al.*, 1987).

2.1.2 Genotypes

Hart and Scott, in 1995, discovered that the carotene and volatile compounds are higher in orange coloured cultivars, whereas tenfold lower lycopene content was recorded for yellow varieties compared to red ones.

It has been reported that compared to commercial cultivars, fruits from wild species of tomato contains twice the amount of vitamin C and lycopene (Dorais and Papadopoulos, 2001)

Variation between the genotypes were recorded for chemical composition of tomato fruits for lycopene, potassium and vitamin C content (Rana *et al.*, 2014).

2.1.3 Physico- morphological parameters

Cherry tomato *(Solanum lycopersicum* L. var. *cerasiforme),* is a botanical variety of cultivated tomato. The plant bears small fruits on a long panicle in clusters. Average diameter of a single fruit is about 1.5 to 3.5 cm. (Kobryn and Hallmann, 2005).

Kumar *et al.* (2014) determined the fruit length, fruit girth, pericarp thickness and fruit weight of 15 genotypes of cherry tomato grown under protected condition. According to them, Cherry Tomato-8 (collected by All India

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Co-ordinated Research Project on vegetable crops, Raichur) recorded highest fruit length (4.17 cm), fruit girth (5.16 cm), pericarp thickness (0.47 mm) and fruit weight (56g). Minimum average fruit weight (2.80 g), fruit length (1.63 cm), fruit girth (1.76 cm) and pericarp thickness (0.10 mm) were observed in Cherry Tomato -1 (IARI, New Delhi).

Cherry tomatoes in general have smaller fruit size and high peel-percentage. All the commercial varieties were typical sized (61- 88 g) with low peel percentage compared to cherry tomato. Cherry tomatoes have compact sized fruits with higher peel percentage (Singh *et al.,* 2016).

In a study conducted by Patil *et al.* (2015) with 22 promising tomato genotypes, maximum juice percentage was recorded for RIIT5P5 (81.73 %) and RIIKT9/8 (80.10 %). High juice content and less pomace are considered as important characters for processing. The minimum pomace percentage was noted in RIIT5P5 (18.27 %).

To assess the size, according to diameter, a classification was suggested by Sales *et al.* (2000) for cherry tomato. The different classes are, very small (less than 13 mm), small (13-21 mm), medium (21-28 mm), large (28- 35 mm) and very large (more than 35 mm). Marketable cherry tomato fruits have an optimal size between 13 and 35 mm. Macua *et al.* (2007) opined that if 81 per cent of fruit had a mean weight of 8-12 grams it can be considered as homogenous.

Based on visual observation of fruit colour, compared with standard tomato colour chart, tomatoes can be divided into six batches. It represents six ripening stages, ranging from mature green to deep red. The six classes are, mature green (mature and entirely light to dark green), breaker (yellow or pink colour appearance first but not more than 10% and 30%), pink (pink or red colour is between 30% and 60%), red (red colour is more than 60% but less than 90%) and deep red (red colour exceed 90%) (Camelo and Gomez, 2004).

2.1.4 Nutritional and biochemical parameters

The average composition profile of cherry tomatoes are different from other groups of tomatoes. The fruits generally have higher content of TSS, dry matter, ascorbic acid, total phenolics, β carotene and antioxidants with high taste index. When compared to normal cultivated tomato, cherry tomatoes are tastier (Zanor *et al.*, 2009).

Study conducted by Rana *et al.* (2014) on quality parameters of tomato grown both under open and polyhouse revealed that open grown fruits had higher TSS (4.49° Brix), acidity (0.49 %), total sugar (2.50 %), ascorbic acid (14.7 mg $100g^{-1}$) and lycopene content (8.70 mg $100g^{-1}$) than the fruits grown under protected condition. However polyhouse favours the growth and development of fruits.

High Total Soluble Solids (TSS) and low acidity are the major qualities considered for the processing of cherry tomato. One per cent increase in TSS content of fruits results in 20 per cent increase in recovery of processed products. Lower acidity is the most deciding factor for processing of tomato as it reduces heating time required for processing (Berry *et al.*, 1998).

2.1.4.1 Total Soluble Solids

Sharma *et al.* (1996) reported that the TSS of cherry tomato is in the range of 4 - 6°Brix. Total Soluble Solid content was mainly affected by harvesting period and secondly by genotype. The total soluble solids content of fruit harvested in summer was comparatively higher than that of the fruits harvested in spring (Toor and Savage, 2006).

The TSS of different cherry tomato cultivars grown under rain shelter, was determined by Kumar *et al.* (2014). The highest TSS was noted in Cherry Tomato -1 (6.44° Brix), which was followed by Cherry Tomato-2 (6.32° Brix), Cherry Tomato -5 (5.81° Brix), Cherry Tomato -3 X Cherry Tomato-4 (5.71° Brix), Cherry Tomato 4 X Pant Tomato-3 (5.47° Brix) and Cherry Tomato -1 X Co-3-3 (5.44° Brix). The lowest TSS was noted in Cherry Tomato -1 X Co-3-1 (3.52° Brix).

Cherry tomato have a higher TSS compared to the normal sized tomatoes. Rana *et al.* (2014) reported that, the normal sized tomato had a TSS of 4.49° Brix in open field condition and 4.48° Brix in rain shelter.

2.1.4.2 Titrable Acidity

Citric acid is the main organic acid present in tomato fruits. (Fernandez *et al.*, 2004, and Siddiqui *et al.*, 2015) followed by malic and oxalic acid, present in much lower levels.

Loures (2001), studied the effect of growing conditions on nutritional quality of 'Carmem' variety of tomato. The study revealed that fruit titrable acidity was 0.46 per cent and 0.49 per cent under polyhouse and field condition respectively. Lower acidity was reported for the fruits obtained from polyhouse.

The study conducted by Rana *et al.* (2014) on tomato grown under open field and rain shelter, revealed that fruits produced in open field were more acidic (0.49 %) than fruits produced in protected environment (0.40 %).

Kumar *et al.* (2014) determined the titrable acidity of 15 genotypes of cherry tomato grown under rain shelter. Acidity ranged from 0.91 per cent (Cherry Tomato- 1 X Co-3-1) to 1.44 per cent (Cherry Tomato - 2) with over all mean of 1.08 per cent.

2.1.4.3 Sugars

The ratio of concentration of sugar and acid determine the taste of tomato fruits (Causse *et al.*, 2010).The main sugars, glucose and fructose are present in tomato at equimolar ratios (Beckles, 2012). The disaccharide, sucrose is not

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present in detectable levels in cultivated tomato fruits, due to the high activity of invertase enzyme (Beauvoit *et al.*, 2014).

According to Rana *et al.* (2014), tomato produced under open field condition had a high total and reducing sugar content compared to the fruits produced from protected environment. Total sugar content was about 5.30 and 4.15 g $100g^{-1}$ for open field and rain shelter respectively. The reducing sugar content of tomato fruits produced in the open field was higher (2.5 g $100g^{-1}$) than the fruits produced in the protected environment (1.92 g 100^{-1}).

Figas *et al.* (2015), studied nutritional the quality of 69 local accessions of tomato, and observed that cherry group of tomatoes contains higher amount of sugars as compared to other accessions with an amount of 9.94 g glucose and 7.78 g fructose per one kilogram of fruit.

2.1.4.4 Vitamin C

Ascorbic acid is an antioxidant and has multiple biological effect for human health like, anticarcinogenic and antiscorbutic properties (Cullen and Buetter, 2012). Significant levels of ascorbic acid is present in tomato fruits (Cortes *et al.*, 2014).

Ascorbic acid biosynthesis is strongly influenced by environmental factors, including light intensity (Venter, 1977). Davis and Hobson, (1981) stated that climatic conditions along with genotypes have a great effect on ascorbic acid content in tomato. They also suggested a variation between 10 and 30 mg $100g^{-1}$ ascorbic acid in protected environment and in open field respectively.

A study conducted by Rana *et al.* (2014) on tomato, revealed that, significantly high ascorbic acid is found in open field (14.50 mg $100g^{-1}$) than the fruits grown in polyhouse (12.82 mg $100g^{-1}$).

According to Figas *et al.* (2015), the amount of ascorbic acid present in cherry tomato is about 19.73 mg $100g^{-1}$.

2.1.4.5 Total phenols

Phenolic compounds are secondary metabolites occurring naturally in many fruits; they also exhibit good radical scavenging activity, maintain food quality, help in preventing cancer and cardiovascular diseases (Kaur and Kapoor, 2001).

Existence of phenolic compounds is the main reason behind the antioxidant nature of any plant. They are important group of secondary metabolites, synthesized due to plant adaptation in response to biotic and abiotic stresses. The antioxidant activity of these compounds depends mainly on molecular structure and availability of phenolic hydrogen which results in phenoxyl radical formation due to hydrogen donation (Rong, 2010).

The tomato phenolics exhibit antioxidant activity and are recognized as having important biological properties, including, antimicrobial, anti-inflammatory, cardio protective and neuro protective effects (Rio *et al*., 2013). Phenolics, in particular chlorogenic acid and quercetin are present in tomato fruits in significant concentrations (Siddiqui *et al*., 2015). Figas *et al*. (2015) reported that the cherry group of tomato contains 6.01mg $100g^{-1}$ total phenols.

Raffo *et al.* (2002) observed that the harvesting period and genotypes does not have significant effect on total phenols.

2.1.4.6 Total carotenoids

The carotenoids present in tomato fruits are lycopene, α- carotene, β-carotene, γ- carotene, phytoene and phytofluene. Among all these, lycopene is the major pigment present in higher quantities in tomato. Generally carotenoids occur in their trans configuration, and are thermodynamically more stable. The total carotenoid content in tomato was recorded as 106 to 139 $\mu g\ g^{-1}$ fresh weight of tomato by Torres *et al*. (2006).

2.1.4.7 Lycopene

Lycopene is the major carotenoid present in tomato and is responsible for the red colour of the ripe fruit.

According to the study conducted by Rana *et al.* (2014) in tomato, there was no significant variation in lycopene content for fruits from open field and rain shelter. Lycopene content of tomato was reported as 9.54 mg $100g^{-1}$.

According to Figas *et al.* (2015) lycopene content of Cherry group of tomatoes is about 3.66 mg $100g^{-1}$. Lycopene content was affected by genotype (Papoutsis *et al.*, 2016). They determined the lycopene content of two cherry tomato varieties. The lycopene content was about 22.10 $\mu g\ g^{-1}$, and 19.60 $\mu g\ g^{-1}$ in Lipso and Genio varieties respectively.

Lycopene accounts greater than 80 per cent of the total carotenoids in fully red ripe fruit. It has the highest antioxidant activity among the dietary antioxidants (Kaur and Bhatia, 2016).

2.1.4.8 β- Carotene

Another carotenoid of bioactive relevance present in the tomato fruit is β carotene. Raffo *et al.* (2002) reported that higher β carotene content was present in summer harvested tomatoes than spring harvested ones. Lycopene and β carotene intake has been correlated to reduce the risk of certain type of cancer and cardiovascular diseases (Keikel *et al.*, 2011). Although the levels of β carotene are normally much lower than that of lycopene (Cortes *et al*, 2014). According to Figas *et al.* (2015) β- carotene content of cherry group of tomatoes was about 0.90 mg $100g^{-1}$ and average antioxidant activity of 2.27 mmol TE kg^{-1}.

According to Papoutsis *et al.* (2016), lycopene, β carotene and total phenols are part of antioxidant component of tomato fruits. The study revealed that β carotene content was affected by genotype and harvesting period. The β

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carotene was about 14.90 μg g^{-1} and 17 μg g^{-1} in Lipso and Genio varieties respectively.

2.2 STANDARDISATION OF PACKAGING AND STORAGE REQUIREMENTS OF CHERRY TOMATO

Tomato have limited shelf life under ambient condition, which along with improper post harvest management and storage leads to huge post harvest losses (Kaur and Bhatia, 2016). This is a matter of concern for a country like India, whose economy is agriculture based. Efficient methods have to be developed to extent the shelf life of cash crops like cherry tomato and thereby improve its marketability.

2.2.1 Storage condition

Respiration in the harvested vegetable tissues, leads to loss of stored substrates in the produce, which hasten senescence. Temperature is well known to be the most important factor influencing respiration rate. So the temperature control provides a great benefit to extent the post harvest life. Biological reactions generally increase two to three fold for every 10°C in rise in temperature.

Controlled Atmosphere Storage (CAS) and Modified Atmosphere Storage (MAS) are the effective methods for prolonging the shelf life of many crops and can be also used for tomato fruits (Ali *et al.*, 2004).

Post harvest treatments of cherry tomato fruits involve the storage of fruits for some days near the vegetable garden, transportation to market in refrigerated trucks (10°C) and storage in domestic refrigerator (5°C) until consumption (Krikland *et al.,* 2009).

Tomato fruits are chilling sensitive, so optimum temperature for the storage of tomato fruits harvested at mature green or breaker stage of maturity is 12-13°C (Suslow and Cantwell, 2013). Low temperature storage can preserve the nutrient quality of tomato fruits.

2.2.2 Packaging materials

Modified Atmosphere Packaging of fresh produce is an option to slow down respiration rate, ripening of fruits and softening, minimize shrinkage water loss (Batu and Thompson, 1998).

The study conducted by Kaur and Batia (2016) on changes in physiological and biochemical parameters of two varieties stored in different packaging material (LDPE, HDPE and PP bags) in ambient condition revealed that, amongst packaging film, LDPE packaging was found to be efficient in maintaining quality attributes of tomato under ambient conditions and extended shelf life of tomatoes by three to four days more than other packages.

Aishwarya (2016) studied the effect of shrink wrap packaging on shelf life and quality of tropical fruits (pineapple, banana and mango). The study revealed that individual shrink wrapping of mango and pineapple was superior with regards to shelf life and quality. Polyolefin film of 25 μ thickness performed well compared to 15 μ and 19 μ thickness.

2.2.3 Physiological parameters

2.2.3.1 Physiological Loss in Weight (PLW)

The loss in weight is an important index of storage life in fresh produce. PLW appeared to be a detrimental factor of storage life and quality of tomato fruits.

Kenwoo *et al.* (2000), studied the weight loss of ripe tomato (cv. Pinky World) enclosed in plastic film packages (Low Density Poly Ethylene, thickness 40 μm) stored for 28 days at 4°C and 10°C. The lower weight loss was recorded for the samples stored at 4°C.

Aguayo *et al.* (2004) observed that the weight loss was lower in tomatoes wrapped with plastic film material compared to those stored unwrapped. Guillen *et al.* (2006) observed a weight loss of approximately 12 per cent in cherry tomatoes stored at 10°C for 28 days.

Lowest weight loss was reported in fruits harvested at mature green stage, and highest weight loss in fruits harvested at light red stage (Getinet *et al.,* 2008).

Barrier properties of packaging material will reduce the migration of moisture, oxygen availability and thereby respiration and weight loss of packed fruits (Abbasi, 2009).

Akbudak *et al.* (2012) evaluated weight loss of cherry tomatoes in passive MAP, using plastic film materials with various O_2 and CO_2 permeability. They found that weight loss was significantly higher for tomatoes stored under ambient atmosphere, compared to MAP.

Weight loss of cherry tomato, stored in Modified Atmosphere Package (5 per cent O_2, 5 per cent CO_2 and 90 per cent N_2) and atmosphere containing synthetic air (control) for 25 days at 5°C, were studied by Fagundes *et al.* (2015). The unpacked cherry tomato recorded a weight loss of 10 per cent after 25 days storage at 5°C and atmosphere relative humidity (80-85%). Weight loss after 25 days in packaged fruits and control samples were 0.18 per cent and 0.26 per cent respectively. Weight loss increased throughout the storage period, but it was lower than the values obtained for unpacked fruits.

2.2.3.2 Shelf life

A study was conducted by Fagundes *et al.* (2015), on the effect of active MAP and cold storage on post harvest quality of cherry tomato. The study revealed that active MAP (Bi-Oriented polypropylene and Low Density Polyethylene films as packaging material) with 5% O_2 and 5% CO_2 extended the shelf life of cherry tomato to 25 days.

Buntong *et al.* (2015) conducted a study on packaging and storage of tomato. Tomato fruits at breaker stage were stored in two types of modified atmosphere packs (using polyethylene film and food wrapping film with polystyrene foam as practiced in super markets) at two conditions (15°C and ambient temperature). Study revealed that keeping fruits in food wrapping film with polystyrene form at 15°C was the most effective in reducing weight loss and retarding ripening. Fruits stored in the open condition at ambient temperature had the highest weight loss and shortest shelf life due to rapid ripening.

Aishwarya (2016) reported that individual shrink wrapping of mango and pineapple and stored under ambient condition prolong the shelf life and maintain superior quality characteristics.

2.2.4 Biochemical analysis

2.2.4.1 TSS

TSS mainly indicate the sugar content of the fruit even though sugars are not the sole soluble fraction. Changes in TSS occur due to the metabolic processes like respiration and senescence. The packaging material highly regulate the rate of respiration and thereby conversion of sugar. Kaur and Bhatia (2016) studied the effect of packaging material on two varieties of tomato (Punjab Upma and Punjab Ratta). Slow increase in TSS was observed in packaged tomato compared to unwrapped ones. TSS was decreased thereafter, towards the end of shelf life, but better retention of TSS was observed for the packaged tomato fruits.

2.2.4.2 Acidity

According to Sadler and Murphy (1998), the concentration of organic acids decreases during postharvest storage periods due to their use as a substrate in the respiration or their transformation into sugars. Reductions observed in organic acid values in relation to ripening resulted from the utilization of acids in respiration and other physiological processes together with carbohydrates (Kader and Ben-Yehoshua, 2000).

Odriozola-Serrano *et al.* (2008) observed no significant loss of acid in fresh-cut tomatoes stored under MAP conditions (5 kPa O_2 + 5 kPa CO_2) for 21

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days at 4 °C. In a study conducted by Akbudak *et al.* (2012), no significant reductions was observed in acidity of cherry tomato cultivars during storage at 5 – 7°C.

Organic acid content of cherry tomatoes stored in modified atmosphere package (MAP) and in normal atmosphere (control) was analyzed by Fagundes *et al.* (2015). They reported that there was a reduction in organic acid content of cherry tomato during the storage both under MAP and control.

2.2.4.3 Sugars

Changes in sugar content indicate ripening of the product. According to Buta and Moline (1999), during postharvest storage, a decrease in organic acid level was observed, since it was used as a substrate in respiration and also transformed into sugars. The fructose and glucose levels in cherry tomatoes were found to be equal. The climacteric rise of ethylene and respiration match the initiation of high sugar import (in the form of glucose and fructose). Consequently, rapid starch degradation was also recorded in cherry tomato fruits (Luengwilai and Beckles, 2009 and Luengwilai *et al.,* 2010).Until 15 days of storage, there was increased production of ethylene and respiratory rate, as well as increased concentrations of fructose and glucose.

Akbudak *et al.* (2007) evaluated the effects of hot water treatment (HWT) and modified atmosphere packaging (MAP) on storage and fruit quality of cherry tomatoes stored in a cold room at 5 to 7°C and 90 to 95 per cent relative humidity. MAP combined with HWT slowed down the changes in total sugar content, indicating retardation of ripening.

Cherry tomatoes, stored in modified atmosphere package (MAP) stored in synthetic air, showed an increase in sugar content during storage due to ripening. The rate of increase was much slower than that of control (Fagundes *et al.*, 2015).

2.2.4.4 Ascorbic Acid

Ascorbic acid accumulation in plant tissues and organs is altered by physiological phenomenon such as senescence, cell expansion, development and various biotic and abiotic stimulations (Davey *et al.*, 2006).

Minor differences in ascorbic acid levels had been recorded in tomato fruits harvested at commercial maturity in 10 days of storage at 7°C, 15°C, and 25°C. (Toor and Savage, 2006). Total ascorbic acid and reduced ascorbic acid concentration exhibited a significant decrease in fruits stored at ambient temperatures. These results were consistent with the findings in pea, broccoli, and spinach. When storage temperature was decreased to 4°C for 14 days significant retention of ascorbic acid content was observed in tomato fruits compared to fruits stored under ambient condition (Proietti *et al.*, 2009).

Similarly ascorbic acid concentration was higher during 14 days of storage in tomato fruits kept at 10°C, compared to tomato fruits stored at ambient temperature (Gharezi *et al.*, 2012).

2.2.4.5 Lycopene

The major pigments of tomatoes include, the yellow pigment beta carotene and the red pigment lycopene (Friedman and Levin, 1998), which are metabolized during the ripening of tomatoes.

Storage conditions can alter the biosynthesis of lycopene. The optimum temperature range for lycopene synthesis is between 12 and 32°C. Temperatures below 12° C inhibit the biosynthesis and above 32°C obstruct the process (Dumas *et al.,* 2003). Akbudak *et al.* (2012) reported that, there was no significant reduction in lycopene content of cherry tomato cultivars during storage under normal atmosphere and also passive MAP storage at 5-7°C.

According to Fagundes *et al.* (2015) lycopene content of cherry tomato increased over the storage period for samples stored under MAP and control. The cherry tomatoes stored under an atmosphere of 5 per cent O_2, 5 per cent CO_2, and

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90 per cent N_2 showed a less pronounced increase of lycopene contents (8.36 g L^{-1}). No significant difference was observed between 15 and 25 days in this condition, a result consistent with the color analysis of the fruit.

2.2.5 Microbial load

Fresh produce are usually consumed as uncooked dishes to enjoy their freshness and to absorb heat sensitive nutrients such as vitamins more efficiently (Lester, 2006). Therefore they are subjected to minimal processing such as cleaning, peeling, slicing and washing after being harvested.

High moisture content of fresh produce also provides the optimal environmental condition for the proliferation of microorganisms during storage (Zavala *et al.*, 2008). However immediately after the harvest, fresh produce are known to contain high levels of microorganisms, those can cause severe outbreaks through the small surface cracks (Olmez and Kretzschamer, 2009).

Many outbreaks caused by *Salmonella enterica* are associated with the fresh produce (Hanning *et al.*, 2009). *Salmonella enterica* is one of the major food borne bacteria that cause food borne outbreaks and it is recognized as a public health risk. Its population was also observed in vegetables, including cherry tomatoes (Bajpai *et al.*, 2012).

Fresh produce is processed after harvesting to remove microbial contamination. It is necessary to control the growth of pathogenic microorganisms during the transportation and distribution. Packaging inhibit the proliferation of microorganisms thereby extending the shelf life of the product (Galet *et al.*, 2012).

The study conducted by Kwon *et al.* (2017) revealed that oreganum oil incorporated polyvinyl acetate films could be employed as packaging material for cherry tomato to enhance microbial safety of fruits from a wide range of microorganisms.

2.2.6 Organoleptic evaluation

High sugar and relatively high acid are required for the flavour development in tomato. Packaging in LDPE film is ideal for retention of total sugar and acidity. Sugar acid ratio is an important factor in determining the taste of tomato fruits (Kaur and Bhatia, 2016).

A study was conducted by Figas *et al.* (2015) on organoleptic quality of 65 local accessions of tomato. The study suggested that more acceptability was towards the local cherry tomato varieties, compared to commercial normal sized tomatoes.

According to Aishwarya (2016), organoleptic scores of individually shrink wrapped mangoes were higher than fruits wrapped in areca plates and control (unwrapped) fruits after one week of storage at ambient condition with 25μ polyolefin film. Better organoleptic acceptability of shrink wrapped fruits is due to the slowed biochemical reactions induced by modified atmosphere packaging.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The research programme "Post harvest evaluation and management of cherry tomato (*Solanum lycopersicum* L. var. *cerasiforme* (Dunal) A. Gray) genotypes" was carried out in the Department of Processing Technology, College of Horticulture, Vellanikkara during the period of 2015-2017.

The study consisted of two experiments.

- Evaluation of quality attributes of cherry tomato grown under rain shelter and open field condition
- Standardisation of packaging and storage requirements of cherry tomato

3.1 EVALUATION OF QUALITY ATTRIBUTES OF CHERRY TOMATO GROWN UNDER RAIN SHELTER AND OPEN FIELD CONDITION

3.1.1 Site selection

The site was selected at Department of Olericulture, which is located at an altitude of 22.25 m above MSL at 10° 32' N latitude and 76° 13' E longitude. This area enjoys a tropical warm humid climate and receives an average rainfall of 2663 mm per year. The climatic conditions during the period of experimentation are shown in Appendix I.

3.1.2 Rain shelter

A low cost rain shelter, with a floor area of 200 m^2 was used for the study. Its frame is made up of G.I pipes and cladded with UV stabilized polythene sheet of 200 micron thickness.

3.1.3 Open field

Plain land adjacent to the rain shelter was utilized for open field evaluation.

3.1.4 Design and layout of experiment

The experiment was laid out in randomized block design (RBD) with three replications. The details of the experiment are given below.

a. Plot size : 3.6 m^2

b. Spacing : 60 x 60 cm

c. Replications : 3

d. Genotypes : 11

R_1	**R_2**	**R_3**
T_2R_1	T_1R_2	$T_{10}R_3$
T_3R_1	T_4R_2	T_2R_3
$T_{11}R_1$	T_7R_2	T_1R_3
T_1R_1	T_8R_2	T_3R_3
T_4R_1	$T_{10}R_2$	T_4R_3
T_5R_1	$T_{11}R_2$	T_5R_3
T_6R_1	T_3R_2	T_9R_3
T_7R_1	T_5R_2	T_6R_3
T_8R_1	T_2R_2	T_7R_3
T_9R_1	T_6R_2	T_5R_3
$T_{10}R_1$	T_9R_2	$T_{11}R_3$

Fig.1. Lay out of experiment plot

3.1.5 Genotypes

Eleven genotypes of cherry tomato raised inside rain shelter and in open field in the Department of Olericulture were characterized based on physico-morphological, nutritive and biochemical parameters. Fully matured fruits were selected for analysis. The source of cherry tomato genotypes is given in Table.1.

Plate 1a. General view of plants inside rain shelter (outside view)

Plate 1b. General view of plants inside rain shelter (inside view)

Plate 1c. General view of plants grown in open field condition

Table-1. List of cherry tomato accessions

Genotype	Name of genotype	Source
SLc.1	BSBS 94	NBPGR, Regional station, Rajendra Nagar,Telangana
SLc.2	BSBS 47	NBPGR, Regional station, Rajendra Nagar,Telangana
SLc.3	PSR 10693	NBPGR, Regional station, Rajendra Nagar,Telangana
SLc.4	PSR 11668	NBPGR, Regional station, Rajendra Nagar,Telangana
SLc.5	BSBS 122	NBPGR, Regional station, Rajendra Nagar,Telangana
SLc.6	BSBS 137	NBPGR, Regional station, Rajendra Nagar,Telangana
SLc.7	BSBS 141	NBPGR, Regional station, Rajendra Nagar,Telangana
SLc.8	BSBS157	NBPGR, Regional station, Rajendra Nagar,Telangana
SLc.9	BSBS 180	NBPGR, Regional station, Rajendra Nagar,Telangana
SLc.10	Pusa Cherry Tomato -1	IARI, New Delhi
SLc.11	IIHR-2871	IIHR, Bangalore

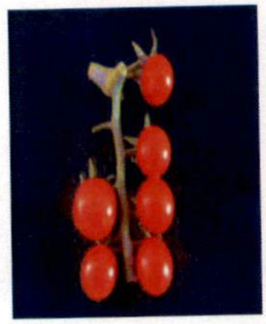
*** SLc – *Solanum lycopersicum* var. *cerasiforme***

3.1.6 Season

The research work was carried out during October- January, 2016-2017, inside rain shelter and open field.

SLc.1

SLc.2



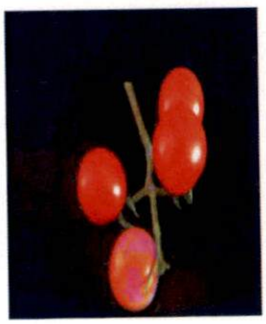
SLc.3

SLc.4

SLc.5

SLc.6

SLc.7



SLc.8

SLc.9

SLc.10

SLc.11

Plate 2. Fruits of different genotypes

3.1.7 Observations

Observations on physico-morphological, nutritional and biochemical parameters were taken as described below.

3.1.7.1 Physico-morphological parameters

3.1.7.1.1 Fruit length

Length of ten fruits was measured by using Vernier calliper and average of these value is expressed in centimeter.

3.1.7.1.2 Fruit diameter

Diameter of ten fruits was measured by using Vernier calliper and average of these values was expressed in centimeter.

3.1.7.1.3 Fruit girth

Girth of ten fruits was measured using a thread and accordingly the girth was determined on a scale of centimeter.

3.1.7.1.4 Rind thickness

Rind thickness of ten fruits was measured by using screw gauge and average of these values expressed in millimeter.

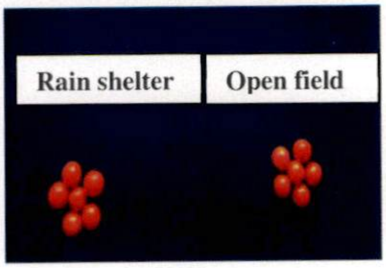
3.1.7.1.5 Fruit weight

Weight of ten fruits was taken by using weighing balance and average values expressed in grams.

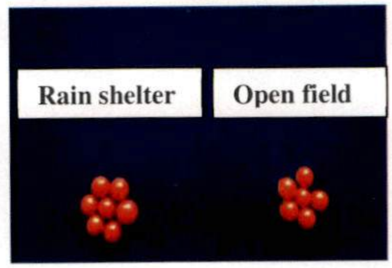
3.1.7.1.6 Juice per cent

Juice extracted from each fruit of all accessions was weighed separately and the average juice per cent was calculated by the formula as given below.

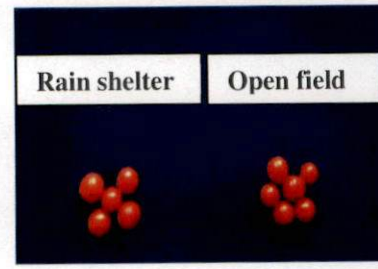
$$\text{Juice (\%)} = \frac{\text{Weight of juice (g)} \times 100}{\text{Weight of fruit (g)}}$$



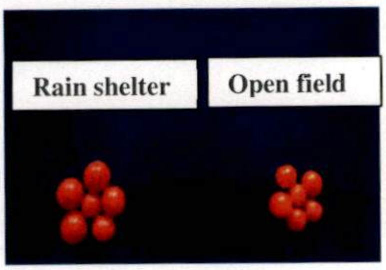
SLc.1



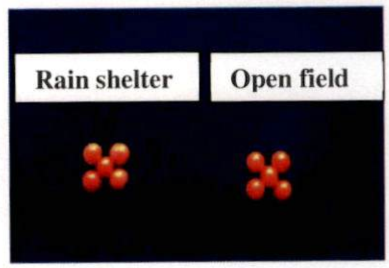
SLc.2



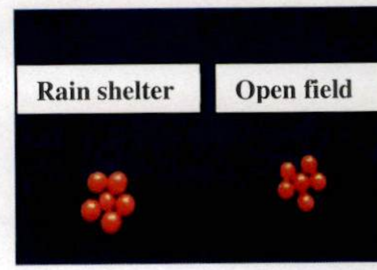
SLc.3



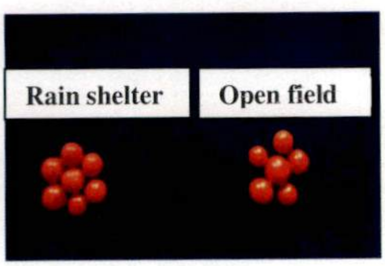
SLc.4



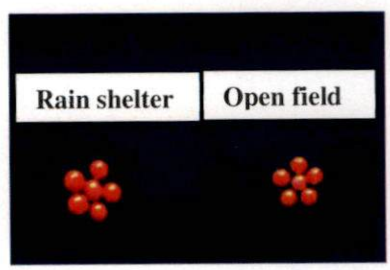
SLc.5



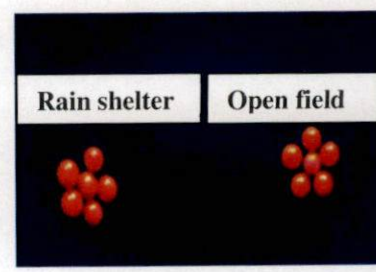
SLc.6



SLc.7

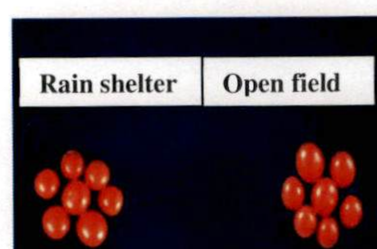


SLc.8



SLc.9

SLc.10



SLc.11

Plate 3. Fruits harvested from rain shelter and open field

3.1.7.1.7 Physical composition

Weight of each physical component of fruits (flesh, seed and peel) of all accessions was taken separately and its proportion to the total weight of fruit was expressed as given below.

$$\text{Physical composition (\%)} = \frac{\text{Weight of physical component (g)} \times 100}{\text{Weight of fruit (g)}}$$

3.1.7.1.8 Colour of rind

Rind colour of sample was visually observed and identified with the help of Universal Colour Language (UCL). The Universal Colour Language is a colour menu defined by the Inter-society Colour Council, National Bureau of Standards in 1946 and approved by Royal Horticultural Society (Anonymous, 1999). A valid UCL colour name contains a value, plus hue and a hue modifier which are denoted by alphabets and numbers.

3.1.7.1.9 Colour of juice

Color of juice was visually identified with the help of Universal Colour Language (UCL). Universal Colour Language was defined by the Inter Society Colour Council, National Bureau of Standards in 1946 and approved by Royal Horticultural Society.

3.1.7.1.10 Fruit size

Fruit size was expressed by the method suggested by Sales *et al.*, (2000). The different classes are, 'very small'(less than 13 mm), 'small' (13-21 mm), 'medium (21-28 mm), large (28-35 mm) and 'very large' (more than 35 mm). Marketable cherry tomato fruits have an optimal size between 13 and 35 mm.

3.1.7.2 Nutritional and biochemical parameters

3.1.7.2.1 Total soluble solids (TSS)

TSS was measured using hand refractometer (range 0-32° Brix), followed by temperature correction and values were expressed in degree Brix.

3.1.7.2.2 Titrable acidity

The titratable acidity was estimated by titrating with 0.1 *N* sodium hydroxide (NaOH) solution using phenolphthalein as indicator and expressed as per cent of citric acid present in the fruit. A known weight of sample was ground using distilled water and made up to 100 ml in a standard flask. An aliquot of 10 ml from this was titrated against 0.1 *N* NaOH (AOAC, 1998).

$$\text{Acidity (\%)} = \frac{\text{Normality x titre value x equivalent weight x volume made up x100}}{\text{weight of sample x aliquot of sample x 1000}}$$

3.1.7.2.3 Reducing, non-reducing and total sugars

Reducing and total sugars were estimated by volumetric method using Fehling's solution and expressed as percentage (Ranganna, 1997). Non reducing sugars were obtained from percentage of total and reducing sugars by subtraction.

3.1.7.2.3.1 Reducing sugars

A known weight of sample was ground in a pestle and mortar and transferred to 100 ml conical flask. About 100 ml distilled water was added followed by 2 ml pre- standardized 45 per cent lead acetate for clarification. Excess lead acetate was neutralized by the addition of 2ml pre- standardized 22 per cent potassium oxalate solution. The clarified solution was filtered and transferred to 250 ml volumetric flask and made up the volume. The reducing sugars were determined by titrating the clarified filtrate against standard Fehling's solution using methylene blue as indicator. The reducing sugar was calculated by the formula given below.

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$$\text{Reducing sugar (\%)} = \frac{\text{Fehling's factor x dilution x 100}}{\text{titre value x weight of sample}}$$

3.1.7.2.3.2 Total sugars

Filtrate (50 ml) used in the estimation of reducing sugars was taken in a 250 ml conical flask. Added 5g of citric acid and 50ml of water and boiled gently for 10 minutes to complete the inversion of sucrose. Transferred the contents to a 250ml volumetric flask and neutralized with 1*N* Sodium hydroxide using phenolphthalein as the indicator and made up the volume. The total sugars were estimated by titrating made up solution against standard Fehling's solution using methylene blue as indicator. The total sugar was calculated by the formula given below.

$$\text{Total sugar (\%)} = \frac{\text{Fehling's factor x 250 x dilution x 100}}{\text{Titre value x weight of sample}}$$

3.1.7.2.3.3 Non reducing sugars

The non reducing sugars in the sample was determined by deducting the reducing sugar content from the total sugar content (Ranganna, 1997).

Non reducing sugar (%) = Total sugar (%) – Reducing sugar (%)

3.1.7.2.4 Vitamin C

Vitamin C was determined by titrating a known weight of sample with 2,6-dichlorophenol indophenol dye, using metaphosphoric acid as stabilizing agent (AOAC, 1998).

A known weight of sample was ground using 3 percent metaphoric acid and the volume was made up to 100 ml. After filtration, 10 ml of aliquot was titrated against 2,6- dichlorophenol indophenol dye. The dye factor was calculated by titrating standard ascorbic acid solution against dye and ascorbic acid content of sample was expressed as

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$$\text{Ascorbic acid (mg } 100g^{-1}) = \frac{\text{Titre value x dye factor x volume made up x 100}}{\text{weight of sample x aliquot of sample}}$$

3.1.7.2.5 Total phenols

Estimation of total phenol was carried out using Folin - Ciocalteau reagent. Phenols react with phosphomolybdic acid in alkaline medium and produce a blue coloured complex (Molybdenum blue) (AOAC, 1998).

The juice sample (5ml) was added to 50 ml of 80 per cent ethanol and the sample was extracted in hot water bath for 25 to 30 minutes. It was then cooled and filtered through Whatman's No.1 filter paper. The extracted sample was made up to a known volume of 50 ml by using distilled water. The supernatant used for total phenol estimation was pipetted out into a series of test tubes. Sample extract (0.5 ml) was pipetted out in other test tubes.

To each test tube including blank, 3ml distilled water was added. It was mixed with 0.5 ml Folin Ciocalteau reagent and allowed to stand for 3 minutes. To all test tubes, 20 per cent sodium carbonate (2 ml) was added, mixed thoroughly and kept for 1 hour. All the tubes were kept in boiling water for exactly one minute and cooled. Optical density values were recorded in spectrophotometer at 650 nm. A standard graph was drawn and amount of total phenols in the sample was calculated.

3.1.7.2.6 Total carotenoids

A known weight of sample was ground in a pestle and mortar with acetone. The extract was poured into a conical flask. Extraction was continued till the residue became colourless. The extract was transferred to a separating funnel and then 10 to 15 ml of petroleum ether, little amount of distilled water and a little amount of anhydrous sodium sulphate was added and it was shaken well. The upper layer was collected and the lower layer was re-extracted. Extraction of acetone phase was repeated with small volume of petroleum ether till it became colourless. The extract was collected into a volumetric flask by passing through

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cotton containing small amount of anhydrous sodium sulphate and then the volume was made up with petroleum ether. The colour was measured at 452 nm using petroleum ether as blank in spectrophotometer. Results were expressed as mg $100g^{-1}$ of material (Ranganna, 1997).

$$\text{Total carotenoids (mg } 100g^{-1}) = \frac{3.857 \times \text{optical density} \times \text{volume made up} \times 100}{\text{weight of sample}}$$

3.1.7.2.7 β Carotene

Took 5 g of fresh sample and crushed in 10 to 15 ml acetone, adding a few crystals of anhydrous sodium sulphate, with the help of pestle and mortar, decanted the supernatant into a beaker, repeated the process twice and transferred the coloured supernatant to a separating funnel. Added 10 to 15 ml petroleum ether and mixed thoroughly. Two layers separated out on standing. Discarded the lower layer and collected upper layer in a 100 ml volumetric flask, made up the volume with petroleum ether and recorded the optical density at 452 nm using petroleum ether as a blank (Ranganna, 1997).

$$\beta \text{ carotene (mg } 100g^{-1}) = \frac{\text{Optical density} \times 13.9 \times 10^4 \times 100}{\text{weight of sample} \times 560 \times 100}$$

3.1.7.2.8 Lycopene

Tomato fruits were pulped to a smooth consistency in a blender. Weighed 5 to 10 g of this sample. Extracted the pulp repeatedly with acetone using mortar and pestle until the residue became colourless. Pooled the acetone extracts and transferred to a separating funnel containing about 20 ml petroleum ether and mixed gently. Added about 20 ml of 5 per cent sodium sulphate solution and shook the separating funnel gently and kept for separation into two layers. Most of the colours were noticed in upper petroleum ether layer. Separated the two phases and re-extracted the lower aqueous layer with additional 20 ml petroleum ether until the aqueous phase was colourless. Pooled the petroleum ether extracts and washed once with little distilled water. Poured the washed petroleum ether extract

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containing carotenoids into a brown bottle containing 10 g anhydrous sodium sulphate. Kept it aside for 30 minutes or longer. Decanted the petroleum ether extract in a 100 ml volumetric flask through a funnel containing cotton wool. Washed the sodium sulphate slurry with petroleum ether until it was colourless and transferred the washings to the volumetric flask. Made up the volume and measured the absorbance in a spectrophotometer at 503 nm using petroleum ether as blank (Ranganna, 1997).

Absorbance (1 unit) = 3.1206 μg Lycopene ml^{-1}

$$\text{Lycopene (mg } 100g^{-1}) = \frac{31.206 \times \text{Absorbance}}{\text{weight of sample in grams}}$$

3.2 STANDARDISATION OF PACKAGING AND STORAGE REQUIREMENTS OF CHERRY TOMATO

Two genotypes, one each from big fruited type (IIHR- 2871), and one from small fruited type (Pusa Cherry Tomato -1) were selected for further studies. Cherry tomato were harvested at mature green stage. Fruits free of damage and bruises were washed in clean tap water followed by immersion in 100 ppm chlorine solution for 15 minutes. The chlorinated fruits were spread out on perforated trays to remove excess surface moisture. The surface dried fruits were subjected to four type of packaging. The packaged fruits were stored at ambient temperature (28-36°C), refrigerated storage (5 ± 2°C) and cold storage (12 ± 3°C). Observations on variation in the quality of fruits were recorded at weekly intervals during storage.

3.2.1 Treatments

T_0 – Control (Unwrapped fruits)

T_1 – Packaging in micro ventilated polyethylene cover (200 gauge)

T_2 – Packaging in polystyrene tray and wrapping with cling film

T_3 – Packaging in polypropylene punnet

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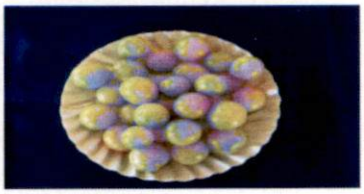
Pusa Cherry Tomato-1 | IIHR-2871

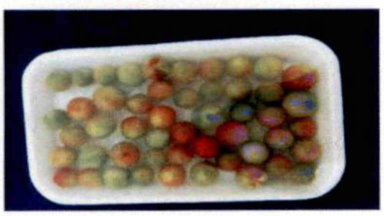


T_0

Control (Unwrapped fruits)

T_1

Packaging in micro ventilated polyethylene cover (200 gauge)



T_2

Packaging in polystyrene tray and wrapping with cling film

T_3

Packaging in polypropylene punnet

T_4

Shrink wrapping in polystyrene tray

Plate 4. Cherry tomato in different packages

T_4– Shrink wrapping in polystyrene tray overwrapping with polyolefin film of 19 μ thickness

3.2.2 Lay out

The experiment was laid out in a Completely Randomized Design with three replications each.

3.2.3 Observations

Observations on both physical and biochemical changes during storage were taken as detailed below.

3.2.3.1 Physical parameters

3.2.3.1.1 Shelf life

Shelf life was noted on the basis of physiological loss of weight (%), visual change like wilting, shriveling and also incidence of spoilage or rotting.

3.2.3.1.2 Physiological Loss of Weight

Physiological loss of weight was calculated by the formula as given below.

$$PLW (\%) = \frac{\text{Initial weight (g)} - \text{Final weight (g)} \times 100}{\text{initial weight (g)}}$$

3.2.3.2 Biochemical parameters

TSS was estimated as in 3.1.7.2.1

3.2.3.2.1 Titrable acidity

Titratable acidity was estimated as 3.1.7.2.2

3.2.3.2.2 Sugars

3.2.3.2.2.1 Reducing sugars

Reducing sugars were estimated as in 3.1.7.2.3.1

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3.2.3.2.2.2 Total sugars

Total sugars were estimated as in 3.1.7.2.3.2

3.2.3.2.2.3 Non reducing sugars

Non- reducing sugars were estimated as in 3.1.7.2.3.3

3.2.3.2.3 Vitamin C

Ascorbic acid was estimated as in 3.1.7.2.4

3.2.3.2.4 Lycopene

Lycopene was estimated as in 3.1.7.2.8

3.2.3.3 Microbial analysis

The estimation of microbial population present in the samples was carried out by serial dilution plate count method as described by Agarwal and Hasija (1986). Sample (10 g) was added to 90 ml distilled water and shaken well to form a suspension. From this suspension, 1ml was transferred to a test tube containing 9 ml distilled water. This gave a dilution of 10^{-2}. Later 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6} dilutions were prepared from these serial dilution.

The cherry tomato was subjected to microbial analysis initially and also at specific intervals during their storage. The samples were analysed for the population of bacteria, fungi and yeast in standard plate count in Nutrient Agar (NA), Martin Rose Bengal Agar (MRBA) and Sabouraud Dextrose Agar (SDA) media, respectively and the results are expressed in cfu g^{-1} of sample.

3.2.3.3.1 Estimation of bacterial population

Bacterial population was estimated using 10^{-5} dilution on nutrient agar medium. One ml of 10^{-5} dilution was pipetted into a sterile petridish using a micropipette. About 20 ml of melted and cooled Nutrient Agar (NA) media was poured into the petridish and it was swirled. After solidification it was kept for incubation at room temperature. Three petridishes were kept as replicate for each

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sample. The petriplates were incubated at room temperature for 48 hours. The colonies developed were counted and expressed as cfu $g^{-1}$of sample.

3.2.3.3.2 Estimation of fungal population

Fungal population was estimated using 10^{-3} dilution on Martin Rose Bengal Agar medium. One ml of 10^{-3} dilution was pipetted into sterile petridish using a micropipette. About 20 ml of melted and cooled Martin Rose Bengal Agar (MRBA) media was poured into the petridish and it was swirled. After solidification, it was kept for incubation at room temperature. Three petridishes were kept as replicate for each sample. The petriplates were incubated at room temperature for 4 to 5 days. The colonies developed were counted and expressed as cfu g^{-1} of the sample.

3.2.3.3.3 Estimation of yeast population

Yeast population was estimated using 10^{-3} dilution on Sabouraud's Dextrose Agar media. One ml of 10^{-3} dilution was pipetted into a sterile petridish using a micropipette. About 20 ml of the melted and cooled, Sabouraud's Dextrose Agar (SDA) was poured into the petridish and it was swirled. After solidification, it was kept for incubation at room temperature. Three petriplates were kept as replicate for each sample. The petriplates were incubated at room temperature for 4 to 5 days. The colonies developed were counted and expressed as cfug^{-1} of sample.

3.2.3.4 Organoleptic evaluation

Quality of cherry tomato was judged by semi trained panel of judges, for appearance, colour, flavour, texture, taste and overall acceptability, based on a 9 point hedonic scale rating (Amerine, *et al.,* 1965). A score of 5.5 above was considered as acceptable.

3.3 Tabulation and statistical analysis

The data obtained were analysed statistically using T test and analysis of variance (ANOVA) technique. The critical difference value at 5 per cent level was

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used for making comparison among different treatments. The score of sensory evaluation were analysed by Kendall's Coefficient of Concordance.

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RESULTS

4. RESULTS

The results of the present study entitled 'Post harvest evaluation and management of cherry tomato [*Solanum lycopersicum* L. var. *cerasiforme* (Dunal) A. Gray] genotypes' is presented under the following sections.

4.1 Evaluation of quality attributes of cherry tomato grown under rain shelter and open field condition

4.2 Standardisation of packaging and storage requirements of cherry tomato

4.1 EVALUATION OF QUALITY ATTRIBUTES OF CHERRY TOMATO GROWN UNDER RAIN SHELTER AND OPEN FIELD CONDITION

Cherry tomatoes raised inside rain shelter and in open field in the Department of Olericulture were characterised based on physico- morphological, nutritional and biochemical parameters. Eleven genotypes were selected for the study, which included 9 accessions from NBPGR Regional station, Rajendra Nagar, one each from IIHR Bangalore and IARI, New Delhi.

The variety Pusa Cherry Tomato-1 (SLc.10) though performed well under rain shelter, did not survive under open field condition because of bacterial wilt. Hence SLc.10 was excluded from experiment 1 for comparison of performance of accessions under open field conditions.

4.1.1 Physico-morphological parameters

4.1.1.1 Fruit length

Fruit length was significantly affected by growing conditions and highly varied among genotypes (Table 2). Higher fruit length was observed for all genotypes grown in rain shelter. Fruit length of cherry tomato accessions ranged from 1.24 cm to 2.60 cm and 1.51cm to 2.89 cm at open field and rain shelter respectively. SLc.11 had the highest fruit length in both open field (2.60 cm) and

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rain shelter (2.89 cm). The lowest fruit length was recorded by SLc.6, both in open field (1.24 cm) and rain shelter (1.51cm).

4.1.1.2 Fruit diameter

Fruit diameter was found to vary significantly between two growing conditions (Table 2). Fruit diameter was comparatively higher for rain shelter grown plants. Fruit diameter of cherry tomato accessions ranged from 1.25 cm to 2.62 cm and 1.57 cm to 3.16 cm in open field and rain shelter respectively. SLc.11 had the highest fruit diameter (2.62 cm) and lowest (1.25 cm) was recorded in SLc.6 in open field condition. SLc.11 had the highest diameter (3.16 cm) and SLc.6 recorded the lowest diameter (1.57 cm) in rain shelter.

4.1.1.3 Fruit girth

Fruit girth of cherry tomato accessions varied from 1.29 to 2.75 cm and 1.59 to 3.11 cm at open field and rain shelter respectively (Table 2). SLc.11 registered the highest value for fruit girth both in open field (2.75 cm) and rain shelter (3.11 cm). The lowest values for fruit girth was observed in SLc.6 both in open field (1.29 cm) and rain shelter (1.59 cm). The difference observed in fruit girth was significant between the growing conditions. Fruit girth varied significantly among genotypes under rain shelter and comparatively higher fruit girth was recorded for rain shelter grown ones.

4.1.1.4 Rind thickness

Rind thickness of cherry tomato accessions was found to range between 0.10 mm to 0.20 mm in open field and 0.34 to 0.46 mm in rain shelter (Table 2). However, the highest value for rind thickness was observed in SLc.11 in both growing conditions (0.20 and 0.46 mm for open field and rain shelter respectively) and it was on par with SLc.8 under rain shelter. The lowest value for rind thickness was observed in SLc.7 under both growing conditions (0.10 mm and 0.34 mm) for open field and rain shelter respectively) and it was on par with SLc.2, 4 and 9 under rain shelter.

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Table 2. Effect of growing conditions on physical parameters of cherry tomato genotypes

Accessions	Fruit length (cm)			Fruit diameter (cm)			Fruit girth (cm)			Rind thickness (mm)		
	Open field	Rain shelter	T value	Open field	Rain shelter	T value	Open field	Rain shelter	T value	Open field	Rain shelter	T value
SLc.1	1.36	1.55^{g}	6.12**	1.41	1.82^{d}	13.22**	1.40	1.80^{d}	16.00**	0.14	0.39^{c}	3.08**
SLc.2	1.52	1.81^{d}	9.35**	1.62	2.00^{b}	12.25**	1.55	1.98^{b}	17.20**	0.13	0.35^{d}	2.71**
SLc.3	1.55	1.90^{c}	11.29**	1.59	1.95^{bc}	11.61**	1.57	1.95^{bc}	15.20**	0.17	0.40^{c}	2.83**
SLc.4	1.38	1.57^{g}	6.12**	1.41	1.73^{e}	10.32**	1.38	1.72^{e}	13.60**	0.11	0.34^{d}	2.96**
SLc.5	1.42	1.72^{e}	9.67**	1.46	1.80^{d}	10.96**	1.47	1.81^{d}	13.60**	0.19	0.43^{b}	2.96**
SLc.6	1.24	1.51^{h}	8.76**	1.25	1.57^{f}	10.32**	1.29	1.59^{f}	12.00**	0.14	0.39^{c}	3.08**
SLc.7	1.41	1.60^{f}	6.12**	1.43	1.76^{d}	10.64**	1.42	1.79^{d}	14.80**	0.10	0.34^{d}	2.96**
SLc.8	1.62	1.95^{b}	10.64**	1.64	1.97^{bc}	10.64**	1.59	1.95^{bc}	14.40**	0.17	0.46^{a}	3.58**
SLc.9	1.45	1.71^{e}	8.38**	1.53	1.92^{c}	12.58**	1.51	1.90^{c}	15.60**	0.12	0.36^{d}	2.96**
SLc.11	2.60	2.89^{a}	9.35**	2.62	3.16^{a}	17.41**	2.75	3.11^{a}	14.40**	0.20	0.46^{a}	2.83**
CD		**0.12**			**0.13**			**0.10**			**0.03**	
SLc.10	Nil	2.16		Nil	2.17		Nil	2.19		Nil	0.36	

SLc - *Solanum lycopersicum* var. *cerasiforme*

** - Significant at both 1% and 5% level of significance

NS-Non significant

Rind thickness varied among the varieties for fruits from rain shelter and also significantly varied between growing conditions. Rind thickness was higher for the fruits grown under rain shelter.

4.1.1.5 Fruit weight

Fruit weight of cherry tomato accessions ranged from 1.96 g in SLc.6 to 18.26 g in SLc.11 in open field (Table 2). In rain shelter, fruit weight ranged from 2.63 g in SLc.6 to 20.67 g in SLc.11. The lowest fruit weight was observed in SLc.6 which was on par with SLc.1 (2.93 g). The fruit weight was higher for genotypes inside rain shelter compared to open field. Significant variation among the genotypes for fruit weight was observed inside rain shelter.

4.1.1.6 Juice per cent

Juice per cent of cherry tomato accessions varied from 35.03 per cent to 47.11 per cent and 45.19 per cent to 58.03 per cent at open field and rain shelter respectively (Table 2). SLc.7 had the highest juice per cent both in open field (47.11%) and rain shelter (58.03%). SLc.1 registered the lowest value under both growing conditions, 35.03 per cent for open field and 45.19 per cent for rain shelter. Juice per cent was significantly affected by the growing conditions and varied among the genotypes. Rain shelter grown fruits had higher juice content than open field ones.

4.1.1.7 Physical composition

Physical composition refers to the per cent of each component (peel, seed, and pulp) to the total weight of the fruit. The range observed for peel, seed and pulp in the different accessions in open field were 6.34 - 9.18 per cent, 30.80 - 44.60 per cent and 48.01 to 61.25 per cent respectively (Table 3). Inside the rain shelter the physical components like peel, seed and pulp varied between 5.05 to 7.39 per cent, 24.94 to 34.44 per cent and 56.51 to 66.95 per cent respectively.

Table 2. Continued

Accessions	Fruit weight (g)			Juice per cent (%)		
	Open field	Rain shelter	T value	Open field	Rain shelter	T value
SLc.1	2.10	2.93^{e}	2.69**	35.03	45.19^{c}	4.51**
SLc.2	3.90	4.48^{c}	1.88^{NS}	37.66	54.72^{ab}	7.54**
SLc.3	4.40	5.33^{b}	3.01**	37.33	55.31^{ab}	7.95**
SLc.4	2.98	3.10^{g}	0.38^{NS}	44.98	53.66^{ab}	3.84**
SLc.5	3.37	3.90^{d}	1.72^{NS}	38.33	49.66^{bc}	5.01**
SLc.6	1.96	2.63^{e}	2.17**	45.73	55.67^{ab}	4.39**
SLc.7	4.60	3.22^{de}	4.48**	47.11	58.03^{a}	4.83**
SLc.8	3.32	5.43^{b}	6.85**	40.24	50.22^{bc}	4.41**
SLc.9	3.54	4.45^{c}	2.95**	43.18	52.33^{ab}	4.08**
SLc.11	18.26	20.67^{a}	7.82**	40.66	57.09^{a}	7.36**
CD		**1.24**			**6.77**	
SLc.10	Nil	6.24		Nil	50.36	

SLc - *Solanum lycopersicum* var. *cerasiforme*

** - Significant at both 1% and 5% level of significance

NS-Non significant

Table 3. Effect of growing conditions on physical composition of fruits

Accessions	Peel (%)			Seed (%)			Flesh (%)		
	Open field	Rain shelter	T value	Open field	Rain shelter	T value	Open field	Rain shelter	T value
SLc.1	7.15	5.05^{i}	116.00**	41.19	33.60^{b}	93.00**	51.66	61.35^{f}	51.81**
SLc.2	7.39	5.39^{h}	111.00**	44.60	30.87^{d}	169.50**	48.01	63.71^{cd}	83.95**
SLc.3	9.18	7.10^{c}	115.00**	42.20	29.62^{g}	155.30**	48.73^{e}	63.28^{cd}	77.80**
SLc.4	8.02	7.26^{b}	42.22**	37.09	30.24^{f}	84.56**	54.91	56.51^{g}	8.55**
SLc.5	7.54	6.95^{d}	32.77**	31.22	30.28^{e}	11.60**	61.25	63.39^{d}	11.44**
SLc.6	6.34	5.60^{g}	41.11**	42.16	30.99^{c}	137.90**	51.50	62.57^{e}	59.19**
SLc.7	7.90	5.61^{g}	127.22**	32.00	30.23^{f}	21.85**	60.11	63.84^{bc}	19.94**
Slc.8	8.79	6.42^{e}	131.00**	42.80	24.94^{i}	220.49**	48.40	66.95^{a}	99.19**
Slc.9	8.09	6.20^{f}	105.00**	31.74	34.44^{a}	33.33**	60.18	62.49^{cd}	12.35**
Slc.11	8.79	7.39^{a}	77.77**	30.80^{i}	26.98^{h}	47.16**	60.40	63.83^{bc}	18.34**
CD		**0.08**			**0.11**			**0.55**	
Slc.10	Nil	5.20		Nil	36.14		Nil	59.64	

SLc - *Solanum lycopersicum* var. *cerasiforme*

** - Significant at both 1% and 5% level of significance

NS-Non significant

In open field, the highest values for peel (9.18 %), seed (44.60 %) and pulp (61.25 %) were recorded for SLc.3, SLc.2 and SLc.5 respectively. SLc.6, SLc.10 and SLc.2 registered least value for peel (6.34 %), seed (30.80 %) and pulp (48.01 %) in open field.

Among the cherry tomato genotypes raised in rain shelter, the highest values observed for peel (7.39 %), seed (34.44 %) and pulp (66.95 %) content was in SLc.11, SLc.9 and SLc.8 respectively. The least content of peel (5.05 %), seed (24.94 %) and pulp (56.51 %) was noted for SLc.1, SLc.11 and SLc.4 respectively.

Physical composition of fruits was significantly influenced by growing conditions and genotypes. The highest pulp content, least peel and seed content were registered for fruits grown inside rain shelter.

4.1.1.8 Colour of rind

The data on rind colour of cherry tomato is presented in Table 4. The skin colour was described using Universal Colour Language (UCL). It was vivid reddish orange (32A) for SLc.1 and 11, vivid orange (28B) for SLc.2, SLc.8 and SLc.11 and vivid yellowish pink (28A) for other accessions, in open field condition. In rain shelter it was strong reddish orange for all the accessions.

4.1.1.9 Colour of juice

The Universal Colour Language (UCL) was used to describe the juice colour of cherry tomato (Table 4). In open field, the juice colour was light orange (26C) for SLc.2, 8 and 9, and light yellowish pink (27A) for other accessions, whereas in rain shelter, strong yellowish pink (31C) for SLc.1, 3, 11 and 10 and strong orange (30D) for other accessions.

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4.1.1.10 Fruit size

The fruits were classified based on diameter as 'very small' (less than 13 mm), 'small' (13-21 mm), 'medium' (21-28 mm), and 'large' 28-35 mm and 'very large' (more than 35 mm) (Sales *et al.,* 2000). SLc.1, 2, 3, 4, 5, 7, 8 and 9 had 'small' sized fruits under both growing conditions (Table 4). Fruits of SLc.6 belonged to category 'very small' under open field and 'small' under rain shelter. Fruits of SLc.11 from open field were classified as 'medium' and those from rain shelter were classified as 'large'. Medium sized fruits were obtained for SLc.10 under rain shelter.

4.1.2 Nutritional and biochemical characteristics

4.1.2.1 Total Soluble Solids

The total soluble solids varied significantly between the growing conditions for all the accessions except SLc.11 (Table 5). TSS of cherry tomato accessions ranged from 5 to 7.5° brix and 4.4 to 7.2° brix for open field and rain shelter respectively. In open field SLc.2 had the highest TSS (7.5° brix), while the lowest (5.0° brix) was recorded in SLc.5. In case of rain shelter highest TSS (7.2° brix) was for SLc.1 and SLc.2, and lowest (4.4° brix) TSS was recorded in SLc.5.

4.1.2.2 Titrable acidity

Titrable acidity of cherry tomato accessions ranged from 0.72 to 1.28 per cent and 0.43 to 1.02 per cent in open field and rain shelter respectively (Table 5). SLc.1 and SLc.4 had the highest titrable acidity (1.28 %) and the lowest (0.72 %) was recorded in SLc.7 and SLc.11 in case of fruits from open field. However SLc.8 had the highest titrable acidity (1.02 %) and SLc.11 had the lowest titrable acidity (0.43 %) inside rain shelter. Significant variation among the genotypes under rain shelter was recorded in titrable acidity, it was comparatively higher for the fruits grown under open field, in SLc.1, SLc.4, SLc.9 and SLc.11.

Table 4. Effect of growing conditions on colour of rind, juice and fruit size

Accessions	Colour of rind		Colour of juice		Fruit size	
	Open field	Rain shelter	Open field	Rain shelter	Open field	Rain shelter
SLc.1	vivid reddish orange (32A)	Strong reddish orange (31 A)	Light yellowish pink (26 D)	Strong yellowish pink (31C)	Small	Small
SLc.2	vivid orange (28B)	Strong reddish orange (31 A)	Light orange (26C)	Strong orange (30D)	Small	Small
SLc.3	Vivid yellowish pink (28A)	Strong reddish orange (31 A)	Light yellowish pink (27A)	Strong yellowish pink (31C)	Small	Small
SLc.4	Vivid yellowish pink(28A)	Strong reddish orange (31 A)	Light yellowish pink (27A)	Strong orange (30D)	Small	Small
SLc.5	Vivid yellowish pink(28A)	Strong reddish orange (31 A)	Light yellowish pink (27A)	Strong orange (30D)	Small	Small
SLc.6	Vivid yellowish pink(28A)	Strong reddish orange (31 A)	Light yellowish pink (27A)	Strong orange (30D)	Very small	Small
SLc.7	Vivid yellowish pink(28A)	Strong reddish orange (31 A)	Light yellowish pink (27A)	Strong yellowish pink (31C)	Small	Small
SLc.8	Vivid orange (28B)	Strong reddish orange (31 A)	Light orange (26C)	Strong orange (30D)	Small	Small
SLc.9	Vivid orange (28B)	Strong reddish orange (31 A)	Light orange (26C)	Strong orange (30D)	Small	Small
SLc.11	Vivid reddish orange (32 A)	Strong reddish orange (31 A)	Light yellowish pink (26 D)	Strong orange (30D)	Medium	Large
SLc.10	-	Strong reddish orange (31 A	-	Strong yellowish pink (31C)	-	Medium

SLc - *Solanum lycopersicum* var. *cerasiforme*

4.1.2.3 Sugars

Wide variation in reducing, non reducing and total sugar content was observed among the different cherry tomato genotypes (Table 5). The reducing sugar ranged from 1.35 to 2.93 per cent and 1.33 to 2.90 % for open field and rain shelter respectively. SLc.2 had the highest reducing sugar content in both open field (2.93 %) and rain shelter (2.90 %). The lowest reducing sugar content was observed for SLc.5 for both open field (1.35 %) and rain shelter (1.33 %). There was no significant difference between the growing conditions for reducing sugar content (except SLc.2, 6, and 11) but between the genotypes it significantly varied under rain shelter.

Non reducing sugar content ranged from 0.51 to 1.73 per cent and 0.42 to 1.50 per cent for open field and rain shelter respectively. The non reducing sugar was highest for SLc.1 for both open field (1.73 %) and rain shelter (1.50 %). The lowest non reducing sugar was registered for SLc.11 under open field (0.51 %) and rain shelter (0.42 %). Significant change in non reducing sugar was observed between the genotypes grown under rain shelter. Non reducing sugar content was significantly high for open field grown fruits except for SLc.6.

The total sugar content ranged from 2.58 to 3.97 per cent and 2.44 to 3.90 per cent for open field and rain shelter respectively. SLc.2 and SLc.1 recorded the highest total sugar content both under open field and rain shelter. SLc.5 had the lowest sugar content for both open field and rain shelter. Significant change between the genotypes was observed under rain shelter but growing condition had significant effect on total sugar only for SLc.3, SLc.6, SLc.7, SLc.8, SLc.9 and SLc.11.Comparison between the two growing conditions revealed that, total sugar content was high for the fruits grown under open field condition.

Table 5. Effect of growing condition on chemical constituents of fruits

Accessions	TSS (° Brix)			Titratable acidity (%)		
	Open field	Rain shelter	T value	Open field	Rain shelter	T value
SLc.1	7.4	7.2^{a}	3.10**	1.28	0.77^{ab}	6.62**
SLc.2	7.5	7.2^{a}	3.79**	0.77	0.64^{b}	1.68^{NS}
SLc.3	6.0	5.5^{d}	5.74**	1.02	0.90^{a}	1.55^{NS}
SLc.4	6.1	5.6^{d}	6.09**	1.28	0.90^{a}	4.93**
SLc.5	5.0	4.4^{g}	6.89**	0.77	0.90^{a}	1.68^{NS}
SLc.6	5.4	5.0^{f}	4.59**	0.90	0.90^{a}	0.00^{NS}
SLc.7	5.2	5.0^{f}	2.29**	0.72	0.64^{b}	1.03^{NS}
SLc.8	5.4	5.2^{e}	2.29**	0.98	1.02^{a}	0.51^{NS}
SLc.9	6.2	5.9^{c}	3.44**	0.98	0.64^{b}	4.41**
SLc.11	6.0	5.9^{c}	1.95^{NS}	0.72	0.43^{bc}	3.76**
CD	-	**0.26**		-	**0.31**	
SLc.10	-	6.3	-	-	0.77	-

SLc - *Solanum lycopersicum* var. *cerasiforme*

** - Significant at both 1% and 5% level of significance

NS-Non significant

Table 5. Continued

Accessions	Reducing sugar (%)			Non reducing sugar (%)			Total sugar (%)		
	Open field	Rain shelter	T value	Open field	Rain shelter	T value	Open field	Rain shelter	T value
SLc.1	2.23	2.39^{c}	1.97^{NS}	1.73	1.50^{a}	8.46**	3.96	3.90^{a}	0.69^{NS}
SLc.2	2.93	2.90^{a}	0.37^{NS}	1.04	0.98^{c}	2.30**	3.97	3.88^{a}	1.03^{NS}
SLc.3	2.16	1.92^{d}	2.96^{**}	1.25	1.19^{b}	2.30**	3.41	3.11^{d}	3.44**
SLc.4	2.59	2.55^{b}	0.39^{NS}	1.04	0.97^{c}	2.69**	3.63	3.52^{b}	1.26^{NS}
SLc.5	1.35	1.33^{e}	0.24^{NS}	1.23	1.11^{bc}	4.61**	2.58	2.44^{f}	1.61^{NS}
SLc.6	2.14	1.90^{d}	2.96^{**}	1.40	1.37^{ab}	1.15^{NS}	3.54	3.27^{cd}	3.10^{**}
SLc.7	2.19	2.15^{cd}	0.49^{NS}	0.73	0.54^{d}	7.30**	2.92	2.69^{e}	2.64**
SLc.8	2.33	2.31^{c}	0.24^{NS}	1.27	1.09^{bc}	6.92**	3.60	3.40^{c}	2.29**
SLc.9	2.51	2.47^{b}	0.49^{NS}	1.24	1.08^{bc}	6.12**	3.75	3.55^{b}	2.29**
SLc.11	2.87	2.69^{b}	2.22^{**}	0.51	0.42^{e}	3.48**	3.38	3.11^{d}	3.10**
CD	-	**0.33**		-	**0.12**		-	**0.24**	
SLc.10	-	2.69	-	-	0.84		-	3.45	-

SLc - *Solanum lycopersicum* var. *cerasiforme*

** - Significant at both 1% and 5% level of significance

NS-Non significant

4.1.2.4 Ascorbic acid

The growing conditions were found to significantly influence the ascorbic acid content of all the genotypes (Table 6). The variation observed between the genotypes inside the rain shelter was also significant. Comparatively high vitamin C content was recorded for the open grown fruits except for SLc.6, SLc.7 and SLc.8. Ascorbic acid content of cherry tomato accessions ranged from 14.28 to 32.59 mg $100g^{-1}$ and 12.50 to 32 mg $100g^{-1}$ for open field and rain shelter respectively. SLc.2 had the highest vitamin C both under open field (32.59 mg100 g^{-1}) and rain shelter (32 mg $100g^{-1}$). SLc.4 had the lowest vitamin C both under open field (14.28 mg $100g^{-1}$) and rain shelter (12.50 mg $100g^{-1}$).

4.1.2.5 Total phenols

Considerable variation in total phenol content was recorded between cherry tomato genotypes (Table 6). Total phenols in cherry tomato genotypes ranged from 0.50 mg $100g^{-1}$ in SLc.4 to 1.10 mg $100g^{-1}$ in SLc.5 and SLc.9 in open field. Inside the rain shelter total phenol content was found to have a range between 0.60 mg $100g^{-1}$ in SLc.5 to 1.10 mg $100g^{-1}$ in SLc.9. Growing conditions were found to influence significantly the total phenol content in SLc.2, 4, 5, 6, 7, 8 and 11. However total phenol was higher in open field grown fruits for SLc.5, SLc.6, SLc.7 and SLc.11. and rain shelter grown fruits of SLc.2, SLc.4 and SLc.8.

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Table 6. Effect of growing condition on nutritional parameters

Accessions	Vitamin C (mg $100g^{-1}$)			Total phenols (mg $100g^{-1}$)		
	Open field	Rain shelter	T value	Open field	Rain shelter	T value
SLc.1	28.57	28.00^{c}	4.91**	0.90	0.83^{d}	1.59^{NS}
SLc.2	32.59	32.00^{a}	5.08**	0.90	1.00^{b}	2.27**
SLc.3	21.13	18.75^{h}	20.51**	0.90	0.90^{c}	0.00^{NS}
SLc.4	14.28	12.50^{j}	15.34**	0.50	0.80^{e}	6.81**
SLc.5	18.57	15.38^{i}	27.50**	1.10	0.60^{g}	11.36**
SLc.6	26.08	30.76^{b}	40.34**	1.03	0.70^{f}	7.50**
SLc.7	19.39	23.07^{f}	31.72**	0.80	0.70^{f}	2.27**
SLc.8	22.78	25.00^{e}	19.13**	0.73	0.90^{c}	2.86**
SLc.9	22.85	19.76^{g}	26.63**	1.10	1.10^{a}	0.00^{NS}
SLc.11	30.77	26.74^{d}	34.74**	0.90	0.60^{g}	6.81**
CD	-	**0.35**		-	**0.13**	
SLc.10	-	32.50		-	0.90	

SLc - *Solanum lycopersicum* var. *cerasiforme*

** - Significant at both 1% and 5% level of significance

NS - Non significant

4.1.2.6 Total carotenoids

Total carotenoid content of cherry tomato genotypes differed significantly inside rain shelter (Table 6). It was significantly high under rain shelter as compared to open field for all genotypes. The total carotenoid content of cherry tomato genotypes ranged from 1.82 to 5.46 mg $100g^{-1}$ in the open field and 3.27 to 6.51 mg $100g^{-1}$ in the rain shelter. SLc.1 had highest total carotenoid content (5.46 mg $100g^{-1}$) and SLc.6 had the lowest (1.82 mg $100g^{-1}$) in open field condition. Inside the rain shelter SLc.2 had highest total carotenoid content (6.51mg $100g^{-1}$) and SLc.7 the lowest total carotenoid content (3.27 mg $100g^{-1}$).

4.1.2.7 β carotene

Considerable variation in β carotene content was recorded in cherry tomato genotypes inside rain shelter (Table 6). Comparison of two growing conditions revealed significantly higher β carotene content in SLc.2, SLc.3, SLc.5, SLc.6 and SLc.7. β carotene in cherry tomato ranged from 0.39 to 1.76 mg $100g^{-1}$ and 0.73 to 1.86 mg 100^{-1} in open field and rain shelter respectively. Highest β carotene content was recorded in SLc.9 for both open field and rain shelter and it was on par with SLc.1 under rain shelter. The lowest β carotene content was recorded for SLc.6 in open field and SLc.11 under rain shelter respectively.

4.1.2.8 Lycopene

Total lycopene content of cherry tomato genotypes differed significantly under rain shelter (Table 9). The lycopene content of cherry tomato genotypes ranged from 1.24 to 3.13 mg $100g^{-1}$ and 2.48 to 3.87 mg $100g^{-1}$ under open field and rain shelter respectively. SLc.1 had highest lycopene content for both open field and rain shelter respectively and it was on par with SLc.2 and Slc.8 under rain shelter. The lowest lycopene content was recorded for SLc.6 (1.24 mg $100g^{-1}$) in open field and SLc.7 (2.48 mg $100g^{-1}$) in rain shelter. Growing conditions had a significant effect on lycopene content. Genotypes grown under rain shelter recorded higher lycopene content than open field grown ones.

Table 6. Continued

Accessions	Total carotenoids (mg 100g^{-1})			β carotene (mg 100g^{-1})			Lycopene (mg 100g^{-1})		
	Open field	Rain shelter	T value	Open field	Rain shelter	T value	Open field	Rain shelter	T value
SLc.1	5.46	6.06^{b}	5.45**	1.71	1.80^{a}	1..11^{NS}	3.13	3.87^{a}	5.69**
SLc.2	2.55	6.51^{a}	36.00**	0.60	1.25^{d}	8.02**	1.31	3.84^{a}	19.46**
SLc.3	4.49	4.15^{i}	3.09**	1.42	1.66^{b}	2.96**	1.43	3.51^{b}	16.00**
SLc.4	3.60	4.98^{e}	12.54**	1.15	1.21^{d}	0.74^{NS}	1.82	3.36^{f}	11.84**
SLc.5	3.70	3.82^{h}	2.54**	1.03	1.18^{d}	1.85**	1.74	3.14^{c}	10.76**
SLc.6	1.82	4.20^{g}	21.63**	0.39	0.90^{e}	6.29**	1.24	3.08^{c}	14.15**
SLc.7	4.47	3.27^{i}	10.90**	1.32	1.56^{c}	2.96**	1.71	2.48^{e}	5.92**
SLc.8	4.37	5.77^{d}	12.72**	0.84	0.71^{f}	1.60^{NS}	2.32	3.81^{a}	11.46**
SLc.9	5.42	5.83^{c}	3.72**	1.76	1.86^{a}	1.23^{NS}	2.27	3.29^{bc}	7.84**
SLc.11	4.16	4.54^{f}	3.45**	0.75	0.73^{f}	0.24^{NS}	3.02	3.38^{bc}	2.76**
CD	-	**0.31**		-	**0.21**		-	**0.42**	
SLc.11	-	6.48		-	2.23		-	3.41	

SLc - *Solanum lycopersicum* var. *cerasiforme*

** - Significant at both 1% and 5% level of significance

NS-Non significant

4.2 STANDARDISATION OF PACKAGING AND STORAGE REQUIREMENTS OF CHERRY TOMATO

Cherry tomatoes harvested at mature green stage cannot be stored at ambient temperature beyond 2 weeks under tropical conditions, as it is prone to losses due to decay. Standardisation of packaging and storage conditions in cherry tomato is important because this crop is mainly grown for export purpose. Fruits from two genotypes, one from small fruited type (Pusa Cherry Tomato-1) and another from big fruited type (IIHR-2871) were selected for the study. The fruits were sanitized with sodium hypochlorite (100 ppm) and packed in the following materials after removing the surface moisture.

1. T_0- Control (Unwrapped fruits)
2. T_1- Packaging in micro ventilated polyethylene cover of 200 gauge
3. T_2- Packaging in polystyrene tray with cling film
4. T_3- Packaging in polypropylene punnet
5. T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ thickness

The packaged materials were stored under three storage conditions.

1. S_1- Ambient (28 – 36°C)
2. S_2- Refrigerated storage (5 ± 2°C)
3. S_3- Cold storage (12 ± 15° C)

4.2.1 Physical parameters

4.2.1.1 Physiological loss in weight (PLW)

Moisture loss of harvested product results in a reduction in the fresh weight, which then sold on a weight basis, is translated into loss in sale value. Physiological loss in weight (PLW) of cherry tomatoes increased in all the treatments during storage under ambient, refrigeration and cold storage condition for both varieties. PLW of fruits kept without packing (control) remained

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significantly higher during storage under three different storage conditions in both the varieties.

4.2.1.1.1 Pusa Cherry Tomato-1

On comparing the three storage conditions (Table 7), after 2 weeks of storage, fruits packed in micro ventilated polythene cover in refrigerator had least PLW (0.31 %), followed by shrink wrapped fruits in polystyrene tray overwrapped with polyolefin film of 19 μ thickness (0.39 %) stored under the same condition. The maximum PLW was recorded for the control treatment under ambient condition (9.79 %).

After 2 weeks of storage under ambient condition, the minimum PLW (2.92%) was observed in fruits packed in micro ventilated polyethylene cover, whereas the control sample had maximum PLW (9.79%). The same trend was observed in refrigeration also where the minimum PLW (0.31 %) was recorded in fruits packed in micro ventilated polythene cover (200 gauge) and maximum PLW (8.58 %) for the unpacked fruits. Under cold storage condition, the minimum PLW (0.46 %) was noticed in fruits shrink wrapped in PS tray over wrapped with polyolefin film and maximum PLW (4.32%) was recorded for the unpacked fruits.

4.2.1.1.2 IIHR - 2871

Among the three storage conditions (Table 8), after 1 week of storage, fruits packed in micro ventilated polythene cover under refrigeration, at 4°C to 7°C had least PLW (0.18 %), followed by shrink wrapped fruits in polystyrene tray overwrapped with polyolefin film of 19μ thickness (0.20 %) stored under refrigerated condition. The maximum PLW was recorded for ambient stored fruits with no package (4.49 %).

The minimum PLW (2.92 %) was observed when fruits were packed in micro ventilated polyethylene cover and the control sample had maximum PLW (10.04 %) after 2 weeks of storage under ambient condition.

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Plate 5 a. Pusa Cherry Tomato -1 after one week of storage

T0 – Control T1 – Micro ventilated PE cover T2 – PS tray wrapped with cling film T3 – PP punnet T4 – Shrink wrapping

T$_0$ T$_1$ T$_2$ T$_3$ T$_4$

Ambient

Refrigeration

Cold storage

Plate 5 b. IIHR-2871 after one week of storage

T0 – Control T1 – Micro ventilated PE cover T2 – PS tray wrapped with cling film T3 – PP punnet T4 – Shrink wrapping

Table 7. Effect of packaging and storage on physiological loss in weight of Pusa Cherry Tomato-1

Storage condition	Treatments	PLW (%)								
		Initial	1WAS	2WAS	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS
S_1- Ambient	T_0	0.00	2.43 (1.56)	9.79 (3.13)	-	-	-	-	-	-
	T_1		1.06 (1.03)	2.92 (1.71)	4.41 (2.10)	5.95 (2.44)	6.75 (2.60)	8.12 (2.85)	9.06 (3.01)	9.98 (3.16)
	T_2		2.34 (1.53)	7.89 (2.81)	10.69 (3.27)	-	-	-	-	-
	T_3		2.04 (1.43)	6.45 (2.54)	10.04 (3.17)	12.60 (3.55)	-	-	-	-
	T_4		1.94 (1.36)	4.04 (2.01)	5.76 (2.40)	8.00 (2.83)	8.82 (2.97)	10.49 (3.24)	11.62 (3.41)	-
	CD		**0.07**	**0.02**	**0.01**	**0.02**	**0.02**	**0.03**	**0.03**	
S_2- Refrigeration	T_0	0.00	6.65 (2.58)	8.58 (2.93)	10.75 (3.28)	-	-	-	-	-
	T_1		0.08 (0.29)	0.31 (0.56)	0.75 (0.87)	-	-	-	-	-
	T_2		1.12 (1.06)	3.49 (1.87)	5.38 (2.32)	7.50 (2.74)	-	-	-	-
	T_3		0.88 (0.94)	1.79 (1.34)	2.68 (1.64)	4.12 (2.03)	5.10 (2.26)	6.30 (2.51)	7.39 (2.72)	-
	T_4		0.14 (0.38)	0.39 (0.63)	0.81 (0.90)	1.06 (1.03)	1.58 (1.26)	1.82 (1.35)	-	-
	CD		**0.10**	**0.04**	**0.04**	**0.02**	**0.01**	**0.03**		
S_3- Cold storage	T_0	0.00	1.93 (1.39)	4.32 (2.08)	6.30 (2.51)	7.72 (2.78)	10.89 (3.30)	14.13 (3.76)	-	-
	T_1		0.13 (0.37)	0.53 (0.73)	0.79 (0.89)	0.90 (0.95)	-	-	-	-
	T_2		1.44 (1.20)	3.84 (1.96)	5.66 (2.38)	8.82 (2.97)	10.56 (3.25)	11.62 (3.41)	14.06 (3.75)	-
	T_3		1.00 (1.00)	2.65 (1.63)	4.16 (2.04)	4.97 (2.33)	7.67 (2.77)	8.88 (2.98)	10.95 (3.31)	12.67 (3.56)
	T_4		0.16 (0.41)	0.46 (0.68)	0.70 (0.84)	1.18 (1.09)	1.61 (1.27)	2.04 (1.43)	2.46 (1.57)	2.92 (1.71)
	CD		**0.05**	**0.04**	**0.02**	**0.02**	**0.01**	**0.02**	**0.03**	**0.05**

WAS – Weeks after storage **T_0**- Control (Unwrapped fruit) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnets

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ

Table 8. Effect of packaging and storage on physiological loss in weight IIHR-2871

Storage condition	Treatments	PLW (%)										
		Initial	1WAS	2WAS	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS	9WAS	10WAS
S_1- Ambient	T_0	0.00	4.49 (2.12)	10.04 (3.17)	-	-	-	-	-	-	-	-
	T_1		1.74 (1.32)	2.92 (1.71)	4.57 (2.14)	5.90 (2.43)	6.81 (2.61)	-	-	-	-	-
	T_2		1.90 (1.38)	5.47 (2.34)	7.34 (2.71)	-	-	-	-	-	-	-
	T_3		1.76 (1.33)	4.66 (2.16)	6.50 (2.55)	9.48 (3.08)	-	-				
	T_4		1.70 (1.31)	3.57 (1.89)	4.24 (2.06)	5.85 (2.42)	6.65 (2.58)					
	CD		**0.03**	**0.03**	**0.03**	**0.02**	**NS**					
S_2- Refrigeration	T_0	0.00	2.13 (1.46)	-	-	-	-	-	-	-	-	-
	T_1		0.18 (0.43)	0.29 (0.54)	0.47 (0.69)	0.72 (0.85)	0.84 (0.92)	1.02 (1.01)	1.27 (1.13)	1.63 (1.28)	1.79 (1.34)	1.90 (1.39)
	T_2		0.96 (0.98)	1.46 (1.21)	1.79 (1.34)	2.31 (1.52)	3.42 (1.85)	4.04 (2.01)	4.32 (2.08)	5.24 (2.29)	-	-
	T_3		0.27 (0.52)	0.96 (0.98)	1.87 (1.37)	2.82 (1.68)	3.09 (1.76)	3.53 (1.88)	4.41 (2.10)	4.62 (2.15)	5.01 (2.24)	5.71 (2.39)
	T_4		0.20 (0.45)	0.32 (0.57)	0.56 (0.75)	0.65 (0.81)	0.79 (0.89)	0.96 (0.98)	1.16 (1.08)	1.41 (1.19)	-	-
	CD		**0.11**	**0.06**	**0.01**	**0.29**	**0.03**	**0.02**	**0.03**	**0.04**	**0.04**	**0.02**
S_3- Cold storage	T_0	0.00	1.16 (1.08)	2.19 (1.48)	2.50 (1.58)	3.45 (1.86)	5.95 (2.44)	7.07 (2.66)	-	-	-	-
	T_1		0.22 (0.47)	0.39 (0.60)	0.38 (0.79)	1.08 (1.04)	-	-	-	-	-	-
	T_2		1.06 (1.03)	1.87 (1.37)	2.28 (1.51)	3.45 (1.86)	4.16 (2.04)	6.10 (2.47)	7.34 (2.71)	8.23 (2.87)	8.52 (2.92)	-
	T_3		1.04 (1.02)	1.74 (1.32)	1.96 (1.40)	3.13 (1.77)	3.84 (1.96)	4.12 (2.03)	4.70 (2.17)	5.06 (2.25)	5.56 (2.36)	5.76 (2.40)
	T_4		0.22 (0.47)	0.41 (0.64)	0.72 (0.85)	1.16 (1.08)	2.01 (1.42)	3.13 (1.77)	3.34 (1.83)	3.72 (1.93)	-	-
	CD		**0.07**	**0.03**	**0.04**	**0.02**	**0.03**	**0.02**	**0.04**	**0.02**	**0.09**	

WAS – Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnets

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ

The same trend was observed in refrigerated condition in which the minimum PLW (0.18 %) was recorded in fruits packed in micro ventilated polythene cover and maximum PLW (2.13 %) was for control sample after 1 week of storage. Under cold storage condition also the minimum PLW (1.08%) was noticed in fruits stored in micro ventilated polyethylene cover (200 gauge) and maximum PLW (3.45 %) was recorded for control sample after 4 weeks of storage.

4.2.1.2 Shelf life

The shelf life was calculated as number of days from harvest till the fruits remained marketable. Unmarketability was attributed when more than 25 per cent of the fruits in a lot showed incidence of spoilage, shriveling and microbial growth.

4.2.1.2.1 Pusa Cherry Tomato-1

The results of shelf life studies in cherry tomatoes stored under ambient, refrigeration and cold storage conditions are given in Table 9. Shelf life of fruits of Pusa Cherry Tomato -1 was longer when stored in different packaging materials under cold storage condition than fruits stored in ambient and refrigeration except in T_1 (fruits packed in micro ventilated polythene cover). In the case of fruits packed in micro ventilated polyethylene cover, longest shelf life was recorded in ambient condition because of the severe condensation of moisture under cold storage and refrigeration.

Crystallization of the condensed water was also observed inside the package under refrigeration. Among the three storage conditions, fruits stored in cold storage packaged in polypropylene punnets had the longest shelf life (71.66 days) followed by fruits shrink wrapped in polystyrene tray with polyolefin film of 19μ thickness. Unpacked fruits at ambient condition were found to have the shortest shelf life of 16 days.

In ambient condition, the micro ventilated polyethylene cover extended the shelf life to 57.66 days whereas the unpacked fruits had the minimum shelf life of 16 days. Under refrigeration, the longest shelf life (53.33 days) was recorded for fruits packed in polypropylene punnet and shortest (20.66 days) was for unpacked fruits and it was on par (21.66 days) with fruits packed in micro ventilated polyethylene cover. Under cold storage conditions all the treatments were found to be in an acceptable condition upto 1 month of storage. The cold storage prolonged the shelf life to a maximum of 71.66 days for the fruits packed in polypropylene punnet and the minimum shelf life (33.66 days) was recorded for fruits packed in micro ventilated polyethylene cover (200 gauge).

4.2.1.2.2 IIHR- 2871

Shelf life of IIHR-2871 variety was longer when stored in different packages under cold storage and refrigeration than fruits stored in ambient condition. The unpacked fruits were found to have the shortest shelf life at refrigeration because of the chilling injury. On comparing the three storage conditions, cold storage stored fruits in polypropylene punnets were found to have an extended shelf life of 87 days followed by refrigerated storage of fruits in polypropylene punnet (81.66 days). Unpacked fruits at refrigerated condition were found to have shortest shelf life of 5.66 days.

Under ambient condition, shrink wrapping in polystyrene tray with polyolefin of 19μ thickness prolonged the shelf life of fruits to 39.66 days, whereas due to rapid ripening, the unwrapped fruits had a minimum shelf life of 13.66 days only. Under refrigeration, chilling injury was not observed in all the treatments. Compared to Pusa Cherry Tomato, incidence of chilling injury was lesser under refrigeration, in all the treatments except in control. The longest shelf life (81.66 days) was for fruits packed in polypropylene punnet and shortest (5.66 days) for unpacked fruits. Storage of fruits under cold storage condition increased the shelf life significantly. In cold storage, maximum shelf life (87 days) was recorded for fruits packed in polypropylene punnets and minimum (29.66 days)

Table 9. Effect of packaging and storage on shelf life of cherry tomato

Storage condition	Treatments	Shelf life (Days)	
		Pusa Cherry Tomato-1	IIHR-2871
S_1- Ambient	T_0	16.00^{k}	13.66^{m}
	T_1	57.66^{c}	37.66^{i}
	T_2	27.66^{i}	24.66^{k}
	T_3	31.00^{h}	28.66^{j}
	T_4	53.66^{d}	39.66^{h}
S_2- Refrigeration	T_0	20.66^{j}	5.66^{n}
	T_1	21.66^{j}	73.66^{c}
	T_2	31.33^{h}	57.66^{e}
	T_3	53.33^{d}	81.66^{b}
	T_4	51.66^{e}	57.33^{e}
S_3- Cold storage	T_0	42.33^{f}	51.33^{g}
	T_1	33.66^{g}	29.66^{j}
	T_2	52.00^{e}	63.66^{d}
	T_3	71.66^{a}	87.00^{a}
	T_4	66.66^{b}	56.66^{f}
	CD	**1.05**	**1.03**

T_0- Control (Unwrapped fruits)

T_1- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film

T_3- Packaging in polypropylene punnets

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ

for fruits packed in micro ventilated polyethylene cover.

4.2.3 Biochemical analysis

4.2.3.1 Total Soluble Solids (TSS)

TSS indicates sweetness, although sugars are not the sole soluble component. TSS was found to increase significantly under ambient and cold storage in both the varieties. Minimum changes in TSS were found in refrigeration. There was a peak in TSS at different storage period for the three storage conditions because of the difference in the rate of ripening in these conditions. A trend of decrease in TSS value was recorded for all the treatments after the peak value.

4.2.3.1.1 Pusa Cherry Tomato -1

TSS of fruits increased during the initial stage of storage for all the treatments. After one week of storage the highest value of TSS (7.5° brix) was obtained for the unpacked fruits under ambient condition and the lowest TSS (4.5° brix) was recorded for T_0, T_1 and T_4 under refrigeration (Table 10).

The peak values for TSS was observed 3 WAS (except the control and T_2) under ambient, 4 WAS under cold storage and 6 WAS under refrigeration. Thereafter, irrespective of packaging materials, a slight decrease was observed under the three storage conditions. The highest values for TSS was recorded in T_3 in all the storage conditions. The values recorded for T_3 were 7.8, 6 and 8° brix for ambient, refrigerated and cold storage respectively. Better retention of TSS was in in T_3 and T_4 in cold storage.

4.2.3.1.2 IIHR-2871

In this variety, one week after storage, the highest value for TSS (6.1° brix) was recorded for the unpacked fruits under ambient condition and the lowest TSS (4.5° brix) was for T_0 under refrigeration (Table 11).

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At the end of 2 weeks of storage, TSS increased in all treatments, except the control under ambient condition. A peak in TSS was registered 3 WAS in ambient storage (except control and T_2), 7 WAS for refrigeration (except control and T_2) and 6 WAS under cold storage condition. Thereafter a slight decline in TSS was observed. The peak values for TSS was noted in T_3 in all the three conditions. The rate of ripening in unpacked fruits and T_2 was much faster compared to the other treatments under ambient and cold storage. Better retention of TSS was in T_3 and T_4 in cold storage. The ripening process was more delayed in this variety as compared to Pusa Cherry Tomato-1 under refrigeration and cold storage as evident from the values of TSS.

4.2.3.2 Titrable acidity

In both the varieties titrable acidity decreased as the ripening progressed during the storage. Changes in the titrable acidity was found to be lower under refrigeration and cold storage.

4.2.3.2.1 Pusa Cherry Tomato-1

On comparing the three storage conditions, after 2 weeks of storage (Table 12), the unpacked fruits under ambient condition had the least acidity (0.54 %). The fruits kept under refrigeration and cold storage maintained a higher level of acidity for all the treatments without any significant change throughout the storage.

After 2 weeks of storage under ambient condition, the minimum titrable acidity (0.54 %) was observed in unpacked fruits, whereas the fruits shrink wrapped in polystyrene tray overwrapped with polyolefin film of 19 μ thickness had maximum titrable acidity of (0.72%).

4.3.3.2.2 IIHR -2871

Among the three storage conditions, after 1 week of storage, significant change in acidity was observed only for ambient condition (Table 13).

Table 10. Effect of packaging and storage on Total Soluble Solids (° brix) of Pusa Cherry Tomato-1

Storage condition	Treatments	TSS (° brix)									
		Initial	1WAS	2WAS	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS	9WAS
S_1- Ambient	T_0	4.5	7.5	7.3	-	-	-	-	-	-	-
	T_1		5.8	6.4	7.6	7.2	6.9	6.2	5.0	4.8	-
	T_2		7.2	7.4	6.0	-	-	-	-	-	-
	T_3		6.0	7.4	7.8	6.4	-	-	-	-	-
	T_4		5.8	6.8	7.7	7.3	6.8	6.0	5.4	-	-
	CD		**0.56**	**0.16**	**0.68**	**0.90**	**NS**	**NS**	**0.38**		
S_2-Refrigeration	T_0	4.5	4.5	4.7	4.9	-	-	-	-	-	-
	T_1		4.5	5.0	5.2	-	-	-	-	-	-
	T_2		4.6	4.8	5.2	5.4	-	-	-	-	-
	T_3		4.6	4.6	5.4	5.7	5.9	6.0	5.9	-	-
	T_4		4.5	4.8	5.2	5.4	5.6	5.5	-	-	-
	CD		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**			
S_3- Cold storage	T_0	4.5	6.1	6.7	7.3	7.7	7.4	6.2^c	-	-	-
	T_1		4.8	5.6	6.8	7.4	-	-	-	-	-
	T_2		6.3	6.4	6.6	7.5	7.3	6.7^a	6.2	-	-
	T_3		5.2	5.4	7.0	8.0	7.8	7.0^b	6.6	6.2	6.0
	T_4		4.8	5.8	6.6	7.2	7.4	7.0^b	6.5	6.0	-
	CD		**0.60**	**0.58**	**NS**	**0.58**	**NS**	**0.58**	**NS**	**NS**	

WAS- Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnets

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ

Table 11. Effect of packaging and storage on Total Soluble Solids (°brix) of IIHR-2871

Storage condition	Treatments	TSS (°brix)										
		Initial	1WAS	2WAS	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS	9WAS	10WAS
S_1-Ambient	T_0	4.4	6.1	5.9	-	-	-	-	-	-	-	-
	T_1		4.8	5.1	6.2	5.4	5.3	-	-	-	-	-
	T_2		5.2	6.2	5.1	-	-	-	-	-	-	-
	T_3		5.0	5.2	6.5	6.1	-	-				
	T_4		4.8	5.0	6.4	5.6	5.2	-	-	-	-	-
	CD		**0.67**	**0.51**	**0.74**	**0.34**	**NS**					
S_2-Refrigeration	T_0	4.4	4.5	-	-	-	-	-	-	-	-	-
	T_1		4.6	4.7	4.9	5.2	5.4	5.5	5.7	5.6	5.5	5.3
	T_2		4.9	5.1	5.4	5.9	6.0	6.1	5.9	5.2	-	-
	T_3		4.7	5.0	5.2	5.5	5.7	6.0	6.2	6.1	5.9	5.7
	T_4		4.6	4.7	5.0	5.4	5.6	5.8	6.0	5.8	-	-
	CD		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
S_3-Cold storage	T_0	4.4	5.5	5.7	5.9	6.2	5.9	5.7	-	-	-	-
	T_1		4.6	5.0	5.2	6.0	-	-	-	-	-	-
	T_2		5.0	5.5	6.0	6.5	6.4	6.3	6.2	5.9	5.6	-
	T_3		5.0	5.4	5.7	6.3	6.5	6.7	6.6	6.4	6.3	6
	T_4		4.6	4.9	5.4	6.1	6.2	6.5	6.3	6.0	-	-
	CD		**NS**	**0.36**	**0.58**	**0.51**	**NS**	**0.41**	**NS**	**0.58**	**0.33**	

WAS- Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnets

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ

The unpacked fruits and fruits packed in polystyrene tray with cling film had the least acidity (0.76 %) and maximum acidity (0.89 %) was for T_1 (fruits packed in micro ventilated PE cover) and T_4 (shrink wrapping in polystyrene tray overwrapped with polyolefin of 19 μ thickness) under ambient condition.

4.2.3.3 Vitamin C

Ascorbic acid is fairly labile and its retention is often monitored when evaluating post harvest storage effects on nutritional quality in fruits and vegetables. In both the varieties an initial increase in ascorbic acid content followed by a decline after reaching a maximum was observed with advancement of storage. Minimum change in vitamin C was found in refrigerated fruits.

4.2.3.3.1 Pusa Cherry Tomato-1

Vitamin C of fruits increased during the initial stage of storage for all the treatments. After one week of storage the highest value of vitamin C (28 mg $100g^{-1}$) was obtained for the unpacked fruits under ambient condition and the lowest vitamin C content (17.86 mg $100g^{-1}$) was recorded for T_0 under refrigeration (Table 14).

The highest values for vitamin C content was recorded in T_4 in all the storage conditions. The peak values for vitamin C content was observed in T_4 ,3 WAS in ambient (28.57 mg $100g^{-1}$), 5 WAS under refrigeration (25.56 mg $100g^{-1}$) and 4 WAS in cold storage (29.08 mg $100g^{-1}$). Thereafter, irrespective of packaging materials and storage condition, a slight decrease was observed in vitamin C content. Better retention of vitamin C was in T_4 and T_3 in cold storage.

4.2.3.3.2 IIHR-2871

In this variety, one week after storage, the highest value for vitamin C (26.50 mg $100g^{-1}$) was recorded for the unpacked fruits under ambient condition and the lowest vitamin C (20.09 mg $100g^{-1}$) was for T_4 under refrigeration (Table 15).

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Table 12. Effect of packaging and storage on titrable acidity of Pusa Cherry Tomato-1

Storage condition	Treatments	Titrable acidity (%)									
		Initial	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS	9 WAS
S_1-Ambient	T_0	0.76	0.55	0.54	-	-	-	-	-	-	-
	T_1		0.71	0.70	0.66	0.63	0.59	0.55	0.51	0.38	-
	T_2		0.68	0.55	0.39	-	-	-	-	-	-
	T_3		0.73	0.64	0.60	0.51	-	-	-	-	-
	T_4		0.72	0.72	0.69	0.64	0.59	0.55	0.51	-	-
	CD		**NS**	**0.11**	**0.14**	**NS**	**NS**	**NS**	**NS**		
S_2-Refrigeration	T_0	0.76	0.73	0.73	0.72	-	-	-	-	-	-
	T_1		0.74	0.74	0.73	-	-	-	-	-	-
	T_2		0.75	0.74	0.62	0.60	-	-	-	-	-
	T_3		0.75	0.75	0.62	0.60	0.58	0.57	0.55	-	-
	T_4		0.76	0.75	0.74	0.69	0.64	0.62	-	-	-
	CD		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**			
S_3-Cold storage	T_0	0.76	0.71	0.65	0.63	0.61	0.53	0.50	-	-	-
	T_1		0.75	0.72	0.69	0.66	-	-	-	-	-
	T_2		0.74	0.73	0.64	0.62	0.60	0.57	0.55	-	-
	T_3		0.73	0.73	0.66	0.64	0.53	0.51	0.49	0.39	0.38
	T_4		0.74	0.72	0.70	0.64	0.61	0.58	0.55	0.51	-
	CD		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	

WAS - Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnets

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ

Table 13. Effect of packaging and storage on titrable acidity of IIHR-2871

Storage condition	Treatments	Titrable acidity (%)										
		Initial	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS	9 WAS	10 WAS
S_1-Ambient	T_0	0.89	0.76	0.58	-	-	-	-	-	-	-	-
	T_1		0.89	0.76	0.63	0.57	0.55	-	-	-	-	-
	T_2		0.76	0.61	0.50	-	-	-	-	-	-	-
	T_3		0.79	0.76	0.62	0.61	-	-				
	T_4		0.89	0.76	0.63	0.56	0.51	-	-	-	-	-
	CD		**0.14**	**0.11**	**0.04**	**NS**	**NS**					
S_2-Refrigeration	T_0	0.89	0.89	-	-	-	-	-	-	-	-	-
	T_1		0.89	0.89	0.89	0.76	0.76	0.64	0.64	0.55	0.55	0.51
	T_2		0.89	0.89	0.76	0.73	0.69	0.64	0.51	0.51	-	-
	T_3		0.89	0.89	0.89	0.76	0.73	0.69	0.55	0.51	0.44	0.40
	T_4		0.89	0.89	0.89	0.76	0.76	0.64	0.64	0.51	-	-
	CD		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
S_3-Cold storage	T_0	0.89	0.86	0.82	0.75	0.63	0.55	0.51	-	-	-	-
	T_1		0.89	0.89	0.87	0.76	-	-	-	-	-	-
	T_2		0.89	0.89	0.76	0.64	0.59	0.55	0.48	0.42	0.37	-
	T_3		0.89	0.89	0.76	0.76	0.67	0.59	0.54	0.52	0.48	0.41
	T_4		0.89	0.89	0.81	0.76	0.64	0.60	0.55	0.52	-	-
	CD		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	

WAS - Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnets

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19 μ

At the end of 2 weeks of storage, vitamin C increased in all treatments, except the control under ambient condition. The highest values for vitamin C content was observed in T_4 in cold storage (30.39 mg $100g^{-1}$, 5WAS) and ambient condition (28.56 mg $100g^{-1}$, 3WAS). In the case of fruits stored under refrigeration T_3 recorded the highest vitamin C (24.72 mg $100g^{-1}$). The rate of ripening in unpacked fruits and T_2 was much faster compared to the other treatments under ambient and cold storage. Better retention of vitamin C was in T_3 and T_4 in cold storage.

4.2.3.4 Lycopene

Lycopene constitute the main red pigment of tomatoes and its concentration was found to increase steadily through the ripening process during storage. Amongst the packaging materials, the cherry tomatoes stored without packaging exhibited greater increase in lycopene content, while packaged fruits, showed lesser and slower accumulation of lycopene. A slight decline in lycopene was observed towards the end of storage.

Comparing three storage conditions, fruits under refrigeration and cold storage showed lesser and slow accumulation of lycopene at initial phase. Thereafter, under cold storage, uniform and high lycopene accumulation was observed in the fruits.

4.2.3.4.1 Pusa Cherry Tomato-1

Lycopene content of fruits increased during the storage for all the treatments. After one week of storage the highest value of lycopene content (3.36 mg $100g^{-1}$) was obtained for the unpacked fruits under ambient condition and the and the lowest lycopene content (0.32 mg $100g^{-1}$) was obtained for T_0 under refrigeration (Table 16).

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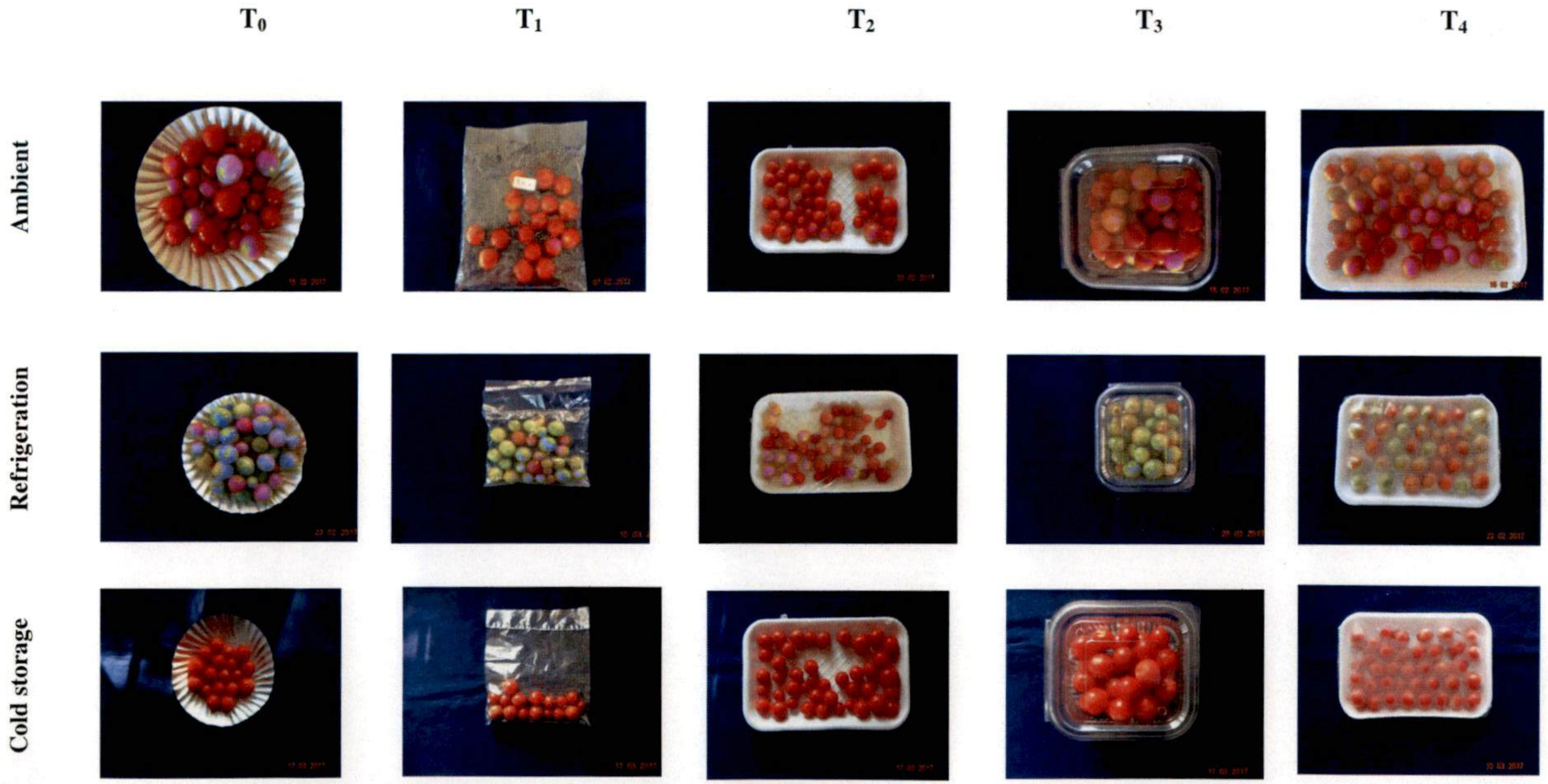

Plate 6a. Changes in colour development of Pusa Cherry Tomato-1

T0 – Control T1 – Micro ventilated PE cover T2 – PS tray wrapped with cling film T3 – PP punnet T4 – Shrink wrapping

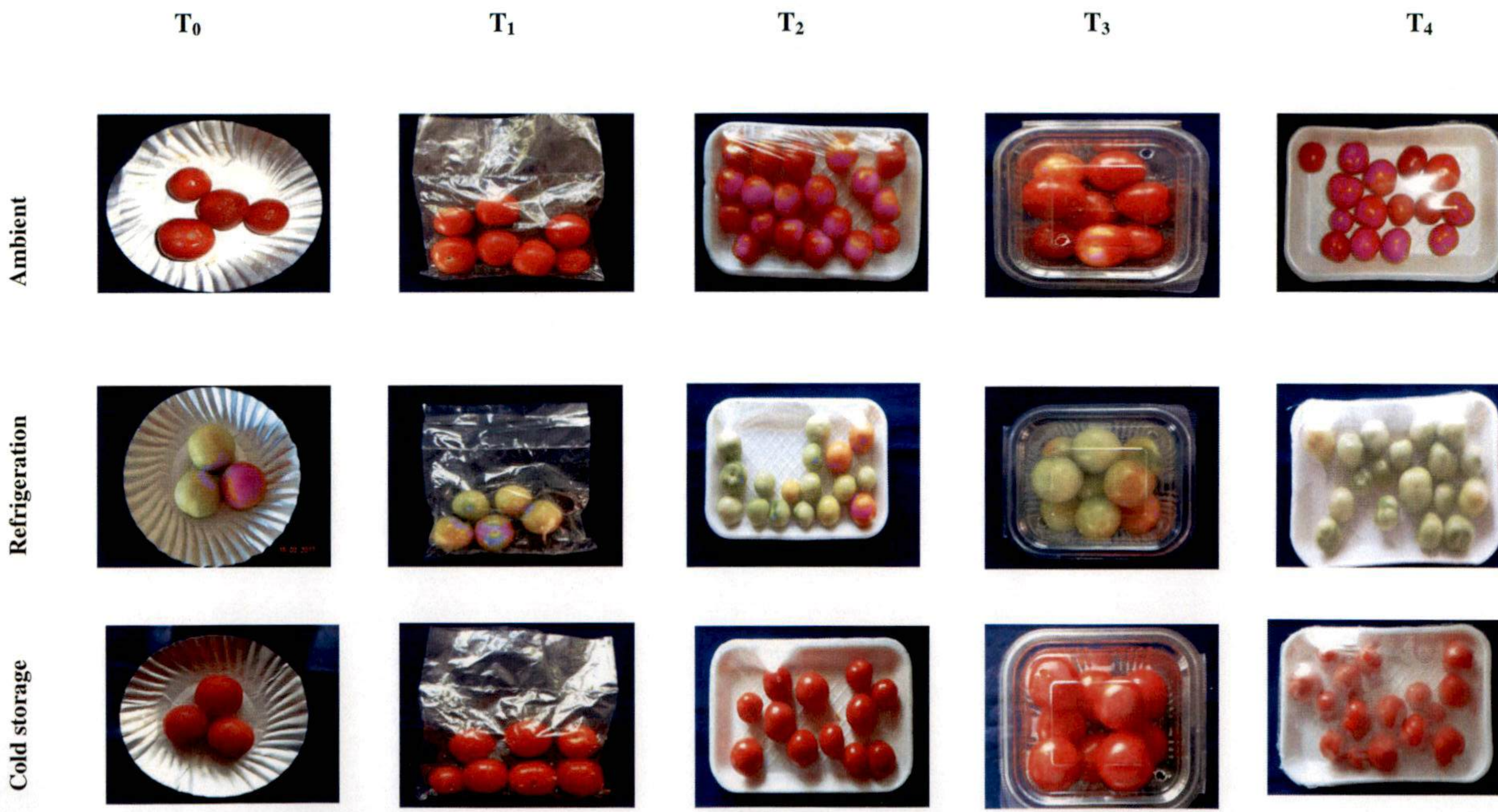

Plate 6 b. Colour development during ripening of IIHR-2871

T0 – Control T1 – Micro ventilated PE cover T2 – PS tray wrapped with cling film T3 – PP punnet T4 – Shrink wrapping

Table 14. Effect of packaging and storage on vitamin C (mg 100^{-1}) of Pusa Cherry Tomato-1

Storage condition	Treatments	Vitamin C (mg $100g^{-1}$)								
		Initial	1WAS	2WAS	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS
S_1-Ambient	T_0	17.39	28.00	25.86	-	-	-	-	-	-
	T_1		22.60	24.35	26.22	25.80	24.95	23.22	22.80	21.87
	T_2		22.92	25.26	26.09	-	-	-	-	-
	T_3		22.80	25.18	28.09	26.87	-	-	-	-
	T_4		24.08	25.98	28.57	27.08	25.57	24.66	23.57	-
	CD		**2.40**	**NS**	**0.89**	**1.09**	**4.76**	**NS**	**NS**	
S_2-Refrigeration	T_0	17.39	17.86	19.47	22.46	-	-	-	-	-
	T_1		18.41	19.59	21.28	-	-	-	-	-
	T_2		19.24	20.59	22.21	24.52	-	-	-	-
	T_3		18.21	20.27	21.51	24.16	24.25	23.13	21.53	-
	T_4		19.30	20.73	22.25	25.01	25.56	22.23	-	-
	CD		**0.75**	**0.76**	**NS**	**NS**	**NS**	**NS**		
S_3-Cold storage	T_0	17.39	23.29	24.96	26.13	27.63	24.25	21.52	-	-
	T_1		20.62	22.54	25.29	27.07	-	-	-	-
	T_2		22.16	23.88	25.27	28.52	27.41	26.01	25.81	-
	T_3		22.51	23.94	26.41	28.92	28.24	27.33	26.30	24.57
	T_4		20.34	23.51	25.19	29.08	28.58	27.19	26.26	25.45
	CD		**0.88**	**0.54**	**0.76**	**0.63**	**2.14**	**1.66**	**NS**	**NS**

WAS - Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnets

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ

Table 15. Effect of packaging and storage on Vitamin C (mg 100g^{-1}) of IIHR-2871

Storage condition	Treatments	Vitamin C (mg 100g^{-1})										
		Initial	1WAS	2WAS	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS	9WAS	10WAS
S_1-Ambient	T_0	20.06	26.50	23.31	-	-	-	-	-	-	-	-
	T_1		22.87	23.42	24.43	23.21	22.71	-	-	-	-	-
	T_2		25.28	26.57	25.06	-	-	-	-	-	-	-
	T_3		24.24	25.21	27.52	25.32	-	-	-	-	-	-
	T_4		22.72	23.29	28.56	26.17	25.42	-	-	-	-	-
	CD		**0.35**	**1.93**	**1.84**	**1.48**	**1.52**					
S_2-Refrigeration	T_0	20.06	21.01	-	-	-	-	-	-	-	-	-
	T_1		21.13	21.45	21.76	22.52	23.29	24.09	23.58	23.58	23.23	23.01
	T_2		21.23	22.52	23.08	23.71	24.58	23.91	23.19	-	-	-
	T_3		21.19	21.49	21.83	22.81	23.52	24.72	24.43	24.18	24.03	23.57
	T_4		20.09	21.31	21.63	22.49	23.14	23.92	23.81			
	CD		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
S_3-Cold storage	T_0	20.06	22.65	25.73	28.70	26.10	25.44	23.18	-	-	-	-
	T_1		21.94	22.63	23.18	22.68	-	-	-	-	-	-
	T_2		22.43	23.01	24.54	26.96	28.44	28.09	27.73	27.14	26.54	26.03
	T_3		22.19	22.79	24.37	25.72	29.73	29.52	29.08	28.97	28.64	27.03
	T_4		22.19	22.52	24.19	26.31	30.39	29.81	29.27	28.94	28.14	
	CD		**NS**	**1.84**	**1.16**	**2.35**	**1.86**	**1.14**	**0.54**	**NS**	**NS**	**NS**

WAS - Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnets

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ

After 2 weeks of storage, the highest lycopene content (5.08 mg $100g^{-1}$) was recorded for unwrapped fruit and the lowest lycopene content (2.42 mg $100g^{-1}$) was recorded for the shrink wrapped fruits in polystyrene tray under ambient condition. Whereas under refrigeration fruits packed in polystyrene tray with cling film recorded the highest value (1.84 mg $100g^{-1}$). The lowest (0.34 mg $100g^{-1}$) lycopene content was recorded for the unwrapped fruits. In cold storage, unwrapped fruits recorded the maximum lycopene content (3.09 mg $100g^{-1}$).

On comparing the storage conditions, maximum lycopene content was recorded by T_2 under cold storage (6.09 mg $100g^{-1}$, 5 WAS) and ambient condition (5.48 mg $100g^{-1}$, 3 WAS) and T_4 under refrigeration (4.51 mg $100g^{-1}$, 6 WAS)

4.2.3.4.2 IIHR -2871

In this variety, one week after storage the highest value for lycopene content (3.41 mg $100g^{-1}$) was recorded for the unpacked fruits under ambient condition and the lowest lycopene content (0.42 mg $100g^{-1}$) was for T_2 under refrigeration (Table 17).

At the end of 2 weeks of storage lycopene content increased in all treatments. A peak in lycopene content was registered by T_2, 3 WAS in ambient storage, 8 WAS for refrigeration and 4 WAS for cold storage conditions. Thereafter a slight decline in lycopene content was observed. The rate of ripening in unpacked fruits and T_2 was much faster compared to the other treatments under ambient and cold storage. The peak values for lycopene content was observed in T_2 under the three storage conditions. The peak values observed were 4.59 mg $100g^{-1}$, 3WAS under ambient, 2.97 mg $100g^{-1}$, 8 WAS under refrigeration and 5.98 mg $100g^{-1}$, 4 WAS under refrigeration.

4.2.3.5 Total, reducing, and non reducing sugars

Total, reducing and non reducing sugars increased after one week of storage in all the treatments in both the varieties.

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Table 16. Effect of packaging and storage on Lycopene content (mg $100g^{-1}$) of Pusa Cherry Tomato-1

Storage condition	Treatments	Lycopene (mg $100g^{-1}$)								
		Initial	1WAS	2WAS	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS
S_1-Ambient	T_0	0.31	3.36	5.08	-	-	-	-	-	-
	T_1		1.25	2.70	3.15	3.29	4.08	4.01	3.95	3.72
	T_2		2.08	3.40	5.48	-	-	-	-	-
	T_3		1.56	2.76	3.52	4.69	-	-	-	-
	T_4		1.29	2.42	3.29	3.71	4.69	5.12	4.34	-
	CD		**0.12**	**0.10**	**0.16**	**0.14**	**0.35**	**0.09**	**0.27**	
S_2-Refrigeration	T_0	0.31	0.32	0.34	0.35	-	-	-	-	-
	T_1		0.33	0.45	0.53	-	-	-	-	-
	T_2		0.84	1.84	3.63	3.92	-	-	-	-
	T_3		0.55	0.74	1.81	2.35	2.75	3.40	3.56	-
	T_4		0.74	1.47	2.75	3.94	4.09	4.51	-	-
	CD		**0.09**	**0.13**	**0.06**	**0.10**	**0.19**	**0.06**		
S_3-Cold storage	T_0	0.31	1.49	3.09	4.02	5.16	6.01	5.84	-	-
	T_1		0..69	2.08	3.95	4.79	-	-	-	-
	T_2		1.21	2.83	4.20	5.75	6.09	5.98	5.30	-
	T_3		1.51	2.12	4.13	5.50	5.91	5.73	5.64	5.61
	T_4		0.85	2.06	4.12	5.47	5.49	5.35	5.12	5.09
	CD		**0.09**	**0.10**	**0.13**	**0.10**	**0.21**	**0.15**	**0.15**	**0.21**

WAS – Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnets

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19 μ

Table 17. Effect of packaging and storage on Lycopene content (mg $100g^{-1}$) of IIHR-2871

Storage condition	Treatments	Lycopene (mg $100g^{-1}$)										
		Initial	**1WAS**	**2WAS**	**3WAS**	**4WAS**	**5WAS**	**6WAS**	**7WAS**	**8WAS**	**9 WAS**	**10 WAS**
S_1-Ambient	**T_0**	0.41	3.41	4.19	-	-	-	-	-	-	-	-
	T_1		1.47	2.34	3.27	3.91	4.12	-	-	-	-	-
	T_2		2.18	3.87	4.54	-	-	-	-	-	-	-
	T_3		2.04	2.81	3.76	4.27	-	-	-	-	-	-
	T_4		1.78	2.29	3.32	3.48	3.82	-	-	-	-	-
	CD		**0.08**	**0.20**	**0.22**	**0.12**	**0.19**					
S_2-Refrigeration	**T_0**	0.41	0.44	-	-	-	-	-	-	-	-	-
	T_1		0.42	0.79	1.09	1.86	2.07	2.33	2.37	2.55	2.62	2.78
	T_2		0.79	0.93	1.11	2.13	2.46	2.79	2.85	2.97	-	-
	T_3		0.61	0.82	1.17	1.92	2.15	2.27	2.34	2.42	2.57	2.66
	T_4		0.86	0.91	1.14	2.17	2.43	2.81	2.89	2.95	-	-
	CD		**0.13**	**NS**	**NS**	**0.22**	**0.17**	**0.22**	**0.19**	**0.19**	**NS**	**NS**
S_3-Cold storage	**T_0**	0.41	1.43	3.21	4.05	5.23	5.37	5.42	-	-	-	-
	T_1		0.90	2.17	3.49	5.13	-	-	-	-	-	-
	T_2		1.28	2.97	4.17	5.98	5.78	5.63	-	-	-	-
	T_3		1.58	3.07	4.14	5.80	5.83	5.81	5.77	5.74	5.74	5.72
	T_4		1.06	2.26	4.10	5.16	5.75	5.84	5.89	5.92	-	-
	CD		**0.16**	**0.12**	**NS**	**0.13**	**0.15**	**NS**	**NS**	**NS**		

WAS – Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnets

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19

4.2.3.5.1 Pusa Cherry Tomato - 1

After 1 week of storage, highest reducing sugar (2.35 %), non reducing sugar (1.53 %) and total sugar (3.88 %) were recorded in the unwrapped fruits under ambient condition and it was on par with T_2 (Table 18). The lowest reducing sugar (1.54 %) and total sugar (2.21 %) were recorded for T_4 under refrigeration. The lowest non reducing sugar was recorded for T_0 under refrigeration (0.52 %).

4.2.3.5.2 IIHR-2871

After 1 week of storage, highest reducing sugar (2.28 %), non reducing sugar (1.04 %) and total sugar (3.32 %) were recorded in the unwrapped fruits under ambient condition (Table 19). The lowest reducing sugar (1.28 %) and total sugar (1.82 %) were recorded for T_4 under refrigeration. The lowest non reducing sugar was recorded for T_1 under cold storage (0.40 %).

4.2.4 Microbial load

Microbial load of cherry tomato was analyzed by estimating the population bacteria, yeast and fungi. Microbial load was found to increase with advancement of storage period. Less microbial contamination was observed for samples kept under refrigeration. Bacterial count was higher for both the varieties.

4.2.4.1 Pusa Cherry Tomato -1

4.2.4.1.1 Bacteria

After the completion of 2 weeks of storage, bacterial population was observed only under ambient condition (Table 20). It was high for control sample (61×10^{-4} cfu g^{-1}), followed by T_2 (29×10^{-4} cfu g^{-1}) and T_3 (7×10^{-4} cfu g^{-1}).

Under refrigeration, bacterial colonization was first noticed at 3 WAS. The number of bacterial colonies was high (32×10^{-4} cfu g^{-1}) for T_2 after 4 weeks of storage. No bacterial population was noticed for T_3 and T_4 until 4 weeks of storage.

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Under cold storage, bacterial load, was noticed from third week of storage onwards. After 4 weeks of storage, maximum microbial load in terms of bacteria was observed for T_1 (72 x 10^{-4} cfug^{-1}). T_3 and T_4 did not recorded any sign of bacterial contamination until 4 weeks of storage.

4.2.4.1.2 Yeast

The population of yeast was not significant during the storage. Yeast colonies were observed towards the end of the storage and not observed under refrigerated condition (Table 21).

4.2.4.1.3 Fungi

After 2 weeks of storage, out of the three storage conditions, samples stored under ambient condition only contaminated by fungi. The highest fungal population was recorded for control (14 x 10^{-2} cfu g^{-1}). In T_1, T_3 and T_4, no fungal load was observed (Table 22).

Throughout the storage, no fungal population was noticed under refrigeration. In cold storage population of fungi was recorded from 3 week after storage onwards. The maximum microbial load in terms of fungi were recorded for T_1 (19 x 10^{-2} cfu g^{-1}) no fungal colonies was observed for T_0, T_2, and T_3 until 4 weeks of storage.

4.2.4.2 IIHR-2871

4.2.4.2.1 Bacteria

After the completion of 2 weeks of storage, bacterial load was observed only under ambient condition (Table 23). It was high for control sample (55 x 10^{-4} cfu g^{-1}), followed by T_2 (36 x 10^{-4} cfu g^{-1}) and T_3 (13 x 10^{-4} cfu g^{-1}).

Under refrigeration, bacterial colonization was first noticed for T_4 (6 WAS). The number of bacterial colonies was high (68 x 10^{-4} cfu g^{-1}) for T_4 after 8 weeks of storage. No bacterial colonies were noticed in T1 until 9 weeks of storage.

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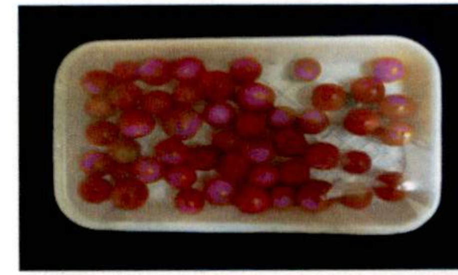
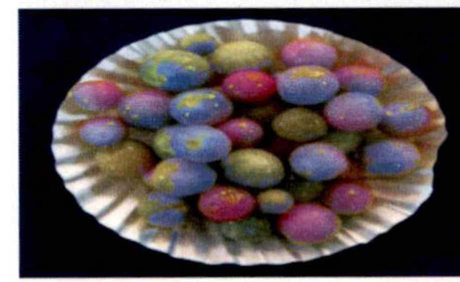
7a. Shrivelling



7b. Chilling injury



7c. Moisture condensation

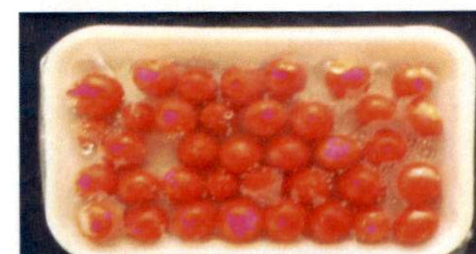


Plate 7. Types of spoilage in cherry tomato

Table 18. Effect of packaging and storage condition on reducing, non-reducing and total sugar content of Pusa Cherry Tomato-1

Storage condition	Treatments	Reducing sugar (%)		Non-reducing sugar (%)		Total sugar (%)	
		Initial	1WAS	Initial	1WAS	Initial	1WAS
S_1-Ambient	T_0	1.19	2.35^{a}	0.27	1.53^{a}	1.46	3.88^{a}
	T_1		1.83^{d}		1.24^{b}		3.07^{d}
	T_2		2.28^{a}		1.58^{a}		3.86^{a}
	T_3		2.17^{b}		1.54^{a}		3.70^{b}
	T_4		2.06^{b}		1.48^{a}		3.54^{c}
S_2-Refrigeration	T_0	1.19	1.85^{cd}	0.27	0.52^{f}	1.46	2.37^{g}
	T_1		1.82^{d}		0.65^{ef}		2.47^{g}
	T_2		1.90^{c}		0.79^{e}		2.69^{f}
	T_3		1.86^{cd}		0.53^{f}		2.38^{g}
	T_4		1.54^{e}		0.67^{e}		2.21^{h}
S_3-Cold storage	T_0	1.19	1.99^{c}	0.27	1.13^{c}	1.46	3.12^{d}
	T_1		1.83^{d}		0.89^{d}		2.72^{ef}
	T_2		1.96^{c}		1.07^{c}		3.03d
	T_3		1.91^{c}		0.90^{d}		2.81^{e}
	T_4		1.87^{cd}		0.90^{d}		2.77^{e}
	CD		**0.14**		**0.15**		**0.13**

WAS- Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnets

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19µ

Table 19. Effect of packaging and storage condition on reducing, non-reducing and total sugar content of IIHR-2871

Storage condition	Treatments	Reducing sugar (%)		Non-reducing sugar (%)		Total sugar (%)	
		Initial	1WAS	Initial	1WAS	Initial	1WAS
S_1-Ambient	T_0	1.28	2.28[a]	0.31	1.04[a]	1.59	3.32[a]
	T_1		1.54[c]		0.48[d]		2.02[f]
	T_2		2.17[ab]		1.01[a]		3.19[b]
	T_3		1.37[d]		0.95[ab]		2.32[d]
	T_4		1.31[e]		0.55[d]		1.86[g]
S_2-Refrigeration	T_0	1.28	1.61[c]	0.31	0.43[de]	1.59	2.04[f]
	T_1		1.42[cd]		0.51[d]		1.93[g]
	T_2		1.43[cd]		0.75[c]		2.18[e]
	T_3		1.33[de]		0.94[ab]		2.27[d]
	T_4		1.28[e]		0.74[c]		1.82[h]
S_3-Cold storage	T_0	1.28	2.19[ab]	0.31	0.93[ab]	1.59	3.13[b]
	T_1		1.52[c]		0.40[e]		1.92[g]
	T_2		2.13[b]		0.89[b]		3.03[c]
	T_3		1.39[d]		0.93[ab]		2.31[d]
	T_4		1.35[de]		0.46[d]		1.84[g]
	CD		**0.13**		**0.15**		**0.12**

WAS- Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in Polypropylene punnet

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19µ

Under cold storage, bacterial population, was noticed from third week of storage onwards. After 4 weeks of storage, maximum microbial load in terms of bacteria was observed for T_1 (62 x 10^{-4} $cfug^{-1}$). T_3 did not show any sign of bacterial contamination until 5 weeks of storage.

4.2.4.2.2 Yeast

Yeast count was not significant during the storage. Yeast colonies were observed towards the end of the storage under ambient and cold storage conditions. The fruits kept under refrigeration was free from yeast contamination (Table 24).

4.2.4.2.3 Fungi

After 2 weeks of storage, out of three storage conditions, samples stored under ambient condition were contaminated by fungi (Table 25). The highest fungal count was recorded for control (9 x 10^{-2} cfu g^{-1}). In T_1, T_3 and T_4, no fungal population was observed.

Throughout the storage, no fungal population was noticed under refrigeration. In cold storage, contamination of fungi was recorded from 3 weeks after storage. The maximum microbial load in terms of fungi were recorded for T_1 (4 x 10^{-2} cfu g^{-1}) no fungal population was observed in T_2, T_3 and T_4.

4.2.5 Organoleptic evaluation

The results of the organoleptic evaluation conducted for Pusa Cherry Tomato-1 and IIHR-2871 is presented in Table 26 to Table 36. It is evident from the figures that the mean rank for all attributes showed an increasing trend at the initial phase of storage and declined towards the end of the storage, but still the fruits were acceptable for consumption under ambient and cold storage.

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Table 20. Bacterial population in storage of Pusa Cherry Tomato-1 (cfu g^{-1})

Storage condition	Treatments	Bacteria (cfu g^{-1})								
		Initial	1WAS	2WAS	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS
S_1- Ambient	T_0	ND	24 x 10^{-4}	61 x1 0^{-4}	-	-	-	-	-	-
	T_1		ND	ND	ND	ND	15 x 10^{-4}	34 x 10^{-4}	79 x 10^{-4}	105 x 10^{-4}
	T_2		13 x 10^{-4}	29 x 10^{-4}	63 x 10^{-4}					
	T_3		ND	7 x 10^{-4}	24 x 10^{-4}	59 x 10^{-4}	-	-	-	-
	T_4		ND	ND	11 x 10^{-4}	17 x 10^{-4}	27 x 10^{-4}	52 x 10^{-4}	111 x 10^{-4}	
	CD		**NS**	**0.10**	**0.001**	**0.14**	**0.18**	**0.08**	**0.06**	
S_2-Refrigeration	T_0	ND	ND	ND	9 x 10^{-4}	-	-	-	-	-
	T_1		ND	ND	4 x 10^{-4}	-	-	-	-	-
	T_2		ND	ND	7x 10^{-4}	32 x 10^{-4}	-	-	-	-
	T_3		ND	ND	ND	12 x10^{-4}	27 x 10^{-4}	65 x 10^{-4}	71 x10^{-4}	-
	T_4		ND	ND	ND	ND	ND	17 x 10^{-4}	-	-
	CD		**-**	**-**	**NS**	**0.12**	**-**	**0.001**		
S_3-Cold storage	T_0	ND	ND	ND	12 x 10^{-4}	27 x 10^{-4}	60 x 10^{-4}	-	-	-
	T_1		ND	ND	16 x10^{-4}	72 x 10^{-4}	-	-	-	-
	T_2		ND	ND	10 x 10^{-4}	24 x10^{-4}	45 x 10^{-4}	89 x 10^{-4}	119 x 10^{-4}	-
	T_3		ND	ND	ND	ND	ND	31 x 10^{-4}	67 x 10^{-4}	99 x 10^{-4}
	T_4		ND	ND	ND	ND	23 x 10^{-4}	71 x 10^{-4}	92 x 10^{-4}	161 x 10^{-4}
	CD		**-**	**-**	**NS**	**0.16**	**0.14**	**0.00**	**0.001**	**NS**

WAS – Weeks after storage

T_0- Control (Unwrapped fruits)

T_1- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film

T_3- Packaging in polypropylene punnet

T_4- Shrink wrapping in polystyrene tray with polyolefin film of 19 μ thickness

Table 21. Yeast population in storage of Pusa Cherry Tomato-1 (cfu g^{-1})

Storage condition	Treatments	Yeast (cfu g^{-1})								
		Initial	1WAS	2WAS	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS
S_1- Ambient	T_0	ND	ND	ND	-	-	-	-	-	-
	T_1		ND	ND	ND	ND	ND	2×10^{-2}	5×10^{-2}	7×10^{-2}
	T_2		ND	ND	ND	-	-	-	-	-
	T_3		ND	ND	ND	3×10^{-2}				
	T_4		ND	ND	ND	ND	ND	2×10^{-2}	6×10^{-2}	10×10^{-2}
	CD		-	-	-	-	-	**NS**	**NS**	**NS**
S_2-Refrigeration	T_0	ND	ND	ND	ND	-	-	-	-	-
	T_1		ND	ND	ND	-	-	-	-	-
	T_2		ND	ND	ND	ND	-	-	-	-
	T_3		ND	ND	ND	ND	ND	ND	ND	
	T_4		ND	ND	ND	ND	ND	ND		
	CD		-	-	-	-	-	-	-	-
S_3-Cold storage	T_0	ND	ND	ND	ND	1×10^{-2}	4×10^{-2}	13×10^{-2}	-	-
	T_1		ND	ND	ND	2×10^{-2}	-	-	-	-
	T_2		ND	ND	ND	ND	1×10^{-2}	2×10^{-2}	6×10^{-2}	
	T_3		ND	ND	ND	ND	ND	ND	ND	ND
	T_4		ND	ND	ND	ND	ND	4×10^{-2}	5×10^{-2}	12×10^{-2}
	CD		-	-	-	**NS**	**NS**	**0.00**	**NS**	-

WAS – Weeks after storage

T_0- Control (Unwrapped fruits)

T_1- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film

T_3- Packaging in polypropylene punnet

T_4- Shrink wrapping in polystyrene tray with polyolefin film of 19 μ thickness

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Table 22. Fungal population in storage of Pusa Cherry Tomato-1 (cfu g^{-1})

Storage condition	Treatments	Fungi (cfu g^{-1})								
		Initial	1WAS	2WAS	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS
S_1- Ambient	T_0	ND	ND	14 x 10^{-2}	-	-	-	-	-	-
	T_1		ND	ND	ND	ND	3 x10^{-2}	8 x10^{-2}	19 x 10^{-2}	27 x10^{-2}
	T_2		ND	10 x10^{-2}	19 x 10^{-2}	-	-	-	-	-
	T_3		ND	ND	7 x 10^{-2}	18 x 10^{-2}	-	-	-	-
	T_4		ND	ND	ND	2 x 10^{-2}	5 x10^{-2}	13 x 10^{-2}	-	-
	CD		**NS**	**0.01**	**0.32**	**0.24**	**NS**	**0.13**	**-**	**-**
S_2-Refrigeration	T_0	ND	ND	-	-	-	-	-	-	-
	T_1		ND	ND	ND	ND	ND	ND	ND	ND
	T_2		ND	ND	ND	ND	ND	ND	ND	ND
	T_3		ND	ND	ND	ND	ND	ND	ND	ND
	T_4		ND	ND	ND	ND	ND	ND	ND	ND
	CD		-	-	-	-	-	-	-	-
S_3-Cold storage	T_0	ND	ND	ND	ND	ND	4 x 10^{-2}	11 x 10^{-2}	-	-
	T_1		ND	ND	8 x 10^{-2}	19 x 10^{-2}	-	-	-	-
	T_2		ND	ND	ND	ND	ND	3 x 10^{-2}	-	-
	T_3		ND	ND	ND	ND	ND	ND	ND	6 x 10^{-2}
	T_4		ND	ND	ND	6 x 10^{-2}	23 x 10^{-2}	31 x 10^{-2}	45 x 10^{-2}	-
	CD		**-**	**-**	**-**	**0.24**	**0.39**	**NS**	**-**	**-**

WAS – Weeks after storage

T_0- Control (Unwrapped fruits)

T_1- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film

T_3- Packaging in polypropylene punnet

T_4- Shrink wrapping in polystyrene tray with polyolefin film of 19 μ thickness

4.2.5.1 Pusa Cherry Tomato -1

On comparing the three storage conditions, after one week of storage, fruits were more acceptable under ambient condition. The highest total score (46) was recorded for control sample, in terms of appearance (7.80), colour (7.70), flavour (7.50), texture (7.60), taste (7.80) and overall acceptability (7.60). The lowest total score was recorded for T_1 under refrigeration, corresponding mean ranks are 2.60 for appearance, colour and overall acceptability, 2.80 for flavour and taste and 2.70 for texture.

Under ambient condition highest total score (46) was registered for control sample and lowest total score was recorded for T_1 (39.20) after one week of storage. The organoleptic score for fruits kept under refrigeration was not in an acceptable range throughout the storage (Table 29 to 32). Highest total score was recorded for control (17.40) and lowest total score was observed for T_1 (16.10) after one week of storage. Highest total score during the storage period was recorded for T_4 (29.50) after 4 weeks of storage with mean rank values 5.20, 5.10, 4.60, 4.70, 4.90, and 5.00 for appearance, colour, flavour, texture, taste and overall acceptability respectively.

In cold storage, highest total score was recorded for control (22.30) and lowest total score was recorded for T_1 (17.90) after 1 week of storage. The highest total score (45.50) during the storage was recorded for T_3 after 4 weeks of storage with mean rank values of 7.60, 7.60, 7.70, 7.60, 7.40 and 7.60 for appearance , colour, flavour, texture, taste and overall acceptability respectively.

4.2.5.2 IIHR-2871

Analyzing the three storage conditions, the highest total score (44.60) was recorded for the control sample in terms of appearance (7.50), colour (7.60), flavour (7.30), texture (7.30) taste (7.50) and overall acceptability (7.40). The lowest total score (16.30) was recorded for T_2 and T_4 under refrigeration after one week of storage.

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Under ambient condition, highest total score (46.50) was registered for T_2, 2 WAS and T_4, 3 WAS. The organoleptic score for fruits kept under refrigeration was not in an acceptable range until 4 weeks of storage. Highest total score was recorded for T_3 (17.50) and lowest total score was observed for T_2 and T_4 (16.30) after one week of storage. Highest total score during the storage period was recorded for T_2 (36.60) after 5 weeks of storage with mean rank values 6.10, 6.10, 6.00, 6.10, 6.20, and 6.10 for appearance, colour, flavour, texture, taste and over all acceptability respectively.

In cold storage, highest total score was recorded for control (24.60) and lowest total score was recorded for T_1 (17.40) after 1 week of storage. The highest total score (45.40) during the storage was recorded for T_4 after 6 weeks of storage with mean rank values of 7.60, 7.70, 7.50, 7.60, 7.50 and 7.50 for appearance, colour, flavour, texture, taste and overall acceptability respectively.

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Table 23. Bacterial population in storage of IIHR -2871 (cfu g^{-1})

Storage condition	Treatments	Bacteria (cfu g^{-1})										
		Initial	1WAS	2WAS	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS	9WAS	10WAS
S_1-Ambient	T_0	ND	21 x 10^{-4}	55 x 10^{-4}	-	-	-	-	-	-	-	-
	T_1		ND	ND	17 x10^{-4}	68 x 10^{-4}	85 x 10^{-4}	-	-	-	-	-
	T_2		15 x 10^{-4}	36 x 10^{-4}	51 x 10^{-4}	-	-	-	-	-	-	-
	T_3		ND	13 x 10^{-4}	29 x 10^{-4}	64 x 10^{-4}	-	-	-	-	-	-
	T_4		ND	ND	11 x 10^{-4}	17 x 10^{-4}	27 x 10^{-4}	52 x 10^{-4}	-	-	-	-
	CD		NS	0.12	0.30	0.12	0.09					
S_2-Refrigeration	T_0	ND	ND	-	-	-	-	-	-	-	-	-
	T_1		ND	ND	ND	ND	ND	ND	ND	ND	ND	18 x 10^{-4}
	T_2		ND	ND	ND	ND	ND	ND	13 x 10^{-4}	57 x 10^{-4}	-	-
	T_3		ND	ND	ND	ND	ND	ND	ND	22 x 10^{-4}	40 x 10^{-4}	73 x 10^{-4}
	T_4		ND	ND	ND	ND	ND	17 x 10^{-4}	35 x 10^{-4}	68 x10^{-4}	-	-
	CD		-	-	-	-	-	-	0.14	0.00	-	0.00
S_3- Cold storage	T_0	ND	ND	ND	14 x 10^{-4}	52 x 10^{-4}	78 x 10^{-4}	-	-	-	-	-
	T_1		ND	ND	10 x 10^{-4}	62 x 10^{-4}	-	-	-	-	-	-
	T_2		ND	ND	18 x 10^{-4}	44 x 10^{-4}	65 x 10^{-4}	93 x 10^{-4}	130 x 10^{-4}	153 x 10^{-4}	160 x 10^{-4}	-
	T_3		ND	ND	ND	ND	ND	27 x 10^{-4}	54 x 10^{-4}	73 x 10^{-4}	89 x 10^{-4}	91 x 10^{-4}
	T_4		ND	ND	ND	13 x 10^{-4}	29 x 10^{-4}	57 x 10^{-4}	110 x 10^{-4}	138 x10^{-4}	-	-
	CD		-	-	NS	0.11	0.04	0.00	NS	NS	0.00	-

WAS – Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnet

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ thickness

Table 24. Yeast population in storage of IIHR -2871 (cfu g^{-1})

Storage condition	Treatments	Yeast (cfu g^{-1})										
		Initial	1WAS	2WAS	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS	9WAS	10WAS
S_1- Ambient	T_0	ND	ND	1×10^{-2}	-	-	-	-	-	-	-	-
	T_1		ND	ND	ND	1×10^{-2}	3×10^{-2}	-	-	-	-	-
	T_2		ND	ND	ND							
	T_3		ND	ND	ND	1×10^{-2}	-	-	-	-	-	-
	T_4		ND	ND	ND	ND	ND	2×10^{-2}	-	-	-	-
	CD		-	-	-	**NS**	-	-	-	-	-	-
S_2 - Refrigeration	T_0	ND	ND	-	-	-	-	-	-	-	-	-
	T_1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	T_2		ND	ND	ND	ND	ND	ND	ND	ND	-	-
	T_3		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	T_4		ND	ND	ND	ND	ND	ND	ND	ND	-	-
	CD		-	-	-	-	-	-	-	-	-	-
S_3 - Cold storage	T_0	ND	ND	ND	ND	2×10^{-2}	5×10^{-2}	-	-	-	-	-
	T_1		ND	ND	ND	3×10^{-2}	-	-	-	-	-	-
	T_2		ND	ND	ND	ND	ND	3×10^{-2}	5×10^{-2}	9×10^{-2}	13×10^{-2}	-
	T_3		ND	ND	ND	ND	ND	ND	ND	ND	ND	7×10^{-2}
	T_4		ND	ND	ND	ND	ND	1×10^{-2}	4×10^{-2}	7×10^{-2}	-	-
	CD		-	-	-	**NS**	-	-	**NS**	**NS**	-	-

WAS – Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnet

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19µ thickness

Table 25. Fungal population in storage of IIHR -2871 (cfu g^{-1})

Storage condition	Treatments	Fungi (cfu g^{-1})									
		Initial	1WAS	2WAS	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS	9WAS
S_1-Ambient	T_0	ND	ND	9 x 10^{-2}	-	-	-	-	-	-	-
	T_1		ND	ND	ND	5 x 10^{-2}	7 x 10^{-2}	-	-	-	-
	T_2		ND	3 x 10^{-2}	6 x 10^{-2}	-	-	-	-	-	-
	T_3		ND	ND	4 x 10^{-2}	10 x 10^{-2}	-	-	-	-	-
	T_4		ND	ND	ND	1 x 10^{-2}	3 x 10^{-2}	8 x 10^{-2}	-	-	-
	CD			**0.25**	**NS**	**0.20**	**0.02**				
S_2 - Refrigeration	T_0	ND	ND	-	-	-	-	-	-	-	-
	T_1		ND	ND	ND	ND	ND	ND	ND	ND	ND
	T_2		ND	ND	ND	ND	ND	ND	ND	ND	-
	T_3		ND	ND	ND	ND	ND	ND	ND	ND	ND
	T_4		ND	ND	ND	ND	ND	ND	ND	ND	-
	CD		-	-	-	-	-	-	-	-	-
S_3 -Cold storage	T_0	ND	ND	ND	1 x 10^{-2}	9 x 10^{-2}	17 x 10^{-2}	-	-	-	-
	T_1		ND	ND	4 x 10^{-2}	15 x 10^{-2}	-	-	-	-	-
	T_2		ND	ND	ND	ND	ND	5 x 10^{-2}	8 x 10^{-2}	16 x 10^{-2}	22 x 10^{-2}
	T_3		ND	ND	ND	ND	ND	ND	ND	ND	1 x 10^{-2}
	T_4		ND	ND	ND	ND	3 x10^{-2}	15 x 10^{-2}	34 x 10^{-2}	43 x 10^{-2}	-
	CD		**-**	**-**	**NS**	**0.09**	**0.24**	**0.18**	**0.17**	**0.05**	**0.10**

WAS – Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnet

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ thickness

Table 26. Mean scores for sensory attributes of Pusa Cherry Tomato -1 (1 WAS)

		Mean sensory scores (1 WAS)						
Storage condition	**Treatments**	**Appearance**	**Colour**	**Flavour**	**Texture**	**Taste**	**Overall acceptability**	**Total score**
S_1-Ambient	**T_0**	7.80	7.70	7.50	7.60	7.80	7.60	46.00
	T_1	6.70	6.50	6.40	6.50	6.60	6.50	39.20
	T_2	7.50	7.40	7.40	7.40	7.40	7.30	44.40
	T_3	7.20	7.10	6.90	7.00	7.10	7.20	42.40
	T_4	6.70	6.70	6.40	6.60	6.50	6.50	42.50
	Kendall's W Test	0.65	0.64	0.49	0.66	0.68	0.67	
S_2 - Refrigeration	**T_0**	2.70	2.80	3.00	3.00	3.00	2.90	17.40
	T_1	2.60	2.60	2.80	2.70	2.80	2.60	16.10
	T_2	2.60	2.70	2.80	2.80	2.80	2.70	16.40
	T_3	2.70	2.70	2.90	2.70	2.80	2.70	16.50
	T_4	2.50	2.60	2.80	2.80	2.90	2.70	16.30
	Kendall's W Test	**0.10**	**0.10**	**0.10**	**0.10**	**0.10**	**0.10**	
S_3 -Cold storage	**T_0**	3.90	3.80	3.70	3.90	3.50	3.50	22.30
	T_1	3.10	2.90	3.20	3.00	2.80	2.90	17.90
	T_2	3.90	3.70	3.80	3.90	3.40	3.50	22.20
	T_3	3.20	3.30	3.30	3.40	3.30	3.30	19.80
	T_4	3.20	3.10	3.20	3.30	3.10	3.10	19.00
	Kendall's W Test	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**	**0.30**	

WAS – Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnet

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ thickness

Table 27. Mean scores for sensory attributes of Pusa Cherry Tomato -1 (2 WAS)

		Mean sensory scores (2 WAS)						
Storage condition	**Treatments**	**Appearance**	**Colour**	**Flavour**	**Texture**	**Taste**	**Overall acceptability**	**Total score**
S_1-Ambient	**T_0**	6.50	6.50	6.30	6.10	6.30	6.20	37.90
	T_1	6.90	6.90	6.80	6.70	6.80	6.80	40.90
	T_2	7.50	7.40	7.50	7.50	7.40	7.40	44.70
	T_3	7.40	7.30	7.40	7.50	7.40	7.40	44.40
	T_4	6.9	6.9	6.8	6.7	6.6	6.6	40.50
	Kendall's W Test	**0.49**	**0.46**	**0.54**	**0.63**	**0.54**	**0.55**	
S_2 - Refrigeration	**T_0**	3.10	3.00	3.20	3.10	3.20	3.10	18.70
	T_1	2.80	2.90	3.00	2.80	3.00	2.90	17.40
	T_2	3.50	3.40	3.40	3.50	3.40	3.40	20.60
	T_3	3.70	3.80	3.70	3.70	3.70	3.60	22.20
	T_4	3.00	2.90	3.00	3.00	3.00	2.90	17.80
	Kendall's W Test	**0.10**	**0.10**	**0.10**	**0.10**	**0.10**	**0.10**	
S_3 -Cold storage	**T_0**	5.50	5.50	5.60	5.60	5.70	5.60	33.50
	T_1	4.60	4.60	4.50	4.40	4.50	4.50	27.10
	T_2	5.30	5.30	5.20	5.40	5.40	5.40	32.00
	T_3	4.90	4.90	4.70	4.80	4.90	4.90	29.10
	T_4	4.80	4.80	4.90	4.70	4.80	4.80	28.80
	Kendall's W Test	**0.41**	**0.42**	**0.45**	**0.51**	**0.51**	**0.51**	

WAS – Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnet

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ thickness

Table 28. Mean scores for sensory attributes of Pusa Cherry Tomato -1 (3 WAS)

		Mean sensory scores (3 WAS)						
Storage condition	Treatments	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability	Total score
S_1-Ambient	T_1	7.20	7.20	7.30	7.40	7.30	7.20	43.60
	T_2	6.40	6.50	6.30	6.40	6.70	6.40	38.70
	T_3	7.40	7.30	7.40	7.20	7.10	7.30	43.70
	T_4	7.30	7.20	7.00	7.10	7.30	7.20	43.10
	Kendall's W Test	**0.38**	**0.31**	**0.39**	**0.31**	**0.19**	**0.38**	
S_2 - Refrigeration	T_0	2.80	2.70	2.80	2.70	2.60	2.70	16.30
	T_1	2.20	2.50	2.50	2.40	2.10	2.40	14.10
	T_2	4.60	4.70	4.70	4.80	4.60	4.60	28.00
	T_3	4.40	4.40	4.40	4.40	4.40	4.40	26.40
	T_4	4.40	4.50	4.50	4.50	4.30	4.30	26.50
	Kendall's W Test	**0.57**	**0.79**	**0.80**	**0.83**	**0.89**	**0.83**	
S_3 -Cold storage	T_0	7.10	7.00	6.80	7.20	7.00	7.00	42.10
	T_1	6.20	6.00	6.00	6.10	6.30	6.00	36.60
	T_2	7.60	7.70	7.50	7.70	7.40	7.50	45.40
	T_3	6.60	6.60	6.50	6.40	6.60	6.50	39.20
	T_4	6.20	5.90	6.10	6.00	6.20	6.00	36.40
	Kendall's W Test	**0.55**	**0.65**	**0.68**	**0.62**	**0.71**	**0.71**	

WAS – Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnet

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ thickness

Table 29. Mean scores for sensory attributes of Pusa Cherry Tomato -1 (4 WAS)

		Mean sensory scores (4 WAS)						
Storage condition	**Treatments**	**Appearance**	**Colour**	**Flavour**	**Texture**	**Taste**	**Overall acceptability**	**Total score**
S_1-Ambient	**T_1**	5.9	6.1	6.2	6.0	6.1	6.1	36.40
	T_3	6.5	6.4	6.5	6.4	6.7	6.6	39.10
	T_4	6.0	6.0	6.1	5.9	6.0	6.0	36.00
	Kendall's W Test	**0.30**	**0.11**	**0.11**	**0.18**	**0.35**	**0.35**	
S_2 - Refrigeration	**T_2**	5.10	5.00	4.30	4.50	4.60	4.70	28.20
	T_3	4.50	4.20	4.70	5.40	5.60	4.60	29.00
	T_4	5.20	5.10	4.60	4.70	4.90	5.00	29.50
	Kendall's W Test	**0.18**	**0.19**	**0.06**	**0.48**	**0.41**	**0.07**	
S_3 -Cold storage	**T_0**	7.00	6.90	7.10	6.90	6.90	6.90	41.70
	T_1	6.70	6.70	6.70	6.60	6.60	6.60	39.90
	T_2	7.30	7.30	7.40	7.30	7.50	7.30	44.10
	T_3	7.60	7.60	7.70	7.60	7.40	7.60	45.50
	T_4	7.00	6.90	6.90	6.80	6.70	6.80	41.10
	Kendall's W Test	**0.14**	**0.16**	**0.15**	**0.17**	**0.17**	**0.17**	

WAS – Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnet

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ thickness

Table 30. Mean scores for sensory attributes of Pusa Cherry Tomato -1 (5 WAS and 6 WAS)

Mean sensory scores (5 WAS)								
Storage condition	**Treatments**	**Appearance**	**Colour**	**Flavour**	**Texture**	**Taste**	**Overall acceptability**	**Total score**
S_3 -Cold storage	T_0	6.90	6.70	6.60	6.80	6.60	6.60	40.20
	T_2	7.20	7.30	7.10	7.20	7.20	7.20	43.20
	T_3	7.50	7.40	7.20	7.40	7.30	7.50	44.30
	T_4	6.60	6.80	6.50	6.70	6.60	6.60	39.80
	Kendall's W Test	**0.31**	**0.30**	**0.28**	**0.43**	**0.32**	**0.16**	

Mean sensory scores (6 WAS)								
Storage condition	**Treatments**	**Appearance**	**Colour**	**Flavour**	**Texture**	**Taste**	**Overall acceptability**	**Total score**
S_3 -Cold storage	T_0	6.40	6.40	6.30	6.20	6.40	6.30	38.00
	T_2	6.80	6.60	6.50	6.60	6.40	6.50	39.40
	T_3	7.20	7.30	7.40	7.10	7.30	7.20	43.50
	T_4	6.80	6.70	6.40	6.50	6.60	6.50	39.50
	Kendall's W Test	**0.17**	**0.25**	**0.16**	**0.26**	**0.18**	**0.32**	

WAS – Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnet

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ thickness

Table 31. Mean scores for sensory attributes of IIHR-2871 (1 WAS)

		Mean sensory scores (1 WAS)						
Storage condition	**Treatments**	**Appearance**	**Colour**	**Flavour**	**Texture**	**Taste**	**Overall acceptability**	**Total score**
S_1-Ambient	**T_0**	7.50	7.60	7.30	7.30	7.50	7.40	44.60
	T_1	6.60	6.50	6.30	6.40	6.30	6.40	38.50
	T_2	7.40	7.10	7.20	7.10	7.20	7.30	43.30
	T_3	7.10	6.90	6.80	6.70	6.90	7.10	41.50
	T_4	6.70	6.60	6.40	6.30	6.50	6.40	38.90
	Kendall's W Test	**0.51**	**0.55**	**0.44**	**0.64**	**0.60**	**0.69**	
S_2 - Refrigeration	**T_0**	2.90	2.90	3.20	3.00	2.60	2.70	17.30
	T_1	2.90	2.90	3.20	2.80	2.40	2.50	16.70
	T_2	2.80	2.80	3.00	2.80	2.40	2.50	16.30
	T_3	3.00	3.00	3.20	3.00	2.60	2.70	17.50
	T_4	2.80	2.80	3.00	2.80	2.40	2.50	16.30
	Kendall's W Test	**0.02**	**0.03**	**0.04**	**0.05**	**0.05**	**0.05**	
S_3 -Cold storage	**T_0**	4.00	4.00	4.20	4.20	4.10	4.10	24.60
	T_1	2.90	2.90	2.90	3.00	2.80	2.90	17.40
	T_2	3.80	3.80	4.00	4.00	3.90	3.90	23.40
	T_3	3.70	3.70	3.70	3.80	3.60	3.70	22.20
	T_4	3.00	3.00	3.20	3.10	3.30	3.10	18.70
	Kendall's W Test	**0.48**	**0.48**	**0.43**	**0.45**	**0.47**	**0.45**	

WAS – Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnet

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ thickness

Table 32. Mean scores for sensory attributes of IIHR-2871 (2 WAS)

		Mean sensory scores (2 WAS)						
Storage condition	**Treatments**	**Appearance**	**Colour**	**Flavour**	**Texture**	**Taste**	**Overall acceptability**	**Total score**
S_1-Ambient	**T_0**	6.60	6.60	6.50	6.30	6.40	6.30	38.70
	T_1	7.00	7.00	6.90	6.80	6.90	6.90	41.50
	T_2	7.70	7.60	7.90	7.90	7.80	7.60	46.50
	T_3	7.50	7.50	7.60	7.60	7.60	7.40	45.20
	T_4	6.90	6.90	7.00	7.00	6.90	6.80	41.50
	Kendall's W Test	**0.65**	**0.66**	**0.72**	**0.79**	**0.77**	**0.78**	
S_2 - Refrigeration	**T_1**	3.50	3.70	3.60	3.60	3.70	3.50	21.60
	T_2	3.80	3.90	4.00	3.90	4.00	3.90	23.50
	T_3	3.80	4.00	3.90	4.00	3.80	3.80	23.30
	T_4	3.50	3.70	3.60	3.60	3.70	3.60	21.70
	Kendall's W Test	**0.25**	**0.15**	**0.19**	**0.20**	**0.21**	**0.20**	
S_3 -Cold storage	**T_0**	5.40	5.40	5.30	5.20	5.50	5.40	32.20
	T_1	4.40	4.40	4.60	4.30	4.20	4.40	26.30
	T_2	5.20	5.20	5.00	5.10	5.30	5.20	31.00
	T_3	4.70	4.70	4.60	4.60	4.50	4.60	27.70
	T_4	4.60	4.60	4.50	4.60	4.60	4.60	27.50
	Kendall's W Test	**0.37**	**0.380**	**0.42**	**0.47**	**0.47**	**0.46**	

WAS – Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnet

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ thickness

Table 33. Mean scores for sensory attributes of IIHR-2871 (3 WAS)

		Mean sensory scores (3 WAS)						
Storage condition	**Treatments**	**Appearance**	**Colour**	**Flavour**	**Texture**	**Taste**	**Overall acceptability**	**Total score**
S_1-Ambient	**T_1**	7.40	7.50	7.60	7.50	7.60	7.40	45.00
	T_2	6.20	6.30	6.00	6.10	6.70	6.20	37.50
	T_3	7.70	7.60	7.70	7.60	7.50	7.70	45.80
	T_4	7.60	7.60	7.70	7.70	7.40	7.60	46.50
	Kendall's W Test	**0.90**	**0.83**	**0.95**	**0.81**	**0.57**	**0.90**	
S_2 - Refrigeration	**T_1**	4.40	4.60	4.50	4.40	4.60	4.50	27.00
	T_2	4.60	4.70	4.60	4.60	4.70	4.60	27.80
	T_3	4.80	4.80	4.70	4.80	4.80	4.70	28.60
	T_4	4.80	4.90	4.80	4.80	4.90	4.80	29.00
	Kendall's W Test	**0.10**	**0.05**	**0.05**	**0.11**	**0.04**	**0.05**	
S_3 -Cold storage	**T_0**	7.20	7.00	7.30	7.20	7.20	7.10	43.00
	T_1	6.30	6.20	6.00	6.10	6.00	6.00	36.60
	T_2	7.60	7.80	7.90	7.70	7.80	7.70	46.50
	T_3	6.90	7.10	6.90	6.80	6.90	6.90	41.50
	T_4	6.20	6.00	6.10	6.30	6.00	6.00	36.60
	Kendall's W Test	**0.50**	**0.60**	**0.69**	**0.66**	**0.66**	**0.65**	

WAS – Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnet

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ thickness

Table 34. Mean scores for sensory attributes of IIHR-2871 (4 WAS)

		Mean sensory scores (4 WAS)						
Storage condition	**Treatments**	**Appearance**	**Colour**	**Flavour**	**Texture**	**Taste**	**Overall acceptability**	**Total score**
S_1-Ambient	**T_1**	6.7	6.7	6.8	6.9	6.8	6.8	40.70
	T_3	6.7	6.6	6.5	6.7	6.7	6.7	39.90
	T_4	6.8	6.9	7.0	7.0	6.9	6.9	41.50
	Kendall's W Test	**0.005**	**0.028**	**0.052**	**0.052**	**0.018**	**0.018**	
S_2 - Refrigeration	**T_1**	4.50	4.40	4.50	4.50	4.70	4.50	27.10
	T_2	5.10	5.20	5.00	5.10	5.20	5.10	30.70
	T_3	4.50	4.30	4.60	5.20	5.40	4.80	28.80
	T_4	5.10	5.20	5.00	5.10	5.20	5.20	30.80
	Kendall's W Test	**0.38**	**0.47**	**0.29**	**0.23**	**0.22**	**0.23**	
S_3 -Cold storage	**T_0**	6.70	6.60	6.90	6.80	6.60	6.70	40.30
	T_1	6.30	6.30	6.30	6.10	6.10	6.10	37.20
	T_2	7.20	7.30	7.50	7.20	7.40	7.20	43.80
	T_3	7.40	7.40	7.60	7.40	7.40	7.40	44.60
	T_4	6.80	6.60	6.70	6.50	6.40	6.50	39.50
	Kendall's W Test	**0.21**	**0.25**	**0.22**	**0.25**	**0.26**	**0.25**	

WAS – Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnet

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19μ thickness

Table 35. Mean scores for sensory attributes of IIHR-2871 (5 WAS)

		Mean sensory scores (5 WAS)						
Storage condition	**Treatments**	**Appearance**	**Colour**	**Flavour**	**Texture**	**Taste**	**Overall acceptability**	**Total score**
S_2 - Refrigeration	T_1	5.00	5.10	5.20	5.30	5.00	5.30	30.90
	T_2	6.10	6.10	6.00	6.10	6.20	6.10	36.60
	T_3	5.10	5.30	5.60	5.60	5.50	5.30	32.40
	T_4	5.90	5.80	5.90	5.90	5.70	5.90	35.10
	Kendall's W Test	**0.43**	**0.44**	**0.27**	**0.28**	**0.27**	**0.35**	
S_3 -Cold storage	T_0	6.80	6.70	6.90	6.60	6.40	6.60	40.00
	T_2	7.30	7.20	7.40	7.30	7.10	7.20	43.50
	T_3	7.60	7.40	7.50	7.30	7.50	7.30	44.64
	T_4	6.60	6.50	6.70	6.40	6.60	6.50	39.30
	Kendall's W Test	**0.43**	**0.44**	**0.27**	**0.28**	**0.23**	**0.35**	

WAS – Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnet

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19µ thickness

Table 36. Mean scores for sensory attributes of IIHR-2871 (6 WAS)

		Mean sensory scores (6 WAS)						
Storage condition	**Treatments**	**Appearance**	**Colour**	**Flavour**	**Texture**	**Taste**	**Overall acceptability**	**Total score**
S_2 - Refrigeration	**T_1**	5.10	5.40	5.10	5.40	5.30	5.20	31.50
	T_2	6.20	6.20	5.80	6.00	6.00	6.10	36.30
	T_3	5.10	5.10	5.20	5.40	5.30	5.40	31.50
	T_4	6.00	6.00	5.70	5.80	5.80	5.90	35.20
	Kendall's W Test	**0.34**	**0.33**	**0.18**	**0.19**	**0.27**	**0.21**	
S_3 -Cold storage	**T_0**	6.60	6.60	6.30	6.50	6.50	6.40	38.90
	T_2	6.70	6.70	6.40	6.50	6.60	6.50	39.40
	T_3	7.60	7.70	7.50	7.60	7.50	7.50	45.40
	T_4	7.00	7.00	6.80	7.00	6.90	6.90	41.60
	Kendall's W Test	**0.33**	**0.32**	**0.59**	**0.48**	**0.44**	**0.23**	

WAS – Weeks after storage **T_0**- Control (Unwrapped fruits) **T_1**- Packaging in micro ventilated polyethylene cover (200 gauge)

T_2- Packaging in polystyrene tray and wrapping with cling film **T_3**- Packaging in polypropylene punnet

T_4- Shrink wrapping in polystyrene tray overwrapped with polyolefin film of 19µ thickness

DISCUSSION

5. DISCUSSION

Cherry tomato is considered as a botanical variety of cultivated tomato, *Solanum lycopersicum* L. var. *cerasiformae* with compact fruits (1.5- 3.5 cm), on extended panicle. The market for cherry tomato has become expanded, principally due to the acceptance of their high quality and fine taste (Kobryn and Hallmann, 2005). Cherry tomatoes are superior sources for providing disease resistance and versatile to cool and hot season. They are well liked far and wide because of its commendatory characteristics such as excellent source of vitamin A, and C, sugars, taste and low calories (Prema *et al.*, 2011).With ever increasing market for cherry tomato, it is important to verify the quality fruits along with resistance to biotic and abiotic pressures and acceptability for fresh market and processing. Identification of genotypes with desirable post harvest attributes suitable for different growing situations in Kerala is very important. Post harvest management of cherry tomato is vital for reducing losses, improving shelf life and maintaining the quality of fruits.

Hence, the study on 'Post harvest evaluation and management of cherry tomato (*Solanum lycopersicum* L. var. *cerasiformae* Dunal A. Gray) genotypes' were conducted at the Department of Processing Technology, College of Horticulture, Vellanikkara, during 2015 - 17.The discussion pertaining to the study is presented under the following heads.

5.1 Evaluation of quality attributes of cherry tomato grown under rain shelter and open field

5.2 Standardisation of packaging and storage requirements of cherry tomato

5.1 EVALUATION OF QUALITY ATTRIBUTES OF CHERRY TOMATO GROWN UNDER RAIN SHELTER AND OPEN FIELD CONDITION

Vegetables are considered as health foods because of the awareness of the nutritional qualities among the people. Hence priority is being given to upgrade the quality of produce along with increasing production. Apart from the genetic potential of a variety, the other factors which influence the productivity and quality of vegetables are growing habitat and agro techniques.

Cherry tomato is rich source of vitamins and antioxidants. The cultivation of cherry tomato under protected conditions is an emerging field since cherry tomatoes are high value crops performing well under protected conditions in tropical areas. Protected cultivation has specific advantages like quality produce for export, increase in production, off season vegetable production etc. Eleven genotypes were raised under rain shelter and open field in Department of Olericulture and they were characterized for physico- morphological, nutritional and biochemical parameters.

5.1.1 Physico- morphological parameters

5.1.1.1 Fruit length

A significant effect of crop environment was observed on the morphological characteristics including fruit length. Higher fruit length was observed for all genotypes grown in rain shelter as compared to open field. Fruit length of cherry tomato accessions ranged from 1.24 cm to 2.60 cm and 1.51cm to 2.89 cm in open field and rain shelter respectively. SLc.11 had the highest fruit length in both open field (2.60 cm) and rain shelter (2.89 cm).

These results are in agreement with Rana *et. al.* (2014). They reported a higher fruit yield of more than 50 per cent for the tomato plants grown in polyhouse (naturally ventilated) compared to open field, associated with a greater length of 4.40 cm compared to a fruit length of 3.80 cm under open field.

A study was conducted by Kumar *et al.* (2014) on 15 genotypes of cherry tomato under open field condition. The maximum fruit length was recorded in Cherry Tomato - 8 as 4.17 cm, whereas the minimum fruit length was recorded as 1.63 cm in Cherry Tomato - 1.

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5.1.1.2 Fruit diameter

SLc.11 had the highest fruit diameter (2.62 cm) and the lowest (1.25 cm) was recorded in SLc.6 in open field condition. In rain shelter also the same accessions recorded highest (3.16 cm) and lowest diameter (1.57 cm).

The diameter of the fruit was greater for the fruits grown under rain shelter than the open field condition. The environment in the polyhouse support the growth and development of cherry tomato plants. The economic parameters like yield is highly influenced by fruit qualities like fruit diameter and are better under rain shelter condition. A similar study conducted by Rana *et al.* (2014) in tomato revealed that a higher fruit diameter of (5.40 cm) were recorded in naturally ventilated polyhouse than open field (4.90 cm).

The fruits diameter of 15 genotypes ranged from 1.76 cm to 5.16 cm in a study conducted by Kumar *et al.* (2014).

5.1.1.3 Fruit girth

Fruit girth of cherry tomato accessions varied from 1.29 to 2.75 cm and 1.59 to 3.11 cm at open field and rain shelter respectively. SLc.11 registered the highest value for fruit girth both in open field (2.75 cm) and rain shelter (3.11 cm). The lowest values for fruit girth was observed in SLc.6 both in open field (1.29 cm) and rain shelter (1.59 cm). The difference observed in fruit girth was significant between the growing conditions.

Safia (2015), from Academy of Climate Change Education and Research, studied the impact of climate change on growth and yield of tomato varieties Anagha and Shakthi, in three growing conditions (polyhouse, rain shelter and open field). The greatest biomass accumulation was observed in polyhouse and rain shelter. The yield associated factors were also better under protected conditions. Similar result was reported by Radhakrishnan (2015) in the same variety of tomato.

An evaluation conducted by Kumar *et al.* (2014) on fruit production and quality of 15 genotypes of cherry tomato revealed that the maximum fruit girth was observed in Cherry Tomato -8 (5.16 cm) and minimum fruit girth (1.76 cm) in Cherry Tomato -1.

Kumar *et al.,* (2015), conducted a study on tomato, where 20 genotypes were evaluated for growth, yield and quality traits. They recorded that the fruit girth of tomato varieties ranged from 4.38 in TODVAR-5) to 6.11cm TODVAR-2.

5.1.1.4 Rind thickness

Rind thickness of fruits varied among the varieties and also significantly varied between growing conditions. Rind thickness was higher for the fruits grown under rain shelter. Rind thickness of cherry tomato accessions was found to range between 0.10 mm to 0.20 mm in open field and 0.34 to 0.46 mm in rain shelter. The highest value for rind thickness was observed in SLc.11 in both growing conditions (0.20 and 0.46 mm for open field and rain shelter respectively). The lowest value was observed in SLc.7 under both growing conditions (0.10 mm and 0.34 mm for open field and rain shelter respectively).

Kumar *et.al.* (2014), in a study conducted on 15 genotypes of cherry tomato, observed that, the maximum pericarp thickness was in Cherry Tomato -8 (0.47 mm). Cherry Tomato -1, Cherry Tomato -3, Cherry Tomato -5 and Cherry Tomato -3 X Cherry Tomato -4 recorded the minimum pericarp thickness of 0.10 mm. However, the very fine pericarp of some genotypes may be the genetic character of specific genotype of small fruited tomato.

Kumar *et. al.* (2015) reported that the pericarp thickness of tomato was in a range of 4.4 mm in Pusa Ruby to 7.5 mm in TODVAR-7.

According to the study conducted by Kumar *et.al.* (2016) root stock had a significant impact on the pericarp thickness of grafted tomatoes. The maximum

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fruit pericarp thickness was about 4.1 mm in grafted plant (brinjal V1034845 as a root stock) in protected environment.

5.1.1.5 Fruit weight (g)

A significant effect of crop environment was discovered for the trait fruit weight of cherry tomatoes. Rain shelter grown crop yielded fruits with higher weight than open field ones. Fruit weight of cherry tomato accessions ranged from 1.96 g in Slc.6 to 18.26 g in SLc.11 in open field. In rain shelter, fruit weight ranged from 2.63 g in SLc.6 to 20.67 g in SLc.11.

Rodriguez *et al.* (2012) conducted a .study on wild germplasm of *S. lycopersicum var. cerasiforme,* in green house condition. The most striking phenotypic difference was in total fruit weight per raceme. The Ocixana accessions were massive (130.60 g) compared to Sinaloa, Nayariti, Jalisco and Michoascan (16.90- 20 g) accessions.

Rana *et al*. (2014) studied the effect of growing condition on tomato. They reached the conclusion that the significant higher yield of tomato in rain shelter was due to the yield contributing factors, including fruit weight. The fruits were heavier inside rain shelter (75 g) than open field (68 g).

Protected structures such as green house, tunnels, mulching and others can play a significant role to mitigate the influence of temperature variations, over and under precipitation, instable sunshine hour and infestation of disease and pest (Spaldon *et al*., 2015).

Singh *et al.* (2016) studied the climate change impact on tomato, under protected condition of 8 tomato varieties. According to the study individual fruit weight ranged from 5 to 88 g.

5.1.1.6 Juice per cent

Juice per cent of cherry tomato fruits were higher in rain shelter condition. Juice percentage of cherry tomato accessions varied from 35.03 per cent to 47.11 per cent and 45.19 per cent to 58.03 per cent at open field and rain shelter respectively. SLc.7 had the highest juice percentage both in open field (47.11 %) and rain shelter (58.03 %).

The rain shelter favours the growth and development of plants. The water use efficiency is high under rain shelter compared to open field condition because of less evaporative loss. This lead to better moisture retention and higher juice content in fruits.

According to the study conducted by Patil *et al.* (2015) in 22 promising tomato genotypes, maximum juice per cent was recorded for RIIT5P5 (81.73 %) and RIIKT9/8 (80.10 %). High juice content and less pomace are considered as important characters for processing. The minimum pomace per cent was noted in RIIT5P5 (18.27%).

Rain shelter grown fruits had high per cent of juice. The results of the study indicate that physical attributes of fruits like fruit length, girth diameter, pericarp thickness and juice percentage is higher for commercial varieties of tomato compared to cherry tomatoes.

5.1.1.7 Physical composition

The quality of fruits depends upon the relative amount of outer and inner wall tissue. Cherry tomato is divided into 5 fractions, such as outer and inner wall, inner locule tissue, gelatinous pulp and seed. The inner and outer wall regions play an important role in the quality of tomato, because of highest content of dry matter, insoluble solids and reducing sugars.

Rain shelter grown fruits had more pulp content, because of the complementary growing condition and vigorous growth of the plant compared to open field. The range observed for peel, seed and pulp in the different accessions in open field were 6.34 to 9.18 per cent, 30.80 to 44.60 per cent and 48.01 to 61.25 per cent respectively. Inside the rain shelter the physical components like peel, seed and pulp varied between 5.05 to 7.39 per cent, 24.94 to 34.44 per cent and 56.51 to 66.95 per cent respectively. In open field, the highest values for peel

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(9.18 %), seed (44.60 %) and pulp (61.25 %) were recorded for SLc.3, SLc.2 and SLc.5 respectively. SLc.6, SLc.11 and SLc.2 registered least value for peel (6.34 %), seed (30.80 %) and pulp (48.01 %) in open field. Among the cherry tomato genotypes raised in rain shelter, the highest values observed for peel (7.39 %), seed (34.44 %) and flesh (66.95 %) content was in Slc.11, SLc.9 and SLc.8 respectively. The least content of peel (5.05 %), seed (24.94 %) and pulp (56.51 %) was noted for SLc.1, SLc.8 and SLc.4 respectively.

Cherry tomatoes in general have smaller fruit size and high peel percentage. All the commercial varieties were typical sized (61 g to 88 g) with low peel percentage compared cherry tomatoes. Cherry tomatoes have compact sized fruits with higher peel percentage (Singh *et al.,* 2016).

5.1.1.8 Colour of rind

Colour of the rind was vivid reddish orange (32A) for SLc.1, and 11, vivid orange (28B) for SLc.2, SLc.8 and SLc.9 and vivid yellowish pink (28A) for other accessions, in open field condition. In rain shelter it was strong reddish orange for all the accessions.

The percentage of two predominant pigments, lycopene and carotene varies depending up on the condition during ripening. The ratio between lycopene and carotene content of fruits is an important factor determining the colour of rind. If the ratio is high, the fruits are dark red coloured, if the ratio is low fruits are an orange or pale yellow in colour

Patil *et.al.* (2015) classified fully ripe tomato into three colour classes of dark red, red, orange red.

5.1.1.9 Colour of juice

In open field, the juice colour was light orange (26C) for SLc.2, 8 and 9 and light yellowish pink (27A) for other accessions. In the rain shelter, colour was strong yellowish pink (31C) for SLc.1, 3, 8, 10 and strong orange (30D) for other accessions. The colour of the juice is determined by the carotenoid pigments present in the fruit. Rain shelter grown fruits were rich in lycopene. They had more reddish coloured juice. The open field grown fruits yielded juices, which was more yellowish in colour, because of less lycopene content and more carotene pigments. Temperature and light intensity greatly influence the colour development in fruits.

5.1.1.10 Fruit size

The crop management in cherry tomato highly concentrate on uniform size of fruits, together with crop load and fruit yield. Potential fruit size is decided by the short period of cell division at the time of early post bloom fruit development, while the definite size achieved at harvest is dependent on longer cell expansion (Roper, 2004).

Accessions SLc.1, 2, 3, 4, 5, 7, 8 and 9 had 'small' sized fruits under both growing conditions. Fruits of SLc.6 belonged to category 'very small' under open field and 'small' under rain shelter. Fruits of SLc.11 from open field were classified as 'medium' and those from rain shelter were classified as 'large'. Medium sized fruits were obtained for SLc.10 under rain shelter.

The fruit size accomplished is associated with the growth conditions (light interceptions, photosynthesis and temperature) from the beginning to end of the cell expansion period (Austin *et al.*, 1999). According to Tijskens *et al.* (2016), under greenhouse condition with controlled temperature and humidity, size of fruits were more uniform compared to fruits from open field.

Rodriguez *et al.* (2012) conducted a study on wild germplasm of cherry tomatoes, in greenhouse condition. The ratio of polar to equatorial diameter in the Ocixana accessions ranged from 2.40 to 2.70. While fruits from other varieties (Sinaloa, Nayarit, Jalisco and Michoascan) had values ranging from 1.30 to 1.50. The smaller fruit size is an indication of the wild origin of cherry tomatoes.

5.1.2 Nutritional and biochemical parameters

5.1.2.1 TSS

The TSS content observed in fruits analyzed in the present study, was higher in open field than rain shelter. TSS of cherry tomato accessions ranged from 5.0 to 7.5° brix and 4.4 to 7.2° brix for open field and rain shelter respectively. In open field, SLc.2 had the highest TSS (7.5° brix), while the lowest (5.0° brix) was recorded in SLc.5. In case of rain shelter highest TSS (7.2° Brix) was for SLc.1 and SLc.2 and lowest (4.4° brix) TSS was recorded in SLc.5.

Cherry tomato TSS mainly describes the reducing sugar present in the fruit (Ho and Hewitt, 1986). Thus any individual factor that alters photosynthetic rate consequently affect sucrose generation and also glucose and fructose accumulation in fruits. Thus TSS of fruits is also affected. The TSS has absolute influence on the flavour of the final product (Gril *et al*., 2004).

Genotypes have a considerable effect on TSS of cherry tomato fruits. Patil *et al*. (2015) conducted a study on 20 tomato genotypes and observed significant difference among the genotypes for TSS content. It was maximum for genotype R1T8P3 (5.96° brix).

5.1.2.2 Titrable acidity

Fruits produced in open field were more acidic than fruits produced inside rain shelter. The environmental effect on fruit acidity is complex. Titrable acidity of cherry tomato accessions ranged from 0.72 to 1.28 per cent and 0.43 to 1.02 per cent in open field and rain shelter respectively. SLc.1 and SLc.4 had the highest titrable acidity (1.28 %) and the lowest (0.72 %) was recorded in SLc.7 and SLc.11 in case of fruits from open field. However SLc.8 had the highest titrable acidity (1.02 %) and SLc.11 had the lowest titrable acidity (0.43 %) inside rain shelter.

Some studies favour the assumption that organic acids are produced in the fruits itself from the stored carbohydrates (Sakiyama and Stevens, 1976), although some of these acids may be translocated from the leaves and roots to the fruits (Bertin *et al.,* 2000). Thus lower acidity of fruits may be as a result of lower photosynthetic activity of the plant (shading in protected environment) in this environment and lower carbohydrate accumulation in the fruits during summer seasons.

5.1.2.3 Sugars

The content of total, reducing and non reducing sugars of cherry tomato fruits produced from the field was higher in fruits produced from rain shelter. The reducing sugar ranged from 1.35 to 2.93 per cent and 1.33 to 2.90 per cent for open field and rain shelter respectively. SLc.2 had the highest reducing sugar content for both open field (2.93 %) and rain shelter (2.90 %). Non reducing sugar content ranged from 0.51 to 1.73 per cent and 0.42 to 1.50 per cent for open field and rain shelter respectively. The non reducing sugar was highest for SLc.1 for both open field (1.73 %) and rain shelter (1.50 %). The total sugar content ranged from 2.58 to 3.97 per cent and 2.44 to 3.90 per cent for open field and rain shelter respectively. SLc.2 and SLc.1 recorded the highest total sugar content in open field and rain shelter respectively.

Beckman *et al.* (2006) opinied that the higher sugar content in the open field grown crop may be due to the greater light intensity and enormous photosynthetic plant activity in this crop environment.

Abscicic acid (ABA) is crucial in fruit maturation and senescence. It is considered as the ripening control factor other than ethylene. When plant adapt to stresses (diseases, high and low temperature *etc.*) abscisic acid (ABA) is produced as a stress hormone. ABA increase levels of sugars in tomato fruit by accelerating the expressions of genes encoding vacuolar invertase and sucrose synthase. The upraised sugar levels, particularly glucose and fructose create a higher ratio of sugar to organic acid making the fruits sweeter and tastier (Patane *et al.*, 2011)

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5.1.2.4 Vitamin C

Comparatively higher ascorbic acid content was found in fruits from open field than the fruits grown in rain shelter. Ascorbic acid content of cherry tomato accessions ranged from 14.28 to 32.59 mg $100g^{1}$ and 12.50 to 32 mg $100g^{-1}$ for open field and rain shelter respectively. SLc.2 had the highest vitamin C both under open field (32.59 mg $100g^{-1}$) and rain shelter (32 mg $100g^{-1}$).

Ascorbic acid biosynthesis is strongly regulated by the environmental conditions. With the high light intensity, ascorbic acid content increases in tomato fruits (Venter, 1997). Together with climatic conditions, the genotypes have a great effect on ascorbic acid content in tomato.

The ascorbic acid content of fruits analyzed in the present study is in agreement with Davies and Hobson (1981), who recorded a fluctuation between 10 to 30 mg $100g^{-1}$ of ascorbic acid in fruits from protected environment and open field. The open field grown fruits recorded higher content of vitamin C, compared to fruits from greenhouse.

Even though not being vital for ascorbic acid synthesis, luminosity may affect the accumulation of vitamin C during growth of the plant and fruits. Ascorbic acid is synthesized from photosynthesis produced sugars. (Lee and Kadar, 2000). Sugar production is a concern of plant's photosynthesis rate, which in turn is an operation of luminosity intensity. Thus reduced ascorbic acid content of fruits produced in protected environment is probably brought about by the lower luminosity in the environment that might have declined the production of sugars. Sugar is a substrate used in the synthesis of ascorbic acid.

5.1.2.5 Total phenols

Considerable variation in total phenol content was recorded between cherry tomato genotypes. Total phenols in cherry tomato genotypes ranged from 0.50 mg $100g^{-1}$ in SLc.4 to 1.10 mg $100g^{-1}$ in SLc.5 and SLc.9 in open field. Inside the rain shelter total phenol content was found to range between 0.60 mg $100g^{-1}$ in SLc.5 to 1.10 mg $100g^{-1}$ in SLc.9. Growing conditions were found to significantly influence the total phenol content in SLc.2, 4, 5, 6, 7, 8 and 11. However total phenol was higher in open field grown fruits for SLc.5, SLc.6, SLc.7 and SLc.11. and rain shelter grown fruits of SLc.2, SLc.4 and SLc.8.

According to the study conducted by Papoutsis *et al*. (2016) on two cherry tomato varieties under greenhouse condition, neither harvesting period nor genotype had a significant effect on total phenols.

5.1.2.6 Total carotenoids

The total carotenoid content was higher for the fruits grown under rain shelter as compared to the fruits from open field. Significant variation among the genotypes was also observed under rain shelter. The total carotenoid content of cherry tomato genotypes ranged from 1.82 to 5.46 mg $100g^{-1}$ in the open field and 3.27 to 6.51 mg $100g^{-1}$ in the rain shelter. SLc.1 had highest total carotenoid content (5.46 mg $100g^{-1}$) in open field condition. Inside the rain shelter SLc.2 had highest total carotenoid content (6.51mg $100g^{-1}$).

Lycopene and carotene are the dominating carotenoid pigment present in cherry tomato. There are also very slight amount of yellow pigment, xanthophyll present. Lycopene imparts the red colour to the fruits and carotene is a yellow pigment. The vitamin A activity of tomato is determined mainly by the carotenoid content.

The formation of carotene in fruits take place over a wide range of temperature and at a more rapid rate than lycopene. Exposure to light increase the carotene content but does not affect the lycopene content.

Under rain shelter condition, increase in total carotenoid was observed which may be due to the quality of light and its intensity that favours pigment development.

5.1.2.7 β carotene

Comparison of two growing conditions revealed, significantly higher β carotene content in SLc.2, SLc.3, SLc.5, SLc.6 and SLc.7. β carotene in cherry tomato ranged from 0.39 to 1.76 mg $100g^{-1}$ and 0.73 to 1.86 mg $100g^{-1}$ in open field and rain shelter respectively. Highest β carotene content was recorded in Slc.9 for both open field and rain shelter.

According to Zivanovic *et al.* (2012), β carotene content of tomato was higher in polytunnels with higher UV transmission rate compared to open field. The arrangement of right light conditions (quality and intensity) for cherry tomato production has a significant effect on the accumulation of carotenoids.

Study conducted by Afraa and Ali (2016) proved that covering material of the green house had a significant effect on elevating β carotene, lycopene, anthocyanin and vitamin C.

5.1.2.8 Lycopene

Total lycopene content of cherry tomato genotypes differed significantly under rain shelter. The lycopene content of cherry tomato genotypes ranged from 1.24 to 3.13 $mg100g^{-1}$ and 2.48 to 3.87 mg $100g^{-1}$ under open field and rain shelter respectively. SLc.1had highest lycopene content for both open field and rain shelter respectively.

Field produced cherry tomato fruits were expected to show a higher lycopene content than fruits produced in a protected environment. Since, under favourable temperatures (22 - 25°C), lycopene biosynthesis is accelerated by luminosity, which was almost 25 per cent more intense in the open field. In the present study, higher lycopene content was observed in rain shelter grown fruits. Similar results were reported by Safia (2015). Radhakrishnan (2015) conducted studies on Anagha variety of tomato at Academy of Climate Change and Education and Research, Vellanikkara. The study proved that, if the temperatures of the atmosphere exceeds 30°C the synthesis of lycopene is inhibited.

The lycopene synthesis is chiefly affected by irradiance, spectral quality and temperature (Adegoroye and Joliffe, 1983). Field temperature above 30°C, arrest lycopene formation, but the production of carotene continues up to 40°C. High light intensity degrades the lycopene pigment (Prohens *et al.*, 2004). In rain

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shelter, there is a protective effect against sun scald due to heavy foliage and shade provided by the infrastructure.

Cherry tomato also have been reported to contain higher lycopene content than local varieties under open condition (Raffo *et al.,* 2006). Peculiarity of small, high pigmented cherry tomato and other normal size cultivar has been identified as the genotype factors, triggering enhanced enzymatic functioning of phytoene synthase -1 that leads to a massive production of lycopene precursors.

The growing condition significantly affected the physico-morphological characters. Performance of most of the genotypes were superior inside the rain shelter as compared to open field condition. SLc.11 recorded the highest fruit length (2.89 cm), fruit diameter (3.16 cm), fruit girth (3.11 cm), rind thickness (0.46 mm) juice per cent (57.09 %) and fruit weight (20.67 g) under rain shelter.

The effect of growing conditions on nutritional and biochemical parameters was also found to be significant for most of the attributes. TSS, sugars and vitamin C content was higher for most of the genotypes under open field condition. Total carotenoids and lycopene content was higher for most of the genotypes when raised inside rain shelter.

The highest content of TSS (7.2° brix), reducing sugar (2.90 %), total sugar (3.88 %), vitamin C (32 mg $100g^{-1}$), total carotenoids (6.51 mg $100g^{-1}$) and lycopene (3.84 mg 100 g^{-1}) was observed in SLc.2 grown inside rain shelter. Thus SLc.2 can be considered as a promising variety of cherry tomato in terms of nutritional and biochemical parameters as well as yield attributes.

5.2 STANDARDISATION OF PACKAGING AND STORAGE REQUIREMENTS OF CHERRY TOMATO

Tomatoes are one of the major and most popular vegetables, efficient source of nutrients, and income to the farmers. Cherry tomato production has been broadening year after year due to increasing demand from fresh market and processing enterprises (Buntong *et al.*, 2012).

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Cherry tomatoes are easily spoiled and immediately deteriorate in quality after harvest as a result of over ripening and rotting (Fiddler, 1982). Inappropriate management after harvest complicate this situation. Insufficient information on proper post harvest handling techniques contributed to limited marketable period of cherry tomatoes. Shelf life is short, only about one to two weeks at ambient condition for cherry tomatoes (Frazier and Westholf, 1986). Efforts to increase production and to achieve maximum profit will be successful only when complemented with corresponding efforts, to put down the post harvest losses and boost shelf life of fruits.

Preserving cherry tomato quality in package and or storage is determined by many factors. The main factor limiting the shelf life is the rate of respiration, which in turn affects the degree of ripening and weight loss.

Convenient packaging could provide consequential benefits in terms of enhancing quality and shelf life of the products, fresh and processed. Modified Atmosphere Packaging (MAP) is commonly applied in packaging of fresh produce. It is done by keeping produce in polymeric films, which is a simple and economic method to improve post harvest life of short lived produce by reducing the rate of respiration (Kader *et al.*, 1978).

Moreover, storage temperature is a principal determinant of shelf life of fresh produce. Conventionally shelf life of tomato is prolonged by refrigerated storage (Risse *et al.,* 1984). Many fruits and vegetables can be preserved for several weeks or even months in refrigerated storage. The lower the temperature, the longer will be the product shelf life (Grierson and Kader 1986).

Fruits from two genotypes, one from small fruited type (Pusa Cherry Tomato -1) and another from big fruited type (IIHR -2871) were selected for the study. Fruits were harvested at mature green stage, sanitized with sodium hypochlorite (100 ppm) and packed in the following materials after removing surface moisture. The treatments were T_0 (control), T_1 (Packaging in micro ventilated polyethylene cover of 200 gauge), T_2 (Packaging in polystyrene tray with cling film), T_3 (Packaging in polypropylene punnet), and T_4 (Shrink wrapping in polystyrene tray with polyolefin film of 19μ thickness).The packaged materials were stored under three storage conditions *viz.* S_1 (Ambient), S_2 (Refrigeration - 5±2°C), and S_3 (Cold storage -12±3° C).

5.2.1 Physiological loss in weight (PLW)

Physiological loss in weight (PLW %) of cherry tomatoes increased in all the treatments during storage irrespective of packaging material and storage conditions. Weight loss was higher under ambient condition for all the treatments, followed by cold storage and refrigeration. PLW (%) of fruits kept without packaging (control) remained significantly higher during storage under the three different storage conditions in both the varieties. The lowest weight loss was observed in fruits kept in micro ventilated poly ethylene cover and shrink wrapped fruits.

In both the varieties (Pusa Cherry Tomato -1, two weeks after storage and IIHR- 2871, one week after storage) least PLW per cent was observed in micro ventilated PE cover followed by fruits shrink wrapped in polystyrene tray, overwrapped with polyolefin film. The highest PLW per cent was in control under ambient condition.

Low temperature storage is noted to be the much practical technique to prolong shelf life of fresh produce including cherry tomatoes (Thanh, 2006). MAP has been found to mark down the weight loss of tomatoes due to regulation of humid atmosphere which is inhibitory to water loss and low oxygen and high carbon dioxide atmosphere which is inhibitory to respiration (Batu and Thomson, 1998, Yaptenco *et al.*, 2004). The results of present study further confirm the inhibitory action of low temperature and MAP on loss of weight in cherry tomato.

5.2.2 Shelf life

In the case of variety Pusa Cherry Tomato -1, among the three storage conditions fruits stored in cold storage packaged in polypropylene punnet had the longest shelf life (71.66 days) followed by fruits shrink wrapped in polystyrene

Fig. 2. PLW (%) of Pusa Cherry Tomato-1 under ambient condition

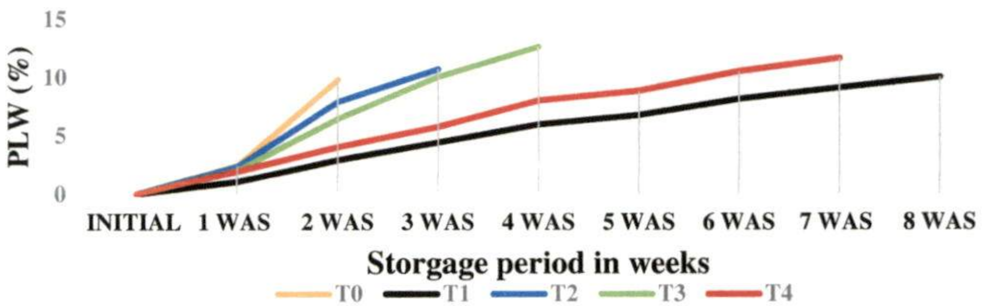


Fig. 3. PLW (%) of Pusa Cherry Tomato-1 under refrigeration

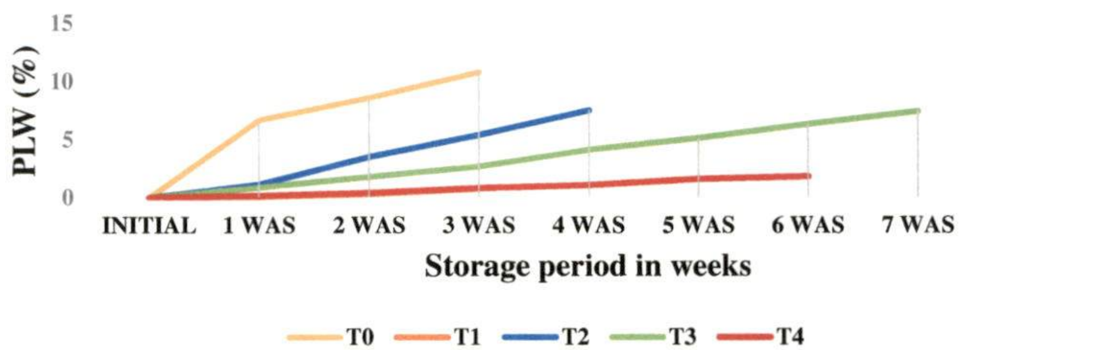
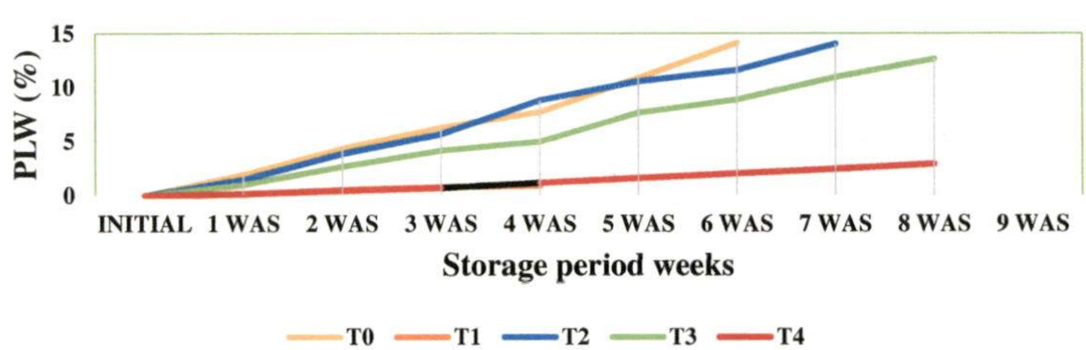


Fig. 4. PLW (%) of Pusa Cherry Tomato-1 under cold storage



Treatments

T_0-Control, T_1- Micro ventilated PE cover, T_2- PS tray wrapped with cling film,

T_3- PP punnets , T_4- Shrink wrapping in PS tray

Fig. 5. PLW (%) of IIHR -2871 under ambient condition

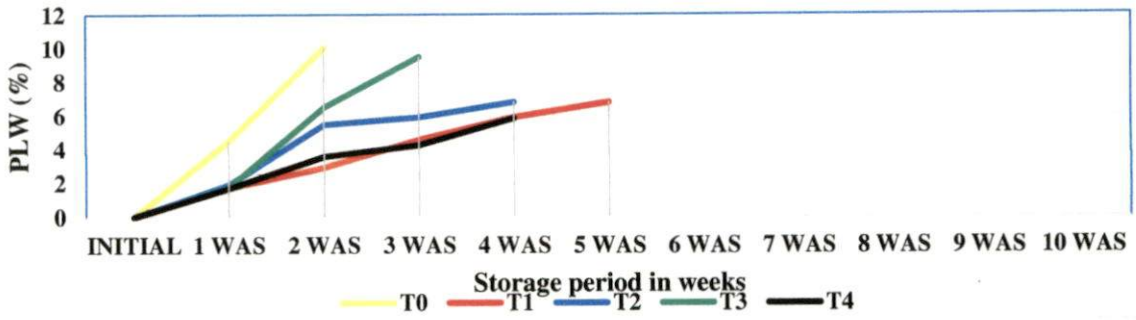


Fig. 6. PLW (%) of IIHR-2871 under refrigeration

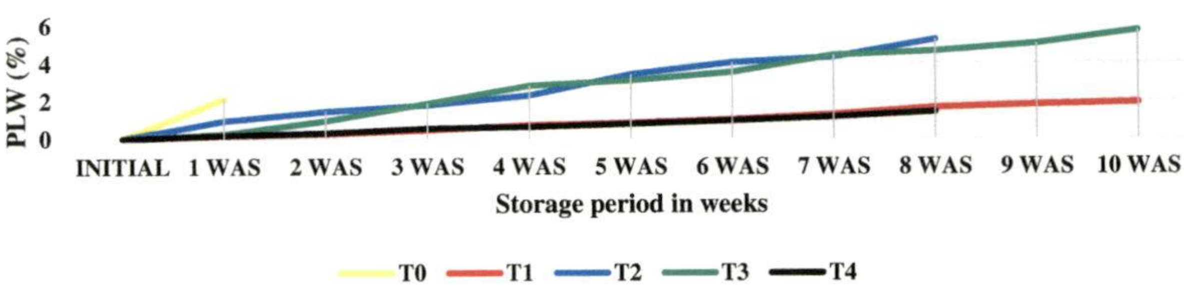
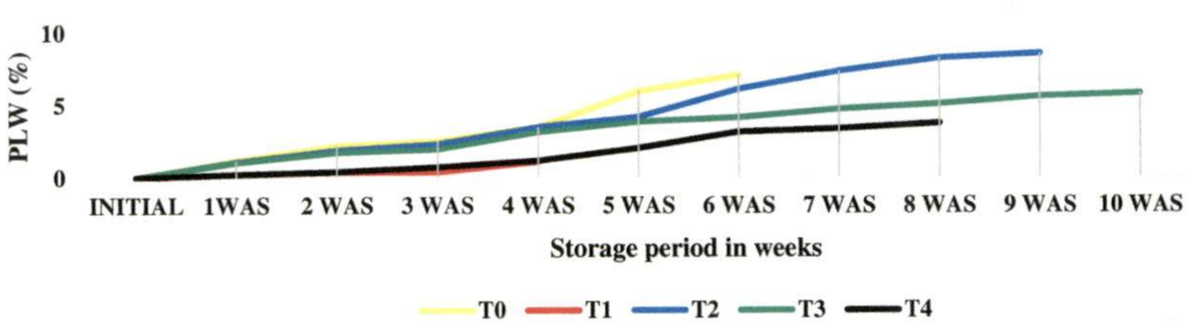


Fig. 7. PLW (%) of IIHR-2871 under cold storage



Treatments

T_0-Control, T_1- Micro ventilated PE cover, T_2- PS tray wrapped with cling film,

T_3- PP punnets , T_4- Shrink wrapping in PS tray

tray with polyolefin film of 19μ thickness. Unpacked fruits at ambient condition were found to have the shortest shelf life of 16 days. The variety IIHR-2871, was found to have an extended shelf life of 87 and 81.66 days for the fruits packed in polypropylene punnet under cold storage and refrigeration respectively. Unpacked fruits under refrigeration were found to have shortest shelf life of 5.66 days.

Risse *et.al.* (1984) reported that for maximum shelf life, a temperature range between 13 and 20° C was the most appropriate for tomatoes, at temperature above 20°C, fruits had a shorter shelf life and was subjected to decay. Storage study on tomato, conducted by Buntong *et al.* (2015), under two storage conditions (ambient and cold storage) revealed that fruits stored at ambient condition had the shortest shelf life due to rapid ripening. Storage of tomato fruits at 15°C was most effective for retarding the ripening process and reducing the weight loss.

The incidence of chilling injury was lesser in variety IIHR-2871, which may be attributed to the thicker skin (0.46 mm) in IIHR-2871 compared to Pusa Cherry Tomato -1 (0.36 mm). The ideal storage temperature of fruits must be greater than the temperature that stimulate chilling injury. Chilling injury happens when the tomatoes are brought to a temperature below 11-12°C (Hobson and Grierson, 1993).

Shrink wrapping extended the shelf life of fruits because of the beneficial effect like maintenance of firmness, reduction in deformation, alleviation of chilling injury, reduction of decay from secondary infection and delay in colour development and senescence (Rana *et al.*, 2015). Most polymer material used in fresh produce packaging have lower water vapour transmission rates relative to transpiration rates of fresh produce. The consequences are high relative humidity level and condensation of vapour inside the package (Rux *et al.*, 2016). Condensation of moisture was lesser in polypropylene punnets compared to shrink wrapping and micro ventilated PE cover. Higher humidity in the package would

Fig. 8. Shelf life of Pusa Cherry Tomato -1

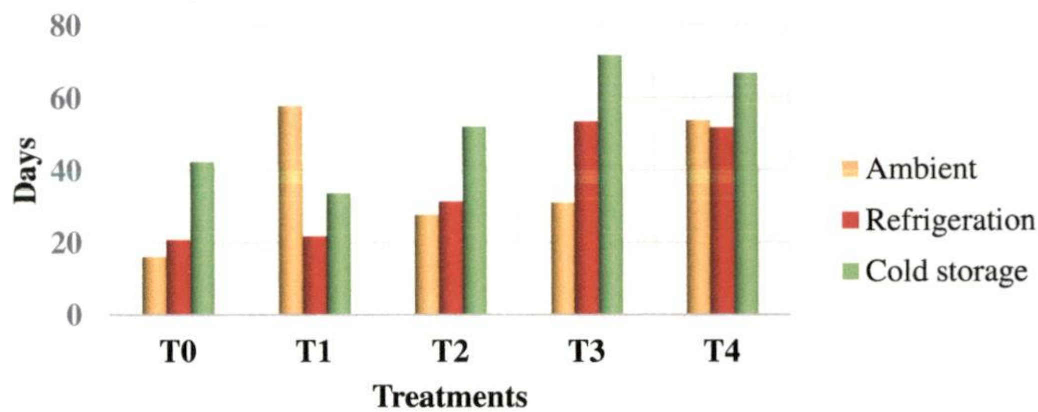
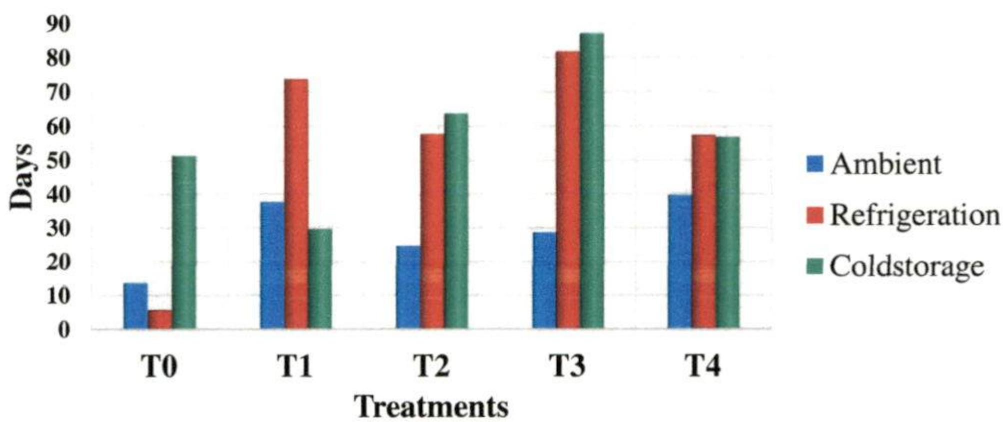


Fig. 9. Shelf life of IIHR-2871



Treatments

T_0-Control T_1- Micro ventilated PE cover T_2- PS tray wrapped with cling film

T_3- PP punnets T_4- Shrink wrapping in PS tray have accelerated microbial growth and hence lowered the shelf life of cherry tomatoes.

5.2.3 Biochemical analysis

5.2.3.1 TSS

Sweetness of fruits is mainly designated by TSS, even if the sugars are not the core soluble component. With respect to TSS the most significant changes were observed for the treatments stored under ambient and cold storage conditions. Minimum changes in TSS were found in refrigeration. There was a peak in TSS at different storage periods for the three storage condition because of the difference in the rate of ripening in these conditions. A trend of decrease in TSS value was recorded for all the treatments after the peak value.

In Pusa Cherry Tomato -1, after one week of storage the highest value of TSS (7.5° brix) was obtained for the unpacked fruits under ambient condition and the lowest TSS (4.4° brix) was recorded for T_0, T_1 and T_4 under refrigeration. The highest values for TSS was recorded in T_3 in all the storage conditions. The values recorded for T_3 were 7.8, 6 and 8° brix for ambient, refrigeration and cold storage respectively. The peak values for TSS was observed 3 WAS in ambient, 4 WAS in cold storage and 6 WAS under refrigeration.

In IIHR variety, one week after storage, the highest value for TSS (6.1° brix) was recorded for the unpacked fruits under ambient condition and the lowest TSS (4.5° brix) was for T_0 under refrigeration. A peak in TSS was registered 3 WAS in ambient storage, 7 WAS for refrigeration and 6 WAS under cold storage. The peak values for TSS was noted in T_3 in all the three conditions. Better retention of TSS was in T_3 and T_4 in cold storage.

The reduction of TSS in refrigeration and cold storage was much lower than fruits stored at ambient condition. The results are in agreement with the findings of Majidi *et al.* (2012) on the storage of tomato under Controlled Atmosphere Storage (CAS), Modified Atmosphere Storage (MAS) and cold

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Fig. 10. TSS of Pusa Cherry Tomato-1 after 1 week of storage

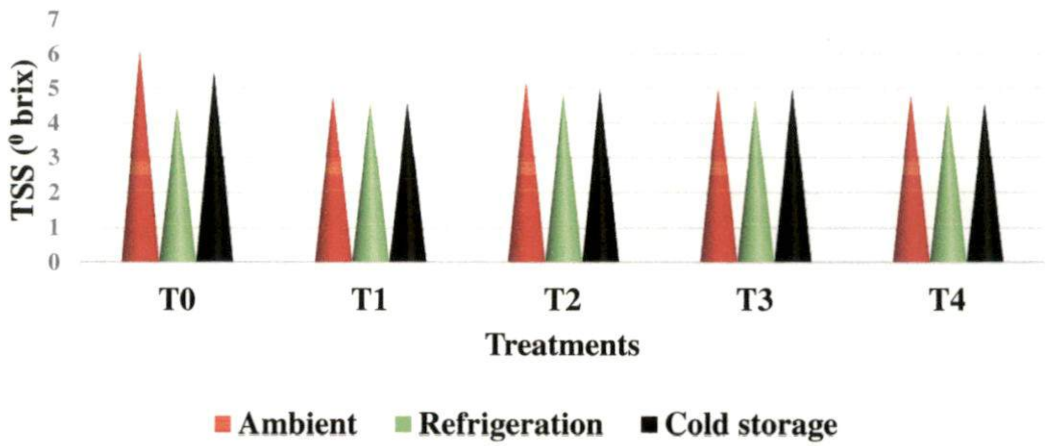
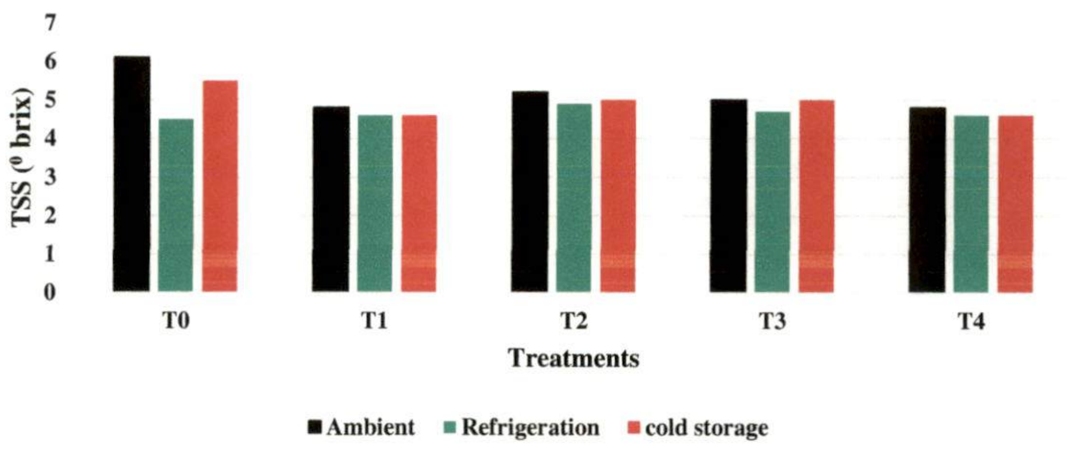


Fig. 11. TSS of IIHR-2871 after 1 week of storage



Treatments

T_0-Control T_1- Micro ventilated PE cover T_2- PS tray wrapped with cling film

T_3- PP punnets T_4- Shrink wrapping in PS tray storage. TSS was found to increase in all the treatments at the initial phase and later it declined.

The reason for this increase in TSS may be due to the degradation of starch during maturity and conversion into sugars. Slow increase in TSS content in packaged tomatoes as compared to fruits held in open may be due to the suppression of respiration and delayed ripening due to packaging which modify the internal atmosphere of the fruits (Saito and Rai, 2005). The results of the present study also indicate that the rate of ripening was retarded under cold storage and refrigeration. Lower the temperature greater is the retardation and hence the delayed ripening. The rate of respiration would be low under refrigeration compared to cold storage.

The increased TSS, could also be due to low moisture content of the fruit or the concentration of soluble solids due to moisture loss (Farooq *et al.*, 2012).

It was found that fruits packed in polypropylene punnet maintained higher TSS than other packaging materials in all the storage conditions. Polypropylene punnets, probably created more favourable atmospheric condition and effectively controlled ripening of cherry tomatoes. Subsequent studies should be conducted to examine atmosphere changes in packages during storage under low and ambient temperature conditions.

The decline in level of TSS is due to respiratory use of sugars. This decline is faster at ambient condition. Higher the temperature, greater will be the rate of metabolic processes. Better retention is observed under cold storage and refrigeration.

5.2.3.2 Titrable acidity

In both the varieties titrable acidity decreased as the ripening progressed during the storage. Amount of organic acid decreases during maturity as they are the substrates of respiration, thus resulting in a decline in titrable acidity. Rate of change in the titrable acidity were found to be lower in refrigeration and cold storage because the ripening process was delayed at these two conditions. Among

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the three storage conditions significant change in acidity was observed only under ambient condition.

In Pusa Cherry Tomato -1, after two weeks of storage under ambient condition, the minimum titrable acidity (0.54 %) was observed in unpacked fruits, whereas the fruits skrink wrapped in polystyrene tray overwrapped with polyolefin film of 19 μ thickness had maximum titrable acidity (0.72 %).

In IIHR-2871, the unpacked fruits and fruits packed in polystyrene tray with cling film had the least acidity (0.76 %) and maximum acidity (0.89 %) was for T_1 (fruits packed in micro ventilated PE cover) and T_4 (shrink wrapping in polystyrene tray with polyolefin of 19 μ thickness) under ambient condition.

There was a decline in titrable acidity with time under refrigeration and cold storage for both the varieties throughout the storage. The rate of decrease in acidity was not significantly different for refrigeration and cold storage.

The unpacked fruits and fruits packed in polystyrene tray overwrapped with cling film maintained lower acidity levels throughout the storage because of the early ripening in these treatments. The fruits packed in micro ventilated poly ethylene cover and shrink wrapping in polystyrene tray overwrapped with polyolefin maintained higher acidity levels during storage, indicating slow onset of ripening.

Decline in titrable acidity of cherry tomatoes during storage may be due to the consumption of organic acids during respiration and conversion of complex carbohydrates into simple sugars. Gafir *et al.* (2009) suggested that during respiration, organic acids are consumed and thus decline in organic acid content occurred during storage.

5.2.3.3 Vitamin C

Besides contributing to nutritive elements, colour and flavour to the diet, tomatoes are also relevant source of antioxidants or chemo-protective constituents, and thus designated as functional foods (Ranieri *et. al.*, 2004).

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Fig. 12. Changes in vitamin C in ambient storage of Pusa Cherry Tomato-1

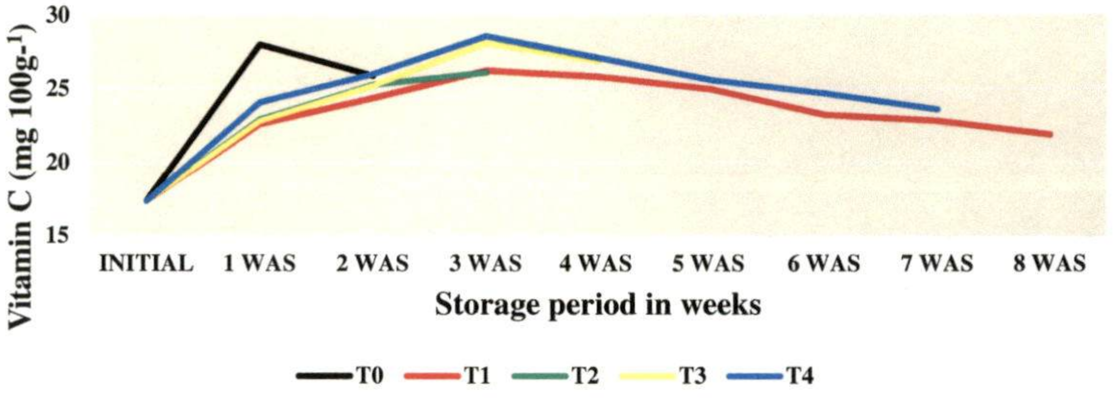


Fig. 13. Changes in vitamin C of Pusa Cherry Tomato-1 under refrigeration

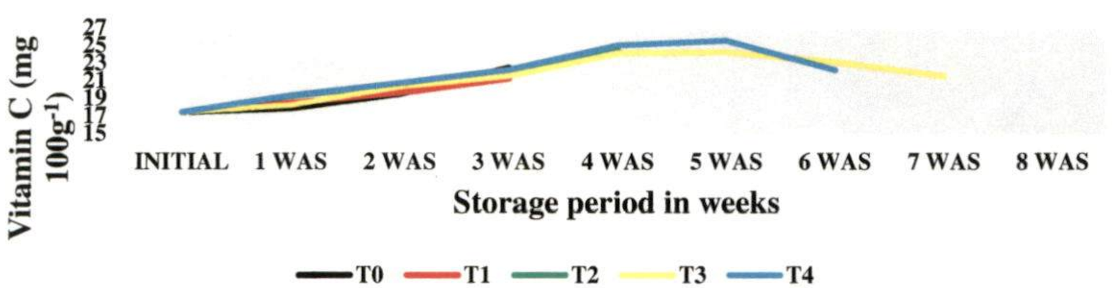
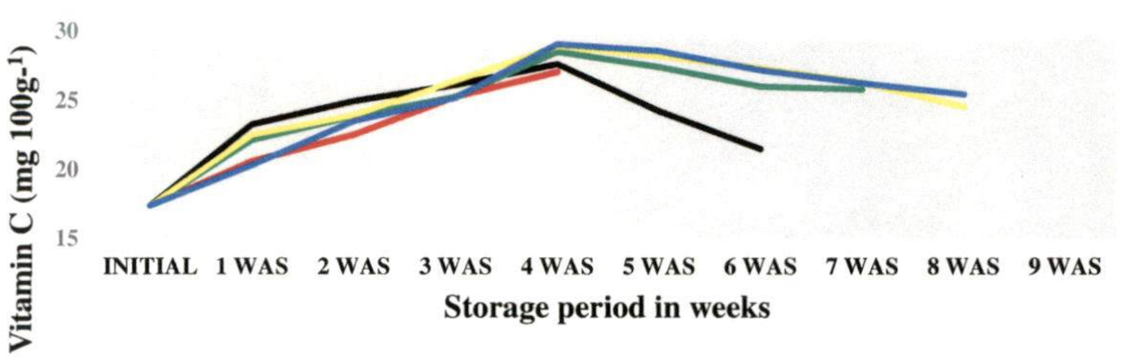


Fig. 14. Changes in vitamin C of Pusa Cherry Tomato-1 under cold storage



Treatments

T_0-Control T_1- Micro ventilated PE cover T_2- PS tray wrapped with cling film T_3- PP punnets T_4- Shrink wrapping in PS tray

Ascorbic acid is reasonably labile and its retention is often updated when assessing post harvest storage effects on nutritional quality in fruits and vegetables (Mathooko, 2003).

In both the varieties, an initial increase in ascorbic acid content, followed by a decline after reaching a maximum was observed with advancement of storage. Minimum change in vitamin C was found in refrigerated fruits. The rate of ripening in the unpacked fruits and fruits in polystyrene tray overwrapped with cling film was much faster compared to the other treatments under ambient and cold storage conditions. Better retention of vitamin C in cold storage was observed for fruits packed in polypropylene punnet and shrink wrapped fruits, in cold storage. Shrink wrapping of fruits in polystyrene tray overwrapped with polyolefin film of 19 μ thickness was found to be ideal for the retention of ascorbic acid.

For Pusa Cherry Tomato -1, the highest values for vitamin C content was recorded in T_4 in all the storage conditions. The peak values for vitamin C content was observed in T_4 were observed 3WAS in ambient (28.57 mg $100g^{-1}$), 4 WAS in cold storage (29.08 mg $100g^{-1}$) and 5WAS under refrigeration (25.56 mg $100g^{-1}$).

In IIHR-2871, the highest values for vitamin C content were observed in T_4 in cold storage (30.39 mg $100g^{-1}$, 5WAS) and ambient condition (28.56 mg $100g^{-1}$, 3WAS). In the case of fruits stored under refrigeration T_3 recorded the highest vitamin C (24.72 mg $100g^{-1}$, 6 WAS). Thereafter, irrespective of packaging materials and storage condition, a slight decrease was observed in vitamin C content. Better retention of vitamin C was in T_4 and T_3 in cold storage

Increase in ascorbic acid content of fruits and vegetables with maturity and phase of ripening and decline thereafter was also reported by other researchers (Adis, 1986., Watada, 1987. and Christakoa *et.al.*, 2005).

Degree of ascorbic acid enhancement was more in unwrapped fruits as compared to the packaged cherry tomatoes. Packaging act as suppressor to the

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synthesis of ascorbic acid but not destroy the fruit's potential to synthesize the vitamin C by interrupting the activity of L-galactano-F-lactone dehydrogenase which is needed for the synthesis of ascorbic acid (Wills, 1981).

Ripening was delayed in low temperature storage of fruits, responsible for low ascorbic acid for the treatments kept under refrigeration and cold storage at the initial phase but better retention of the same was noticed in these two conditions.

The loss of vitamin C during storage of vegetables is caused by oxidation that occurs due to the presence of catalysts and oxidizing enzymes (Lee and Kader, 2000).

5.2.3.4 Lycopene

Lycopene constitute the main red pigment of cherry tomatoes. Its concentration was found to increase steadily through the ripening process during storage with corresponding increase in red colour. A slight decline in lycopene was observed towards the end of the storage.

Among the storage conditions refrigeration and cold storage showed lesser and slower accumulation of lycopene at the initial phase. Thereafter under cold storage, uniform and high lycopene accumulation was observed in the fruits. For Pusa Cherry Tomato -1, after one week of storage the highest value of lycopene content (3.36 mg $100g^{-1}$) was obtained for the unpacked fruits under ambient condition and the lowest lycopene content (0.32 mg $100g^{-1}$) was recorded for T_0 under refrigeration. In IIHR-2871, one week after storage the highest value for lycopene content (3.41 mg $100g^{-1}$) was recorded for the unpacked fruits under ambient condition and the lowest lycopene content (0.42 mg$100g^{-1}$) was for T_1 under refrigeration.

On comparing the packaging materials, cherry tomatoes stored without packaging exhibited greater increase in lycopene content than other treatments except under refrigeration. Fruits packed in polystyrene tray with cling film

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Fig. 15. Changes in lycopene content of Pusa Cherry Tomato-1 under ambient condition

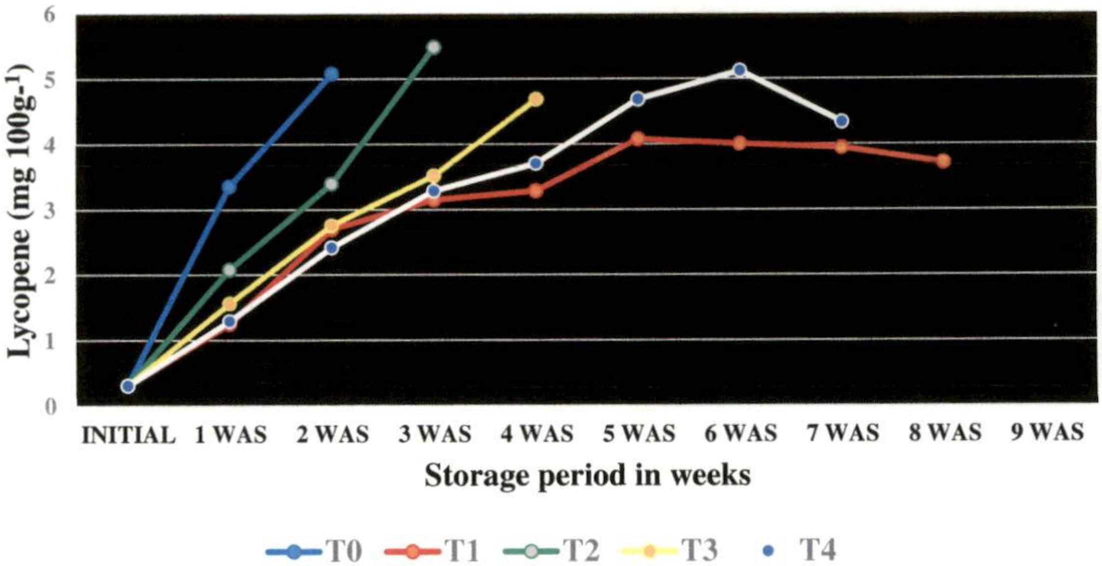


Fig. 16. Changes in lycopene content of Pusa Cherry Tomato-1 under refrigeration

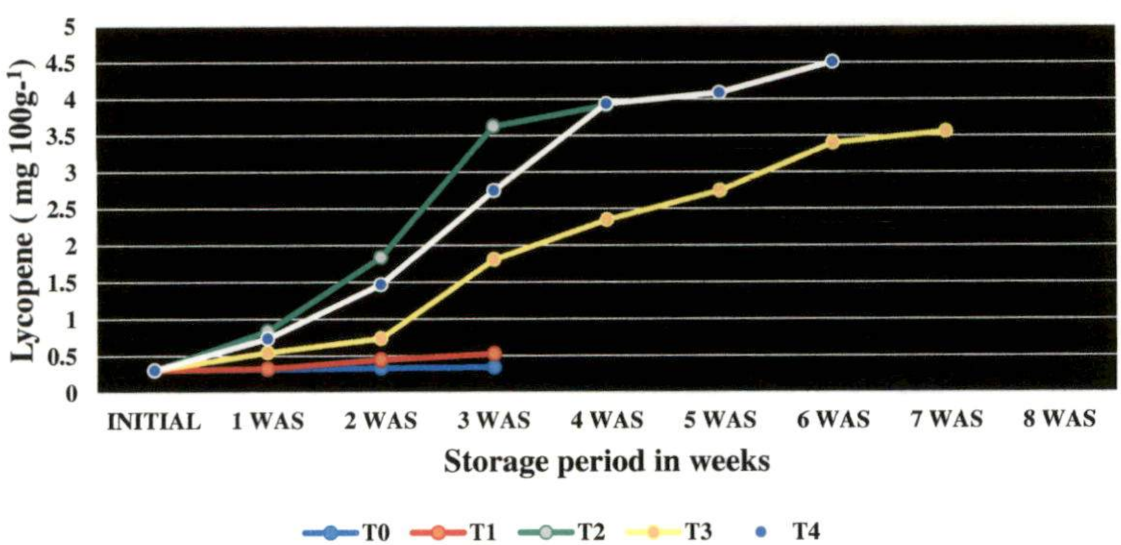
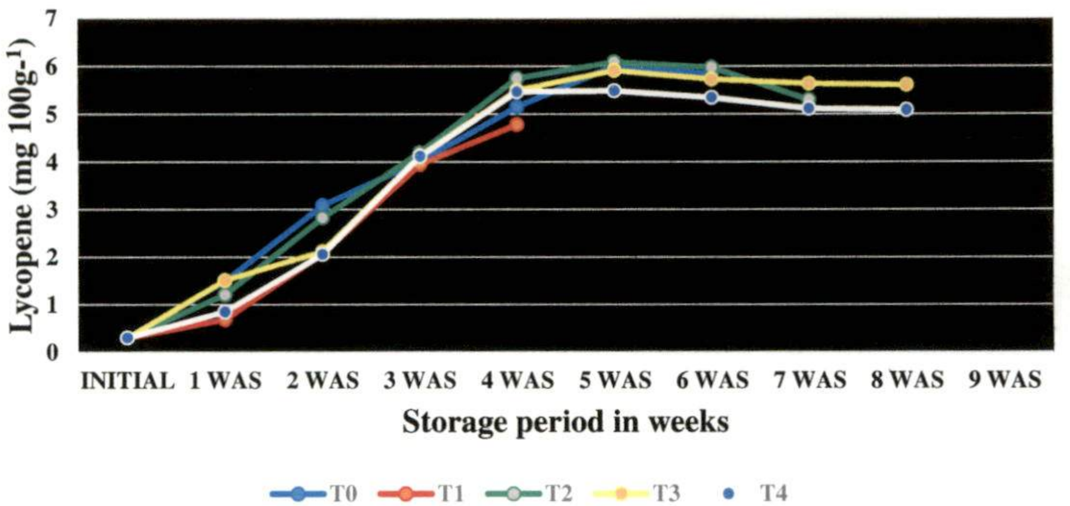


Fig. 17. Changes in lycopene content of Pusa Cherry Tomato-1 under cold storage



Treatments

T_0-Control

T_1- Micro ventilated PE cover

T_2- PS tray wrapped with cling film

T_3- PP punnets

T_4- Shrink wrapping in PS tray

maintained a higher level of lycopene under all the three storage conditions for both the varieties.

Modified atmosphere packaging reduced the rate of ripening and the colour development in both the varities. The packaging condition leads to the enhancement of lycopene content at the later phase, due to the modification of internal atmosphere of fruits. An immediate decline in green colour pigment at the ripening was observed for both cherry tomato varieties. This decline was more for unwrapped fruits and fruits stored under ambient condition. Similar results were reported by Kaur and Batia (2016).

The ripening of tomato is associated with the colour change in fruits, reflecting the transformation of chloroplast into chromoplast (Pretel *et al.,* 1995).

5.2.3.5 Total, reducing and non reducing sugars

In both the varieties, one week after storage higher reducing, non reducing and total sugars were recorded in unwrapped fruits under ambient condition. The lowest reducing and total sugars were recorded for T_4 (shrink wrapping in polystyrene overwrapped with polyolefin film) under refrigeration.

The increase in sugar content may be due to the conversion of starch into sugars, such as glucose and fructose as the ripening progresses. Increase in sugar content was higher in unwrapped fruits under ambient condition for both the varieties as compared to the packaged cherry tomatoes, due to the reduced respiration metabolism under packaging. Minimum changes in sugar content was observed for fruits stored under refrigeration and cold storage.

Studies conducted by many researchers have revealed that, during the storage of mature green tomatoes, there will be an increase in sugar content at the initial phase of storage followed by a decline thereafter. The decline in sugar content during the later storage period is because of the increased respiration and metabolisms which utilizes much of the available sugars (Adis, 1986).

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Fig. 18. Reducing sugar content of Pusa Cherry Tomato-1 (1 WAS)

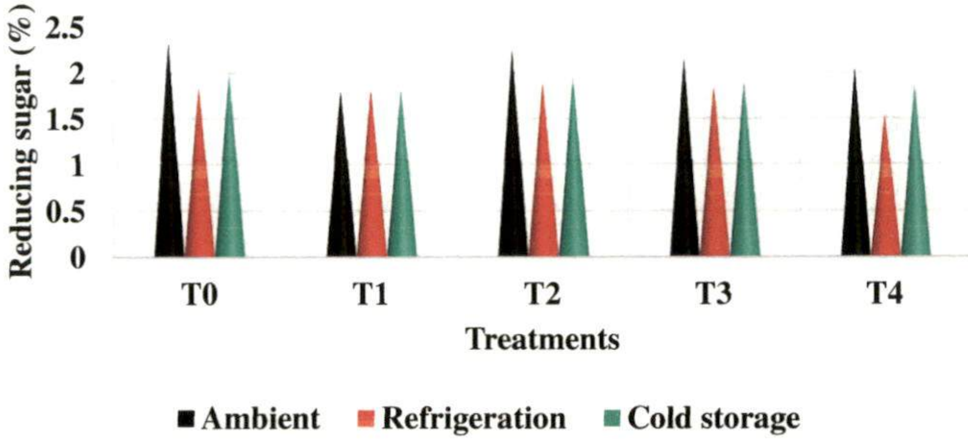
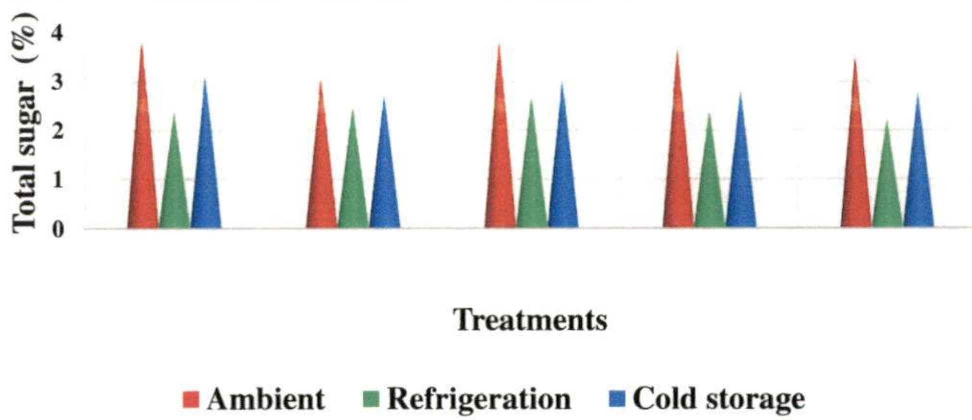


Fig. 19. Total sugar content of Pusa Cherry Tomato-1 (1 WAS)



Treatments

T_0-Control

T_1- Micro ventilated PE cover

T_2- PS tray wrapped with cling film

T_3- PP punnets

T_4- Shrink wrapping in PS tray

The loss in sugar during storage is probably due to its transformation to cell wall material, lignin and other structural substances (Kaur and Batia, 2016).

5.2.4 Microbial load

The results of microbial analysis revealed that the major spoilage of cherry tomato was caused by bacteria in all the three storage condition. Colonization of microorganisms, was much slower for fruits stored under refrigeration and cold storage compared to fruits stored under ambient condition. Unwrapped fruits showed a higher degree of microbial population in both varieties under ambient condition. For Pusa Cherry Tomato -1, it was 61 x10^{-4} cfu $g^{-1}$for bacteria and 14 x 10^{-2} cfu g^{-1} for fungi. In case of IIHR-2871, a population of 55 x10^{-4} and 9 x 10^{-2} cfu g^{-1} was observed for bacteria and fungi respectively.

Under refrigeration and cold storage, the high amount of condensed water accelerated microbial spoilage in MAP including T_2 and T_1 for Pusa Cherry Tomato -1. In IIHR -2871 microbial load was high for T_4 under refrigeration and T_1 under cold storage. Less microbial population was recorded for T_3, under prolonged storage under the three conditions.

In order to grow and multiply in number, all microorganisms need sufficient moisture. In general, bacteria require more water compared to yeast and fungi. Major constituent of cherry tomato is water (around 80%). This might have led to the high population of bacteria in cherry tomato samples. Condensation of moisture inside the packages favours this condition (Srilakshmi, 2012).

Cold temperatures inhibit growth of microorganisms and freezing may result in destruction of cells of microorganism. This may be the reason for the slow multiplication of microorganisms in fruits under cold storage and refrigeration.

5.2.5 Organoleptic evaluation

The mean rank for all attributes exhibited an increasing trend at the initial phase of storage and declining trend towards the end of the storage, but still the fruits were acceptable for consumption under ambient and cold storage. The ripening rate for unwrapped fruits were much faster than that of packaged fruits. This might have led to the high organoleptic scores at the initial phase of storage.

Under refrigerated condition, ripening was arrested due to the very low temperature. Chilling injury also affected the sensory qualities of the fruits, resulting in the low organoleptic scores for the fruits stored under refrigeration. In case of Pusa Cherry Tomato -1, because of high incidence of chilling injury, the fruit quality was not at an acceptable range.

Modified Atmosphere Packaging, helps for the better retention of organoleptic qualities due to the slower rate of biochemical reactions as compared to the control. Among the packaging materials polypropylene punnets, shrink wrapping in polystyrene tray, and polystyrene tray were wrapped with cling film was found to retain the sensory attributes for a longer period, in all the three storage conditions.

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SUMMARY

6. SUMMARY

The project entitled 'Post harvest evaluation and management of cherry tomato [*Solanum lycopersicum* L. var. *cerasiforme* (Dunal) A. Gray] genotypes' was carried out in Department of Processing Technology, College of Horticulture, Vellanikkara.

The objectives of the study were evaluation of quality attributes of cherry tomato genotypes grown under open field and rain shelter and standardization of packaging and storage requirements of cherry tomato.

Eleven genotypes of cherry tomato raised inside rain shelter and open field were evaluated for the quality attributes.

The growing condition significantly affected the physico-morphological characters. Performance of most of the genotypes were superior inside the rain shelter as compared to open field condition. SLc.11 recorded the highest fruit length (2.89 cm), fruit diameter (3.16 cm), fruit girth (3.11 cm), rind thickness (0.46 mm) juice per cent (57.09 %) and fruit weight (20.67 g) under rain shelter.

The effect of growing conditions on nutritional and biochemical parameters was also found to be significant for most of the attributes. TSS, sugars and vitamin C content was higher for most of the genotypes under open field condition. Total carotenoids and lycopene content was higher for most of the genotypes when raised inside rain shelter.

The highest content of TSS (7.2° brix), reducing sugar (2.90 %), total sugar (3.88 %), vitamin C (32 mg $100g^{-1}$), total carotenoids (6.51 mg $100g^{-1}$) and lycopene (3.84 mg 100 g^{-1}) was observed in SLc.2 grown inside rain shelter. Thus SLc.2 can be considered as a promising variety of cherry tomato in terms of nutritional and biochemical parameters as well as yield attributes.

Packaging and storage studies were conducted in 2 genotypes, SLc.10 (small fruited type) and SLc.11 (large fruited type) by subjecting fruits to five methods of packaging *viz.*, packing in micro ventilated polythene cover (T_1), polystyrene tray covered with cling film (T_2), polypropylene punnets (T_3) and shrink wrapping in polystyrene tray (T_4). Each package was stored in ambient (28 - 36°C), refrigeration (5 ± 2°C) and cold storage (12 ± 3°C) conditions.

The shelf life of cherry tomato was extended to 87 days for IIHR- 2871 and 71 days for Pusa Cherry Tomato -1 under cold storage. Fruits packed in polypropylene punnets had longer shelf life for both varieties under refrigeration and cold storage conditions. In ambient storage condition, fruits packed in micro ventilated PE cover recorded longer shelf life for Pusa Cherry Tomato – 1 (57 days) and shrink wrapped fruits recorded longer shelf life for IIHR- 2871 (39 days) respectively.

The physiological loss in weight (PLW %) of cherry tomatoes increased in all the treatments during the storage under ambient, refrigeration and cold storage conditions for both the varieties. The highest weight loss was recorded for fruits stored under ambient storage condition followed by cold storage and refrigeration. PLW (%) of fruits kept without packaging (control) remained significantly higher and shelf life lower under the three different storage conditions, in both the varieties. The lowest weight loss was recorded for fruits packed in micro ventilated polyethylene cover (T_1) and shrink wrapped fruits (T_4) in all the three storage conditions for both the varieties.

Shriveling and chilling injury were the major problems faced during the storage of cherry tomato under ambient and refrigeration respectively. Moisture condensation was a common problem encountered under cold storage and refrigeration. Severe moisture condensation was observed for the treatments T_1 and T_4.

The highest content of TSS, vitamin C and lycopene was observed at different storage period under the three different storage conditions, because of the difference in rate of ripening in these conditions. A trend of decrease in TSS, vitamin C and lycopene content was recorded for majority of treatments after a peak value. Minimum changes of TSS, vitamin C and lycopene content was observed for fruits stored under refrigeration. TSS, vitamin C and lycopene content was comparatively higher for T_3, T_4 and T_2 respectively under the three storage conditions.

In both the varieties, titable acidity decreased as the ripening progressed during the storage. Significant changes in titrable acidity was found in ambient storage of fruits.

Total, reducing and non reducing sugars increased after one week of storage in all the treatments in both the varieties. Higher sugar content was observed for the fruits stored under ambient condition at one week after storage. Control under ambient condition recorded highest sugar content for both the varieties.

Microbial load of cherry tomato was analyzed by estimating the population of bacteria, yeast and fungi. Microbial load was found to increase with the advancement of storage period. Less microbial contamination was recorded for the treatments kept under refrigeration. Bacterial count was higher for both the varieties during storage compared to yeast and fungi. The population of yeast was not significant during the storage of cherry tomato. Yeast colonies were observed towards the end of the storage and not observed for fruits stored under refrigeration. Throughout the storage, no fungal population was noticed for fruits stored under refrigeration for both the varieties.

Organoleptic evaluation for both varieties revealed that the mean scores for all the attributes showed an increasing trend at the initial phase of storage and declined towards the end of the storage, but still the fruits were acceptable for consumption under ambient and cold storage.

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APPENDIX

APPENDIX I

Meteorological observations

Open field									
Standard week	Morning (9 am)				Afternoon (2 pm)				
	Temp. Max (^{0}C)	Temp. Min (^{0}C)	Temp. Min (^{0}C)	Light intensity (Lux)	Temp. Max (^{0}C)	Temp. Min (^{0}C)	Temp. Min (^{0}C)	Light intensity (Lux)	Rain fall (mm)
1	33.60	32 .61	73	2657.5	35.20	30.50	37	3245.70	000.0
2	31.51	28.72	75	2485.0	34.50	31.50	37	3354.78	000.0
3	32.50	30.54	64	2478.6	36.70	33.48	34	1245.70	000.0
4	30.10	28.50	63	1478.94	35.40	30.32	40	2479.20	000.0
5	31.60	31.51	67	2014.52	32.50	31.50	35	1247.21	000.0
6	32.70	30.50	68	1247.20	31.50	30.48	25	3012.4	000.0
8	31.40	29.80	59	1475.52	35.20	32.50	26	3201.15	000.0
9	33.20	31.50	89	2301.45	34.50	31.15	38	2014.78	000.0
10	32.40	32.60	64	2134.10	34.10	34.78	36	3241.60	000.0
11	31.78	31.05	88	2027.23	32.47	30.56	55	1045.56	002.7
12	30.45	30.25	90	1247.53	33.75	31.48	51	2145.20	010.2
13	32.46	30.85	91	2361.40	34.68	33.68	50	1357.56	000.3
40	32.76	31.78	85	2014.45	35.75	34.26	46	2156.20	000.0
41	31.50	30.50	93	798.26	33.50	32.10	63	1467.47	000.0
42	32.15	29.50	91	656.66	32.60	30.20	68	1598.67	014.5
43	31.14	28.30	94	1008.38	33.50	32.40	70	1299.6	000.6
44	32.50	31.20	94	780.52	34.50	32.10	69	1270.52	003.5
45	32.00	31.50	91	1098.54	35.20	32.10	70	2051.74	018.7
46	32.15	31.50	88	981.45	33.45	32.50	53	1548.25	002.9
47	30.50	29.50	82	812.10	32.50	31.50	53	3214.74	010.9
48	29.80	28.70	74	2254.85	30.28	29.80	48	927.70	000.0
49	33.50	32.40	83	3652.74	31.50	29.50	55	1287.0	000.8
50	32.50	31.40	83	1451.57	32.50	28.50	52	2874.2	046.3
51	32.50	31.62	91	3247.45	31.60	29.60	61	1522.09	005.8
52	30.80	28.51	85	2687.54	32.45	31.50	46	1356	000.0

Appendix-I Contd...

Inside rain shelter								
Standard week	Morning (9 am)				Afternoon (2 pm)			
	Temp. Max (^{0}C)	Temp. Min (^{0}C)	Temp. Min (^{0}C)	Light intensity (Lux)	Temp. Max (^{0}C)	Temp. Min (^{0}C)	Temp. Min (^{0}C)	Light intensity (Lux)
1	32.12	28.75	75.42	498.83	38.12	31.24	48.87	854.72
2	34.50	27.84	78.57	568.75	36.14	31.65	53.71	754.20
3	35.50	28.50	81.71	458.32	35.22	33.47	46.57	561.75
4	33.25	27.60	69.92	354.72	34.45	32.87	48.42	632.10
5	34.50	28. 50	70.12	564.78	36.50	33.50	30.40	963.12
6	34.40	32.80	58.20	652.78	34.78	30.50	28.45	1333.20
8	33.47	30.98	70.56	562.42	33.15	30.48	31.20	789.45
9	33.50	31.20	60.40	785.40	33.56	32.56	33.20	964.50
10	31.60	29.50	63.40	586.12	34.65	31.58	30.45	874.45
11	32.56	30.60	70.20	612.45	37.45	32.78	40.50	647.20
12	31.40	28.50	73.45	600.45	36.40	33.50	42.50	756.40
13	34.62	29.78	66.40	789.45	35.40	32.50	43.50	865.40
40	32.68	28.68	74.71	670.40	33.60	30.24	52.44	706.58
41	32.38	29.68	73.28	734.00	34.45	32.45	49.51	458.72
42	33.98	30.91	77.42	575.40	35.78	30.68	49.52	581.23
43	34.66	32.81	77.71	625.40	36.56	30.67	50.12	546.70
44	33.53	30.41	74.21	666.50	35.54	30.68	48.72	542.13
45	33.63	31.92	71.14	586.80	36.42	29.05	47.57	623.15
46	34.83	30. 35	73.14	456.72	34.16	30.28	52.14	430.60
47	35.41	30. 52	68.28	445.70	34.56	32.25	48.42	478.91
48	34.25	32. 47	66.85	563.40	34.42	29.42	48.14	786.21
49	36.61	32. 86	76.57	603.30	31.45	27.95	51.57	654.28
50	34.32	29. 87	75.14	728.86	32.52	29.96	54.28	541.38
51	32.75	29. 80	70.85	765.80	33.75	30.52	46.57	521.47
52	33.25	30.52	81.28	689.80	36.74	32.56	61.28	687.42

APPENDIX II

Media composition

1. NUTRIENT AGAR MEDIA (FOR BACTERIA)

Beef extract	: 3 g
Peptone	: 5 g
Sodium chloride	: 5 g
Agar	: 18 g
Distilled water	: 1000 ml
pH	: 6.8-7.2

2. ROSE BENGAL AGAR MEDIA (FOR FUNGUS)

Papaic digest of soyabean meal	: 5 g
Dextrose	: 10 g
Monopotassium phosphate	: 1 g
Magnesium sulphate	: 0.50 g
Rose Bengal	: 0.05 g
Agar	: 15 g
pH	: 5.6

3. SABAURAUD DEXTROSE AGAR (FOR YEAST)

Mycological peptone	: 10 g
Dextrose	: 40 g
Agar	: 15 g
Distilled water	: 1000 ml
pH	: 5.6

APPENDIX III

Score card for organoleptic evaluation

Characteristics Treatments	Score				
	T_0	T_1	T_2	T_3	T_4
Appearance					
Colour					
Flavour					
Texture					
Taste					
Overall acceptability					

9 point Hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

POST HARVEST EVALUATION AND MANAGEMENT OF CHERRY TOMATO [*Solanum lycopersicum* L. var. *cerasiforme* (Dunal) A. Gray] GENOTYPES

By

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ABSTRACT OF THE THESIS

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ABSTRACT

The present study entitled 'Post harvest evaluation and management of cherry tomato [*Solanum lycopersicum* L. var. *cerasiforme* (Dunal) A. Gray] genotypes' was undertaken with the objectives of evaluating quality attributes of cherry tomato under rain shelter and open field conditions, and to standardise the packaging and storage requirements.

Eleven genotypes of cherry tomato raised inside rain shelter and in open field were evaluated for the quality attributes.

The physico-morphological characters showed significant variation among the cherry tomato accessions inside rain shelter. The desirable attributes like high fruit length, diameter, fruit girth, rind thickness, fruit weight, and juice per cent were observed for SLc.11, under both growing conditions. Performance of most of the genotypes was superior inside the rain shelter as compared to open field condition.

The highest content of TSS, reducing and total sugar, vitamin C, total carotenoids and lycopene was observed in SLc.2 grown inside rain shelter. TSS, sugars and vitamin C content was higher for most of the genotypes under open field condition. Total carotenoids and lycopene content was higher for most of the genotypes when raised inside rain shelter.

Packaging and storage studies were conducted in fruits of two genotypes, SLc.10 (small fruited type) and SLc.11 (large fruited type) by subjecting to four methods of packaging *viz.* packing in micro ventilated polyethylene cover (200 gauge), polystyrene tray covered with cling film, polypropylene punnets and shrink wrapping in polystyrene tray. Each package was stored in ambient (28 - 36°C), refrigerated (5 ± 2°C) and cold storage (12 ± 3°C) conditions.

The shelf life of cherry tomato was longer under cold storage than ambient and refrigerated condition. The shelf life of cherry tomato was extended to 87 days for IIHR- 2871 and 71 days for Pusa Cherry Tomato -1 under cold storage. Fruits packed in polypropylene punnets had longer shelf life for both varieties under refrigeration and cold storage conditions. The physiological loss in weight (PLW %) was significantly higher and shelf life was lower in unwrapped fruits under the three different storage conditions.

The highest content of TSS, vitamin C, and lycopene was observed at different storage periods under three different storage conditions, because of the difference in the rate of ripening in these conditions. A trend of decrease in TSS, Vitamin C and lycopene content was recorded for majority of the treatments after reaching a peak value. TSS, Vitamin C and lycopene content was comparatively higher for fruits packed in polypropylene punnets, shrink wrapped fruits in polystyrene tray and fruits in polystyrene tray overwrapped with cling film respectively under the three storage conditions.

In both the varieties, titrable acidity decreased as the ripening progressed during the storage. Significant changes in the titrable acidity was found in ambient storage of fruits. Total, reducing and non reducing sugars increased after one week of storage in all the treatments in both the varieties.

Microbial load of cherry tomato was analyzed by estimating the population of bacteria, yeast, and fungi. Microbial load was found to increase with the advancement of storage period. Less microbial contamination was observed for samples kept under refrigeration.

Organoleptic evaluation of both varieties revealed that the mean scores for all the attributes showed an increasing trend in the initial phase of storage and declined towards the end of the storage, but still the fruits were acceptable for consumption under ambient and cold storage.