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EFFECT OF DIFFERENT LEVEL OF POST-HARVEST TREATMENTS ON PHYSICO-CHEMICAL CHARACTERISTICS AND SHELF LIFE OF TOMATO FRUITS UNDER AMBIENT STORAGE CONDITION

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ABSTRACT
The present investigation aimed to evaluating the effect of different level post-harvest treatments on physico-chemical characteristics and shelf life of tomato fruits during storage. Changes in weight loss, fruit firmness, skin resistance, total soluble solid, pH, titratable acidity, lycopene as well as percentage of spoilage periodically recorded. The results indicated that the combined effect of pre-cooling and edible coating have better potential to reduce the spoilage and maintain the quality of fruits at greater extent. During storage decrease in fruit firmness, skin resistance, acidity and increase in weight loss, total soluble solid, pH, percentage of spoilage as well as lycopene content was observed. A fruit treated with combination of hydro-cooling at 4oC and edible coated with 2.5% corn starch, 2% glycerol, 2% oleic acid is an effective strategy for maintaining quality characteristics and as well prolonging of post-harvest life in tomatoes.

KEYWORDS: Shelf life, Spoilage, Edible coating, Tomato, Hydro-cooling.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is one of the highly perishable and widely consumed fresh vegetables in the world. Major losses in tomato quality and quantity occur between harvest and consumption. Qualitative losses include loss in edibility, nutritional quality, caloric value and consumer acceptability of the products. Therefore, the application of new technologies to extend the postharvest life of this commodity is needed (Brooks *et al.,* 2008). Several pre-harvest, harvest or post harvesting interacting factors greatly affect the quality of fresh tomato. These factors include crop variety, climate, cultural practices, harvesting techniques, handling, and storage conditions (Majidi *et al*., 2011). It is essential to use mature fruit with an acceptable eating quality processing. Over-mature fruit will deteriorate rapidly (Mallik and Bhattacharya, 1996).

A number of physico-chemical reactions take place in vegetables during storage. Quality of fruits and vegetables mainly affected by water loss during storage, which depends on the temperature and relative humidity conditions (Perez *et al.,* 2003). Storage under low temperature has been considered the most efficient method to maintain and preserve the quality of most fruits and vegetables due to its effects on reducing respiration rate, ethylene production, ripening, senescence and rot development (Hardenburg *et al.,* 1986).

Pre-cooling is the process or method of removing field heat from freshly harvested fruits that reduces metabolic activity, respiration rate, ethylene production, diminishes water loss and decay of the fruits were reduced considerably. Thus, helps preserving quality and prolonging shelf life of the fruits (Ferreira *et al.,* 1994). Edible films or coatings are defined as a thin layer of material which can be consumed and provides a barrier to moisture, oxygen and solute movement for the food (Guilbert, 1986). The fundamental purpose of edible films or coatings is to inhibit migration of moisture, oxygen, carbon dioxide, or any other solute materials, serve as a carrier for food additives like antioxidants or antimicrobials and reduce the decay without affecting quality of the food (Arvanitoyannis and Gorris, 1999).

Tomatoes being a climacteric fruit, there is prerequisite to reduce spoilage and wastage though processing and preservation into other forms thereby tackling the problem of glut during production and scantiness during off season. Post-harvest treatments like pre-cooling, edible coating, low temperature storage, irradiation, MAP packaging and other technologies has greater potential to reduce the post-harvest loses. Therefore, the present experiment was undertaken to study the effect of different level of post-harvest treatments on physico-chemical characteristics and shelf life of tomato fruits during storage.

MATERIALS AND METHODS

Procurement of Plant Materials and Edible Coating Materials

For present study *cv.* Narendra-2, one of the very important commercial varieties of tomato was selected. Fully matured breaker stage tomatoes were freshly harvested from the local fields. Fruits were selected on the basis of size, color, and absence of external injuries. The tomatoes were further washed with fresh water to remove dirt and soil.

Food grade edible coating material like corn starch, glycerol and oleic acid were purchased from local market, further study was conducted at the College of Food

Processing Technology and Bio-Energy, Anand Agricultural University, Anand. Gujarat.

Treatments and Experimental Design

Tomato fruits of uniform size, shape were selected and they have been sorted out to eliminate bruised, damaged and punctured ones. Sorted fruits were washed with clean water to remove the dust from the surface of the fruits, they were surface sterilized with sodium hypochlorite (500ppm) for 10 minutes so as to reduce the microbial infection and air-dried. The post-harvest treatments were conducted as per completely randomized design with sixteen treatments with three replicates:

TABLE 1. Treatment Combinations

SL. No.	Treatment code	Description
1	T_0C_0	Without pre-cooling + without coating (Control)
2	T_0C_1	Without pre-cooling + (Corn starch 2.5% (W/V) + Glycerol 2% (V/V)+ Oleic acid 2% (V/V) + Distilled water for balance)
3	T_0C_2	Without pre-cooling + (Corn starch 5% (W/V) + Glycerol 2% (V/V) + Oleic acid 2% (V/V) + Distilled water for balance)
4	T_0C_3	Without pre-cooling + (Corn starch 7.5% (W/V) + Glycerol 2% (V/V) + Oleic acid 2% (V/V) + Distilled water for balance)
5	T_1C_0	Hydro-cooling at 4 °C + Without coating
6	T_1C_1	Hydro-cooling at 4 °C + (Corn starch 2.5% (W/V) + Glycerol 2% (V/V)+ Oleic acid 2% (V/V) + Distilled water for balance)
7	T_1C_2	Hydro-cooling at 4 °C + (Corn starch 5% (W/V) + Glycerol 2% (V/V) + Oleic acid 2% (V/V) + Distilled water for balance)
8	T_1C_3	Hydro-cooling at 4 °C + (Corn starch 7.5% (W/V) + Glycerol 2% (V/V) + Oleic acid 2% (V/V) + Distilled water for balance)
9	T_2C_0	(Hydro-cooling at 6 °C + Without coating)
10	T_2C_1	Hydro-cooling at 6 °C + (Corn starch 2.5% (W/V) + Glycerol 2% (V/V)+ Oleic acid 2% (V/V) + Distilled water for balance)
11	T_2C_2	(Hydro-cooling at 6 °C + (Corn starch 5% (W/V) + Glycerol 2% (V/V) + Oleic acid 2% (V/V) + Distilled water for balance)
12	T_2C_3	Hydro-cooling at 6 °C + (Corn starch 7.5% (W/V) + Glycerol 2% (V/V) + Oleic acid 2% (V/V) + Distilled water for balance)
13	T_3C_0	Hydro-cooling at 8 °C + without coating
14	T_3C_1	Hydro-cooling at 8 °C + (Corn starch 2.5% (W/V) + Glycerol 2% (V/V)+ Oleic acid 2% (V/V) + Distilled water for balance
15	T_3C_2	Hydro-cooling at 8 °C + (Corn starch 5% (W/V) + Glycerol 2% (V/V) + Oleic acid 2% (V/V) + Distilled water for balance)
16	T_3C_3	Hydro-cooling at 8 °C + (Corn starch 7.5% (W/V) + Glycerol 2% (V/V) + Oleic acid 2% (V/V) + Distilled water for balance)

As per experimental design fruits were pre-cooled with three different cooling medium temperature i.e. hydro-cooling at 4, 6 and 8 ^{o}C. Pre-cooled samples were immediately divided in to two batches, first batch tomatoes were directly transferred to storage room (28±2 ^{o}C). Whereas second batch tomatoes were dipped in three different coating solutions (2.5, 5.0 and 7.5 % corn starch) for 30s, the excess coating was drained and the coated tomatoes were kept for surface drying under natural convection for 2-3 h. Then fruits were transferred to storage room (28±2 ^{o}C). During storage parameters like physiological loss in weight, firmness, skin resistance, percent spoilage, pH, titratable acidity, total soluble solids, and lycopene content were examined at three days interval throughout shelf life.

Physiological loss in weight

For determining the physiological loss in weight, fruits weights were taken after imposing the treatment, which served as the initial fruit weight. The loss in weight was recorded at 3 days interval, which served as the final weight. The physiological loss in weight was determined by the following formula and expressed as percentage (Karki, 2005).

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

Firmness and Skin resistance

Texture of tomato fruit was measured in terms of firmness (compression test) and skin resistance (puncture test). The firmness of tomato fruits were analyzed using Texture Analyzer of Stable Micro System Ltd. (Make- TA-HD*i*, UK), equipped with 75 mm Compression Platen (P/75) and 100 kg load cell, was used to measure the tomatoes response to compression as firmness. The operating conditions for the texture analysis were pre-test speed 1 mm/s, compression speed (test speed) 1 mm/s and post-test speed of 5 mm/s. Once a trigger force of 20g has been achieved the compression platen proceeds to move down onto the tomato and a rapid rise in force is observed until the tomato was compressed 10 mm in the equatorial zone. During this stage the sample deform under applied force but there will be no apparent breakdown of the product. The compression force, maximum force (N) needed to compress 10 mm the tomato in the equatorial zone was obtained (Arazuri *et al.*, 2007).

Texture analyzer equipped with a needle probe of 2 mm maximum diameter (P/2) was used in order to measure the skin resistance by puncture test. Puncture speed was 0.83 mm/s until punch penetrated 10 mm in to the tomato. The puncture test was performed on the equatorial zone of each

fruit without skin removal. The measured variable was force (N), needed to puncture tomato skin (Arazuri *et al.*, 2007).

Total soluble solids (TSS)

The total soluble solids (TSS) of tomato fruits were measured using an PAL-1 hand-held refractometer (ATAGO, Japan) at temperature of 20°C.

pH

Pre-treated tomato fruits were cut into small pieces and macerated with hand blender and pulp filtered through filter paper (Whatman-44). The filtrate was used for measuring the pH using pH meter.

Titratable acidity

The titratable acidity of tomato fruits was determined in terms percent anhydrous citric acid (CA). Where, 10 g of the ground and filtered sample diluted in 90 ml of distilled water. The volume was made up and aliquot was titrated with 0.1N NaOH using 1% phenolphthalein solutions as an indicator (Ranganna, 1986).

$$\text{TA}(\%\ \text{CA}) = \frac{Titre \times Normality\ of\ alkali \times Volume\ made\ up \times Eq.\ Wt\ of\ acid \times 100}{Volume\ of\ aliquote\ \text{taken} \times \text{Volume of sample taken} \times 1000}$$

Lycopene content

Lycopene was extracted and analysed according to Thimmaih (1999). Where, tomato juice was extracted from 5-10 g pulp with acetone until the residue is colourless. The liquid extracts were transferred to a separate funnel containing 20 ml petroleum ether and mixed gently. Subsequently, added 20 ml of 5% sodium sulphate solvent. The two phases formed were separated and the lower aqueous phase was re-extracted with additional petroleum ether, until the aqueous phase was colourless. Petroleum ether extracts were pooled in a brown bottle containing 10 gm anhydrous sodium sulphate. After standing it for ten minutes the petroleum ether extract was decanted in 100 ml volumetric flask through a funnel containing cotton wool. The volume was made up and the absorbance measured using a UV-visible double beam spectrophotometer (Shimadzu-UV-160) at 503 nm using petroleum ether as blank. The lycopene content (mg/100g) was calculated using molar extinction coefficient $\Sigma = 17.2 \times 10^{-4}\ M^{-1}cm^{-1}$.

$$\text{Lycopene}\left(\frac{\text{mg}}{100}\text{g}\right) = \frac{3.1206 \times OD\ of\ sample \times Volume\ made\ up \times Dilution}{Weight\ \text{of sample} \times 1000} \times 100$$

Shelf life

The shelf life was calculated by counting the days required to attain the last stage of ripening, but up to the stage when fruit remained still acceptable for consumption or marketing i.e. When 40 per cent of fruits showed symptoms of spoilage, the fruits were considered to have reached end of the shelf life (Rai *et al.*, 2012).

Statistical analysis

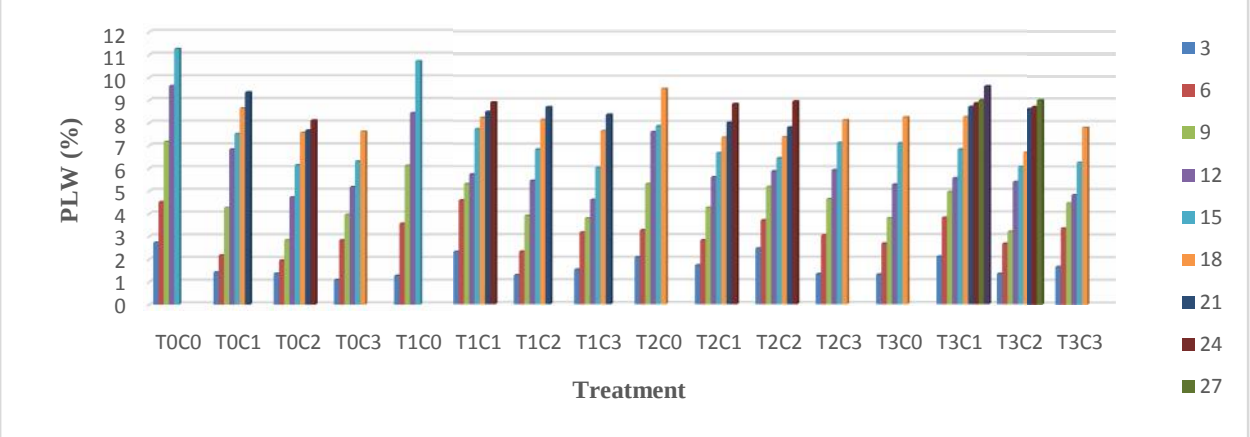
The experiments were conducted with a minimum of three replicates and subjected to statistical analysis using completely randomized design (CRD). The critical difference value at 5% level of probability was used for comparison among treatment means.

RESULTS AND DISCUSSION

Effect of post-harvest treatment on physiological loss in weight (PLW %) of tomato fruits during storage

The physiological weight loss in tomatoes during the storage are shown in Fig. 1. With increase in storage period increase in PLW (%) and was found to be more in untreated sample T_0C_0 i.e. 11.26%, while minimum in treated sample T_0C_3 (7.62%) at the end of shelf life. These results also satisfy the findings of Bhaumik *et al*., (2015). The fact behind the increase in physiological loss in weight is usually due to loss of water through transpiration. Which can lead to wilting and shrivelling, finally reduces the market value and consumer acceptability (Ball, 1997).

FIGURE 1. Effect of post-harvest treatments on physiological loss in weight of tomato during storage



Effect of post-harvest treatment on fruit firmness and skin resistance during storage

Changes in fruit firmness during storage are shown in Fig. 2. Firmness of tomatoes decreased with storage time. At the end of storage maximum firmness found in treated sample T_2C_3 (378.52 N), while minimum in sample T_2C_2 (187.59 N). The rate of decrease in fruit firmness is minimum in treated sample than untreated sample during storage. Similar results were also reported by Pinheiro *et al*., (2005). Paul *et al.,* (1999) reported that the change in fruit firmness can occur due to the loss of moisture through transpiration phenomenon, as well as enzymatic changes. In addition, hemicelluloses and pectin become more soluble, which resulted in to disruption and loosening of the cell walls.

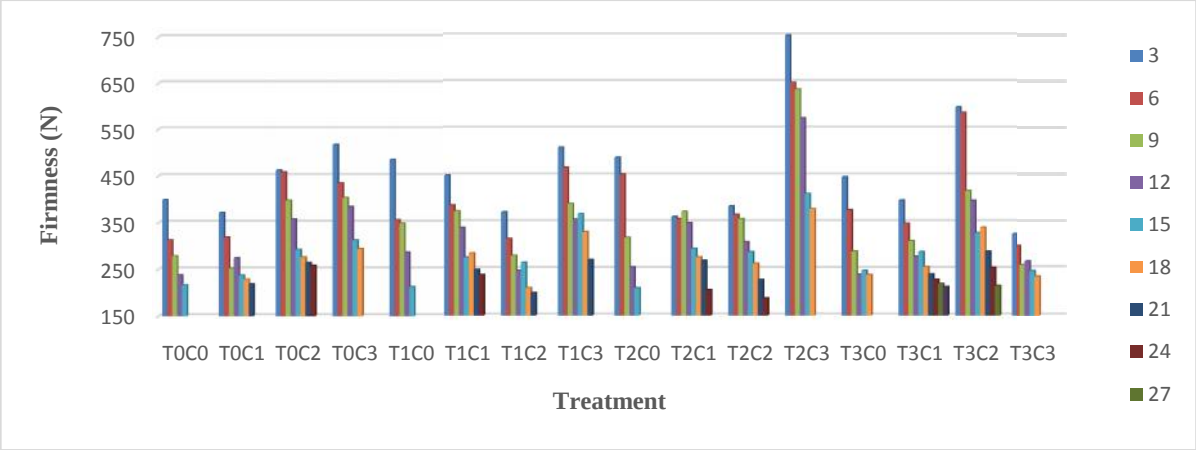


FIGURE 2. Effect of post-harvest treatment on fruit firmness during storage

The results of skin resistance of tomato fruits for different pre-treatment during storage are presented in Fig. 3. Skin resistance of fruit significantly (P≤0.05) decreased with storage period for both treated and control samples. At the end of storage, treated fruit T_0C_2 (23.83 N) clearly showed the lowest skin resistance. The maximum skin resistance was maintained by the treated tomato fruit T_0C_1 (29.46 N) until day 30.

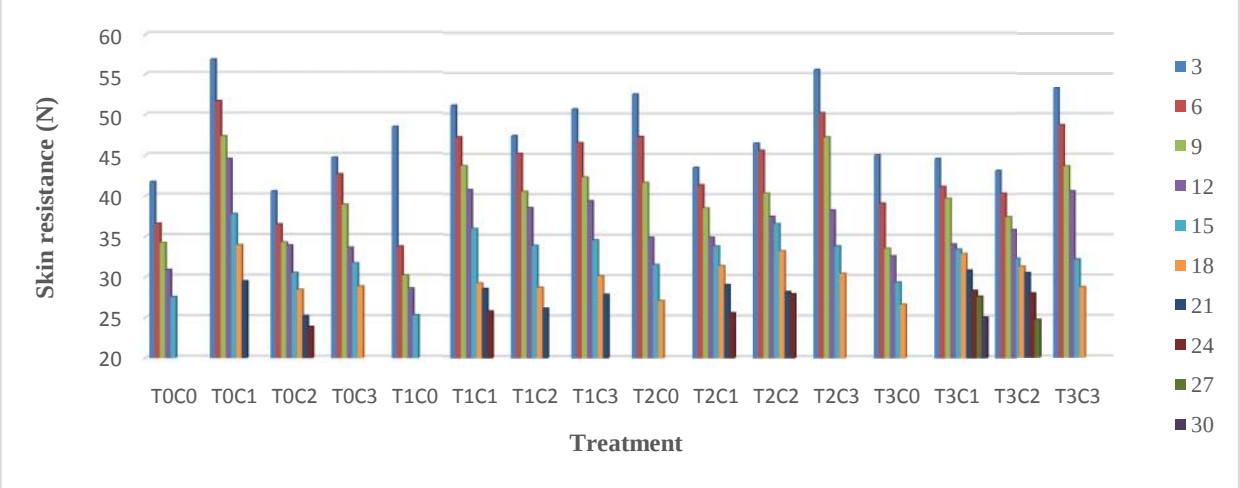


FIGURE 3. Effect of post-harvest treatment on skin resistance of tomato fruit during storage

Effect of post-harvest treatment on total soluble solids (TSS) during storage

Fig 4. Shows variation in total soluble solids content in both treated and untreated samples during storage. It was observed that rate of increase in TSS is comparatively lower in treated tomato fruit than untreated fruits. At the end of shelf life treated sample T_3C_1 (4.97 ^{o}Brix**)** is higher in TSS while, sample T_3C_3 (4.41 ^{o}Brix**)** is minimum. Ali *et al.,* (2010) also reported increase in total soluble solid content as storage period increased. De Sousa *et al.,* (2014) and Duma, (2015). Naik *et al.,* (1993) reported increase in TSS during ripening due to degradation of polysaccharides to simple sugars. Increase in TSS of tomato fruits could be due to excessive moisture loss which increases concentration as well as the hydrolysis of carbohydrates to soluble sugars (Waskar *et al.,* 1999).

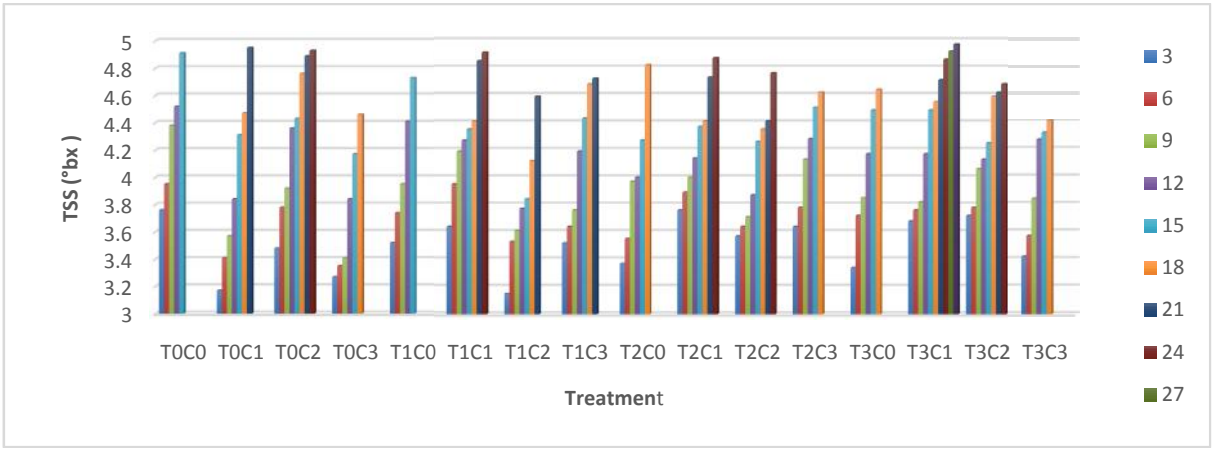


FIGURE 4. Effect of post-harvest treatment on total soluble solids (TSS) during storage

Effect of post-harvest treatment on titratable acidity of fruits during storage

Data obtained pertaining to the titratable acidity as affected by the treatments tested under current study are presented in Fig 5. During storage it was found that the titratable acidity in both controlled and treated samples decreased significantly. At the end of storage, it was observed that acidity was low in T_3C_1 (0.10%) followed by T_1C_1 (0.12%) and high in T_3C_0 (0.22%). Generally during storage acidity decreases with ripening as the organic acids get metabolized (Richard and Hobson, 1987).

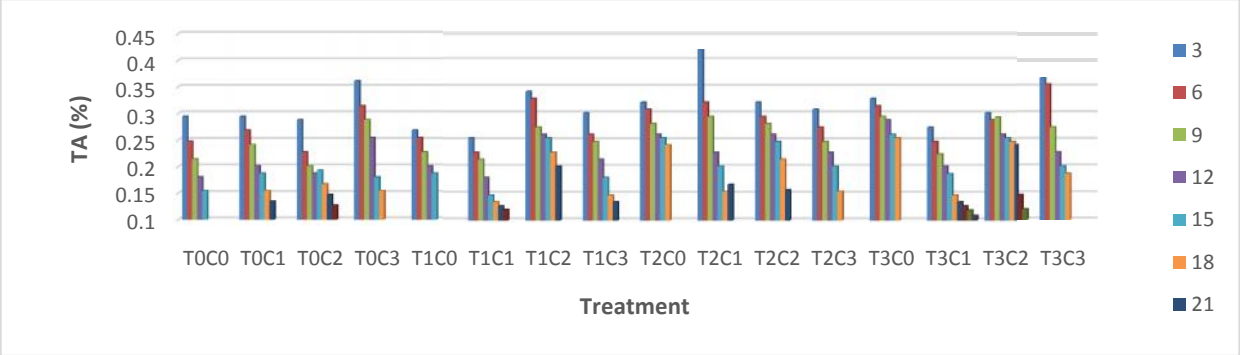


FIGURE 5. Effect of post-harvest treatment on titratable acidity of fruits during storage

Effect of post-harvest treatment on pH during storage

The influence on pH by pre-treatment and storage temperature are depicted in Fig. 6. It was observed that pH of tomato increased throughout the shelf life. During storage the pH of fruits varies from 3.5-4.5 which is acidic in nature. Acidity was inversely correlated to pH. The ripen tomato fruit samples which had a low acid content had a correspondingly high pH. It was highest in treatment T_1C_1 (3.97) followed by T_2C_0 (3.98) and T_0C_0 (4.02) at the end of storage life. From the treatment mean it was observed that all the treatments were par at 5% significance level. These findings are greed with those from Bhaumik *et al.*, (2015) presenting an pH increase with maturity evolution.

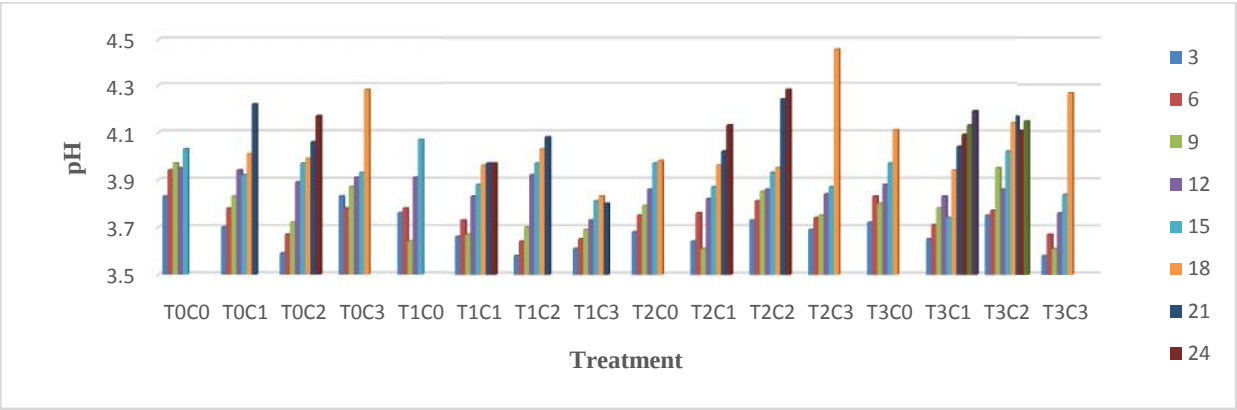


FIGURE 6. Effect of post-harvest treatment on pH during storage

Effect of post-harvest treatment on biosynthesis of lycopene content during storage

The influence on lycopene content by pre-treatments and storage temperature are presented in Fig. 7. It was observed that with the advancement of ripening and storage period lycopene content increased. At the end of storage, it was found that the lycopene content was minimum in T_1C_0 (3.76 mg/100g) and maximum in T_3C_2 (5.17 mg/100g). From the treatment, mean it was observed that all the treatments were significance at (P = 0.05) 5% level. These results were correlated with findings of Isac and Monica (2013). The rate of development of colour in tomatoes increased with increase in maturity (Batu, 2003).The changes in fruit color corresponds to a reduction in chlorophyll and an proliferation in carotenoid synthesis (Pretel *et al.*, 1995), reflecting the transformation of chloroplasts in to chromoplasts (Leshem *et al.*, 1993).

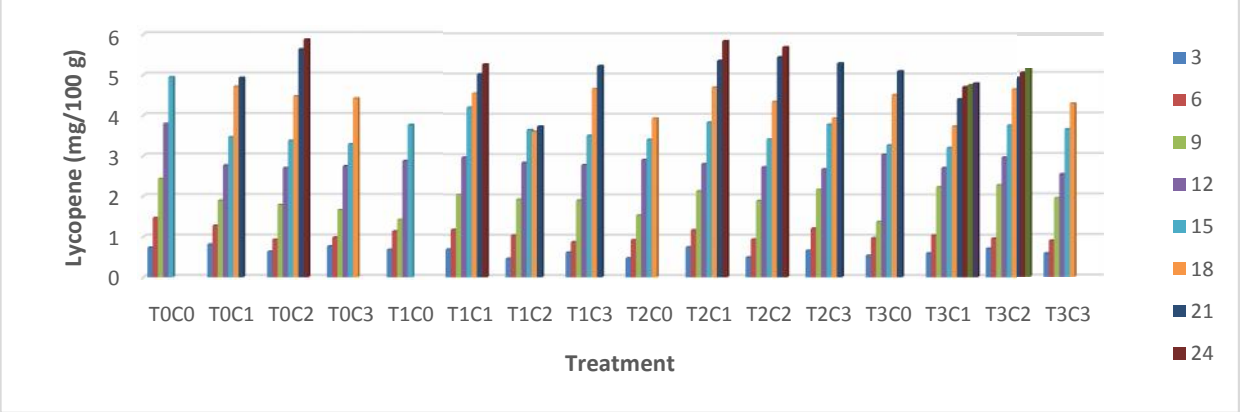


FIGURE 7. Effect of post-harvest treatment on biosynthesis of lycopene

Effect of post-harvest treatment on percentage of spoilage

The results shown that spoilage of tomato fruits was increased in all the treatments over storage time (Fig. 8). The least spoilage (33%) was recorded in treated sample (T_0C_3, T_1C_0) at the end of shelf life. At the end of storage life maximum spoilage noted in treated samples like T_0C_2, T_1C_2, T_2C_2 and T_3C_1 at the level of 40%. Spoilage is the condition of a commodity where the quality attribute referring usually to freshness, stage of senescence, ripeness, the extent of mechanical damage and pest or disease incidence. Spoilage mainly occurs due to Physiological disorder, transpiration, damage by insects, growth of micro-organisms and subsequent water loss can result loss of quality due to spoilage.

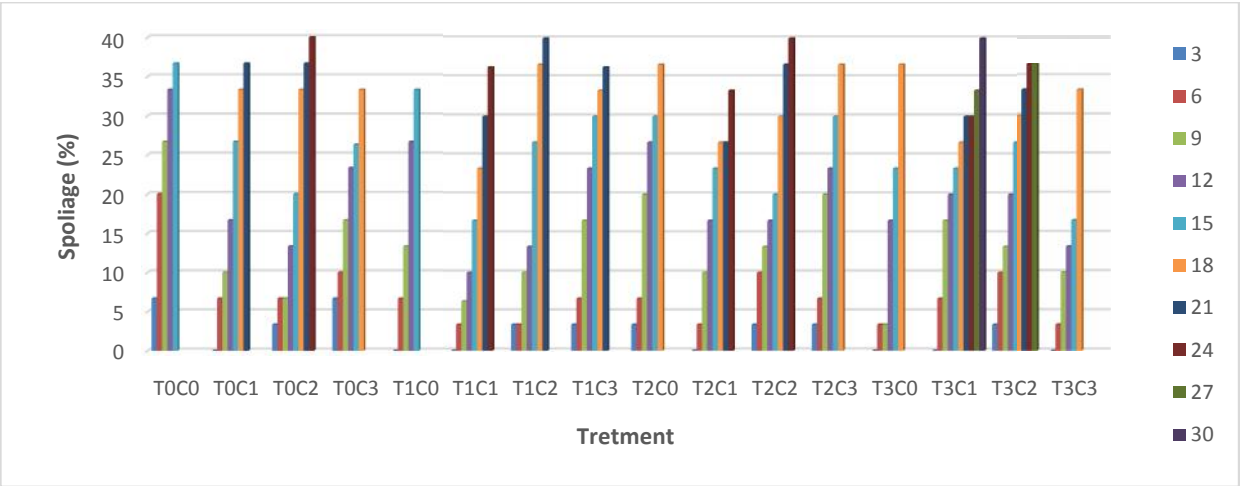


FIGURE 8. Effect of post-harvest treatment on percentage of spoilage

Effect of post-harvest treatments on shelf life of tomato fruits

The data pertaining to the shelf life of tomato for different treatments are illustrated in Fig. 9. It was noticed that all treated samples have higher shelf life than untreated once. Treated sample (T_3C_1) have higher shelf life with an advantage of 15 days shelf life compare to untreated sample (T_0C_0). It was found that all the treatments were greatly affect the shelf life fruit. From the experimental study during storage it was observed that the pre-cooling medium temperature, composition of coating materials and storage condition mainly affects the keeping quality of fruits.

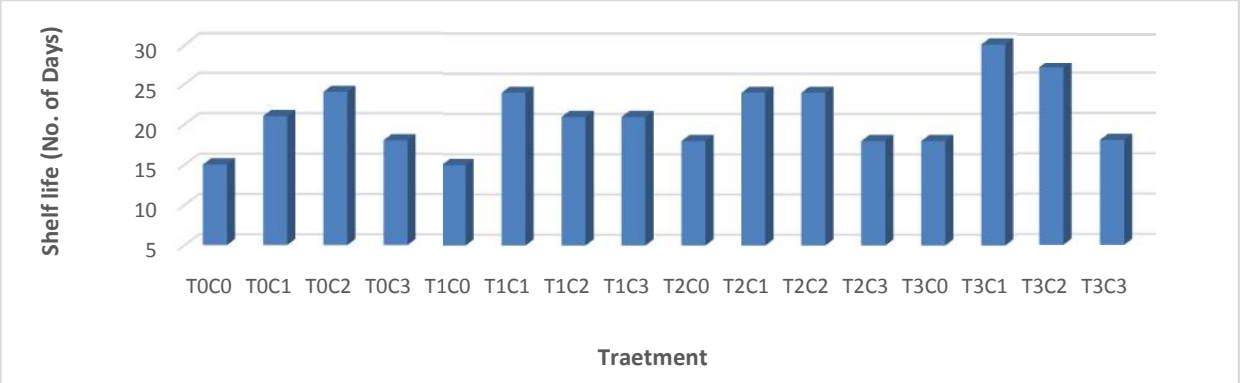


FIGURE 9. Effect of post-harvest treatments on shelf life of tomato fruits

CONCLUSION

The experimental results revealed that post-harvest treatments plays a significant role in order to maintain and preserve the quality of fruits throughout the shelf life during storage. Among all the treatments combination of pre-cooling and edible coating **(**T_3C_1 - Hydro-cooling at 8°C + **(**Corn starch 2.5% (W/V) + Glycerol 2% (V/V)+ Oleic acid 2% (V/V) + Distilled water for balance**)** have a substantial and efficient effect on shelf life. This treatment has delayed the ripening process more effectively and with a minimum quality loss as compared to the control sample during storage (28±2°C). It was noticed that the effect of edible coating on fruits quality is directly depends of concentration of corn starch used and storage temperature.

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