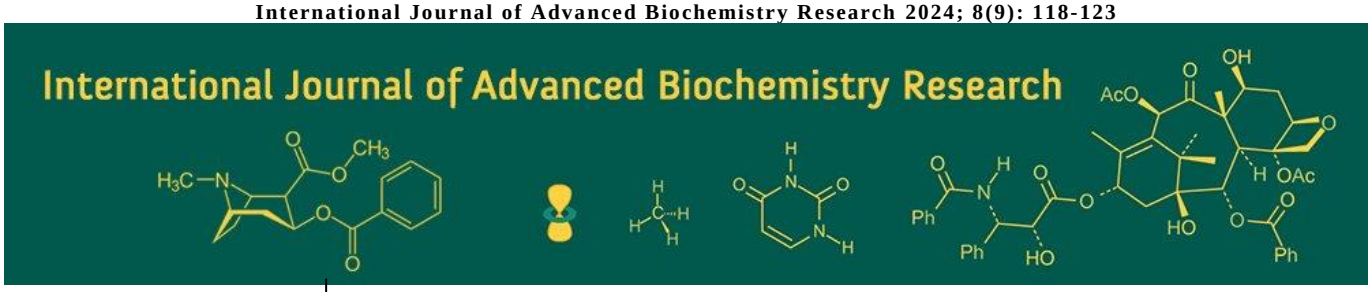

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Effect of different natural edible waxes on post-harvest quality and shelf life of red cherry tomato fruit (*Solanum lycopersicum* L.) during storage

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Abstract
The present investigation entitled "Effect of different natural edible waxes on post-harvest quality and shelf life of red cherry tomato fruit (*Solanum lycopersicum* L.) during storage" was undertaken at Processing Laboratory of Department of Vegetable Science, College of Agriculture, Raipur, during the year 2023-2024 employing completely randomized design having 11 treatments and three replications. The five edible waxes used in the experiment and each treatment consisted two different concentrations viz. T_0: Control, T_1: chitosan (0.25%), T_2: chitosan (0.5%), T_3: beeswax (10%) T_4: beeswax (5%), T5: aloe vera gel (15%), T_6: aloe vera gel (10%), T_7: guar gum (0.5%), T_8: guar gum (1%), T_9: carnauba wax (1%), T10: carnauba wax (2%). At every 5 days of interval, all the parameters were recorded till 20th days of storage. Amongst the different treatments 10% beeswax emulsion coated fruit was recorded minimum weight loss % (1.34, 1.52, 1.69, 1.76%) as compared to control during 20th days of storage. Similarly, maximum firmness of tomato fruits (2.56, 2.23, 1.86, 1.72 & 1.67N) was observed under the superiority of treatment 10% beeswax emulsion coated fruits during storage period. The treatment beeswax emulsion (10%) registered minimum total soluble solids (5.78ºB), pH (4.11) and lycopene content (5.34mg/100 g). However, the titratable acidity (0.44%) and ascorbic acid (19.89mg/100 g) of cherry tomato fruits was recorded maximum on 20th day of storage under ambient condition.

Keywords: Natural edible waxes, cherry tomato

Introduction
The climacteric fruit tomato (*Solanum lycopersicum* L.) has a relatively limited postharvest life due to various factors that reduce its quality and storability, such as high respiration rates, transpiration, postharvest infections, and the acceleration of ripening and senescence (Zapata *et al*. 2008) [19]. Once harvested, tomato quality is always changing. Firmness, flavor, color, nutritional content, shelf life, processing characteristics, and infection resistance are some of the factors that determine fruit quality (Ju *et al*. 2000). Natural edible coatings offer fresh food an extra layer of protection and have the same potential to alter the composition of internal gases as modified environment storage (Park *et al*., 1994) [8]. Given the emphasis on high quality and minimal food processing and storage technologies, the idea of employing edible coatings to increase the shelf life of fresh and little processed product and protect it from hazardous environmental effects has been highlighted (Tharanathan, 2003) [15]. Beeswax is a naturally occurring wax that is made by honeybees (*Cera alba*) and is primarily composed of fatty alcohols and long- chain fatty acids. Beeswax may be added to the edible film's composition to enhance the fresh produce's look, mechanical qualities, and moisture barrier. Strawberries and eggplants can have their respiration rate and senescence reduced by applying a layer of beeswax. This is why this study was carried out to evaluate the possibility of using beeswax as an edible tomato coating. Chitin, an edible polymer that is separated from the shells of crustaceans, is the source of chitosan. It is a natural substance that is safe for the environment and non-toxic. Chitosan, a cationic polysaccharide with a high molecular weight that is obtained from the deacetylation of chitin, is extensively used in postharvest treatments due to its exceptional qualities in film formation, biochemistry, antifungal, and antibacterial activities.

Due to its biological activities, such as its antimicrobial (Tsai *et al*., 2004) [17], antitumor (Tokoro *et al*., 1988) [16], antioxidative, and hypocholesterolemic (Sugano *et al*., 1992) [13] qualities, chitosan has garnered significant attention recently. Chitosan is therefore a polymer that is strongly advised for the creation of edible film coatings (Chien *et al*., 2007) [3]. Edible coatings based on aloe vera gel have been demonstrated to stop moisture and firmness loss, regulate respiration rate and maturation development, postpone oxidative browning, and lessen the growth of microorganisms on delicious cherries (Lin and Zhao, 2007) [7]. This study looked at how aloe vera and functional components applied as an edible coating affected the physicochemical parameters that affect tomato quality during storage and how long tomatoes can last on the market. Guar gum is a naturally occurring polymer derived from guar bean seeds that contains a cis-hydroxyl group (Eilen and Whister, 1948) [5]. Carnauba wax (CW) has been widely used as an edible coating under the lipid group to extend the shelf life of a variety of fruits and vegetables. Carnauba wax, which is extracted from the leaves of the *Copernica cerifera* Brazilian palm tree, is primarily used to preserve glossy appearance and minimize water loss (Baldwin, 1994) [2]. Commercial carnauba-shellac coatings are said to prevent pears from ripening too quickly because they have higher CO_2 concentrations than unwaxed fruit, which keeps the fruit solid and delays color changes. The commercial method of waxing involves spraying melted wax, which is then mechanically brushed to produce the required thickness of coating. It aids in lowering respiration, which postpones quick ripening and reduces post-harvest loss (Drake and Nelson, 1990) [4].

Materials and Methods

Experimental materials

Cherry tomato variety Siri grown at the Protected cultivation of University, Raipur College of Agriculture, was used in present investigation. Tomatoes with similar size, firmness and colour were selected for the experiment. The chemicals such as Hexane, Acetone, Ethanol, HCl, NaOH, Glycerol, Ascorbic acid, Citric acid and Phenolphthalein indicator for shelf-life study were purchased from Ideal chemical shop, Raipur, Chhattisgarh state.

Preparation of formulations

Chitosan solutions with concentrations C1-0.25% and C2-0.5% were prepared by adding 0.6% acetic acid and 25% glycerol (w/w chitosan). Each of the solutions were thoroughly mixed, filtered and the pH was adjusted to 5.6 using 1 M sodium hydroxide (Park *et al*., 1994) [8]. Beeswax weighing 100 g and 50 g was each dissolved in 1 L of distilled water in addition to 50 ml of Olive oil which was added to improve the flexibility and strength of the beeswax. The content was heated for 15 min at 60 °C and brought to cool for 5 min at room temperature (Tedeschi, *et al*., 2018) [14]. The outer layers of tissue were removed in order to separate the aloe (hydroparenchyma) from the leaves. To create a homogenous mixture, the hydroparenchyma gel matrix was combined in a mixer grinder for 15 minutes. The resulting homogenous mixture was then filtered through a muslin cloth measuring 1-2 mm to remove any coarse particles and fibers. Using a heating plate, the gel was heated to 70 °C for 45 minutes in a stainless-steel jar to pasteurize it. After that, it was cooled to room temperature (28 °C) to stabilize it. Every coating solution of AVG (15% and 10%) was made with citric acid (0.5 g/l) and ascorbic acid (0.1-0.5 g/l) as antioxidants. To complete the solution volume, distilled water was added. A coating solution of guar gum was made using distilled water on a % of weight basis. One litre of water was combined with five grams and ten grams of guar gum powder to create 0.5% and 1% solutions, respectively. Fruits were dipped in solutions that had been heated in an oven and cooled in the air. After that, fruits were allowed to air dry at room temperature in accordance with Wijewardane *et al* (2013) [18]. The Carnauba wax obtained from the Department of Vegetable Science, Raipur. Carnauba wax weighing 10 g and 20 g was each dissolved in 1 L of distilled water in addition to 50 ml of Olive oil which was added to improve the flexibility and strength of the carnauba wax. The content was heated for 15 min at 60°C and brought to cool for 5 min at room temperature (Tedeschi, *et al*., 2018) [14].

Physico-chemical analysis Weight loss (%)

The loss in weight of cherry tomato fruits was recorded on the basis of their initial weight. After each interval weight of the fruits were recorded and per cent of physiological loss in weight (PLW) was obtained by noting both initial weight and final weight of tomato as follows:

$$\text{Physiological loss in weight (\%)} = \frac{W1 - W2 \times 100}{W1}$$

Fruit firmness

Using a penetrometer (model number FT327), the firmness was determined. The mean value was then calculated and given in Newtons (N).

Total Soluble Solids

Method described in AOAC 1990 for total soluble solid content was used to obtain TSS in cherry tomato fruits. ATAGO digital hand refractometer was used for estimation of TSS. The units expressed in percentage (Correcting factor at 20 ºC).

Titratable Acidity (%)

The acidity was determined by titrating 10 ml of fruit juice/ pulp sample against 0.1 sodium hydroxide using phenolphthalein as an indicator. The end point appeared as light pink colour (Ranganna, 1986). The acidity was expressed in per cent.

pH

The pH of tomato fruit was determined by using digital pH meter.

Ascorbic acid (mg/100 g or ml)

The ascorbic acid of juice was determined by the procedure given by Ranganna (1986) [11].

Lycopene (mg/100 g)

Content of lycopene carefully measuring out 4 grams of fresh cherry tomato juice, the mixture was placed in a 200 mL flask and covered with aluminum foil to keep the light out. After adding a 100 mL of a 2:1:1 (v/v%) hexane-acetone-ethanol mixture to the flask, it was shaken constantly for 10 minutes. 15 mL of water was then added, and the mixture was shaken for an additional five minutes. Subsequently, the mixture was allowed to separate into discrete polar and non-polar layers and filtered through filter paper (Whatman grade 42). The extract's absorbance at 503 nm was measured using a UV VIS Spectrophotometer, with hexane serving as a blank, to quantify the quantity of lycopene (Ranveer *et al*. 2013) [12]. The specific extinction coefficient (E1%, 1 cm) of 3120 for lycopene in hexane at 503 nm was used to determine the concentration of the substance. Based on the following formula, the lycopene concentration was determined as mg/100 g fresh tomato:

$$\text{Lycopene (mg/100g)} = \frac{A_{503}\times 537\times 100\times 0.55\times 100}{4\times 172}$$

Where,

537 g/mole is the molecular weight of lycopene 100 mL is the volume of mixed solvent

0.55 is the volume ratio of the upper layer to the mixed solvents 4g is the weight of tomato added

172 mM-1 is the extinction coefficient for lycopene in hexane.

Results and Discussion

Changes in weight loss %

The reduction of fruits weight was observed to rise the storage time continue with respect of treatments. Fruit coated with beeswax (10%) registered minimum physiological loss in weight (1.34, 1.52, 1.69 and 1.76%) respectively at 5, 10, 15 and 20th days of storage. The treatment (T_3) beeswax (10%) proved to be significant among all other treatments followed by treatment (T_4) at same alternate days of storage period. The maximum physiological weight loss (6.17, 7.57, 10.38 and 11.06per cent) were recorded under control at 5, 10, 15 and 20th days of storage.

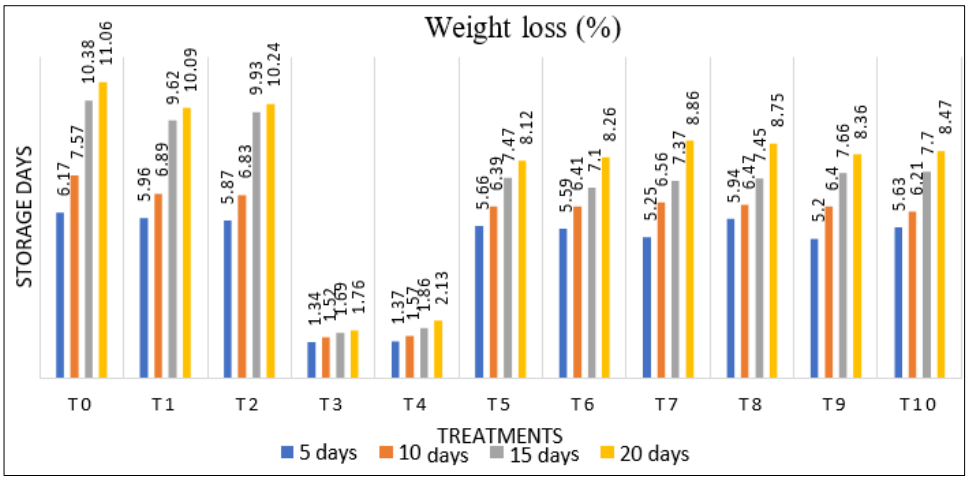

Fig 1: Weight loss (%) as affected by different natural edible waxes on cherry tomato fruit during storage

Changes in firmness (N)

In this case, the highest value of firmness—1.67 N—was recorded under the treatment T_3 (beeswax emulsion 10%), while the lowest value of firmness— 1.38 N—was recorded by the untreated control at the 20th day of the storage period. The initial value of firmness for the control was 2.64 N.

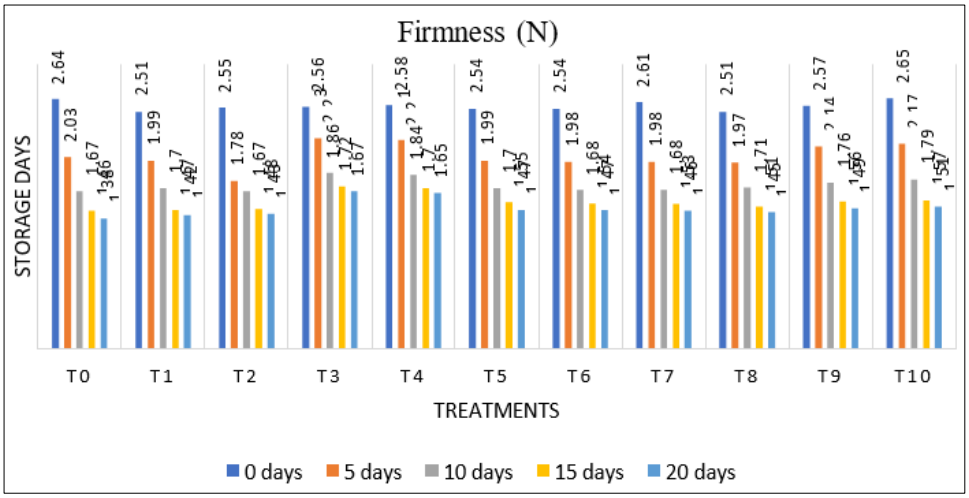

Fig 2: Firmness (N) as affected by different natural edible waxes on cherry tomato fruit during storage.

Changes in pH

The minimum pH values of cherry tomato (3.94, 3.99, 4.06, 4.09, 4.11) was recorded under the treatment T_3 (beeswax emulsion 10%) followed by the treatment T_4 at 0, 5, 10, 15 & 20th days of storage. The maximum pH value of cherry tomato (3.75, 4.07, 4.23, 4.32, 3.38) was noticed under control. The rate of pH value increased higher in control as compared to other treatments during storage period.

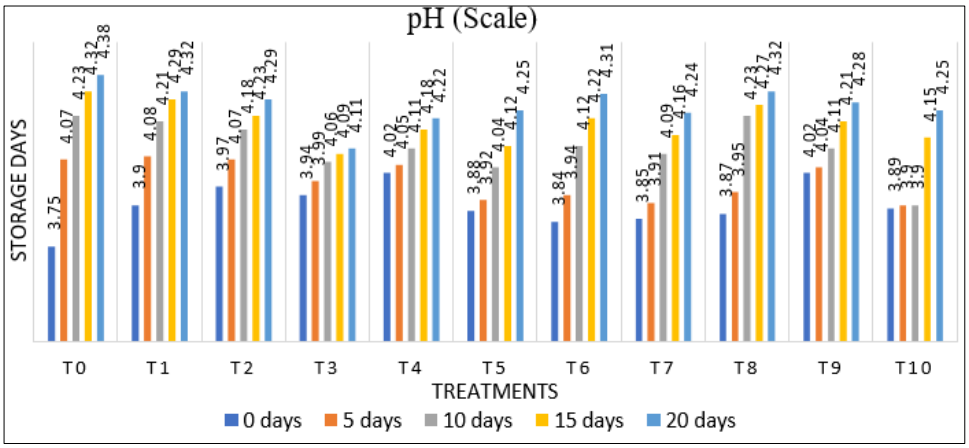

Fig 3: pH as affected by different natural edible waxes on cherry tomato fruit during storage

Changes in Total soluble solids (ºBrix)

The treatment T_3 (beeswax emulsion 10%) recorded minimum total soluble solids contents (4.09, 4.83, 5, 5.07, 5.78ºbrix) followed by Treatment T4 at 0, 5,10, 15 & 20th days of storage. However, the treatment T_0 (control) having maximum total soluble solids content (4.02, 5.25, 6.11, 6.48, 7.08ºbrix) were recorded at 0, 5, 10, 15 and 20th days storage.

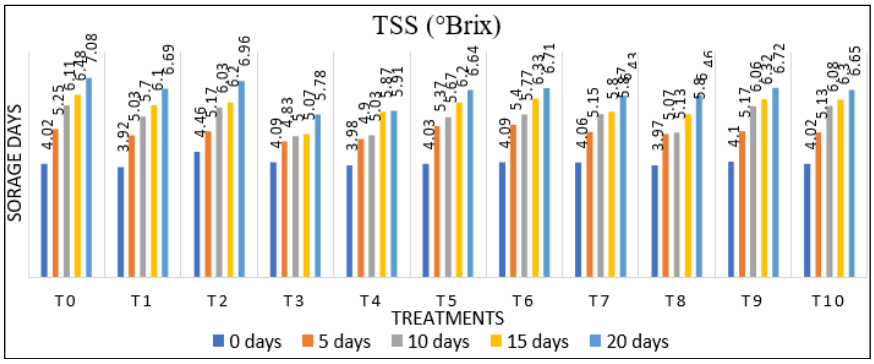

Fig 4: TSS (ºBrix) as affected by different natural edible waxes on cherry tomato fruit during storage.

Titratable Acidity (%)

The minimum acidity per cent (0.50, 0.48, 0.47, 0.46, 0.44%) was recorded under the treatment beeswax emulsion 10% (T_3) followed by the treatment T_4 at 0, 5, 10, 15 & 20th days of storage period. The maximum acidity per cent (0.53, 0.49, 0.44, 0.38 & 0.34%) was registered under the control (T_0). It is revealed from the data that the acidity content of cherry tomato is decreased, when the days of storage period extended. As the cherry tomatoes get older, their titratable acidity (TA) drops. Research by Raffo *et al*. (2002) [10] found similar results, demonstrating that acidity decreased during maturation.

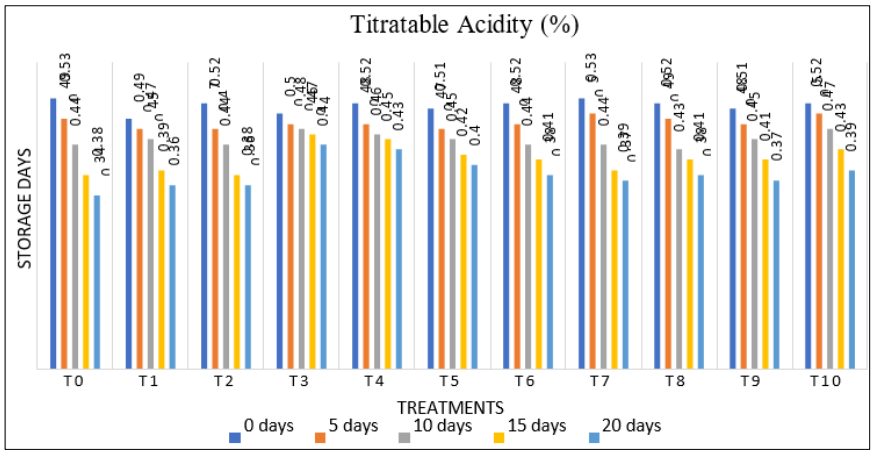

Fig 5: Titratable Acidity (%) as affected by different natural edible waxes on cherry tomato fruit during storage.

Changes in Ascorbic Acid (mg/100 g)

In our study, it has been observed that fruit vitamin-C content reduced with increase in storage time. The superiority of treatment T_3 (beeswax emulsion 10%) recorded maximum ascorbic acid content (24.75, 23.11, 22.19, 20.92, & 19.89 mg/100 g) which was followed by the treatment T4 at 0, 5, 10, 15 & 20th days of storage period. The minimum ascorbic acid content of cherry tomato fruit (25.27, 21.78, 17.71, 14.96 & 11.84mg/100 g) was observed under the control.

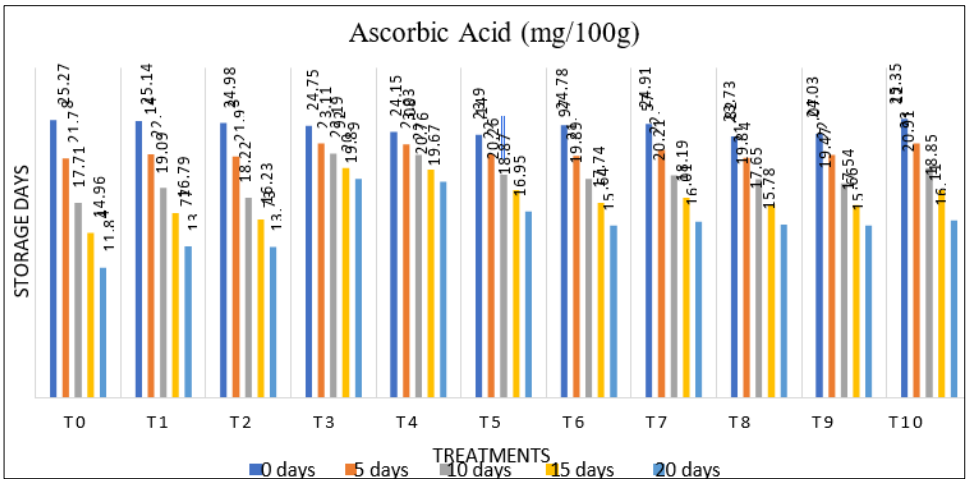

Fig 6: Ascorbic acid (mg/100 g) as affected by different natural edible waxes on cherry tomato fruit during storage

Changes in Lycopene content (mg/100 g)

During ripening the chlorophyll content decreased, and there was a rapid synthesis of the red pigment lycopene. The lycopene content of control during its red stage on the 10th day was 5.11 mg/100 g, whereas lycopene of 10% beeswax coated fruit on the same day was 4.36mg/100 g. The lycopene content of tomato increased during its ripening. The lycopene content of 10% beeswax coated fruit during its red stage on the 20th day was 5.34mg/100 g which is lower than all other treatments. It indicates that 10% concentration beeswax emulsion treatment was much effective in delaying the ripening and extending the shelf life of tomatoes.

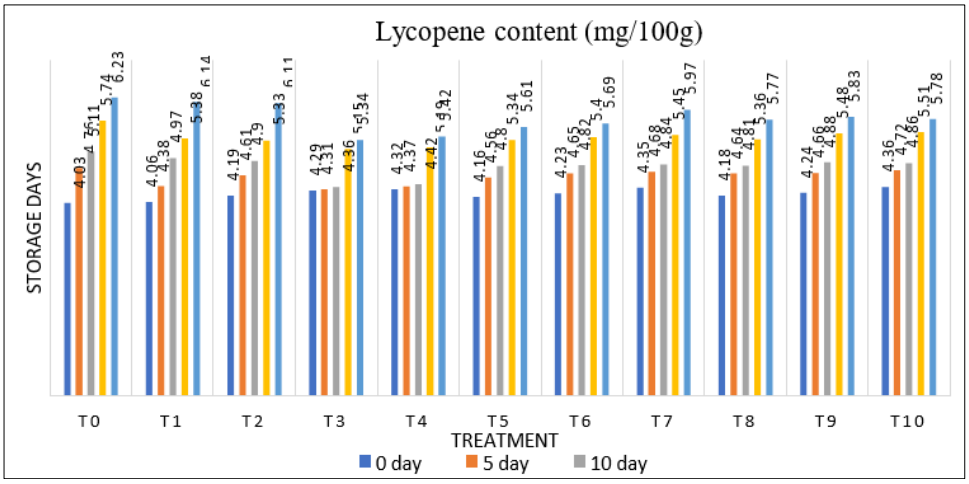

Fig 7: Lycopene content (mg/100 g) as affected by different natural edible waxes on cherry tomato fruit during storage.

Conclusion

It is clear from the present study that beeswax emulsion (10%) was found superior among all other post-harvest treatments. The beeswax emulsion (10%) was found effective for enhancing physico-chemical composition of cherry tomato fruit during storage period at ambient storage condition. Beeswax emulsion (10%) coating delayed the ripening process and prolonged shelf-life and storability of cherry tomato fruits up to 20th days of storage without affecting their physico-chemical composition. Based on the results of this investigation, the optimal beeswax emulsion (10%) was discovered to increase the cherry tomato fruit's physico- chemical composition, shelf life, and storability. Applying a 10% concentration of beeswax coating can be suggested as a way to extend the shelf life of cherry tomatoes that are highly beneficial and storable.

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