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EFFECT OF BIO-PRESERVATIVES ON THE SHELF LIFE OF TOMATO FRUIT (LYCOPERSICON ESCULENTUM MILL)

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Abstract

Tomato (Lycopersicon esculentum Mill.) is a soft fruit and has a very short shelf life. Environmental factors decreased its quality and shelf life like microbial diseases and high respiration and transpiration rate. Bio-preservation is a novel technique for the preservation of food products by the utilization of natural antimicrobials substances to increase the shelf life of fruits and vegetables. Fruit and vegetables are naturally soft and they want protection against microorganisms during formulation, preservation, and supply. The objective of this research was to evaluate the effect of bio-preservatives such as Turmeric, Aloe vera and Moringa on the shelf life of tomato fruit at room temperature. Treatments were applied in a completely randomized design (CRD) with three replications. Bio-preservatives aqueous solutions with 10% (w/v) concentration were used. All morphological, physiochemical, and biochemical analysis were done after every 5 days. Highest weight loss and decrease in firmness were observed in control set and lowest in T4 (Turmeric + Aloe vera 10%) coated tomatoes. Similarly, the highest reduction in pH and TA were observed in the control set and lowest in T4. The cellulase enzyme activity increased with the storage time. T4 (Turmeric + Aloe vera 10%) showed minimum increase in cellulase activity. Thus, it is concluded that T4 showed significant results and thus caused an increase in the shelf life of tomato fruit. It is also concluded that Bio-preservatives such as Turmeric, Aloe vera, Moringa, are recommended to enhance the shelf life and physiochemical constituents of tomato (Lycopersicon esculentum Mill.) fruit at room temperature. Bio-preservatives are easily available, low cost, ecofriendly and have no health hazards as compared to chemical preservatives.

Keywords: Edible Coating, Bio-preservatives, Tomato, Ecofriendly, Lycopene, Phenolic

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1. INTRODUCTION

Tomato (Lycopersicon esculentum Mill.) belongs to the Solanaceae family. Tomato is one of the second most important vegetable crops. It has become an important commercial crop when we talk about human nutrition (Sharma et al., 2019). Tomato is an important food because it contains important bioactive compounds such as carotenoids, lycopene, vitamins, and flavonoids. However due to antioxidant properties and anticancer activity of tomatoes lycopene, it has gained much importance in recent years (Fentik et al., 2017). Tomatoes contain compounds that promote human health and can be easily included in nutrition as a controlled diet (Martí et al., 2016).The nutritional importance of tomatoes is largely explained by their various health-promoting compounds, including vitamins, carotenoids, and phenolic compounds. These bioactive compounds have a wide range of physiological properties, including anti-inflammatory, anti-allergenic, antimicrobial, vasodilatory, antithrombotic, cardio-protective, and antioxidant effects (Li et al., 2018).

Tomato (Lycopersicon esculentum Mill.) is a soft fruit, has a very short shelf life. Environmental factors decreased its quality and shelf life like microbial diseases and high respiration and transpiration rate (Vignesh and Nair, 2019). After harvesting tomato fruit quality like the firmness, color, taste, and moisture content rapidly change (Zanetti et al., 2018). Mostly the loss of fruits and vegetables occur due to improper storage and postharvest handling therefore it is a matter of huge interest in the agricultural countries like Pakistan and India. Fruits are very sensitive and liable to decay therefore these require the most care to reduce the loss of fruits. There is approximately 20 to 50% loss of fruits during the improper storage and poor handling of fruits in developing countries (Manoj et al., 2016). Fresh fruits and vegetables have high moisture content because they are living beings (75-95%) and carry on respiration so producing heat and water at the expenditure of stored food. Fresh produced fruits and vegetables cannot restock water or carbohydrates after harvesting. Fresh produce uses deposited sugar or starch in the respiration process until such resources ended (Yousaf et al., 2018).

Bio-preservation is a novel technique for the preservation of food products by the utilization of natural antimicrobials substances to increase the shelf life of fruits and vegetables. Fruit and vegetables are naturally soft and they want protection against microorganisms during formulation, preservation, and supply. As they are sold far distances from the production site, a large amount of food damage occurred during shipping and preservation due to food microbial attacks and mechanical injuries (Islam et al., 2018). From the earliest time, drying, freezing, and use of antimicrobial substances are mostly used for food storage for a long time. Chemical preservatives are used to enhance the shelf life of foodstuffs to fulfill people's demands. But nowadays consumers do not have an interest on chemical preservation due to its toxicity and health hazards (Mohammed et al., 2017).

In recent years, more advanced trends in food bio-preservation have resulted in the use of non-conventional approaches such as the application of edible coatings that help to extend the shelf-life of perishable fruits and vegetables. The edible coating application is

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a novel technique to increase the shelf life of extremely delicate fruits and vegetables. The edible coatings form a thin layer on the surface of fruit or vegetable by dipping, spraying or smearing method at ordinary temperature to enhance the shelf life and quality after harvesting. Edible coatings are usually made from materials such as polysaccharides, proteins chitosan, alginates, gums, cellulose derivatives, and pectins. Food coatings form a barrier for outside elements and enhance the shelf life of fresh products by decreasing the transpiration rate (Suriati et al., 2018). One of the best things about edible coatings is that these coatings are eco-friendly, and decomposable in nature as compared to the other chemical methods of postharvest management (Kumar and Kapur, 2016).

2. MATERIALS AND METHODS

2.1. Experimental sample

The experimental sample for the present study was tomato (Lycopersicon esculentum Mill.) The experiment was carried out in laboratory of department of Botany, University of Gujrat, Pakistan. Tomatoes were brought in laboratory of department of Botany from the fields of Jalal Pur Jattan Gujrat Pakistan. Healthy tomato fruits were selected according to similar sizes, shape, color, ripeness, quality, and maturity level with no visual symptoms of disease and decay. Tomato fruits washed with tap water to remove dust and fungal infection and then dried with a soft cloth. After this weighed all the tomatoes put in boxes. Each box has 1 kg tomato and was considered as one treatment.

2.2. Treatments

The experiment was conducted in Completely Randomized Design (CRD) with three replications and seven treatments. The present research was conducted by applying the treatments i.e., T1 = Control, T2 = Turmeric + Moringa 10%, T3 = Aloe vera + Moringa10%, T4 = Turmeric + Aloe vera 10%, T5 = Turmeric 10%, T6 = Aloe vera 10%, T7 = Moringa 10%

2.3. Preparation of Plant Extracts

Moringa and turmeric powder was weighed for water extractions. In 100 mL of sterile distilled water weighed powder was added and soaked overnight with continually shaking. After this the extract was filtered with whatmann filter paper and stored for further dipping process. Khan et al. (2019) method was used to prepare the aloe vera gel extract.

2.4. Dipping Treatment with Different Plant Extracts

Tomato fruits were dipped into different plant extract e.g., Moringa, Turmeric, and Aloe vera separately and in combination for 15 mints. Control tomato fruits only dipped in distilled water. After removing from plants extract tomatoes were allowed to dry at room temperature for some time and then stored in the boxes at room temperature for 35 days.

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2.5. Preparation of Tomato Juice

The tomato was washed with tap water. Then the tomato was cut into small pieces with the help of a knife and crushed in pestle and mortar to extract the juice. Tomato juice free from pulp and seeds were filtered through whatmann filter paper and stored in clean tubes for further analysis.

2.6. Parameters

Morphological and physiological parameters have been studied to evaluate the effect of bio-preservatives coating on shelf life of tomato.

2.6.1. Weight Loss (%)

Tomato fruit weight was measured on the 1st day of storage and called it Wi. Later on, the weight of fruits was measured after every five days and called a final weight that was W_f (Duan et al., 2011).

$$\text{Weight loss} = \frac{W_i - W_f \times 100}{W_i}$$

2.6.2. Firmness

A penetrometer was used to measure the firmness of tomato fruit.

2.6.3. Cell Membrane Stability (µs/cm)

Tomato fruit peel was removed with a knife and stored in a 20 ml caped vial containing 10 ml distilled water. Then incubated for 24 hours at room temperature. A conductance meter was used to measure the electrical conductance. (Blum and Ebercon, 1981).

2.6.4. Marketability

Scoring method based on a 1 – 9 rating scale was used to evaluate the marketable quality of tomato samples (Kator et al., 2019). Thus;

1 – 2.49 = unsalable

2.5 - 4.49 = saleable

4.5 - 6.49 = Good

6.5 - 8.49 = Very good

8.5 – 9.00 = Excellent

The marketability qualities were determined according to the fruit color, firmness, surface defects, and signs of mold growth as visual parameters.

2.6.5. pH Measurement

20 g tomato sample was crushed in pestle and mortar. Then tomato juice was extracted and mixed with 90ml distilled water. A digital pH meter was used to measure the pH of juice (Maftoonazad et al., 2008).

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2.6.6. Titritable Acid (%age)

In the 10 ml of tomato juice, 10 ml of water was added and filtered through with whatmann filter paper. Titritable acid was measured by juice titration with 0.1N NaOH solution, (Abid et al., 2013).

2.6.7. Beta - Carotenoids (mg/10 mL)

Tomato fruits were cut into small pieces and crushed into a fine paste by an electric blender for one minute. Then tomato juice was extracted and 10 ml of the juice was added in 10 ml of petroleum ether and shaken vigorously for 1 minute. The Whatman filter paper was used to filter the solution and the filtrate absorbance was measured at 451 nm. Beta-carotene was calculated using the formula as given below (Kator et al., 2018).

Beta Carotenoids = A451 x 19.96 [mg / 100 g]

Where A451 - absorbance at 451 nm, 19.96 - extinction coefficient

2.6.8. Lycopene content (mg/100 g)

Two grams of tomato fruit was grounded with acetone and the volume was made up to 50 ml. Lycopene was determined by protocol described by Thimmaiah (1999). Absorbance was taken at 503 nm and the amount of lycopene was calculated using the formula.

Lycopene (mg/100 g) = 3.1206 × absorbance × dilution/weight of sample (g) × 1000 ×100

2.6.9. Phenolic Contents (µg GAE/mL)

20 g tomato sample was crushed in pestle and mortar. Tomato juice extracted by squeezing. This juice was added to 7.5% sodium carbonate solution. After this folin reagent was added to the juice and stored at room temperature for half an hour. The absorbance was measured in a spectrophotometer at 765 nm. Gallic acid was taken as standard (Singleton and Rossi, 1965). Total phenolic content was estimated as µg Gallic acid equivalent (GAE)/mL of juice.

2.6.10. Tannins content (µg/mL)

The tannins contents were determined by using the Folin ciocalteu reagent. In 1 ml of tomato juice 7.5 ml of distilled water, 0.5 mL of F-C reagent, and 1 mL of 35% sodium carbonate solution were added one by one and 10mL total volume was adjusted by adding distilled water. The mixture was incubated at room temperature. Gallic acid was taken as standard and absorbance was checked using a spectrophotometer at 725 nm. Results were expressed in terms of Gallic acid/mL.

2.6.11. Flavonoids Content (µg/mL)

10 ml tomato juice was added in 2% ethanolic aluminum chloride solution and incubated at room temperature for 1 hour. Absorbance was checked at 550 nm after 1 hour (Miguel et al., 2010). Quercetin was taken as standard.

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2.7. Statistical Analysis

Analysis of the data was carried out by using Minitab software (version 19) at 95% confidence level. The significance of differences among treatment means was determined by analysis of variance (two-way ANOVA).

3. RESULTS

3.1. Weight Loss (%age)

The present study indicated that weight loss of coated and uncoated tomato fruits increased throughout the postharvest storage period at room temperature. Increasing trend shown in the Figure 1. A substantial weight loss was observed during the post-harvest storage period of tomatoes at room temperature. Tomatoes coated with T4 (Turmeric + Aloe vera 10%), T2 (Turmeric + Moringa 10%), T3 (Aloe vera + Moringa10%), showed substantial delay in weight loss during storage period as compared to other coatings i.e., T5 (Turmeric 10%), T6 (Aloe vera 10%), T7 (Moringa 10%) and control set. Similarly at the last day of the storage period tomato coated with T4 (Turmeric + Aloe vera 10%) maintained the weight and had minimum weight loss as compared to the other coatingsand control set. The highest mean values of weight loss were observed in T1 (3.01 to 18.88) and lowest weight loss mean values were observed in T4 (7.91 to 77.96). Similar results showed that weight loss increased significantly in mangoes coated with Aloe vera L. gel during the storage period in all the treatments but control fruits showed maximum weight loss (Daisy et al., 2020). It has been reported that strawberries coated with Aloe vera L. gel solution combined with gum arabic solution showed a significant delay in weight loss during storage (Emmamifar and Bavaisi., 2017)

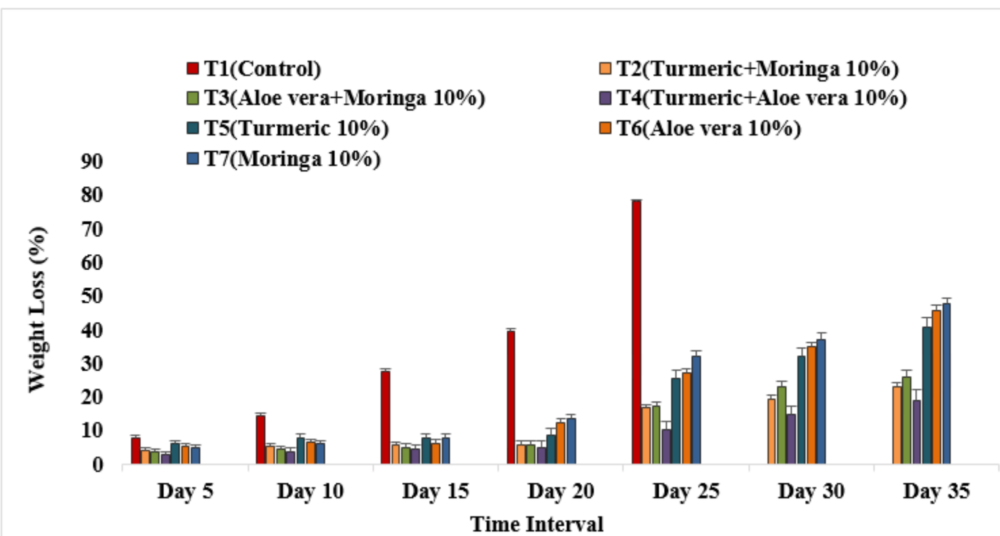

Figure 1: Effect of Biopreservatives (Aloe vera, Turmeric, Moringa, Neem) Extracts on the Weight Loss (%) of Tomato (Lycopersicon esculentum Mill.) Fruit during Storage Period at Room Temperature

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3.2. Firmness

The present study indicated that firmness of coated and uncoated tomato fruits decreased throughout the postharvest storage period at room temperature. Increasing trend shown in Figure 2. Tomatoes coated with T4 (Turmeric + Aloe vera 10%), T2 (Turmeric + Moringa 10%), T3 (Aloe vera + Moringa10%), showed significantly delay in reduction in firmness during storage period as compared to other coatings i.e., T5 (Turmeric 10%), T6 (Aloe vera 10%), T7 (Moringa 10%) and control set. Similarly at the last day of the storage period coated tomato with T4 (Aloe vera gel + gum Arabic) maintained the highest fruit firmness as compared to the other coatings and control set. The highest mean values of firmness were observed in T4 (67.73 to 4.73) and lowest mean values were observed in T1 (5.1 to 1.01). Similar results showed that banana fruit coated with gum arabic had a substantial delay in the reduction of fruit firmness (Maqbool et al., 2011). The most important quality parameter is firmness during postharvest storage (Pasquariello et al., 2013). Similarly Aloe vera gel coating in combination with calcium chloride delayed fruit firmness by decreasing the respiration rate (Khan et al., 2019).

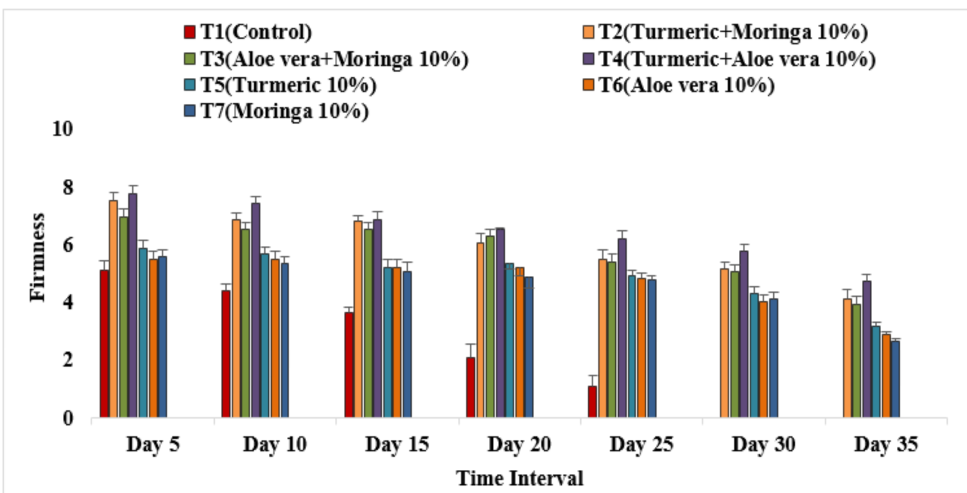

Figure 2: Effect of Biopreservatives (Aloe vera, Turmeric, Moringa, Neem) Extracts on the Firmness of Tomato (Lycopersicon esculentum Mill.) Fruit during Storage Period at Room Temperature

3.3. Cell Membrane Stability (µs/cm)

Results of the present study indicated that cell membrane stability of coated and uncoated tomato fruit considerably decreased throughout the postharvest storage period at room temperature. Decreasing trend shown in Figure 3. Tomatoes coated with T4 (Turmeric + Aloe vera 10%), T2 (Turmeric + Moringa 10%), T3 (Aloe vera + Moringa10%), showed substantial delay in reducing the cell membrane stability during storage as compared to the other coated tomato T5 (Turmeric 10%), T6 (Aloe vera 10%), T7 (Moringa 10%) and control set. Similarly at the last day of the storage period tomato coated with T4 (Turmeric + Aloe vera 10%) had maximum membrane stability as compared to the other coatings

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and control set. The lowest mean values of cell membrane stability were observed in T1 (3.01 to 18.88) and highest values were observed in T4 (7.91 to 77.96).

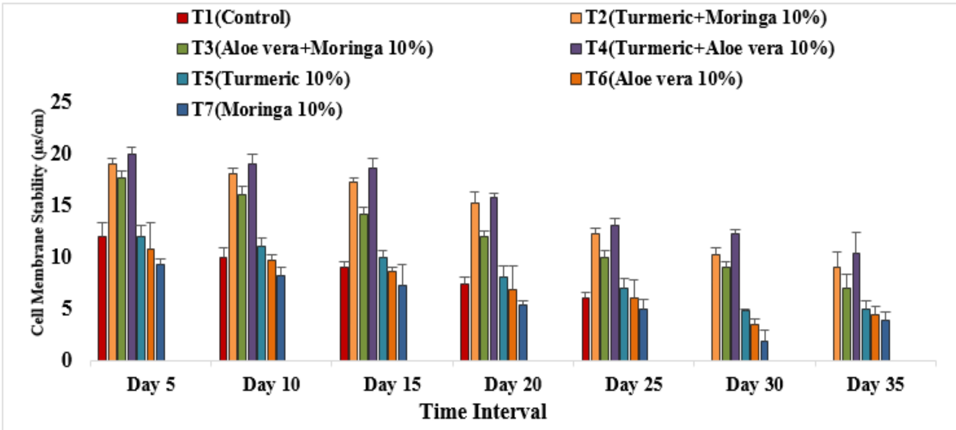

Figure 3: Effect of Biopreservatives (Aloe vera, Turmeric, Moringa, Neem) Extracts on the Cell Membrane Stability (µs/cm) of Tomato (Lycopersicon esculentum Mill.) Fruit during Storage Period at Room Temperature

3.4. Marketability

The present study indicated that marketability of coated and uncoated tomato fruit considerably decreased throughout the postharvest storage period at room temperature. Decreasing trend shown in the Figure 4. Tomatoes coated with T4 (Turmeric + Aloe vera 10%), T2 (Turmeric + Moringa 10%), T3 (Aloe vera + Moringa 10%), showed the best marketability values during storage as compared to the other coatings i.e., T5 (Turmeric 10%), T6 (Aloe vera 10%), T7 (Moringa 10%) and control set. Similarly at the last day of storage tomato coated with T4 (Turmeric + Aloe vera 10%) had best marketability values as compared to other coatings i.e., T2 (Turmeric + Moringa 10%), T3 (Aloe vera + Moringa10%), T5 (Turmeric 10%), T6 (Aloe vera 10%), T7 (Moringa 10%) and control set. The lowest mean values of marketability were observed in T1 (2.08 to 5.51) and highest mean values of marketability were observed in T4 (7.91 to 77.96).Similarly tomato fruits coated with moringa, neem and bitter leaf powder showed the best marketability values during the storage period as compared to the control fruits. Because leaf powder coatings controlled the microbial growth on fruit which cause the fruit rotting and decay (khan et al., 2019).

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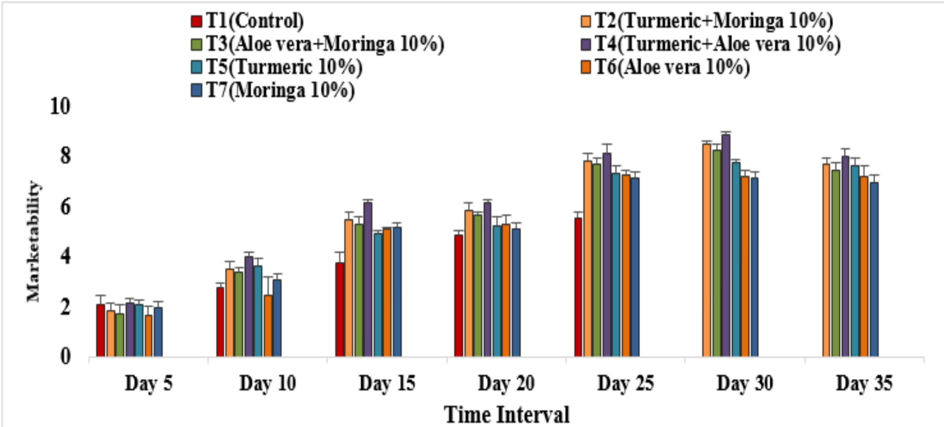

Figure 4: Effect of Biopreservatives (Aloe vera, Turmeric, Moringa, Neem) Extracts on the Marketabilty of Tomato (Lycopersicon esculentum Mill.) Fruit during Storage Period at Room Temperature

3.5. pH Measurement

The present study showed that pH of coated and uncoated tomato fruit considerably increased throughout the postharvest storage period at room temperature. Increasing trend shown in the Figure 5. Tomatoes coated with T4 (Turmeric + Aloe vera 10%), T2 (Turmeric + Moringa 10%), T3 (Aloe vera + Moringa10%), showed a significant delay in increasing pH as compared with other coatings i.e., T5 (Turmeric 10%), T6 (Aloe vera 10%), T7 (Moringa 10%) and control set. Similarly at the last day of storage period tomatoes coated with T4 (Turmeric + Aloe vera 10%) showed low pH values than other coatings i.e., T2 (Turmeric + Moringa 10%), T3 (Aloe vera+Moringa10%), T5 (Turmeric 10%), T6 (Aloe vera 10%), T7 (Moringa 10%) and control set. The lowest mean values of pH were observed in T4 (4.9 to 5.11) and highest mean values were observed in T1 (5.63 to 6.5). Similar results have shown that Aloe vera gel coating maintains the pH of tomato fruit compared to control fruit (Khan et al., 2019). In another study it was reported that the pH level of kiwi fruit increased during post-harvest but the use of Aloe vera gel adhesive solution reduced the pH of the fruit compared to the control set. Aloe vera in combination with chitosan maintains a pH level of blueberries than clusters of unripe berries (Vieria et al., 2016).

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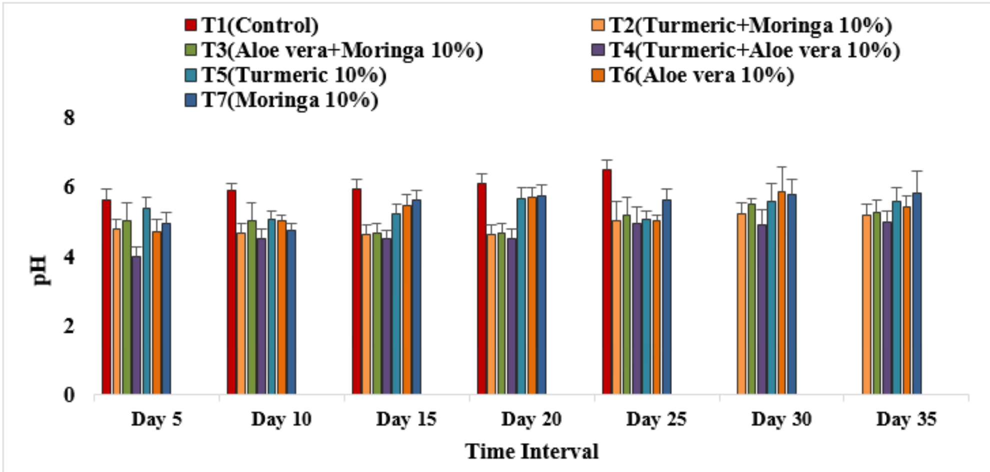

Figure 5: Effect of Biopreservatives (Aloe vera, Turmeric, Moringa, Neem) Extracts on the pH of Tomato (Lycopersicon esculentum Mill.) fruit during Storage Period at Room Temperature

3.6. Titritable Acid (%)

The present study indicated that Titritable acidity of coated and uncoated tomatoes considerably decreased throughout the postharvest storage period at room temperature. Decreasing trend shown in the Figure 6. Tomatoes coated with T4 (Turmeric + Aloe vera 10%), T2 (Turmeric + Moringa 10%), T3 (Aloe vera + Moringa10%), T4 (Turmeric + Neem10%) showed a significant delay in TA reduction as compare to other coatings i.e., T5 (Turmeric 10%), T6 (Aloe vera 10%), T7 (Moringa 10%) and the control set. Similarly at the last day of storage period T5 (Turmeric + Aloe vera 10%) showed significant delay in TA reduction than other coatings i.e., T2 (Turmeric + Moringa 10%), T3 (Aloe vera+Moringa10%), T4 (Turmeric + Neem10%), T6 (Aloe vera + Neem 10%), T7 (Neem + Moringa 10%) and control set.The highest mean values of TA were observed in T4 (0.56 to 5.89) and lowest mean values were observed in T1 (0.55 to 0.11). Similarly, the TA of mangoes was significantly higher in all the treatments as compared to the control during the storage period (Daisy et al., 2020). In another study reported that strawberries treated with Aloe vera gel showed a delay in titritable acidity as compared to the untreated (control) fruits. (Emamifer and Bavaisi, 2017).

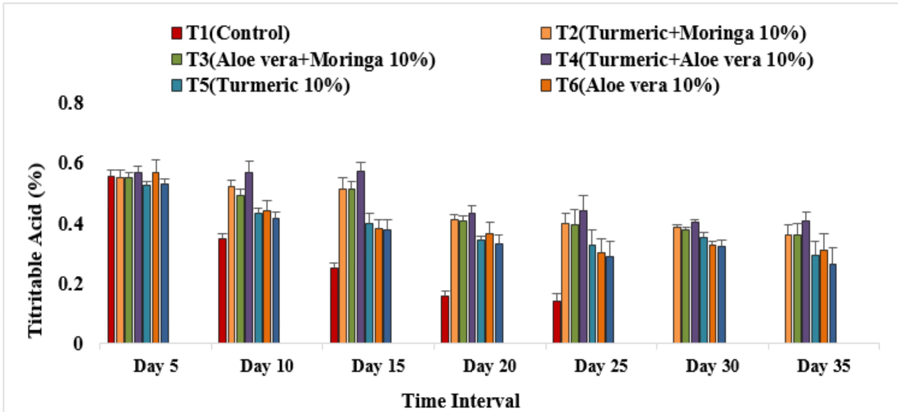

Figure 6: Effect of Biopreservatives (Aloe vera, Turmeric, Moringa, Neem) Extracts on the Titritable Acid (%) of Tomato (Lycopersicon esculentum Mill.) Fruit during Storage Period at Room Temperature

3.7. Beta-Carotenoid Content (mg/10mL)

The present study indicated that Beta-carotenoid content of coated and uncoated tomato fruit considerably decreased throughout the postharvest storage period at room temperature. Decreasing trend shown in the Figure 7. Tomatoes coated with T5 (Turmeric + Aloe vera 10%), T2 (Turmeric + Moringa 10%), T3 (Aloe vera + Moringa 10%), showed significant delay in carotenoid content reduction as compared to the other i.e T5 (Turmeric 10%), T6 (Aloe vera 10%), T7 (Moringa 10%) and control set. Similarly at the last day of storage period, the T4 (Turmeric + Aloe vera 10%) had maximum carotenoid content as compared to the other coatings i.e., T2 (Turmeric + Moringa 10%), T3 (Aloe vera + Moringa10%), T5 (Turmeric 10%), T6 (Aloe vera 10%), T7 (Moringa 10%) and control set. The lowest mean values of Beta-carotenoids were observed in T1 (0.139 to 0.271) and highest weight loss mean values were observed in T5 (0.168 to 0.178).

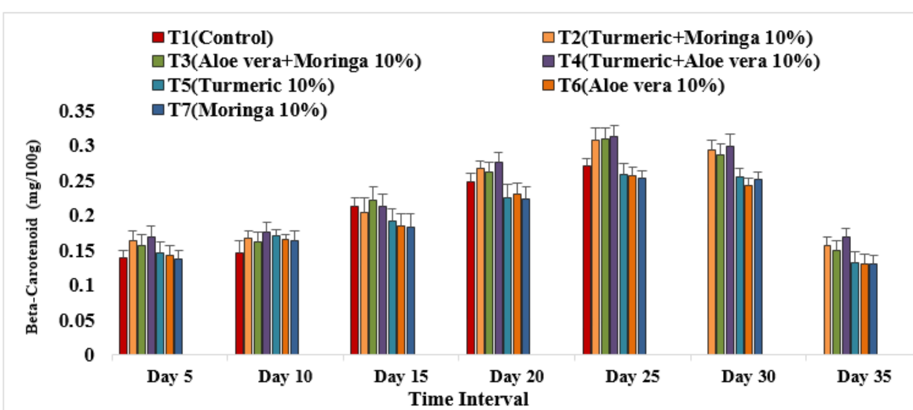

Figure 7: Effect of Biopreservatives (Aloe vera, Turmeric, Moringa, Neem) Extracts on the Beta-Carotenoid content (mg/10mL) of Tomato (Lycopersicon esculentum Mill.) Fruit during Storage Period at Room Temperature

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3.8. Lycopene Content

The present study indicated that lycopene content of coated and uncoated tomatoes substantially increased throughout the postharvest storage period at room temperature. Increasing trend shown in Figure 8. Tomatoes coated with T4 (Turmeric + Aloe vera 10%), T2 (Turmeric + Moringa 10%), T3 (Aloe vera + Moringa 10%), showed a significant delay in the synthesis of lycopene content in tomato fruit during storage period as compared to T5 (Turmeric 10%), T6 (Aloe vera 10%), T7 (Moringa 10%) and control set. Similarly at the last day of storage period T4 (Turmeric + Aloe vera 10%) showed lowest lycopene content as compared to other coatings and control set. The highest mean values of lycopene content were observed in T4 (0.47 to 0.81) and lowest mean values were observed in T1 (0.71 to 1.44). Results of another study showed that in uncoated tomato fruit lycopene content increased sharply and attain maximum value after 12 days of storage but tomato fruits coated with gum Arabic show the maximum lycopene content after 16 days of storage period (Ali et al., 2013).

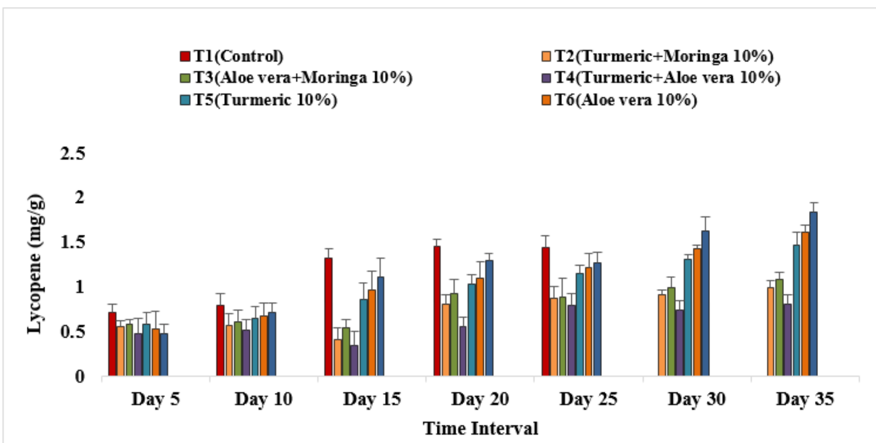

Figure 8: Effect of Biopreservatives (Aloe vera, Turmeric, Moringa, Neem) Extracts on the Lycopene Content (mg/100g) of Tomato (Lycopersicon esculentum Mill.) Fruit during Storage Period at Room Temperature

3.9. Phenolic Content (µg GAE/mL)

The present study indicated that phenolic content of coated and uncoated tomatoes increased throughout the postharvest storage period at room temperature. Increasing trend shown in Figure 9. Tomatoes coated with T4 (Turmeric + Aloe vera 10%), T2 (Turmeric + Moringa 10%), T3 (Aloe vera + Moringa 10%), showed substantial delay in phenolic content reduction as compared to the other coatings i.e, T5 (Turmeric 10%), T6 (Aloe vera 10%), T7 (Moringa 10%) and control set. Similarly at the last of storage tomatoes coated with T4 (Turmeric + Aloe vera 10%) had highest the phenolic content as compared to the other coatings i.e., T2 (Turmeric + Moringa 10%), T3 (Aloe vera + Moringa10%), T5 (Turmeric 10%), T6 (Aloe vera 10%), T7 (Moringa 10%) and control set. The highest mean values of phenolic content were observed in T4 (20.1 to 8.85) and

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lowest mean values were observed in T1 (17.66 to 4.23).It has been reported that Mexican lime fruits when coated with savory essential oils showed a significant delay in reduction in phenolic content as compared to the control set (Atrash et al., 2018). Similar results were found in apricots coated with putrescien showed a significant delay in phenolic content reduction as compared to the control set (Davarsynejad et al., 2013).

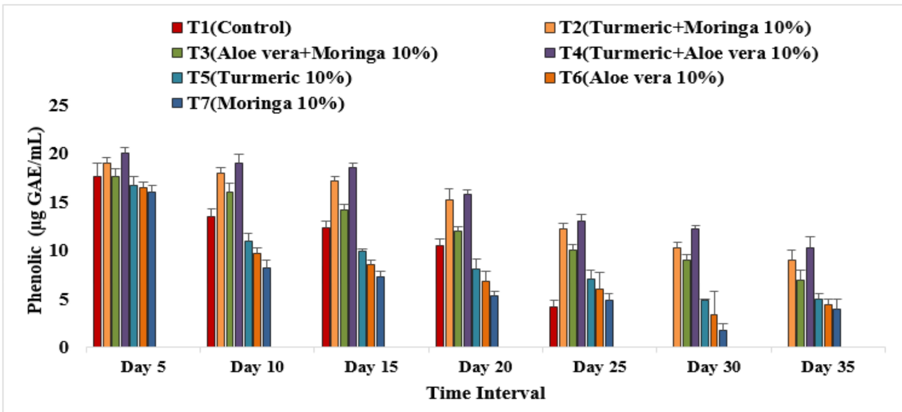

Figure 9: Effect of Biopreservatives (Aloe vera, Turmeric, Moringa, Neem) Extracts on the phenolic Content (µg GAE/mL) of Tomato (Lycopersicon esculentum Mill.) Fruit during Storage Period at Room Temperature

3.10. Tannins Content (µg/mL)

The present study indicated that the tannins content decreased throughout the postharvest period at room temperature. The decreasing trend is shown in Figure 10. Tomato coated with T4 (Turmeric + Aloe vera 10%), T2 (Turmeric + Moringa 10%), T3 (Aloe vera + Moringa 10%), showed substantial delay tannins content reduction during storage as compared to the other coatings i.e., T5 (Turmeric 10%), T6 (Aloe vera 10%), T7 (Moringa 10%) and control set. Similarly at the last day of the storage period tomato coated with T4 (Turmeric + Aloe vera 10%) had highest tannins content as compared to the other coatings i.e T2 (Turmeric + Moringa 10%), T3 (Aloevera + Moringa10%), T5 (Turmeric 10%), T6 (Aloe vera 10%), T7 (Moringa 10%) and control set. The lowest mean values of tannins content were observed in T1 (5.11 to 1.12) and highest mean values were observed in T5 (5.86 to 3.16). A variety of edible coatings are used to help maintain fruit quality. Similar results have shown that a decrease in the total tannins content was delayed in date palm fruit coated with chitosan and aloe vera gel solution compared to the control fruit (Sohar et al., 2019). The current study is consistent with the report that grapes treated with chitosan and calcium chloride have shown a significant decrease in the content of tannins compared to untreated fruit (El-wahab et al., 2014). Decreased tannins content is due to increased respiratory rate after harvesting (Nasasiri et al., 2019).

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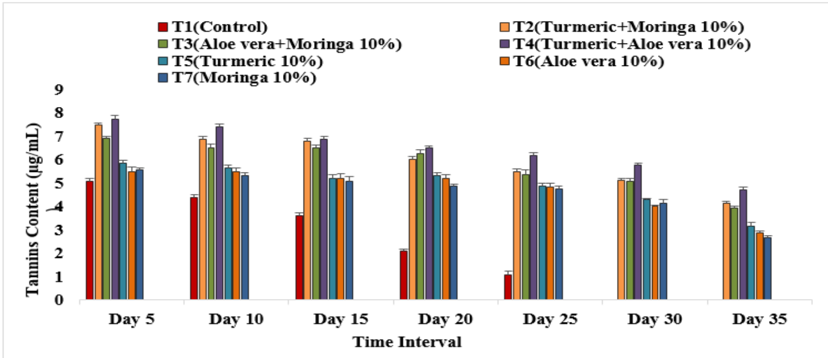

Figure 10: Effect of Biopreservatives (Aloe vera, Turmeric, Moringa, Neem) Extracts on the Tannin Content (µg/mL) of Tomato (Lycopersicon esculentum Mill.) Fruit during Storage Period at Room Temperature

3.11. Flavonoid Content (µg/mL)

The present study indicated that flavonoid content of coated and uncoated tomato fruits decreased throughout the postharvest storage period at room temperature. Decreasing trend shown in Figure 11. Tomatoes coated with T4 (Turmeric + Aloe vera 10%), T2 (Turmeric + Moringa 10%), T3 (Aloe vera + Moringa 10%), showed significant delay in flavonoids content reduction during storage perios as compared to the other coatings i.e T5 = Turmeric 10%, T6 = Aloe vera 10%, T7 = Moringa 10% and control set. Similarly at the last day of the storage period coated tomato with T5 (Turmeric + Aloe vera 10%) retained the highest flavonoids content than other coatings including T2 (Turmeric + Moringa 10%), T3 (Aloe vera + Moringa 10%), T5 (Turmeric 10%), T6 (Aloe vera 10%), T7 (Moringa 10%) and control set. The lowest mean values of flavonoids were observed in T1 (0.17 to 0.15) and highest weight loss mean values were observed in T4 (0.35 to 0.41).Similarly gambullo fruits coated with tomato oil extract retained higher flavonoid content as compared to the control fruits during the post-harvest storage period (Lopez-Palistena et al., 2018).

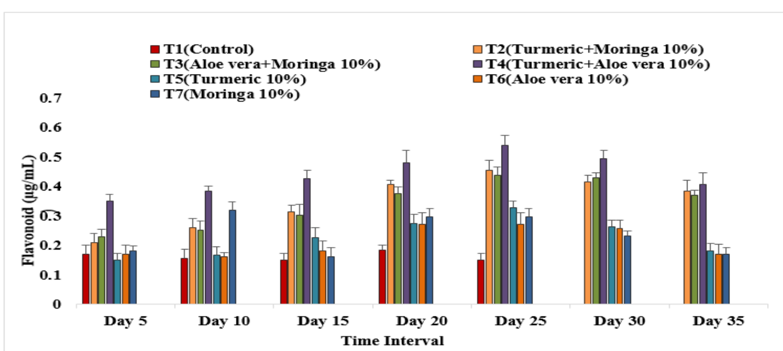

Figure 11: Effect of Biopreservatives (Aloe vera, Turmeric, Moringa, Neem) Extracts on the Flavonoid Content (µg/mL) of Tomato (Lycopersicon esculentum Mill.) Fruit during Storage Period at Room Temperature

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4. DISCUSSION

The tomato weight loss showed an increasing trend during a prolonged storage period in both coated and uncoated samples at room temperature. Tomatoes coated with Turmeric + Aloe vera 10% had minimum weight loss. Weight loss increased during postharvest period due to increased moisture loss, decreased cell membrane stability, solute movement, and rapid gaseous exchange (O_2 and CO_2). Edible coatings are effective in the maintenance of cell membrane functionality and integrity by binding to the polar head group of the phospholipids. And reduced the ion leakage which could be responsible for reduced weight loss in coated tomatoes. The efficacy of bio-preservatives extracts in reducing post-harvest weight loss is an agreement with the work by Emmamifar and Bavaisi, (2017) who inferred those strawberries coated with *Aloe vera* L. gel solution combined with gum arabic solution showed a significant delay in weight loss during storage as compared to control.

The tomato firmness showed a decreasing pattern with the advancement of the storage period and the change being faster for uncoated tomatoes as compared to coated tomatoes. Tomatoes coated with Turmeric + Aloe vera 10% exhibited a better degree of fruit firmness. Fruit softening is associated with the processes of solubilization of pectic substances, breakdown of starch to soluble sugars and loss of water from peel. This decrease in tomato fruit firmness is due to the higher rate of metabolic activities and cell wall degrading enzymes that loosen the fruit skin and decrease the firmness. The presence of edible coating film on tomatoes increases the stability of the cell wall and middle lamella by forming new cross links between anionic homogalacturons, that strengthen the cell wall and middle lamella. Thus, the fruit developed resistance to the fungal enzymes and exhibited a better degree of firmness. Maqbool et al., (2011) also observed that banana fruit coated with gum arabic had substantial delay in the reduction of fruit firmness as compared uncoated fruit. Similarly, *Aloe vera* L. gel extract and okra extract edible coating on tomatoes maintained the firmness as compared to the control during storage period (Maji et al., 2018).

The electrical conductance of the fruits significantly increased during the postharvest storage period. Application of 10% Turmeric + Aloe Vera retained the cell membrane stability during the whole storage period as compared to the other coating materials and control. The cell membrane stability increased because electrical conductance of the tomatoes increased during the postharvest storage period resulting in ion leakage and excessive formation of reactive oxygen species (ROS), leading to cell death. Edible coatings lower electrical conductance of the fruit peel and maintained the cell membrane stability. Edible coatings also regulate the process of lipid peroxidation which is responsible for cell wall breakdown and free radicals generation which eventually affects cell membrane stability. Mendy et al., (2019) showed that the aloe vera gel edible coating on papayas maintained the physicochemical properties of the fruit after harvest by making a partial barrier to water movement and reducing moisture loss as compared to the control fruits. Present study results showed harmony with Maji et al., (2018) that *Aloe vera* L. gel

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extract and okra extract edible coatings on tomato fruit delayed moisture loss as compared to the control fruits.

Marketability of coated and uncoated tomato fruit decreased throughout the postharvest storage period at room temperature. It was also revealed that tomato fruits treated with 10% Turmeric + Aloe vera extract were still marketable at 35th day of the storage period as compared to control. The marketability of tomatoes decreased because after harvesting respiration and transpiration rate constantly increased resulting in the highest moisture loss and weight loss percentage. Edible coatings application helped in increasing stability of the cell wall and middle lamella by forming new cross links between anionic homogalacturons, that strengthening the cell wall and middle lamella. Thus, the fruit developed resistance to the fungal enzymes and remained marketable. The edible coating acts as a physical barrier that helps to reduce moisture loss, solute movement, and gaseous exchange (O_2 and CO_2) due to the formation of a film/coating on top of the skin and keep the tomatoes marketable during postharvest period for long time at room temperature. Zakkiet et al., (2017) also observed that tomatoes showed highest marketability values treated with neem leaf powder as compared to control fruits.

The pH showed an increasing trend during a prolonged storage period in both coated and uncoated samples. The present study indicated that tomato fruits coated with Turmeric + Aloe vera 10% maintained the lowest pH values during postharvest storage period as compared with other coatings and control. Control fruits had maximum pH values because of the utilization and breakdown of starch and pectin substances that results in the formation of free acids. The pH level in tomatoes is inversely proportional to the organic acids. pH level increases due to reduction in organic acids due to the oxidation process. Khan et al., (2019) also noted that Aloe vera gel coating maintains the pH of tomato fruit compared to control fruit. In another study it was reported that the pH level of kiwi fruit increased during post-harvest but the use of Aloe vera gel adhesive solution reduced the pH of the fruit compared to the control set (Benitez et al., 2013). Aloe vera gel coatings in combination with chitosan maintained pH level of blueberries as compared to control fruits (Vieria et al., 2016). Athmaselvi et al., (2013) also reported that tomatoes treated with aloe vera were better at maintaining pH and showed better results compared to untreated fruit.

Titritable acidity of tomatoes was reduced during the storage period. Tomatoes coated with 10% Turmeric + Aloe vera extract significantly maintained acid contents and low pH values during storage period. Control fruit has very low acid content and these organic acids represent the appropriate substrates needed for respiration, so a decrease in acidity predict that fruits have high respiration rate. The decrease in TA of uncoated fruits is due to the oxidation of organic acids that converts the organic acids into sugars. Higher retention of acidity in coated tomatoes is due to its ability to lower the respiration rates and delay the metabolic activities thereby, preventing the loss of organic acids during the storage. Strawberries treated with Aloe vera gel showed a delay in titritable acidity reduction as compared to the untreated (control) fruits (Emamifer and Bavaisi, 2017).

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Beta-carotenoids showed a decreasing trend during a prolonged storage period in both coated and uncoated samples. In the present study tomatoes treated with 10% plants extracts showed maximum beta-carotenoids content upto 35 day of storage period as compared to control fruits. On the 35th day of storage tomatoes with 10% Turmeric + Aloe vera extract had maximum beta-carotenoids content (0.312 mg/100 g) and control fruit had minimum beta-carotenoids content (0.16 mg/100 g). Beta-carotenoids content deceased due to conversion or isomerization of beta-carotenoids into other derivative compounds including flavor and aroma constituents and they converted back into lycopene. Edible coatings application effectively retained beta-carotenoids in tomatoes during storage because of their ability to lower the gas permeability, inhibiting the respiratory rates and retarding the metabolic activities. Mendy et al., (2019) showed that the aloe vera gel edible coating on papayas maintained the beta-carotenoids content of the fruit after harvest by making a partial barrier to reduce water movement and moisture loss as compared to the control fruits."

Bio-preservatives 10% extracts delayed in the lycopene synthesis when applied on tomatoes and enhanced the shelf life. Tomato fruits coated with 10% Turmeric + Aloe vera slowed the process of lycopene biosynthesis. Due to ripening process and postharvest storage period the chlorophyll content decreases continually and there is a rapid increase in the synthesis of red pigment lycopene. The efficacy of bio-preservatives extracts is to delay the ripening process by making a film on tomatoes skin which slowdown the process of metabolic activities and hence delay synthesis of lycopene. It is an agreement with works by Ali et al., 2013 who inferred that uncoated tomato fruit lycopene content increased sharply and attain maximum value after 12 days of storage but tomatoes coated with gum arabic showed the maximum lycopene content after 16 days of storage period.

The phenolic content of coated and uncoated tomatoes increased throughout the postharvest storage period at room temperature. Tomatoes coated with 10% Turmeric + Aloe vera extract showed substantial delay in phenolic content synthesis as compared to the other coatings materials and control set. Phenolic content of the fruits increases continually after harvesting due to the conversion of flavonoids to secondary phenolic compounds. The phenolic contents of the tomato are influenced by the ripening stage. An increase in phenylalanine ammonia-lyase (PAL) enzyme is responsible for synthesizing phenolic compounds in tomatoes. Edible coatings form a thin layer when applied on tomatoes that slow down the process of respiration and transpiration which decreased the production of phenolic compounds during storage. It has been reported that Mexican lime fruits when coated with savory essential oils showed a significant delay in phenolic content synthesis as compared to the control set (Atrash et al., 2018). Similar results were found in apricots coated with putrescien showed a significant delay in phenolic content synthesis as compared to the control set (Davarsynejad et al., 2013).

Tannins content in tomatoes progressively decreased during the storage period Tomatoes coated with 10% Turmeric + Aloe vera extract showed substantial delay tannins content reduction during storage as compared to the other coatings materials and

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control set. This decline in tannins content is due to hydrolytic tannin being decomposed into pirogalol and CO_2, making the tomatoes turn to ripening. Turmeric + aloe vera gel extract application significantly synthesizes the tannins during storage period because of its ability to decrease the gas permeability, respiratory rates and retarding the metabolic activities of tomatoes. Similar results have shown that decrease in the total tannins content was delayed in date palm fruit coated with chitosan and aloe vera gel solution compared to the control fruit (Sohar et al., 2019). The current study is consistent with the report that grapes treated with chitosan and calcium chloride have shown a significant decrease in tannins as compared to untreated fruit (El-wahab et al., 2014).

Flavonoid content decreased during the postharvest storage of tomato fruit at room temperature up to 35 days. Though tomato fruits coated with 10% Turmeric + Aloe vera gel extract had maximum flavonoids content when compared other coatings and control. This reduction in the content of flavonoids is due to the dysfunction of phenylalanine ammonia lipase (PAL) which is very important in the synthesis of these metabolites. This activity of PAL decreased naturally during the ripening and storage of tomatoes. Edible coatings produced abiotic stress on tomatoes, modify its metabolism, and affect the production of secondary metabolites such as flavonoid compounds. Similarly, gambullo fruits coated with tomato oil extract retained higher flavonoid content as compared to the control fruits during the post-harvest storage period (Lopez-Palistena et al., 2018).

5. CONCLUSIONS AND RECOMMENDATIONS

Present study was conducted in the laboratory of Department of Botany, University of Gujrat, Pakistan. A single variety of tomato was taken and the extracts of different bio-preservatives (Aloe vera, turmeric, morings) were applied on tomato and stored at room temperature for 35 days. Bio-preservatives aqueous solutions with 10% (w/v) concentration were used. Various morphological, physiological, biochemical parameters and enzyme assays were tested after every five days. The result obtained from the showed that extracts of different Bio-preservatives were able to extend shelf life and quality of tomato. Tomato coated with T4 (Turmeric + Aloe vera 10%) had more shelf life than other coatings i.e., T2 (Turmeric + Moringa 10%), T3 (Aloe vera + Moringa10%), T5 = Turmeric 10%, T6 = Aloe vera 10%, T7 = Moringa 10% and control set. So T4 (Turmeric + Aloe vera 10%) has the potential to increase the shelf life of tomato fruit. So T4 (Turmeric + Aloe vera) is considered as the best edible coating material to enhance the shelf life of Tomato fruit because it increased the shelf life and physiochemical constituents of tomato fruit during postharvest storage period. Thus, it can be concluded that bio-preservatives can be used to enhance the shelf life of tomato fruit without any side effects on human health and environment as compared to the chemical preservatives. However further research is needed to check the molecular basis and bioactive components of different bio-preservatives to increase the shelf life and quality parameters of fruits and vegetables to reduce the postharvest losses.

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