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Effect of Selected Concentration of Sunflower Oil and Olive Leaf Extract on the Shelf Life Stability of Guava Fruit

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Abstract

This research focused on formulation of combined coating from olive leaves extract, sunflower oil on the life span of guava fruits during storage. The treatments were as follows: To (control), T_1 (2% olive leaves extract and1% sunflower oil), T_2 (4% olive leave extract and 2% sunflower oil), T_3 (6% olive leaves extract and 3% sunflower oil), T_4 (8% olive leaves extract and 4% sunflower oil), T_5 (10% olive leaves extract and 5% sunflower oil), T_6 (12% olive leaves extract and 6% sunflower oil) and T_7 (14% olive leaves extract and 7% sunflower oil)Physicochemical and organoleptic properties were assessed at seven-day intervals over a period of 28 days. Decline was observed in firmness, moisture content, weight loss, acidity, vitamin C levels, appearance, flavor, texture, and overall acceptability. While pH and TSS increased significantly. There was a notable ($p<0.05$) rise in pH from 4.12 to 5.29 and TSS from 7.63 to 10.72˚brix. The titrable acidity, on the other hand, reduced significantly ($p<0.05$) from 0.69 to 0.47, the vitamin C content from 180.11 to 165.41 mg/100g, and the moisture content. (from 85.96 to 74.18), firmness (from 7.40 to 3.34),weight loss (from 5.17 to 10.86), reducing sugar (from 4.39 to 5.25), non-reducing (from 3.11 to 3.62), flavor (from 8.11 to 4.41), appearance (from 8.05 to 2.40) and overall acceptability (from 8.18 to 4.44).Sunflower oil and olive leaf extract synergistically enhance fruit coatings by forming a protective film, providing antioxidant and antimicrobial properties, and acting as a moisture barrier to preserve shelf life while retaining quality. While the physicochemical and sensory analysis, T_7 (14% olive leaves extract and 7%), followed by T_6 (12% olive leaves extract and 6% Sunflower oil), was found best than other treatments, demonstrating superior quality and stability throughout storage.

Key Words: Postharvest Technology; Fruit Coating; Guava Storage; Olive Leaf Extract; Sunflower Oil; Quality Parameters; Shelf Life Extension; Natural Additives

Introduction

The genus Psidium and the Myrtaceae family include the important fruit crop known as guava (*Psidium guajava*). Around the world, it is grown in regions that are tropical or subtropical. Tropical America was where it was initially grown before spreading to other nations as per a crop of major fiscal importance because of its resilience, fruiting, and huge vintage with marginal work (Rajan *et al.,* 2019). Its flavor, aroma, and dietary makeup add to its significance. Around 78.56

billion kilograms of guavas were produced worldwide as of 2022, According to the most recent data available, Pakistan is a major producer of guava, with an estimated 2.78 billion kg produced at a growth rate of 3.95%. Guava production in Pakistan is currently the sixth greatest in the world. Pakistan cultivates 58,500 hectares of guava, yielding about 560,000 tons of guava per year. Sindh produces about 71,000 tons of guavas annually, making it the nation's second-largest producer. (GOP, 2022). Over the years, Pakistan's guava production has been gradually growing in terms of volume between 2014 and 2022, the output volume increased from 2.33 billion kilograms to 2.78 billion kilograms (Tridge 2022). With a projected 9 billion people on the earth by 2050, the need for food which degrades more quickly will increase due to population expansion, necessitating a 70% to 70% increase in food production (FAO, 2009).

Fruit post-harvest handling has a negative economic impact, leading to a rise in poverty, malnutrition, and hunger. A decreased fruit supply as a result of post-harvest losses raises marketing and transportation expenses per unit (Subrahmanyam 1986). Another major factor contributing to the decrease in supply is the significant post-harvest losses which can range from 15% to 50% that happen at different phases of marketing (Pessu *et al.,* 2011). Guava is a good source of dietary minerals and phytonutrients. Because of the fruit's enormous yield and wide range of goods, it is highly valued economically in many nations worldwide. Minerals such as iron, calcium, phosphorus, and vitamins A and C are abundant in guava fruit. There are large amounts of a variety of chemical and inorganic substances, including metabolites such polyphenols, antioxidants, antiviral, and anti-inflammatory substances (Yu *et al*.,2022).

Guava phenolic chemicals prevent premature skin aging and treat malignant cells (Nasir et al., 2018). Vitamins found in guavas support the healthy operation of the human immune system. Moreover, toward rectifying calorie constraint, it is essential for the brain, eyesight, and defense against diseases like scurvy and thyroid disease (Vijaya *et al.,* 2020).

A lower fruit supply as a result of post-harvest losses raises the price of selling and shipping each unit (Subrahmanyam 1986). Again, one of the primary causes of the supply decline is the significant post-harvest losses which can range from 15% to 50% that take place at different stages of marketing (Pessu *et al*., 2011). One major issue related to hunger in the majority of countries is maintaining the shelf life and reducing losses of these horticultural commodities (fruits and vegetables). Reducing fruit decline is crucial for the public's sustainable food supply because over 50% of fruits and vegetables are lost each year. The phenomenon of deterioration is nearly solely responsible for the problem of fruits and vegetables having a lower shelf life and becoming unavailable to most people. Appropriate management (processing, packaging, shipping, storage, etc.) is necessary to limit the reduction. The post-harvest to retail and consumer stages was mostly responsible for the reduction. (Elik *et al.,* 2019).

Edible coatings and oils have gained interest as promising post-harvest methods to prolong fruit shelf life by forming a protective layer that reduces moisture loss, slows respiration, and prevents microbial growth (Khan *et al.,* 2016).

Sunflower oil (Helianthus annuus) has been identified as a promising alternative for fruit preservation among the various edible oils due to its natural antioxidant properties and capability to form a thin, protective film on the fruit's surface (Chitravathi *et al.,* 2014). Pakistan ranked 35th in the world with 36,990 metric tons of sunflower oil produced in 2021. By 2026, however, production is predicted to decline by about 19%. After mustard, rapeseed, and cotton, sunflower is Pakistan's third-most important oilseed crop. Eleven percent of the nation's local oil production comes from it. Pakistan used 2,000 metric tons of sunflower oil in 2018. Over 4.7 million tons of edible oil is needed in Pakistan, and that amount is projected to rise to 5.9 million tons in 2025–2026. (GOP,2025). Sunflower oil (Helianthus annuus L.) seed contains the essential linoleic acid (9cis, 12cisoctadecadienoic acid), which is widely utilized in nutrition. According to a USDA study, sunflower oil is the second-major vegetable oil produced globally. Sunflower oil is rich in

unsaturated fatty acids and omega3 fatty acids, which are considered to be part of the healthy fat category They also cause the oxidative instability of this oil over the use of natural substances, like plant extracts, to preserve fruits and vegetables (Zambiazi *et al.,* 2007). Olive leaf extract has gained popularity because of its potent antioxidant and antibacterial qualities. Bioactive substances such oleuropein, hydroxytyrosol, and flavonoids, which are abundant in olive leaf extract made from Olea europaea, have been shown to have potent antifungal, antibacterial, and antioxidant properties by preventing the growth of spoilage bacteria and reducing oxidative damage during storage, olive leaf extract has the latent to extend the lifespan of fruits like guava. (Benavente *et al.,* 2000). Numerous fruits and vegetables' post-harvest quality and shelf life can be enhanced using olive leaf extract, according to prior research. To keep apples, grapes, and strawberries firm during storage, for example, olive leaf extract has been used to inhibit microbial growth (Sirikantaramas *et al.,* 2017). Furthermore, its antioxidant capacity aids in lowering oxidative stress, which can cause vitamins and other fruit nutrients to deteriorate (Lee, 2010). Due to customer preferences for environmentally friendly, chemical-free preservation techniques, the use of natural plant extracts, such as olive leaf extract, has also grown in popularity (Qurashi *et al*., 2018). Considering the demonstrated role of sunflower oil and olive leaf extract on the shelf life stability of guava fruit this study was designed with the following objectives:

- To assess the impact of olive leaf extract and sunflower oil on the physico-chemical characteristics of guava fruit.
- To evaluate the combined effects of selected concentration of olive leaf extracts and sunflower oil on the storage stability and sensory evaluation of guava fruit.

Materials and Methods

Experimental Site and Duration

The experiment was carried out in December at the Department of Food Science and Technology, Agriculture Research Institute Tarnab, located in Peshawar district, Khyber Pakhtunkhwa, Pakistan. All laboratory analyses were conducted under controlled ambient conditions (20 ± 2 °C; 40–70% relative humidity).

Fruit Procurement and Selection

Fresh guava (*Psidium guajava L*.) fruits were procured from a local fruit market in Peshawar near Tarnab. Fruits were transported to the laboratory in ventilated plastic crates to minimize mechanical injury. Selection was based on uniform size, characteristic peel color, physiological maturity, and absence of visible defects such as bruising, fungal infection, or insect damage. Prior to treatment, fruits were washed with running tap water to remove surface dust and debris.

Sorting and Sanitization

Fruits were manually sorted to eliminate immature, diseased, or damaged samples. Sanitization was performed using a 2% (v/v) sodium hypochlorite solution prepared in distilled water to reduce microbial load. After sanitization, fruits were rinsed with distilled water and air-dried at room temperature.

Preparation for Olive Leaf Extract

Fresh and dried olive (*Olea europaea L*.) leaves were used for extract preparation. Fresh leaves were washed thoroughly with distilled water to remove contaminants, while dried leaves were ground to a fine powder to enhance extraction efficiency. Extraction was performed using ethanol as solvent. The leaf material was mixed with solvent, heated gently under continuous stirring to facilitate phytochemical release, and subsequently filtered through Whitman filter paper. The

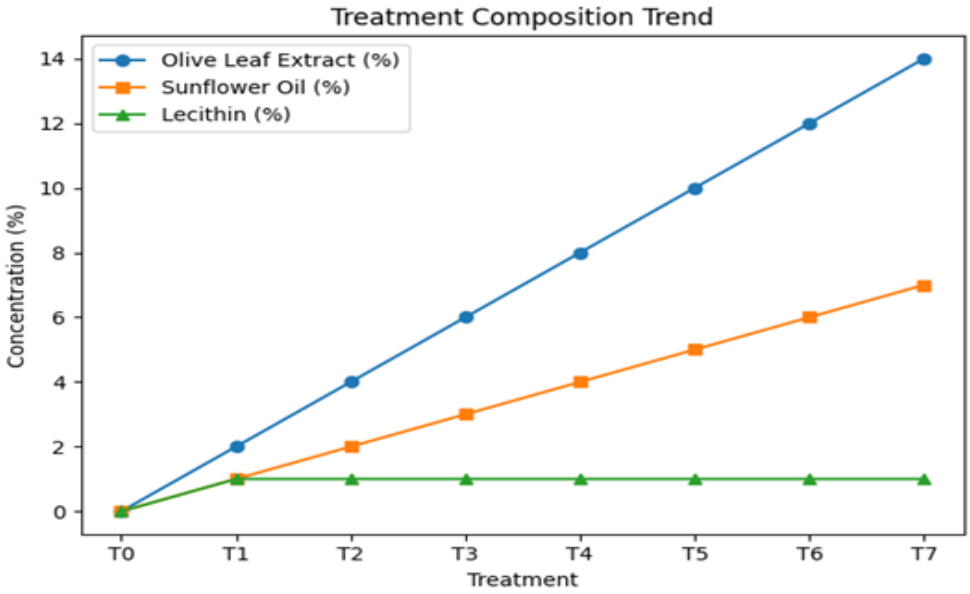
filtrate was stored overnight in airtight containers wrapped with aluminum foil at room temperature to prevent photo degradation.

Preparation for Coating Solutions

Coating solutions were prepared by dissolving olive leaf extract at varying concentrations in 250 mL aqueous solution. Sunflower oil (1–7%) was incorporated as a lipid phase to improve barrier properties, while 1% lecithin was added as an emulsifier to enhance stability and homogeneity. All components were mixed using a magnetic stirrer until a uniform emulsion was obtained.

Experimental Design and Treatments

The study followed a completely randomized design (CRD) with factorial arrangement. Treatments consisted of varying concentrations of olive leaf extract and sunflower oil, while lecithin concentration remained constant (1%).



Fruit Coating and Storage

The dipping method was employed for coating applications. Each fruit was immersed in the respective coating solution for 5 minutes to ensure uniform coverage (Sherani et al., 2021). After coating, fruits were air-dried and stored under ambient laboratory conditions (20 ± 2 °C; 40–70% RH). Observations were recorded at predetermined storage intervals.

Physio-Chemical Analyses

All analyses were performed in triplicate following standard methods of the Association of Official Analytical Chemists (AOAC, 2012).

- **Total Soluble Solids (TSS, °Brix)**
  TSS was determined using a digital refractometer (AOAC Methods 932.12 and 932.14). The instrument was calibrated with distilled water prior to measurement. A drop of filtered juice was placed on the prism, and readings were expressed as °Brix.
- **pH**
  pH was measured using a calibrated digital pH meter (AOAC Method 2005.02). Calibration was performed using standard buffer solutions (pH 4.0, 7.0, and 10.0). The electrode was rinsed with distilled water between measurements.

- **Firmness (kg cm^{-2})**
  Fruit firmness was measured using an Instron Universal Testing Machine (Model 5542, Instron, Norwood, NJ, USA) following Zhu et al. (2019). A standardized probe was inserted into opposite sides of the fruit to minimize variability. Results were expressed in kg cm^{-2}.
- **Weight Loss (%)**
  Initial fruit weight (W_1) was recorded at the start of storage, and final weight (W_2) was measured at seven-day intervals. Weight loss was calculated using:

  Where Weight loss %age = (initial weight— current Weight/initial weight) ×100

  $$W\% = \frac{w1-w2}{w1} x100$$
- **Moisture Content (%)**
  Moisture content was determined by oven-drying 5 g of sample at 100 °C for 4 h (AOAC, 2012).
  $$\text{Moisture (\%)} = \frac{\text{Wt initial}-\text{Wt final}}{Wt\ initial} x100$$
  where Wi is initial weight and Wf is final dried weight.

Titratable acidity (%)
Guava fruit acidity was measured using the procedure outlined in (AOAC 2012), and the results were then analyzed using the given formula.

$$\text{Acidity (\%)} = \frac{C.F \times N \times T \times D \times 100}{V \times S}$$

Where

- C.F: correction factor for guava i.e. 0.064
- V: volume of the sample before dilution
- N: Normality of NaOH used
- D: dilution factor
- S: volume of the sample after dilution
- T: volume in ml of NaOH used

Sample titration
90 ml of distilled water was used to dissolve the 10 ml sample, increasing the volume up to 100 ml. Afterwards, the conical flask containing 10 ml of the sample that was diluted was filled with two or three drops of phenolphthalein served as a color indicator. The 0.1 NaOH titration was then initiated until the flask began to become pink. The acidity was calculated using the following formula.

$$T.A = \frac{N \times T \times 100 \times 100}{S \times D}$$

Where

- N=normality of NaOH
- T=volume in ml of 0.1 NaOH used
- D=volume in ml of samples taken for dilution
- S=volume in ml of diluted samples taken for titration

1. **Reducing sugar (%)**
   To find the reducing sugar content, the Lane & Eyon method of AOAC (2012), no. 920.183, was used.

- **Fehling A**
  The 34.65 grams of $CuSO_4$, $4H_2O$ was dissolved in 500 ml distilled water, and prepared the Fehling-A solution.
- **Fehling B**
  The 173 grams of $KNaC_4H_4O_6 \cdot 4H_2O$ and 50 grams of NaOH was dissolved in 500 ml of distilled water and prepare the Fehling-B solution.
- **Procedure**
  A graduated cylinder was used to measure the 10 ml of guava fruit sample. It was then placed into a beaker and filled with distilled water to attain a level of 100 ml. Filter paper was used to filter the diluted sample, and the burette was filled with liquid. Then, 10 ml of distilled water was added to a conical flask containing 5 ml of Fehling A and 5 ml of Fehling B. After being placed on the electric heater, the conical flask was allowed to reach the boiling point. The titration from the burette to the conical flask began cautiously after the boiling process was completed. When the conical flask reached the brick red hue after continued heating, three drops of methyl blue were added, turning the solution blue once more. Then, the solution was allowed to regain its red brick color. After the procedure was completed and the flask had a constant brick red tint, the readings were recorded.

2. **Non-reducing sugar (%)**
   To evaluate non- reducing sugar content, the Lane & Eyon method of AOAC (2012), no. 920.184 was used.

- **Fehling A**
  The 34.65 grams of $CuSO_4$, $5H_2O$ was dissolved in 500ml distilled water, and made the Fehling-A solution.
- **Fehling B**
  The 173 grams of $KNaC_4H_4O6$, 4H2O and 50 grams of NaOH were dissolved in 500 ml of distilled water and prepared the Fehling-B solution. After dissolving a 10-ml sample of guava fruit in distilled water, the mixture was combined with 100 ml in a beaker. A 250 ml solution was then created by adding 10 ml of 0.1N HCl and 0.1N NaOH to 20 ml of this diluted material in a conical flask. This solution was put into the burette so that it could be titrated. 5 ml of Fehling A and 5 ml of Fehling B were then added were placed in a conical flask, along with ten ml of distilled water, and the flask was placed on an electric heater and allowed to boil. Following the boiling, the titration from burette to conical flask was carefully started, and the flask turned brick red following the continual heating. The solution then became blue again after the three drops of methyl blue were added hue, and the process was repeated until the flask was continuously brick red, at which point the readings were recorded.

Vitamin C (mg/100gm)
The AOAC-recommended methodology (2012) was used for determining the amount of ascorbic acid of a guava fruit sample.

Procedure
Preparation of dye solution
The mixture was filled to a capacity of 250 ml after roughly weighed and dissolved in distilled water. Where 50 mg of sodium bicarbonate and 42 mg of dichlorophenol indophenol color solution was made. This solution was sterilized & kept in a dry, cold place for a full day before usage.

Preparation of standard ascorbic acid solution
0.4% oxalic acid was added to a 50 ml volumetric flask that contained roughly 50 mg normal ascorbic acid. The mixture was then kept in a cool, dark location.

Preparation of oxalic acid solution
One liter of distilled water was added to a volumetric flask containing 4 mg of oxalic acid.

Standardization of dye solutions
The dye solution was titrated with 5 ml of standard ascorbic acid solution in a conical flask until pink shade was attained, which was sustained for 15 sec. Dye factor (f) = ml of ascorbic acid/ml of dye used

Titration of Samples
A 100 ml volumetric flask was loaded with 10 ml sample, and a level has been created up to the region with a 0.4% oxalic acid solution. 10 ml of the prepared sample were put in a dye-filled flask, and the mixture was left to titrate for 15 secs, or until a faint pink hue emerged. Each sample had three consecutive readings collected. Using a formula, the amount of vitamin C was determined.

Sensory analysis
Using the same methods as Ali *et al*., ten skilled sensory panelists participated in a panel test to evaluate sensory attributes. A nine-point hedonic scale was used to assess taste, fragrance, and general acceptability (7 being very much liked, 8 being very much liked, 7 being liked somewhat, 6 being liked, 5 being neither liked nor despised, 4 being disliked somewhat, 2 being disliked very much significantly, and 1 being highly detested). Fruits were cleaned, sliced, and their peels were used to test their flavor.

Statistical analysis
Data were analyzed using a two-factor completely randomized design (CRD). Analysis of variance (ANOVA) was performed, and treatment means were separated using the Least Significant Difference (LSD) test at 5% probability level (Abbas *et al.,* 2025).

Result
Figure 1 shows the data regarding Total Soluble Solid (TSS °Brix), Titratable acidity (TA) (%), Firmness (kg/cm2), Percent fruit weight loss (%), Moisture content, Reducing sugar (%) effect of selected concentration of sunflower oil and olive leaf extract on the shelf life stability of guava fruit. The statistical analysis showed that both treatment and storage significantly affected all observed parameters of guava fruit, including Total Soluble Solid (TSS °Brix), After 28 days of varying treatments at room temperature, the total soluble solid in guava fruit samples treated with sunflower oil and olive leaf extract increased significantly when stored at 20°C. The TSS levels were 7.60 to 7.76 on the first day (T0–T7) and 12.43 to 9.13 on the last day (28 days), respectively. Between T0 and T7, the overall percentage growth ranged from 63.55% to 17.50%. The mean values from the first day (the first day) to the last day (the 28th day) were 7.63 to 10.72, and the mean values between treatments from T0 to T7 were 10.22 to 8.37. The highest value was observed in T0 (control and T7, which contains 14% olive extract and 7% sunflower oil combined, had the lowest value during the research. T7 outperformed T0 (uncoated) and the other samples that were treated with varying ratios of olive extract and sunflower oil (Figure 1 (A). The data (Figure 1 (B)) indicated that The titrable acidity showed significance decrease in guava samples treated with olive leaves extract and sunflower oil at 20°C for 28 days. Titratable acidity is one of the primary

ingredients that give fruit their sour or tart flavor. Fruits with an acid content that can be measured are said to have titratable acidity. According to this study, titratable acidity decreases with storage. When compared to the control, the combined effects of sunflower oil and olive extract are superior. Measured from T0 to T7, the initial data was 0.66 to 0.75; on the 28th day, it was 0.32 to 0.61, and the percentage decline was 51.52 to 18.67. The lowest mean was found in T0 (0.50), while the highest mean, 0.68, was found in T7. These findings suggest that coating assisted in preserving organic acids by reducing their consumption in metabolic processes, as seen by the minimal losses in T7 and the maintenance of a high acidity value. Figure 1(C) shows the firmness (N) showed the gradual decrease in guava fruit treated with olive leaves extract and sunflower oil during storage at 20°C for 28 days. The degree of softening and hardening is correlated with the firmness of the fruit, enabling us to distinguish amidst ripe and unripe fruit. Ripe fruit is typically less hard than immature fruit. After 28 days of storage, the initial firmness values from T0 to T7, which were 7.20 to 7.55, decreased to 0.57 and 5.32, respectively, which is significantly less effective than the T0 control and best treatment was T7 treatment (14% olive extract + 7% sunflower oil). Firmness scores decreased by 92.08 and 29.54 percent between T0 and T7, indicating a considerable minimum reduction and treatment efficacy. The treatments were superior to the control, as indicated by the mean values from T0 to T7, which were 3.01 and 5.99, respectively. The firmness of the guava was greatly maintained during storage by using sunflower oil and extracting from olive leaves as a covering material. Sunflower oil reduces transpiration and respiration rate, which improves fruit firmness throughout marketing and storage. Treatments with these coatings (T5, T6, and T7) maintained maximal firmness as compared to the uncoated control (T0). Percent fruit weight loss (%) the guava sample treated with sunflower oil and olive extract during storage had a significantly higher mass loss percentage. at 20°C for 28 days. The reduction in weight results from the water content being reduced as a result of transpiration-induced dehydration. Weight loss from T0 to T7 started out at 8.37 and 1.37, respectively, then raise to 17.21 and 5.91. With a mean value of 5.91 percent minimal physiological weight loss, T7 (olive extract 14% and sunflower oil 7%) achieved the best physiological weight outcome. whereas T0 (control) had the highest mean value (17.21%). The physical mass loss mean values for T6, T5, T4, T3, T2, and T1 were also displayed in the results; they were 7.39%, 9.82%, 10.21%, 11.08%, 12.21%, and 13.08%, respectively. According to the statistics, the treatment significantly affects storage at 20°C when compared to the control show in (Figure 1 (D). The moisture content showed the significance increase in guava samples treated with olive leaves extract and sunflower oil during storage at 20°C for 28 days. Dehydration during the transpiration process causes the water content to decrease, which in turn causes the moisture content to decrease. From T0 to T7, the moisture content started off at 85.0 to 87.0 and then reached 62.0 and 82.9, respectively. With a mean value of 85.94%, T7 (olive extract 14% + sunflower oil 7%) achieved the best physiological moisture results, whereas T0 (control) had the highest mean value at 77.30%. Mean physiological moisture content values for T6, T5, T4, T3, T2, and T1 were also displayed in the results; these were 84.64%, 83.30%, 82.04%, 80.74%, 79.32%, and 77.82%, respectively. Statistics show that when guava fruit is stored at 20°C, the treatment has a substantial effect when compared to the control (Figure 1 (E). Reducing sugar showed a significant increase in guava samples treated with olive leaves extract and sunflower oil during storage at 20°C for 28 days. The combination of sunflower oil coating and olive leaf extract at seven-day intervals had a substantial impact on the guava sample's lowering sugar. After 28 days of storage, the three replications' mean values, which ranged from 4.49 to 4.32 on the first day from T0 to T7, progressively increased to 5.39 and 4.84, respectively. From the first day through the last day (28 days), the mean scores of treatments were 4.39 to 5.25, and from T0 to T7, they were 5.24 to 4.50. T0 showed the largest percentage rise (20.04%), while T7 showed the smallest gain (12.04%). These results showed that treatments were successful and guava fruit's lowering sugar values rose when stored at 20°C shown in Figure 1 (F).

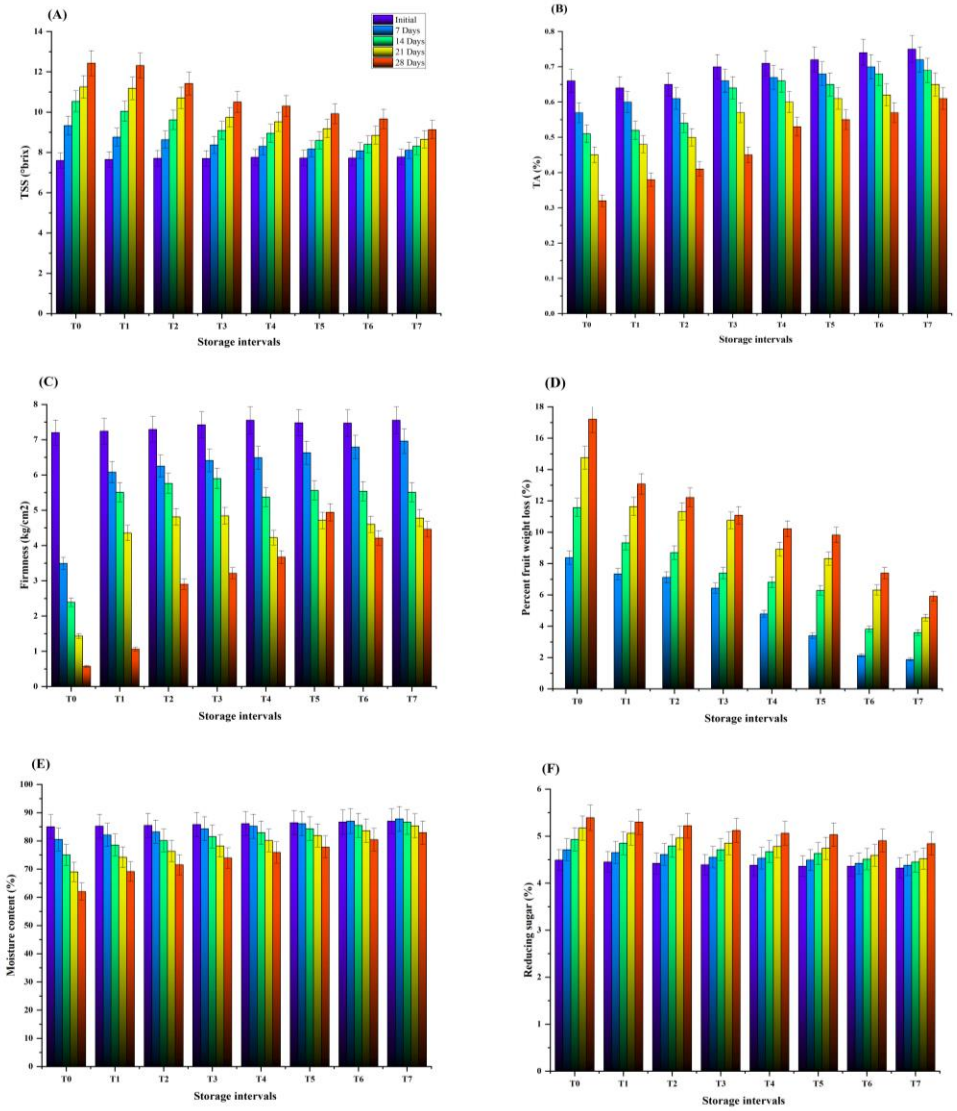


Fig 1. Total Soluble Solid (TSS °Brix), Titratable acidity (TA) (%), Firmness (kg/cm2), Percent fruit weight loss (%), Moisture content, Reducing sugar (%) effect of selected concentration of sunflower oil and olive leaf extract on the shelf life stability of guava fruit.

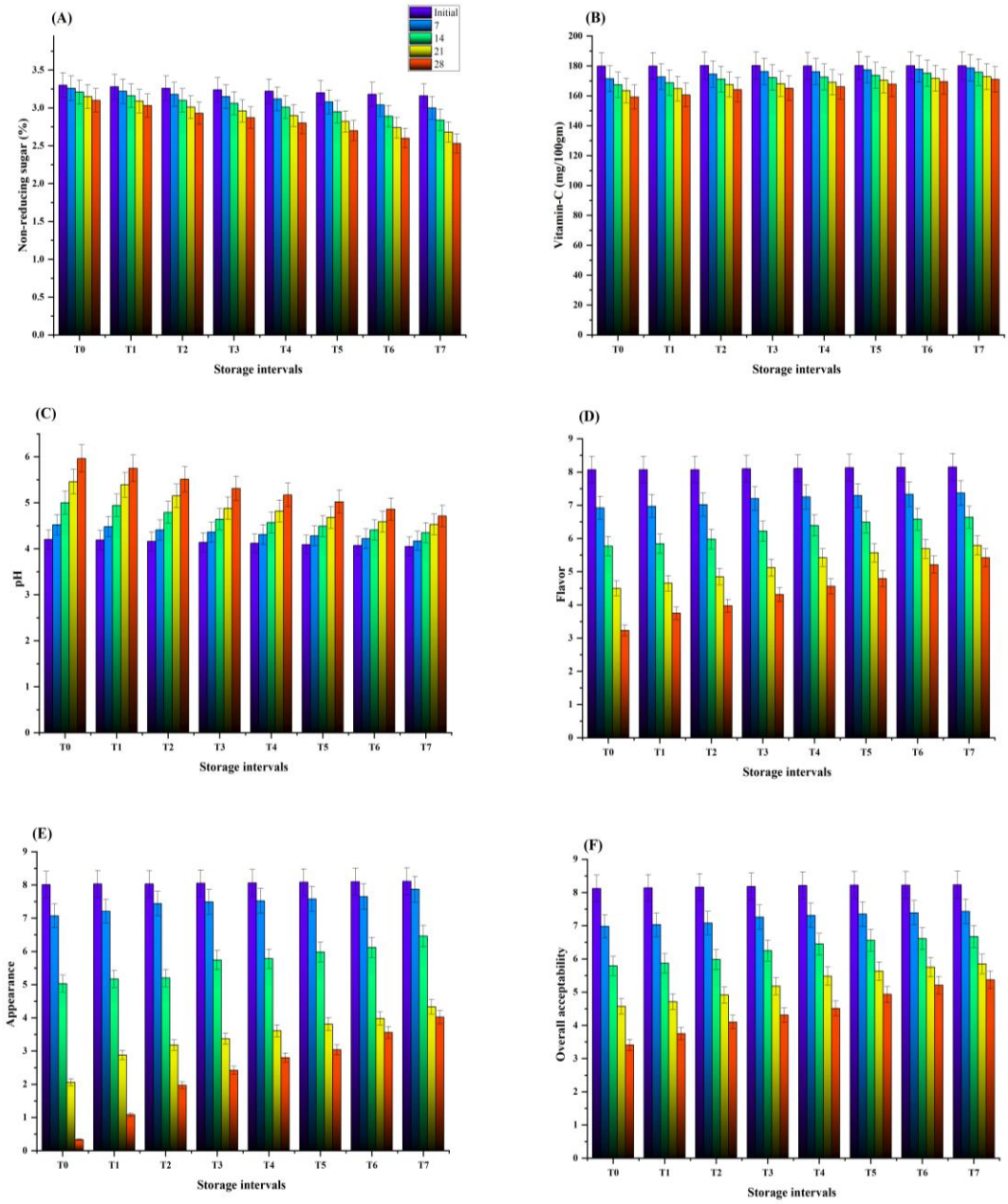


Fig 2. Non-reducing sugar (%), Vitamin-C (mg/100gm), pH, Flavor, Appearance, Overall acceptability effect of selected concentration of sunflower oil and olive leaf extract on the shelf life stability of guava fruit.

Figure 2 show the data regarding Non-reducing sugar (%), Vitamin-C (mg/100gm), pH, Flavor, Appearance, Overall acceptability effect of selected concentration of sunflower oil and olive leaf extract on the shelf life stability of guava fruit. The statistical analysis showed that both treatment and storage significantly affected on all observed parameters of guava Fruit. (Figure 2 A) The non-reducing sugar showed the significance decrease in guava samples treated with olive leaves extract and sunflower oil during storage at 20°C for 28 days. The combine effect of olive leaves extract, and sunflower oil at seven days of intervals on Non-reducing sugar in guava sample was affected significantly. The primary cause of the decrease in non-reducing sugar is the guava natural ripening process, which involves enzyme activity hydrolyzing complex carbs like sucrose into simpler reducing sugars like glucose and fructose. However, the coating materials used had a major impact on the rate of this hydrolysis. After 28 days of storage, the starting values from T0 to T7, which were 3.30 to 3.16, progressively drop to 3.10 to 2.53 accordingly. Treatment mean values ranged from 3.20 to 2.84 from T0 to T7 and from 3.23 to 2.81 from the first to the last day (28 days). T0 showed the lowest percentage decrease (6.06%), while T7 showed the largest decrease (19. 94%).The results show that treatments were successful and guava fruits non reducing sugar values dropped when stored at 20̊ C. (Figure 2 (B)) Show Vitamin-C (mg/100gm), The ascorbic acid content showed decrease during storage at 20°C for 28 days. A perishable fruit with a higher vitamin C concentration is the guava. After 28 days of storage, the original Vitamin-C content levels from T0 to T7 (179.91 to 180.11) dropped to 159.20 and 171.00, respectively. T7 (14% olive extract + 7% sunflower oil) was the most successful treatment this is much less than T0 control (distilled water alone). Between T0 and T7, the average percentage drop in Vitamin-C concentration was 11.51 and 5.06, with treatments exhibiting the least amount of loss. The mean values from day 1 to 28 day were 180.11 and 165.41, and the average value from T0 to T7 were 168.27 and 155.65. Sunflower oil performed better when combined with olive extract, and both treatments had a positive effect on the Vitamin-C content of the guava fruit over a 28-day storage period. Olive extract shows good results, though the results vary depending on concentration variation. Figure 2 (C). The pH content showed the significant decrease in guava samples treated with olive leaves extract and sunflower oil during storage at 20°C for 28 days. Most fruit's pH typically rises as it ripens. The pH values were 4.20 to 4.05 from T0 to T7 and 5.96 and 4.71 on the last days (28 days). T0 (5.03) had the highest mean value, followed by T1 (4.91), while T7 (4.36), followed by T6 (4.43), had the lowest mean value. The pH levels decreased during the 28-day storage period; the average was 4.12 on the first day and 5.29 on the last. T0 showed the largest percentage gain (29.53%), while T7 showed the smallest increase (14.01%). The flavor content showed the significance decrease in guava samples treated with olive leaves extract and sunflower oil during storage at 20°C for 28 days. After 28 days of storage, the original data, which were obtained on the first day judgment from T0 to T7, had mean values of 8.07 to 8.15, which progressively dropped to 3.23 and 5.42, respectively. The guava fruit decreased during storage, as evidenced by the average treatment values from T0 to T7, which ranged from 5.70 to 6.67, and from the first day to the last day (28 days), which ranged from 8.11 to 4.41. T0 had the largest percentage drop (59.97%), while T7 had the smallest (33.49%), demonstrating the efficacy of therapy while being stored at 20°C Figure 2 (D). The appearance showed the significant decrease in guava samples treated with olive leaves extract and sunflower oil during storage at 20°C for 28 days. Following 28 days of storage, the initial data gathered on the initial day of survey assessment between T0 to T7 showed mean values ranging from 8.00 to 8.09, which progressively dropped to 2.06 and 4.33, respectively. From day 1 to 28 days the mean ratio for treatment was 5.54 to 6.69 and 8.05 to 3.04, respectively. T0 showed the largest percentage decrease (64.09%), while T7 showed the smallest decrease (46.48%). These results showed that treatments were successful and guava fruit aesthetic values decreased when stored at 20°C C Figure 2 (E). The overall acceptability showed the significant decrease in guava samples treated with olive leaves extract

and sunflower oil during storage at 20°C for 28 days. After 28 days of storage, the original data, which was gathered on the first day of survey judgment from T0 to T7, showed mean values of 8.12 to 8.23, which progressively dropped to 3.41 and 4.56, respectively. From the first day to the last day (28 days), the mean values of treatments were 5.77 to 6.71 and 8.18 to 4.44, respectively. T0 showed the largest percentage drop (58.77%), while T7 showed the smallest (34.75%). These results showed that treatments were successful and guava fruit's general acceptance levels decreased when stored at 20°C Figure 2 (F).

Discussion

According to Chawla *et al.* (2018), the enzyme amylase digested the starch and converted it to sugar, increasing the fruit's TSS. The transformation of starches and other polysaccharides into soluble forms of sugar is what causes the early stage's increase in TSS. The beneficial compounds oleuropein and verboscoside, which suppress ethylene synthesis and enzymatic activity, are responsible for the slower TSS increase (Malik *et al.,* 2006). The lipid layer of sunflower oil creates an efficient oxygen barrier that limits breathing and postpones the metabolic conversion linked to ripening (Ranjan *et al.,* 2018). TSS may rise because of the edible coatings' decreased permeability to CO2. Sunflower oil in guava fruit positively reduced the rise in TSS (Verma *et al.,* 2023). When sunflower oil is added to olive extract treatment, the coating layer becomes thicker which lowers transpiration and respiration. As organic acid (citric acid and malic acid) decreases, so does the titratable acidity (Jia *et al.,* 2023). Because organic acids are necessary as a substrate for enzymatic respiration, there is a decrease in titratable acidity (Yaman *et al.,* 2002). Therefore, during storage, titratable acidity eventually diminishes; however, sunflower oil slows this loss (Revathi *et al* 2023). With a concentration of 3.2%, sunflower oil decreased titratable acidity and respiration. According to (Singh *et al.,*2017), sunflower oil retains greater titratable acidity at ambient temperature and in cold storage than control. kumquat fruit's titratable acidity is positively impacted by the combination of essential oil and banana olive extract (Hosseini *et al.,* 2019). When sunflower oil is added to olive extract treatment, the transparency decreases and the film thickness increases (Silva *et al.,* 2020). This reduces permeability and respiration opportunities, which in turn maintains the titratable acidity reduction, which support my findings. Wang *et al*. (2023) claim that one fruit quality is firmness metric that may be used to assess packing, shelf life, and storage conditions. Enzymes like galactosidase, glucanase, and pectin methyl-esterase are responsible for softening fruit Ali *et al.,* (2004). According to Robbins et al., (1989), hardness in red raspberries is negatively correlated with respiration. Fruit coating lowers respiration and pectin methyl-esterase activity (Garcia *et al.,* (2017). Using 1% sunflower oil and 1% cassava starch resulted in a progressive decline in fruit firmness over storage, with sunflower oil being the most successful treatment in maintaining a higher mean value. (58.59) the fruit hardness in the control samples decreased more, from 70.89 to 37.00N (Wijewardana *et al.,* 2014). Consequently, the current study illustrates how coating affects the firmness of guava fruit. When combined with olive extract, the hardness of the fruits coated with sunflower oil was higher than that of the control group. (Nasrin *et al,* 2018) According to their findings, an edible covering can lessen the likelihood of surface damage, water loss, and interactions between fruit and relative humidity that could arise from respiration during fruit storage. The findings also demonstrate that sunflower seed oil has the intended impact on fruit weight decrease while it is being stored. (Singh *et al,* 2021). The results show that fruit length was unaffected by sunflower oil during marketing and storage because it limits transpiration and respiration rate, which is supported by (Shri 2011) in grapes and Xing (2015) in jujube fruits. The results show that fruit weight loss during storage is mostly caused by transpiration and carbon atom loss, whereas transpiration is slowed down by edible covering (Kittur *et al.,* 2001). Yamanur *et al.* (2021) examined the effects of aloe vera gel, sunflower oil, and olive oil at 100% concentrations each, as well as olive oil at different concentrations of 0.5%,

1.0%, and 2.0%. Sunflower oil had the greatest weight loss reduction of any treatment, followed by olive oil by 2%. According to Silva *et al.* (2020) adding sunflower oil to an olive extract treatment thickens the film and reduces transparency. According to the findings, transpiration and carbon atom loss contribute more to fruit moisture content during storage, and edible covering slows down transpiration (Kittur *et al.,* 2001). When it came to lowering the moisture content, sunflower oil outperformed olive oil by 2%. According to Silva *et al*. (2020), adding sunflower oil to an olive extract treatment thickens the film and reduces transparency. In his findings, Rizvi (1985) demonstrates that during cold and room temperature storage, a thinner layer (0.6 mm) permits greater water loss from the fruit than a thicker one (1.0 mm). Shamshad *et al.* discovered that the amount of reducing sugar reduces at both ambient and cold (fridge) temperatures. Their findings were similar to mine. Sunflower 2% has a noticeably smaller rise in the reducing-sugar content at both temperatures. Verma *et al.* (2023) found that the 1% sunflower oil was likewise successful in raising lowering sugar. Olive oil proved successful in preserving the decreasing sugar in strawberry fruit (Hazarika *et al.,* 2019) and guava fruit (Singh *et al.,* 2017). Film thickness is increased when sunflower oil is added to the olive leaf extract procedure. According to Binsi *et al.* (2013), the film's thickness may be the cause of the treatment's increased effectiveness. According to the data presented by (Ahmad *et al.,* 2020), guavas treated with natural coating showed a slower rise in reducing sugar and a slower decrease in non-reducing sugar. Edible coating was found to slow down the conversion of non-reducing to reducing sugar during storage (Rathore *et al.,* 2007). The combined coating of olive leaf extract and sunflower oil, which slows down metabolic activities and respiration rate, may be the reason for the increase in treatment effectiveness. (Binsi *et al.,* 2013) found that olive leaf extract coating effectively delayed ripening and reduced the degradation of non-reducing sugars in guava during storage. (Sajid *et al.,* 2016) demonstrates the efficacy of these coatings in guava postharvest treatments. According to the findings, guava fruit continuously loses vitamin C when being stored after harvest (Azam *et al.,* 2020). According to Lee *et al.* (2000), vitamin C levels are lowered by exposure to the outdoors or by a rise in oxygen and carbon dioxide. The thickness of the film is increased when sunflower oil is added to the olive extract treatment (Silva *et al.,* 2020). According to this study, applying a natural coating, specifically T7 (14%olive leaf extract +7% sunflower oil), effectively preserved vitamin C in guava fruits during storage, improving their nutritional value and shelf life. This strategy encourages the adoption of environmentally friendly, plant-based preservation techniques to increase the marketability of perishable fruits, such as guava. Sothornvit (2012) noted, the guava fruit's pH rise. When it came to the pH of mango fruit, the 2% sunflower oil was more effective than the control (Eshetu *et al.,* 2019). Tussaadah et al. (2023) reported that sunflower oil had a favorable effect on guava fruit. Lemongrass essential oil and 2% sunflower oil were used to regulate the guava fruit's pH rise (Oliveira *et al*.,2020). Antioxidant-enriched edible coating preserved the acidity of coated fruits by lowering oxidative alterations. (Rojas *et al* 2008) In similar research, coated fruits maintained more organic acids than untreated controls, according to Sogvar *et al.* (2016). Coatings support the preservation of cellular integrity. The quality of the guava was maintained throughout room temperature storage thanks in large part to the application of coating, especially T6 and T7. According to my findings, sunflower oil and olive leaf extract were able to regulate the guava fruit's ph. Following storage, the flavor mean values dropped, which is in line with Kumar *et al.* (2017).'s findings that guava fruit flavor benefits from 2% sunflower oil. My findings regarding the olive leaf extract are consistent with those of Kumar *et al.* (2018), who note that the olive extract preserved the guava's general acceptability, including its flavor. The guava fruit's flavor was enhanced considerably by the combination of the coating made of olive leaf extract and sunflower oil. According to Souza *et al.* (2020), the quantities of sunflower oil and olive leaf extract create a thick layer that reduces respiration and transpiration, which in turn reduces sensory alterations. As storage increases, the apparent mean values fall, as confirmed by

Kumar *et al.* (2017). who found that 4% sunflower oil improves the appearance of guava fruit. My findings with sunflower oil are consistent with those of Pandey *et al.* (2010), who observed that sunflower oil improved the guava fruit's appearance. Depending on quantities, sunflower oil and olive leaf extract form thick layers. The coating hence lessens transpiration, respiration, and subsequently sensory alterations (Silva *et. al*, 2020). After storage, the overall acceptance mean values decreased which is consistent with the findings of Kumar *et al*. (2017), who found that 2% sunflower oil improved the overall acceptability of guava fruit. My findings with sunflower oil are consistent with those of Pandey *et al.* (2010), who observed that sunflower oil was superior in terms of the guava fruit's overall acceptance. The coating decreases respiration, transpiration, and subsequently sensory alterations because olive leaf extract and sunflower oil form thick layers based on concentrations (Silva *et al,* 2020).

Person correlation and PCA Analysis

The correlation analysis revealed very strong associations among the physico-chemical traits of guava fruit, with clear positive and negative groupings. TSS showed an almost perfect positive correlation with pH (r = 0.989) and reducing sugars (rs; r = 0.973), and a strong positive association with fruit weight (Wl; r = 0.948), while it was strongly negatively correlated with vitamin C (V-c; r = −0.976), moisture content (Mc; r = −0.965), titratable acidity (TA; r = −0.960), firmness (F; r = −0.937), ash (A; r = −0.915), and organic acids (OA; r = −0.934). TA and Mc were strongly positively correlated (r = 0.970) and both showed strong negative relationships with pH, TSS, and rs. Vitamin C exhibited strong positive correlations with firmness (r = 0.974), organic acids (r = 0.973), and ash (r = 0.951), but strong negative correlations with pH (r = −0.979), TSS (r = −0.976), rs (r = −0.973), and Wl (r = −0.972). Firmness, ash, and organic acids were almost perfectly positively correlated with each other (F–OA, r = 0.999; F–A, r = 0.986; A–OA, r = 0.985). In contrast, non-reducing sugars (Nrs) showed only moderate positive correlations with OA (r = 0.538), A (r = 0.536), F (r = 0.530), and V-c (r = 0.364), and weak relationships with most other traits. Overall, the results indicate a strong inverse relationship between sugar-related traits (TSS, rs, pH, Wl) and acid- and vitamin-related traits (TA, V-c, F, A, OA, Mc), while Nrs remained comparatively less associated with the majority of parameters.

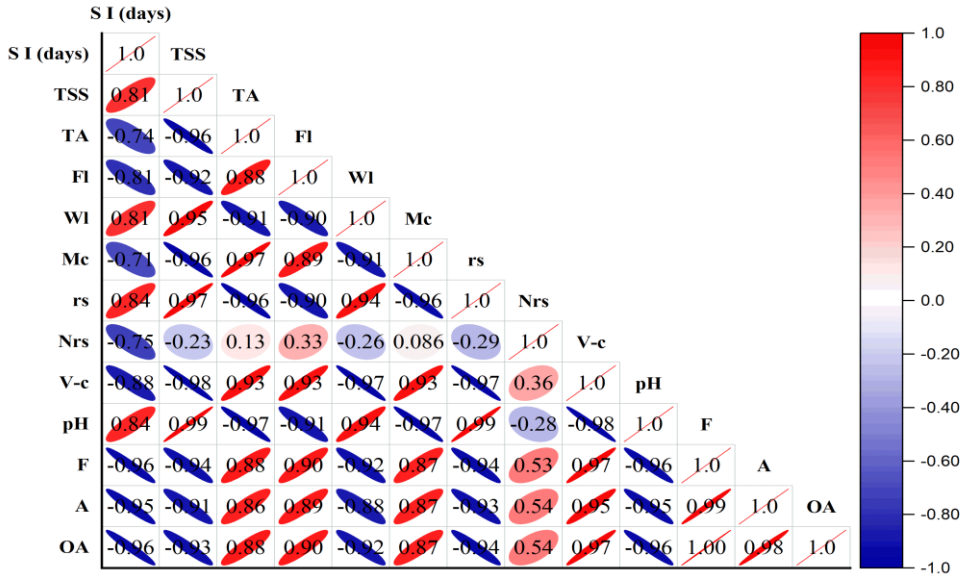


Fig.3 correlation of different attributes of guava fruit Total Soluble Solid (TSS °Brix), Titratable acidity (TA) (%), Firmness (kg/cm2), Percent fruit weight loss (%), Moisture content, Reducing sugar (%), Non-reducing sugar (%), Vitamin-C (mg/100gm), pH, Flavor, Appearance, Overall acceptability

Principal component analysis (PCA) was performed using the mean values of all studied parameters. The scree plot indicated that PC1 accounted for 87.29% of the total variance, followed by PC2 explaining 9.65%, together contributing 96.94% of the overall variability, while the remaining components showed negligible eigenvalues. The biplot revealed a clear separation of traits along PC1, where TSS, pH, reducing sugars (rs), and fruit weight (Wl) were positively loaded on the positive side of PC1, whereas titratable acidity (TA), moisture content (Mc), vitamin C (V-c), firmness (F), ash (A), and organic acids (OA) were positioned in the opposite direction, indicating strong inverse relationships between sugar-related and acid-related attributes. Non-reducing sugars (Nrs) showed a relatively higher contribution toward PC2, suggesting a distinct but comparatively smaller role in overall variability. Most of the studied traits exhibited strong loadings, confirming high correlations among parameters, with PC1 serving as the principal axis differentiating sweetness-related traits from acidity and quality-associated characteristics.

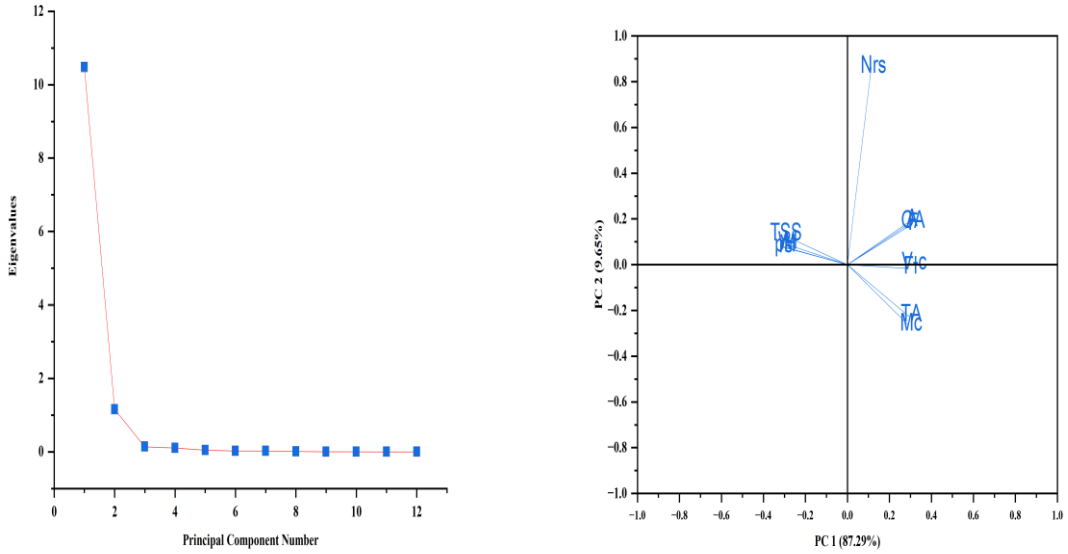


Fig.4 Principle component analysis of guava fruit

Conclusions

The results of this study revealed that storage and treatment had a significant (P≤0.05) impact on the physicochemical characteristics and sensory qualities of the edible coating made from sunflower oil and olive leaf extract for guava. Guava fruit shelf life is increased under storage conditions by edible coatings made with extract from olive leaves, which have antibacterial and antioxidant properties. Due to the antibacterial qualities of olive extract, the results showed that sunflower oil and olive leaf extract together could effectively retain hardness, reduced losses of vitamin C, total acid, and sugar, and inhibit microbial development. Treatments T6 (6% sunflower oil and 12% OLE) and T7 (7% sunflower oil and 14% OLE) had the best outcomes when compared to the other treatments, according to sensory and physiochemical research.

Recommendation

- Further research is needed on the profile of olive leaves extract.
- To study the phenolic properties of olive leaves extract and sunflower oil.
- Evaluate the economic feasibility of scaling up production of these coating for commercial use.

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