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INFLUENCE OF BIO-EDIBLE AND NANO-ENRICHED COATINGS ON ENHANCEMENT OF SHELF LIFE OF GUAVA (*PSIDIUM GUAJAVA* L.) FRUITS C.V. ALLAHABAD SAFEDA

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ABSTRACT

The present study was conducted to analyze the effects of different bio-edible and nanoparticle enriched coatings on the shelf life of guava fruits c.v. Allahabad Safeda. The study was conducted at School of Agriculture, ITM University, Gwalior in the year 2023-24. Fourteen treatment combination of bio-edible and nanoparticle coatings were applied on guava fruits to check their effects on fruit weight, polar diameter, equator diameter, fruit firmness, pH, total soluble solids, total titratable acidity and vitamin C content of fruit juice of guava fruits. The experiment was laid in Completely Randomized Design with three replications in each treatment. The treatments consisted of several combinations of aloe vera gel coatings such as with tulsi extract, neem extract, periwinkle extract, titanium dioxide nanoparticles, colloidal silver nanoparticles and zinc oxide nanoparticles. Out of all the treatment combinations, treatment T_3 (Aloe vera 250 ml extract / gel+ periwinkle extract 12.5ml) proved to be the best treatment for enhancing the shelf life of guava fruits and reducing the post-harvest losses to a great extent.

Key words : Guava, Bio-Edible Coating, Nanoparticle Coating, Shelf life.

Introduction

Guava (*Psidium guajava* L.) a fruit of family Myrtaceae with chromosome number 2n=2x=22 is one of the most important tropical and subtropical fruits globally. It is native to and widely distributed in Mexico and Central America. However, the plant is cultivated today from the west coast of Africa to the Pacific region, including India and China, with varieties originally introduced over the past 300 years from the United States. It was introduced in India by the Portuguese in the 17th century.

Psidium guajava Linn. is a large tropical evergreen shrub or small shade tree. Generally, guava plant has spread widely throughout the tropics because it thrives in a variety of soils, propagates easily, and bears fruit relatively quickly. It bears fruit twice in a year but the best quality fruit is obtained in winter (Bal and Dhaliwal, 2004). The guava berry is an important tropical fruit that is mostly consumed fresh (Lapik *et al.*, 2005). It is the fourth most important fruit after mango, banana, and citrus.

It has a high nutritive value and can be grown under different soil and climatic conditions. Guava is a hundred percent edible fruit and is considered as 'Apple of the poor' due to its low cost, easy availability and high nutritive value. Guava contains both carotenoids and polyphenols – the major classes of antioxidant pigments – giving them relatively high potential antioxidant value among plant foods (Escrig *et al.*, 2001).It plays an important role in reducing nutritive disorders due to deficiency of vitamin C in human health (Archana and Siddiqui, 2004).

India is home to several famous guava varieties, including Khaja (Bengal Safeda), Chittidar, Harija, Lalit, Pant Prabhat, Dhareedar, and Arka Mridula. Hybrid species such as Kohir, Safed Jam, and Arka Amulya furthermore, Allahabad Safeda was developed. Guava (*Psidium guajava* L.) is one of the important commercial fruits in India. According to Horticultural Statistics at a Glance (2021) in India, the total area of guava was 3.08 lakh ha and recorded a total production of 45.82 lakh MT.

The guava harvesting point for 'in nature' marketing varies according to the destination of final consumption. However, because it is a climacteric fruit, the maturation process continues even after harvesting, exhibiting a high respiration rate due to metabolic activities, which contributes to its rapid perishability, preventing its storage for long duration (Nair *et al*., 2018).

Applications of nanoparticles (nano ZnO_2) also represents an alternative to improve and modify the physicochemical properties of biopolymer films and hydrogels. Fruit quality is associated with management and climatic conditions during the production phase, so it is necessary to use other processes to prevent microbiological deterioration and minimize the physiological and biochemical changes responsible for post-harvest degradation of fruits (Guerreiro *et al*., 2016).

Nano-enriched coatings are applied on guava fruits to extend their shelf life by reducing the rate of spoilage and preserving their quality. They work by reducing water loss, they form a barrier that minimizes water loss from the fruit, which helps maintain its firmness and juiciness. These coatings regulates the exchange of gases like oxygen and carbon dioxide, which can slow down the respiration rate and delay ripening and senescence. They can incorporate antimicrobial agents that inhibit the growth of spoilage microorganisms and pathogens, reducing decay. The coatings can provide a protective layer that reduces mechanical damage during handling and transportation. They help maintain the fruit's natural color and gloss, making it more appealing to consumers. By slowing down metabolic processes, nano-coatings helps to preserve the nutritional content of the fruit over a longer period.

Materials and Methods

The present study was conducted at Post Harvest Laboratory, School of Agriculture, ITM University, Sitholi, Gwalior, Madhya Pradesh, India.

Climatic conditions : Sithouli is located at 26.146° N, latitude and 78.187°E longitude at altitude 227 m MSL. The subtropical climate in Gwalior has both summer and winter seasons. It can get as hot as 46 degrees Celsius in the summer and as cold as 3^0C to 7^0C in the winter. Winter and summer rains are unusual, especially from July through September.

Treatment combinations : The current investigation was performed in the year 2023-24 in order to test the response of guava fruits *c.v.* Allahabad Safeda for bio-edible and nano-enriched coatings. The experiment was aid in Completely Randomized Design having fourteen treatments and three replications. Table 1 represents the treatment combinations.

Table 1 : Treatment combinations.

Symbol	Treatment combinations
T_0	Control
T_1	Aloe vera 250 ml extract /gel + Tulsi extract 12.5ml
T_2	Aloe vera 250 ml extract / gel + Neem extract 12.5ml
T_3	Aloe vera 250 ml extract / gel+ periwinkle extract 12.5ml
T_4	Aloe vera 250 ml extract/gel + Titanium dioxide (TiO_2) (NP) 5 ppm
T_5	Aloe vera 250 ml extract / gel + Titanium dioxide (TiO_2) (NP) 15 ppm
T_6	Aloe vera 250 ml extract / gel + Titanium dioxide (TiO_2) (NP) 25 ppm
T_7	Aloe vera 250 ml extract / gel + Silver NP 5 ppm
T_8	Aloe vera 250 ml extract / gel + Silver (NP) 15 ppm
T_9	Aloe vera 250 ml extract / gel + Silver (NP) 25 ppm
T_{10}	Aloe vera 250 ml extract / gel + Zinc oxide (NP) 5 ppm
T_{11}	Aloe vera 250 ml extract / gel + Zinc (NP) 15 ppm
T_{12}	Aloe vera 250 ml extract / gel + Zinc (NP) 25 ppm
T_{13}	Only aloe vera extract

Preparation of Aloe vera extract: For the preparation of aloe vera extract, fresh aloe vera leaves were collected from Tapovan Government Plant Nursery, Gwalior. Leaves were washed thoroughly with distilled water 2-3 times to remove the dirt and dust particles from them. After washing, the rind of the leaves were removed and the gel was extracted. The extracted gel was grinded in a mixer grinder to get uniform consistency. 250ml of the prepared aloe vera extract was measured in a measuring cylinder and was utilized for coating of the fruits.

Preparation of Tulsi extract : For the preparation of tulsi extract, fresh tulsi leaves were collected and washed thoroughly with distilled water 2-3 times. After washing the leaves were crushed in pestle and mortar. The coating was made up by adding 80% acetone and 20% distilled water to the crushed leaves. 12.5ml of the prepared tulsi extract was measured by measuring cylinder and was used for coating of fruits

Preparation of Neem extract : Neem extract was prepared by collecting fresh neem leaves. The leaves were washed 2-3 times with distilled water to remove the dirt and dust particles. Followed by crushing of leaves with pestle and mortar to prepare a fine paste and addition of 80% acetone and 20% water to make up a consistent coating. For coating the fruits 12.5ml of the freshly prepared extract was measured by measuring cylinder.

Preparation of Periwinkle extract : Fresh leaves of periwinkle were collected and washed thoroughly with distilled water 2-3 times. The leaves were then crushed in pestle and mortar to get a uniform paste. To the paste 80% acetone and 20% distilled water was added to prepare a uniform coating. Fruits were coated by using 12.5ml of the freshly prepared extract which was measured by measuring cylinder.

Titanium dioxide NP : Titanium dioxide nanoparticles nanopowder (99.9%) was purchased from the market. To prepare 5ppm solution of titanium dioxide nanoparticle, 5mg of the powdered nanoparticle was added in 1000ml of distilled water in a measuring cylinder. To prepare 15ppm solution of titanium dioxide nanoparticle, 15mg of the powdered nanoparticle was added in 1000ml of distilled water in a measuring cylinder. To prepare 25ppm solution of titanium dioxide nanoparticle, 25mg of the powdered nanoparticle was added in 1000ml of distilled water in a measuring cylinder.

Colloidal Silver NP : Colloidal Silver nanoparticles was purchased from the market. To prepare 5ppm solution of colloidal silver nanoparticle, 5ml of the colloidal nanoparticle solution was added in 1000ml of distilled water in a measuring cylinder. To prepare 15ppm solution of colloidal silver nanoparticle, 15ml of the colloidal nanoparticle solution was added in 1000ml of distilled water in a measuring cylinder. To prepare 25ppm solution of colloidal silver nanoparticle, 25ml of the colloidal silver nanoparticle solution was added in 1000ml of distilled water in a measuring cylinder.

Zinc oxide NP : Zinc oxide nanoparticles nanopowder (99.9%) was purchased from the market. To prepare 5ppm solution of zinc oxide nanoparticle, 5mg of the powdered nanoparticle was added in 1000ml of distilled water in a measuring cylinder. To prepare 15ppm solution of zinc oxide nanoparticle, 15mg of the powdered nanoparticle was added in 1000ml of distilled water in a measuring cylinder. To prepare 25ppm solution of zinc oxide nanoparticle, 25mg of the powdered nanoparticle was added in 1000ml of distilled water in a measuring cylinder.

Collection of fruits : Fresh guava fruits were collected from the guava orchard and washed thoroughly with distilled water 2-3 times to remove the dirt and dust particles.

Coating of fruits : To coat the fruits with uniform coating of various bio-edible and nanoparticles, the freshly plucked and washed fruits were dipped in different freshly prepared solutions according to the treatment combinations.

Physical parameters

Fruit weight (g) : Three fruits per treatment were weighed on an electronic balance and average weight (g) was obtained by dividing the total weight of the fruits with the number of fruits. The weight of the fruits were measured at 0, 4th, 8th, 12th and 16th day after coating. The weight of the fruits was expressed in grams.

Average fruit weight = Total weight of fruits (g)/ Number of fruits

Polar diameter (mm) : The polar diameter of the fruits were measured at 0, 4th, 8th, 12th and 16th days after coating. Vernier calipers was utilized to obtain the polar diameter of fruits. The polar diameter of the fruits was expressed in millimeters.

Equator diameter (mm) : The equator diameter of the fruits were measured at 0,4th, 8th, 12th and 16th days after coating. Vernier calipers was utilized to obtain the polar diameter of fruits. The equator diameter of the fruits was expressed in millimeters.

Firmness (lbf) : To determine the firmness of fruit penetrometer model no FT-327, manufactured in USA, was utilized at every interval. Treated and untreated fruits, after removing of thin peel were punctured with a stainless-steel probe with a plunger (1 cm) facing opposite points to each other on the fruit surface. The firmness of the fruits was expressed in pounds-force.

Biochemical parameters

pH : The pH of the fruit juice was determined with pH meter

Total Soluble Solids (ºBx) : Fruit juice was extracted by crushing the fruits followed by filtering of juice through muslin cloth. The TSS of the extracted juice was determined with the help of computerized hand refractometer. TSS was expressed in ºBx.

Total Titrable Acidity : 2ml of the extracted fruit juice was taken in a volumetric flask. 180ml of distilled water was added to it to make up the final volume 20ml. 0.1N NaOH solution was used to titrate the fruit juice, utilizing phenolphthalein as an indicator. During the process of titration, the color change of the solution into light pink indicated the end point of titration. The following equation was adopted to determine the total titrable acidity:

$$TA = \frac{0.0067 \times 0.1N\ NaOH(ml) \times 100}{\text{Volume of juice taken (ml)}}$$

Vitamin C : To determine the ascorbic acid content of guava fruit fresh 2, 6-dichlorophenol indophenols dye (DCPIP) was used. The rate of titre was recorded and calculated according to the Ranganna method (2000). Reagents used are as follows: Metaphosphoric acid and acetic acid, Indophenols and Ascorbic acid.

For standardization of indophenol dye 2ml of ascorbic acid was taken in a volumetric flask, then 5ml of metaphosphoric acid and acetic acid was added to it. For quick titration indophenols was applied until the appearance of rose pink color. The color factor was determined by the following formula:

$$\text{Dye factor} = \frac{\text{Concentration of ascorbic acid/ml}}{\text{Volume of dye used}}$$

To determine the vitamin C content from fruit juice the following procedure was adopted. 2ml of fruit juice was taken in a volumetric flask, 5ml of metaphosphoric acid and acetic acid was added to it and titration was performed with indophenols. The volume of indophenols utilized was measured. Vitamin C content was expressed in mg $100g^{-1}$. The following formula was adopted to estimate the vitamin C content of guava fruits:

$$\text{Vitamin C (mg/100g)} = \frac{\text{Vol of dye used} \times \text{Dye factor} \times \text{Vol made 100 ml}}{\text{Vol of the sample taken} \times \text{Weight of the sample}}$$

Results and Discussion

Physical parameters

Fruit weight (g) : The weight of the fruits reduced gradually with the increasing number of storage days irrespective of the treatments. The maximum weight of the fruits on 0, 4^{th}, 8^{th}, 12^{th} and 16^{th} day was recorded in treatment T_3 (Aloe vera 250 ml extract / gel+ periwinkle extract 12.5ml) *i.e.* 167g, 157g, 155g, 151g and 142g, respectively. Followed by treatment T_5 (Aloe vera 250 ml extract / gel + Titanium dioxide (TiO,) (NP) 15 ppm) with 155.67g, 144.33g, 137.66g, 123.66g and 119.66g, respectively. While the lowest fruit weight was observed in control with 95.33g, 83.66g, 76.66g, 63.66g and 57.66g, respectively. The findings are in agreement with Tripathi and Dubey (2004), who reported that aloe vera gel (100%) was helpful to preserve papaya fruits under room temperature (25-29°C) and relative humidity 82-84%. The uncoated papaya fruits showed 22.5% loss in weight, whereas the weight loss of coated fruits was 7.93%. Table 2 represents the weight of fruits at different intervals.

Polar diameter (mm) : A gradual reduction in the polar diameter of the fruits was noticed with the increased number of storage days. The fruits coated with treatment T_3 (Aloe vera 250 ml extract / gel+ periwinkle extract 12.5ml) showed the maximum polar diameter at 0,4^{th}, 8^{th}, $12^{th,}$ and 16^{th} day of coating with 75.66mm, 68.66mm, 63.66mm, 57.66mm and 54.66mm, respectively. The result is in accordance with Sree *et al.* (2022), who reported that edible coatings based on aloe vera gel and its

Table 2 : Influence of bio-edible and Nano enriched coating on fruit weight of guava.

Treatment	0-day (g)	4^{th} day (g)	8^{th} day (g)	12^{th} day (g)	16^{th} day (g)
T_0	95.33 ± 1.19	83.66 ± 2.02	76.66 ± 1.45	63.667 ± 1.45	57.667 ± 1.45
T_1	137.33 ± 0.86	125.66 ± 1.85	111.66 ± 1.66	99.667 ± 1.66	83.667 ± 1.76
T_2	135.66 ± 0.26	123.66 ± 1.85	106.66 ± 1.76	93.667 ± 1.76	79.667 ± 1.45
T_3	167.00 ± 1.21	157.66 ± 2.02	155.00 ± 2.64	151.667 ± 2.96	142.667 ± 2.02
T_4	129.33 ± 0.03	111.33 ± 1.45	104.33 ± 1.76	90.333 ± 1.76	77.667 ± 1.66
T_5	155.67 ± 1.30	144.33 ± 1.85	137.66 ± 2.02	123.667 ± 2.02	119.667 ± 2.02
T_6	135.33 ± 0.86	123.00 ± 2.08	117.33 ± 1.20	105.667 ± 2.02	96.667 ± 1.45
T_7	134.99 ± 0.02	125.00 ± 1.73	115.66 ± 1.45	101.667 ± 0.88	94.333 ± 1.20
T_8	133.00 ± 0.01	120.33 ± 0.33	114.66 ± 1.45	102.667 ± 1.45	89.667 ± 2.02
T_9	130.67 ± 0.34	119.00 ± 1.15	113.66 ± 0.88	101.667 ± 1.45	86.667 ± 1.45
T_{10}	149.99 ± 0.04	140.00 ± 1.15	129.66 ± 1.45	116.667 ± 1.45	106.667 ± 1.45
T_{11}	124.67 ± 0.25	114.66 ± 1.45	100.66 ± 1.45	87.667 ± 1.45	76.667 ± 0.88
T_{12}	138.66 ± 0.15	131.33 ± 1.76	119.66 ± 2.02	104.667 ± 1.45	99.667 ± 1.45
T_{13}	137.00 ± 0.86	126.66 ± 1.76	117.66 ± 1.45	104.333 ± 1.20	99.333 ± 1.76
C.D.	2.06	4.86	4.86	4.97	4.68
SE(m)	0.70	1.67	1.67	1.70	1.60

Table 3 : Influence of bio-edible and Nano enriched coating on polar diameter of guava fruits.

Treatment	0-day (mm)	4th day (mm)	8th day (mm)	12th day (mm)	16th day (mm)
T_0	40.667 ± 0.66	38.667 ± 1.45	35.667 ± 1.45	31.667 ± 1.45	27.667 ± 1.45
T_1	58.667 ± 1.45	51.333 ± 1.20	46.333 ± 1.20	40.333 ± 1.20	36.333 ± 1.20
T_2	58.333 ± 1.76	49.333 ± 1.76	43.667 ± 1.76	38.667 ± 1.76	33.667 ± 1.76
T_3	75.667 ± 2.02	68.667 ± 2.02	63.667 ± 2.02	57.667 ± 2.02	54.667 ± 2.08
T_4	53.667 ± 1.76	39.667 ± 1.45	43.333 ± 1.76	37.333 ± 1.76	31.667 ± 1.43
T_5	66.667 ± 1.66	59.667 ± 0.88	53.667 ± 0.88	49.667 ± 0.88	44.667 ± 0.88
T_6	64.667 ± 1.45	56.667 ± 1.45	52.667 ± 1.45	49.667 ± 2.02	40.667 ± 1.66
T_7	60.667 ± 1.45	55.667 ± 1.45	49.667 ± 1.45	45.667 ± 1.45	39.667 ± 1.45
T_8	60.333 ± 1.20	54.667 ± 2.02	49.667 ± 2.02	43.667 ± 1.45	38.667 ± 1.45
T_9	61.667 ± 2.02	52.667 ± 1.45	47.667 ± 1.45	43.667 ± 2.02	38.667 ± 2.02
T_{10}	66.667 ± 1.45	60.667 ± 1.45	54.667 ± 2.02	48.667 ± 1.66	43.667 ± 1.45
T_{11}	45.667 ± 1.45	48.667 ± 1.76	36.333 ± 0.66	34.333 ± 0.88	29.333 ± 1.76
T_{12}	67.667 ± 2.02	60.333 ± 2.02	52.667 ± 1.45	48.667 ± 1.45	43.333 ± 1.45
T_{13}	64.667 ± 0.88	55.667 ± 1.66	51.667 ± 1.66	48 ± 1.15	42.333 ± 2.33
C.D.	4.57	4.68	4.57	4.54	4.76
SE(m)	1.57	1.60	1.57	1.56	1.63

Table 4 : Influence of bio-edible and Nano enriched coating on equator diameter of guava fruits.

Treatment	0-day (mm)	4th day (mm)	8th day (mm)	12th day (mm)	16th day (mm)
T_0	49.66 ± 1.76	44.00 ± 1.15	39.33 ± 1.76	39.33 ± 1.76	31.33 ± 1.76
T_1	54.66 ± 1.45	49.67 ± 1.45	45.66 ± 1.45	42.00 ± 1.00	37.33 ± 1.20
T_2	54.33 ± 1.20	48.33 ± 1.66	42.33 ± 1.20	42.67 ± 2.02	37.66 ± 2.02
T_3	64.66 ± 2.02	56.66 ± 1.45	51.66 ± 1.45	50.66 ± 1.45	44.66 ± 1.66
T_4	50.66 ± 1.45	45.66 ± 1.45	40.66 ± 1.45	40.66 ± 1.45	32.66 ± 1.45
T_5	61.66 ± 1.45	53.00 ± 4.93	49.66 ± 1.66	49.33 ± 1.86	41.66 ± 2.02
T_6	58.67 ± 1.45	53.67 ± 1.45	50.66 ± 2.02	49.66 ± 2.08	43.66 ± 2.02
T_7	59.66 ± 2.02	51.66 ± 0.88	47.66 ± 0.88	46.00 ± 1.15	39.66 ± 1.45
T_8	55.66 ± 0.88	53.66 ± 2.02	49.66 ± 2.02	46.66 ± 2.08	39.67 ± 1.45
T_9	55.66 ± 1.45	50.66 ± 1.45	48.66 ± 2.02	44.66 ± 1.43	40.66 ± 2.02
T_{10}	61.66 ± 2.02	53.66 ± 1.66	49.66 ± 1.45	49.66 ± 1.43	44.66 ± 1.45
T_{11}	51.33 ± 1.76	45.33 ± 1.76	39.66 ± 1.76	39.66 ± 1.74	32.66 ± 1.76
T_{12}	58.67 ± 1.66	54.67 ± 1.45	48.66 ± 0.88	49.66 ± 1.43	44.67 ± 1.45
T_{13}	59.66 ± 1.45	55.67 ± 2.02	49.67 ± 1.45	47.66 ± 0.82	41.66 ± 0.88
C.D.	4.68	5.82	4.59	4.64	4.81
SE(m)	1.60	2.00	1.57	1.59	1.65

combinations applied to tomato, Improved its quality and shelf life during storage. The physical parameters of the coated and uncoated tomato samples were determined through ambient storage for a period of 30 days. At the same time, the minimum polar diameter of the fruits was recorded under control with 40.66mm, 38.66mm, 35.66mm, 31.66 and 27.66mm at 0,4th, 8th, 12th and 16th days after coating, respectively. Table 3 depicts the response of various coatings on the polar diameter of fruits.

Equator diameter (mm) : As concerned with the equator diameter of the fruits, it was found decreasing simultaneously with the increasing time period. Treatment T_0 *i.e.* control recorded the minimum fruit equator diameter at 0, 4th, 8th, 12th and 16th days after coating with 49.66mm, 44mm, 39.33mm, 39.33 and 31.33mm, respectively. Whereas, the maximum equator diameter was observed under treatment T_3 (Aloe vera 250 ml extract / gel+ periwinkle extract 12.5ml) with 64.66mm, 56.66mm, 51.66mm, 50.66mm and 44.66mm at different intervals. The result is in agreement with Martinez-Romero *et al.* (2006), Marpudi *et al.* (2011) and Asghari

Table 5 : Influence of bio-edible and Nano enriched coating on firmness of guava fruits.

Treatment	0-day (kg/m^3)	4th day (kg/m^3)	8th day (kg/m^3)	12th day (kg/m^3)	16th day (kg/m^3)
T_0	7.46 ± 0.44	7.03 ± 0.03	5.70 ± 0.36	4.70 ± 0.36	3.33 ± 0.08
T_1	10.10 ± 0.52	10.08 ± 0.33	7.83 ± 1.45	6.83 ± 1.45	7.96 ± 0.79
T_2	10.46 ± 0.48	10.90 ± 0.28	10.83 ± 0.33	9.83 ± 0.33	7.83 ± 0.33
T_3	11.96 ± 0.42	10.50 ± 1.52	9.50 ± 1.52	8.50 ± 1.52	8.50 ± 2.46
T_4	9.43 ± 0.43	9.03 ± 0.57	8.03 ± 0.57	7.03 ± 0.58	8.50 ± 0.57
T_5	11.43 ± 0.39	11.33 ± 1.20	10.33 ± 1.22	9.33 ± 1.22	9.00 ± 0.57
T_6	11.13 ± 0.58	8.33 ± 0.88	10.50 ± 0.28	9.50 ± 0.29	8.16 ± 0.81
T_7	9.96 ± 0.37	9.43 ± 0.06	7.33 ± 0.82	6.33 ± 0.82	8.43 ± 0.56
T_8	9.43 ± 0.4	9.83 ± 0.33	8.43 ± 0.07	7.43 ± 0.07	7.33 ± 0.23
T_9	9.43 ± 0.4	8.50 ± 0.57	7.50 ± 0.57	6.50 ± 0.57	6.86 ± 0.48
T_{10}	11.46 ± 0.37	11.00 ± 1.00	10.00 ± 1.00	9.00 ± 1.00	8.83 ± 1.17
T_{11}	8.46 ± 0.37	6.73 ± 0.39	7.16 ± 0.67	6.17 ± 0.67	8.16 ± 0.61
T_{12}	10.96 ± 0.16	9.83 ± 0.88	9.50 ± 0.57	8.50 ± 0.57	10.50 ± 0.29
T_{13}	10.93 ± 0.46	8.83 ± 1.45	8.13 ± 0.87	7.83 ± 0.82	7.73 ± 1.32
C.D.	1.24	2.40	2.48	2.48	2.78
SE(m)	0.42	0.82	0.85	0.85	0.94

Table 6 : Influence of bio-edible and Nano enriched coating on pH of guava fruit juice

Treatment	0-day	4th day	8th day	12th day	16th day
T_0	4.483±0.15	5.09± 0.19	5.65 ± 0.18	5.67 ± 0.15	6.06 ± 0.32
T_1	4.06 ±0.21	4.78 ± 0.22	5.05 ± 0.22	5.51 ± 0.13	5.55 ± 0.28
T_2	4.04 ± 0.13	4.77 ± 0.12	5.04 ± 0.02	5.41 ± 0.02	5.41 ± 0.21
T_3	3.87 ± 0.17	4.33 ± 0.12	4.59 ± 0.13	4.79 ± 0.37	4.81 ± 0.62
T_4	4.00 ± 0.15	4.76 ± 0.02	5.00 ± 0.13	5.26 ± 0.15	5.54 ± 0.26
T_5	3.93 ± 0.02	4.56 ± 0.13	4.85 ± 0.22	5.08 ± 0.22	5.16 ± 0.62
T_6	4.39 ± 0.12	5.07 ± 0.21	5.57 ± 0.19	5.66 ± 0.13	5.47 ± 0.59
T_7	4.37 ± 0.19	5.06 ± 0.15	5.36 ± 0.12	5.62 ± 0.15	5.72 ± 0.09
T_8	4.34 ± 0.02	4.86 ± 0.15	5.27 ± 0.21	5.62 ± 0.19	5.64 ± 0.27
T_9	4.21 ± 0.36	4.79 ± 0.22	5.17 ± 0.12	5.53 ± 0.12	5.68 ± 0.41
T_{10}	3.91 ± 0.13	4.48 ± 0.13	4.72 ± 0.13	5.07 ± 0.18	5.27 ± 0.22
T_{11}	3.99 ± 0.21	4.63 ± 0.12	4.93 ± 0.12	5.28 ± 0.02	5.50 ± 0.11
T_{12}	3.88 ± 0.13	4.43 ± 0.34	4.69 ± 0.06	4.84 ± 0.13	4.97 ± 0.13
T_{13}	3.96 ± 0.12	4.57 ± 0.15	4.88 ± 0.15	5.08 ± 0.22	5.14 ± 0.38
C.D.	**0.54**	**0.54**	**0.55**	**0.56**	**0.054**
SE(m)	**0.26**	**0.18**	**0.19**	**0.27**	**0.21**

et al. (2013), who reported that *Aloe vera* gel can be used as an edible coating. It prevents loss of moisture and softening, control respiration and senescence rate, reduce oxidative browning and microorganism contamination in fruit *viz.* sweet cherries, table grapes, nectarines and papaya. Table 4 represents the equator diameter of fruits at different treatment combinations.

Firmness (lbf) : The firmness of the fruits reduced gradually with the increase in the number of storage days. The highest fruit firmness at 0, 4th, 8th, 12th and 16th day was recorded in treatment T_3 (Aloe vera 250 ml extract / gel + periwinkle extract 12.5ml) with 11.96lbf, 10.5lbf, 9.5lbf, 8.5lbf and 8.5lbf, respectively. While the lowest fruit firmness was recorded in control with 7.46lbf, 7.03lbf, 5.7lbf, 4.7lbf, 3.3lbf, respectively. The findings are in accordance with Brishti *et al.* (2013), who found that papaya treated with 100% *Aloe vera* gel-maintained fruit firmness for eight days at 25°C-29°C and 82-84% RH. This indicated that the ripening of coated fruit was delayed by delaying softening. Table 5 represents the fruit firmness at different intervals (Fig. 1).

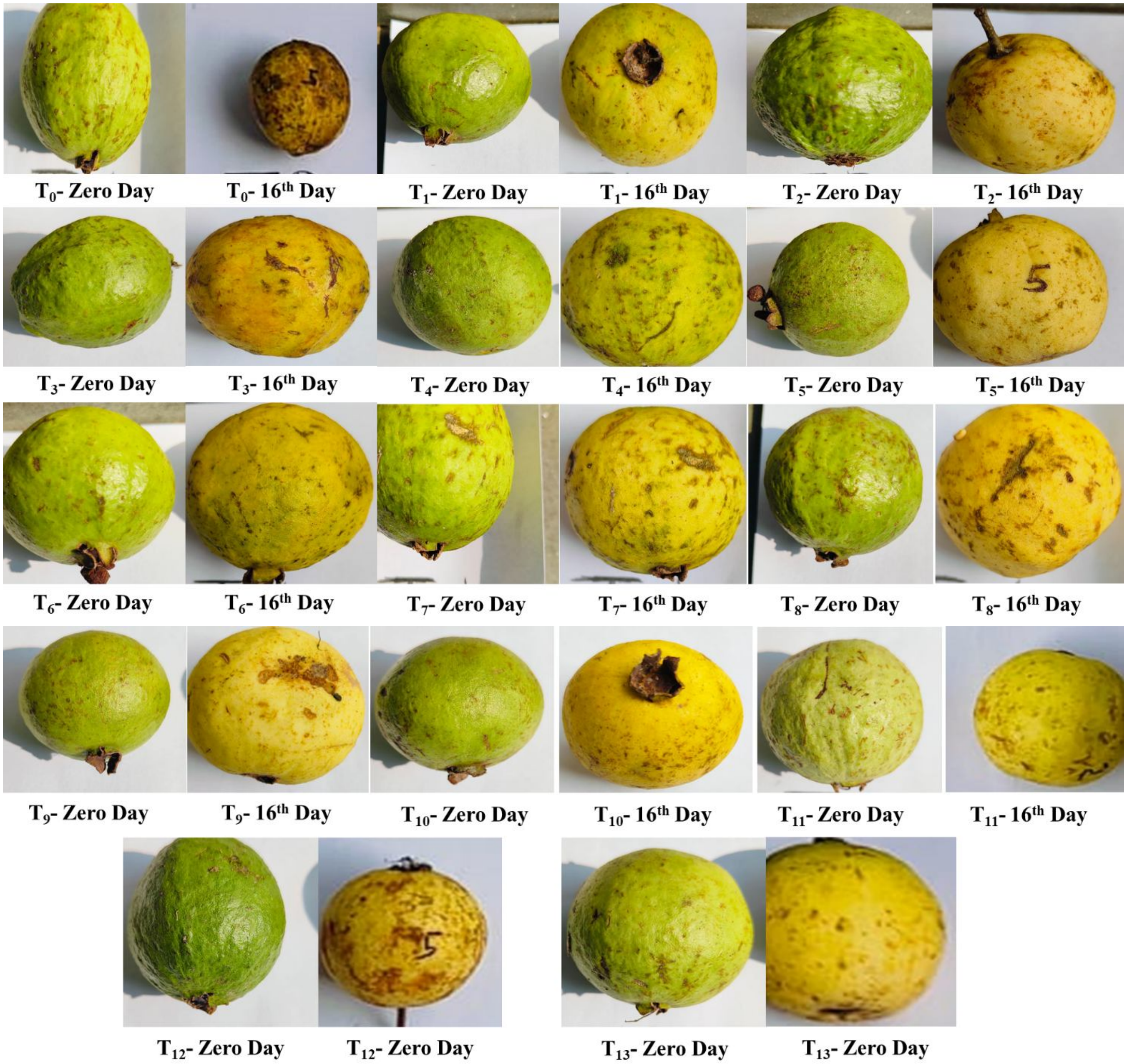

Fig. 1 : Day (Zero day and 16th day) wise comparison of Guava Physical attributes.

Biochemical parameters

pH : A gradual increase in the pH of the fruit juice was noticed with the increased number of storage days. The lowest pH at 0 day (3.87) was recorded in treatment T_3 (Aloe vera 250 ml extract / gel+ periwinkle extract 12.5ml), which gradually increased on 4th,8th,12th and 16th day after coating as 4.34, 4.59, 4.80 and 4.81. While the highest pH at 0 day (4.48) was recorded in control. The findings are in accordance with Kumar and Bhatnagar (2014), who reported that a coating of aloe vera gel (25 and 33%) maintained fruit juice pH of papaya. Table no.6 shows the pH of guava fruit juice for different treatment combinations at various intervals.

Total Soluble Solids (ºBx) : An enhancement in the total soluble solids was recorded with the increase in the number of storage days. The highest TSS at 0 day (5.8°Bx) was observed in treatment T_0 (control) while the lowest TSS at 0 day was observed in treatment T_3 (Aloe vera 250 ml extract / gel + periwinkle extract 12.5ml) which gradually increased with increase in a number of days as 3.13°Bx, 3.47°Bx, 3.83°Bx, 4.97°Bx and 5.30°Bx. The results are in agreement with Mani *et al.* (2017), who reported that aloe vera coated ber fruits showed lower TSS as compared to uncoated fruits. Sharma *et al.* (2015) observed that during storage of 12 days, 1.5% aloe vera gel-treated papaya fruits showed

Table 7 : Influence of bio-edible and Nano enriched coating on TSS of guava fruit juice.

Treatment	0-day (ºBx)	4th day (ºBx)	8th day (ºBx)	12th day (ºBx)	16th day(ºBx)
T_0	5.26 ± 0.08	5.60 ± 0.115	5.96 ± 0.12	6.30 ± 0.115	5.63 ± 0.318
T_1	5.76 ± 0.37	6.40 ± 0.115	6.46 ± 0.176	8.30 ± 0.058	6.40 ± 0.252
T_2	5.66 ± 0.37	5.86 ± 0.033	6.43 ± 0.145	7.46 ± 0.145	6.10 ± 0.416
T_3	7.26 ± 0.14	8.13 ± 0.067	8.86 ± 0.12	9.63 ± 0.142	9.06 ± 0.067
T_4	4.40 ± 0.32	5.20 ± 0.379	6.03 ± 0.354	7.16 ± 0.41	5.36 ± 0.24
T_5	5.46 ± 0.29	7.13 ± 0.393	7.30 ± 0.351	8.53 ± 0.517	8.13 ± 0.606
T_6	5.66 ± 0.33	6.26 ± 0.067	6.66 ± 0.88	7.40 ± 0.153	6.73 ± 0.067
T_7	5.47 ± 0.24	6.43 ± 0.233	6.56 ±0.145	7.40 ± 0.493	6.86 ± 0.433
T_8	4.90 ± 0.15	5.23 ± 0.384	5.93 ± 0.86	6.96 ± 0.26	5.96 ± 0.12
T_9	5.33 ± 0.14	5.43 ± 0.384	5.70 ± 0.379	5.60 ± 0.2	5.36 ± 0.176
T_{10}	5.03 ± 0.13	6.30 ± 0.252	6.50 ± 0.265	7.13 ± 0.348	6.76 ± 0.296
T_{11}	5.30 ± 0.30	5.83 ± 0.536	6.56 ± 0.203	7.33 ± 0.467	6.63 ± 0.067
T_{12}	6.33 ± 0.26	7.67 ± 0.448	7.76 ± 0.504	8.86 ± 0.033	8.46 ± 0.133
T_{13}	5.93 ± 0.06	6.26 ± 0.203	6.63 ± 0.088	7.33 ± 0.233	6.73 ± 0.24
C.D.	**0.734**	**0.88**	**0.912**	**0.874**	**0.843**
SE(m)	**0.252**	**0.302**	**0.313**	**0.3**	**0.29**

Table 8 : Influence of bio-edible and Nano enriched coating on titratable acidity of guava fruit juice.

Treatment	0-day (g/L)	4th day (g/L)	8th day (g/L)	12th day (g/L)	16th day (g/L)
T_0	0.51 ± 0.12	0.46 ± 0.12	0.42 ± 0.06	0.403 ± 0.07	0.37 ± 0.06
T_1	0.44 ± 0.01	0.40 ± 0.07	0.37 ± 0.06	0.35 ± 0.06	0.31 ± 0.06
T_2	0.46 ± 0.12	0.40 ± 0.09	0.39 ± 0.12	0.38 ± 0.06	0.32 ± 0.06
T_3	0.33 ± 0.12	0.32 ± 0.06	0.30 ± 0.09	0.27 ± 0.06	0.26 ± 0.06
T_4	0.48 ± 0.15	0.46 ± 0.13	0.35 ± 0.28	0.35 ± 0.09	0.33 ± 0.06
T_5	0.35 ± 0.12	0.35 ± 0.12	0.33 ± 0.12	0.30 ± 0.01	0.28 ± 0.37
T_6	0.44 ± 0.12	0.42 ± 0.09	0.38 ± 0.06	0.36 ± 0.06	0.32 ± 0.06
T_7	0.46 ± 0.06	0.43 ± 0.06	0.40 ± 0.07	0.38 ± 0.09	0.36 ± 0.09
T_8	0.41 ± 0.01	0.38 ± 0.06	0.35 ± 0.09	0.34 ± 0.09	0.31 ± 0.09
T_9	0.43 ± 0.12	0.41 ± 0.03	0.38 ± 0.03	0.37 ± 0.06	0.35 ± 0.06
T_{10}	0.36 ± 0.12	0.34 ± 0.07	0.31 ± 0.03	0.29 ± 0.06	0.26 ± 0.09
T_{11}	0.45 ± 0.12	0.44 ± 0.09	0.38 ± 0.03	0.31 ± 0.19	0.27 ± 0.09
T_{12}	0.42 ± 0.12	0.38 ± 0.06	0.36 ± 0.06	0.35 ± 0.07	0.24 ± 0.06
T_{13}	0.44 ± 0.17	0.42 ± 0.06	0.40 ± 0.07	0.36 ± 0.06	0.31 ± 0.29
C.D.	**0.35**	**0.24**	**0.03**	**0.25**	0.41
SE(m)	**0.12**	**0.08**	**0.01**	**0.09**	0.14

minimum TSS value as compared to the control. Table 7 represents the TSS value of fruits at different intervals.

Total Titrable Acidity : A gradual decrease in the titrable acidity of the fruits were observed. The minimum titratable acidity at 0, 4th, 8th, 12th and 16th day was seen treatment T_3 (Aloe vera 250 ml extract / gel+ periwinkle extract 12.5ml) with 0.34g/L, 0.32g/L, 0.31g/L, 0.27g/L and 0.26g/L, while the maximum values of titrable acidity of the fruit juice was obtained in control with 0.51 g/L, 0.46 g/L, 0.42 g/L, 0.40 g/L and 0.37 g/L. the findings are in agreement with Kumar and Bhatnagar (2014), who reported that *Aloe vera* gel (at 25 and 33%) retained titratable acidity content in sweet Cheery (*Prunus avium* cv. Napoleon) fruit during 30 days of storage at 1±0.5°C with 85-95% RH. Table 8 represents the value of titrable acidity of fruits at different intervals.

Vitamin C : It was observed that the vitamin C content of the reduced gradually with the increase in the number of storage days. The lowest vitamin C content was recorded in control on 0, 4th, 8th, 12th and 16th day with 7.47 mg $100g^{-1}$, 7.03 mg $100g^{-1}$, 5.70 mg $100g^{-1}$, 4.70 mg $100g^{-1}$ and 3.33 mg $100g^{-1}$. Whereas, the highest

Table 9 : Influence of bio-edible and Nano enriched coating on vitamin C content of guava fruit juice.

Treatment	0-day (mg 100g^{-1})	4th day (mg 100g^{-1})	8th day (mg 100g^{-1})	12th day (mg 100g^{-1})	16th day (mg 100g^{-1})
T_0	184.81 ± 0.45	174.00 ± 0.45	164.333 ± 1.84	150.00 ± 0.37	142.02 ± 0.74
T_1	194.12 ± 0.43	183.02 ± 0.43	172.03 ± 0.43	169.00 ± 0.37	152.00 ± 0.35
T_2	194.06 ± 0.41	183.00 ± 0.4	172.00 ± 0.41	166.01 ± 0.35	151.00 ± 0.33
T_3	206.15 ± 0.77	196.05 ± 0.74	185.00 ± 0.37	183.02 ± 0.37	173.03 ± 0.74
T_4	192.78 ± 0.43	177.00 ± 0.34	163.33 ± 1.22	160.00 ± 0.46	150.01 ± 0.65
T_5	203.63 ± 0.37	193.00 ± 0.34	182.00 ± 0.34	174.03 ± 0.40	165.00 ± 0.67
T_6	192.07 ± 0.35	182.00 ± 0.43	171.00 ± 0.43	163.04 ± 0.40	160.06 ± 0.42
T_7	190.38 ± 0.45	181.04 ± 0.35	170.00 ± 0.35	162.02 ± 0.43	160.00 ± 0.73
T_8	188.25 ± 0.37	180.00 ± 0.42	169.01 ± 0.42	162.00 ± 0.47	160.03 ± 0.74
T_9	187.38 ± 0.46	177.00 ± 0.45	164.33 ± 2.48	161.00 ± 0.43	159.00 ± 0.41
T_{10}	201.17 ± 0.46	191.06 ± 0.46	180.00 ± 0.46	171.00 ± 0.41	162.04 ± 0.40
T_{11}	187.08 ± 0.42	176.00 ± 0.43	163.00 ± 0.46	153.05 ± 0.45	143.00 ± 0.45
T_{12}	197.24 ± 0.49	187.00 ± 0.49	176.00 ± 0.49	170.00 ± 0.41	160.03 ± 0.35
T_{13}	195.42 ± 0.37	185.00 ± 0.37	174.00 ± 0.37	170.02 ± 0.37	160.06 ± 0.40
C.D.	**1.19**	**1.2**	**2.56**	**1.2**	**1.19**
SE(m)	**0.41**	**0.41**	**0.88**	**0.41**	**0.41**

vitamin C content of the fruit juice was recorded in treatment T_3 (Aloe vera 250 ml extract / gel+ periwinkle extract 12.5ml) with 11.97 mg 100g^{-1}, 10.50 mg 100g^{-1}, 9.50 mg 100g^{-1}, 8.50 mg 100g^{-1} and 8.50 mg 100g^{-1}. The findings are in agreement with Adetunji *et al* (2012) who found that *Aloe vera* gel coatings were effective in maintaining ascorbic acid content in both cold as well as ambient storage conditions of *Ananas comosus* (L.) *cv* Pineapple. Mani *et al.* (2017) observed that slower decline in the rate of ascorbic in *Aloe vera* gel (2%) treated ber fruit. Sharma *et al.* (2015) found that the ascorbic acid content was higher in 1.5% *Aloe vera* treated papaya and lower was in control papaya. Table 9 represents the values of vitamin C content of fruit juice at different treatment combinations.

Conclusion

From the present study, it tends to be concluded that aloe vera gel @ 250ml + periwinkle extract @ 12.5ml proved to be the most effecting among all the bio-edible and nanoparticle coatings on guava fruits. This treatment was found effective in reducing the weight loss, polar diameter, equator diameter and firmness of the fruits. It was effective in increasing the pH and total soluble solids, whereas in decreasing total titrable acidity and Vitamin C content of fruit juice. Therefore, aloe vera gel alone and as a combination along with other edible coating can be applied to enhance the shelf life of fruits as well as vegetables. It is very helpful in reducing the post-harvest losses of fruits due to spoilage, high respiration, microbial activity and unfavorable environmental conditions.

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