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# Effect of *Aloe vera* based composite edible coatings in retaining the postharvest quality of litchi fruits (*Litchi chinensis* Sonn. ) cv. Rose Scented

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**ABSTRACT:**Litchi (*Litchi chinensis* Sonn. ) is a highly perishable fruit, prone to rapid deterioration due to microbial spoilage, physiological weight loss, and browning of the pericarp. Therefore, an evaluation of study *Aloe vera*-based composite edible coatings was conducted for preserving the postharvest quality of litchi cv. Rose Scented under ambient storage. Litchi fruits were coated with *Aloe vera* gel in combination with ascorbic acid and hydrogen peroxide. The coated and uncoated (control) fruits were stored and assessed periodically for key quality parameters, including physicochemical, phytochemical, and sensory quality attributes. Results revealed that the composite coating comprising (30% *Aloe vera* gel + 1% ascorbic acid + 1% hydrogen peroxide) was the most effective in reducing physiological loss in weight (PLW), decay (%) and browning while significantly retaining acceptable TSS, acidity, ascorbic acid, total sugar, total anthocyanin and total antioxidant capacity compared to the control up to 15$^{th}$day of storage. Coated fruits also maintained better sensory appeal throughout the storage period. The combined effect of *Aloe vera* and antioxidant additives helped delay senescence and maintain the structural and nutritional integrity of litchi fruits. These findings suggest that *Aloe vera*based edible coatings, particularly those with antioxidant fortification, offer a promising and eco-friendly approach for reducing postharvest losses of litchi fruits under non-refrigerated conditions.

**Keywords:***Aloe vera*, ambient storage,edible coating, Litchi, postharvest quality

Litchi (*Litchi chinensis* Sonn. ) is a significant subtropical evergreen fruit of the Sapindaceae (Soapberry) family, known for its delicious taste, rich flavour, pleasant aroma, attractive appearance, and high nutritional value (Arora *et al.,* 2017). Litchi originated in the region near South China and North Vietnam around 1500 BC and has since spread to various parts of the world. It was introduced to India in the 18$^{th}$ century and later reached Nepal and Bangladesh. India is the second-largest producer of litchis globally, following China. The country produces approximately 578 thousand metric tons of litchis annually, cultivated over an area of around 98 thousand hectares, with an average productivity of 7.43 metric tons per hectare (Anonymous, 2025). The leading litchi-producing states in India are Bihar, West Bengal, Punjab, and Jharkhand. In Uttarakhand, litchi cultivation covers about 5,260 hectares, yielding an annual production of approximately 18,710 metric tons (Anonymous, 2025). Litchi fruits are rich in B-complex vitamins, protein, pectin, dietary fiber, fats, and natural acids. They also serve as a good source of essential minerals such as calcium, potassium, phosphorus, iron, magnesium, zinc, copper, *etc* (Mani and Krishna, 2023). The major chemical components of litchi fruits include carbohydrates, organic acids, vitamins, pigments, proteins, and fats (Janmejay and Nikky, 2020).

Litchi fruit features a rough, indehiscent pericarp that encloses the edible aril and a central seed. It is classified as a non-climacteric fruit and is harvested only when it reaches full maturity (Akamine and Goo, 1973). After harvest, the litchi fruit's pericarp is highly prone to desiccation when exposed to dry air, causing it to quickly turn brown and become brittle. Litchis have a very short postharvest shelf life, with the red pericarp losing its color and texture within just 2 to 4 days. This limited shelf life presents a major challenge in litchi production. Therefore, proper postharvest management including careful handling, prompt cooling, appropriate packaging,

storage, and transportation is essential to preserve the fruit's freshness, quality, and nutritional value, while also reducing postharvest losses (Mani *et al.,* 2023). Pericarp browning typically results from the deterioration of the fruit's skin. The formation of multiple micro-cracks contributes to this browning. Another possible cause is the breakdown of the sugar moiety from the anthocyanin compounds, triggering the browning reaction. It is also believed that the presence of mycorrhizal fungi in litchi fruit contributes to its browning (Mani *et al.,* 2021). The combined effects of skin cracking and fungal infection are considered major factors behind the fruit's short shelf life. As the cracks widen over time, they facilitate direct contact between the fungus and the fruit, accelerating deterioration (Mani *et al.,* 2021). To preserve the red colour of litchi fruits and minimize pericarp browning over a longer period, it is essential to use edible coatings, suitable packaging, acid dips, and maintain optimal storage temperatures (Kumar *et al.,* 2024). Edible coatings help prevent the transpiration of water vapor from the fruit to the surrounding environment, thereby reducing the risk of wilting and weight loss. They also lower the fruit's susceptibility to insects and microbial attacks, effectively minimizing postharvest losses (Maringgal *et al.,* 2020).

Edible coatings derived from natural biomaterials are gaining recognition as a safer and more sustainable alternative to traditional synthetic waxes. They provide an effective means of improving postharvest quality and extending the shelf life of perishable fruits. By using biodegradable, food-safe ingredients in place of synthetic compounds, these coatings help maintain freshness while meeting consumer preferences for natural and eco-friendly preservation methods **(**Mani *et al.,* 2024). *Aloe vera* gel possesses excellent antibacterial properties, primarily due to the presence of aloin (Ahmed *et al.,* 2009). Its gel serves as an excellent edible coating for fruits and vegetables due to its strong antifungal properties (Kumar and Bhatnagar, 2014). *Aloe vera* is a well-known herbaceous medicinal plant, highly regarded since ancient times for its wide range of therapeutic benefits. In recent years, the use of natural medicinal herbs has emerged as a safer approach to extend the shelf life of delicate and highly perishable fruit crops. Hydrogen peroxide ($H_2O_2$) is a widely used alternative sanitizing agent for fruits and vegetables, applied in both liquid and gaseous forms for preservation, disinfection, and sterilization (McDonnell, 2014). As a strong oxidizing agent, $H_2O_2$ is an effective biocide with broad-spectrum antimicrobial activity, targeting various microorganisms such as bacterial endospores, protozoal cysts, and, in some cases, even infectious proteins like prions (Linley *et al.,* 2012). Ascorbic acid, primarily used as an antioxidant food additive, enhances the effectiveness of edible coatings (Ali *et al.,* 2020). Incorporating additives such as nutrients, flavoring agents, antimicrobials, antioxidants, and anti-browning compounds into edible coatings improves their ability to preserve produce, making them more efficient than when used alone (Han *et al.,* 2004). In this context, the present experiment has been designed to assess the impact of an *Aloe vera*-based composite edible coating on pericarp browning and postharvest quality of litchi fruits cv. Rose Scented.

## MATERIALS AND METHODS

### *Experimental site and weather condition*

Fully matured and uniformly sized litchi fruits cv. 'Rose Scented' was harvested from the Horticulture Research Centre, Pattharchatta, Pantnagar during the fruiting season in 2023-24. Care was taken to ensure that only fruits of uniform maturity and free from blemishes were selected. The freshly harvested fruits were immediately brought to the Postharvest Laboratory, Department of Horticulture, G. B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand) for treatment application. Geographically, Pantnagar is located in the *Tarai* region at the foothills of the Himalayas, positioned at 29° N latitude, 79.3° E longitude, and an elevation of 243.84 meters above mean sea level. The region receives an average annual rainfall of about 145 cm, with notable seasonal variations. Pantnagar experiences a wide range of temperatures, with summer highs reaching 42–45°C and winter lows dropping to 2–4°C while relative humidity ranges from 33% to 97%, depending on the time of day and season.

***Experimental design and Treatment details***

The experiment was laid out in a two-factor Completely Randomized Design (CRD) with three replications. The first factor included four treatments involving a 30% *Aloe vera* gel-based coating enriched with functional additives (ascorbic acid and hydrogen peroxide/$H_2O_2$), along with an untreated control. The second factor comprised different storage intervals (0, 3, 6, 9, 12, and 15 days) under ambient conditions (24-30°C). Uniformly graded fruits with consistent size, shape, and colour were selected and initially treated by dipping them in a 2% sodium hypochlorite solution for 2 minutes to eliminate surface impurities and pathogens. This was followed by thorough rinsing with tap water and air-drying of the fruits. Subsequently, the fruits were subjected to various edible coating treatments as per the following combinations: $T_1$- *Aloe vera* @ 30% + Ascorbic acid @ 1%, $T_2$-*Aloe vera* @ 30% + $H_2O_2$ @ 1%, $T_3$-*Aloe vera* @ 30% + Ascorbic acid @ 1% + $H_2O_2$ @ 1% and $T_4$ Control (Untreated).

***Aloe vera gel coating preparation***

*Aloe vera* gel was prepared according to the method outlined by Ramachandra and Rao (2008), which emphasizes processing the leaves within two hours of harvest to prevent oxidation due to air exposure. Fresh *Aloe vera* leaves were sourced from the Medicinal Research and Development Center (MRDC), Pantnagar, and brought to the Postharvest Laboratory of the Department of Horticulture. The leaves were thoroughly washed to remove any surface dirt. The gel matrix was then carefully extracted from the leaf cortex using a sharp knife. The colourless hydroparenchyma was blended and filtered through muslin cloth to eliminate fibrous material, constituting fresh, pure *Aloe vera* gel (AG; 100%). The prepared *Aloe vera* gel was pasteurized at 70°C for 45 minutes and then cooled to ambient temperature, following the procedure described by Maughan (1984). To prepare a 30% concentration as required by the treatments, distilled water was added to the gel. Ascorbic acid and hydrogen peroxide ($H_2O_2$) were then incorporated into the base coating solution at a concentration of 1%, as per the specific treatment combinations. This mixture was subsequently pasteurized again at 85°C for 15 minutes and immediately cooled to room temperature. The final gel solution was stored in pre-sterilized glass bottles. Fresh litchi fruits were coated with the prepared gel using the dipping method, as described by Marpudi *et al*. (2011).

***Application of coating, packaging and storage***

For each treatment, a total of sixty fruits were used and divided into three replications of 20 fruits each and dipped in the *Aloe vera* gel solution for one minute. Additionally, a separate set of 30 coated fruits per treatment was kept for organoleptic evaluation. After coating, the fruits were air-dried at room temperature for 20–25 minutes using a fan to accelerate the drying process. The treated fruits were then packed in perforated LDPE bags (57.15µ thickness, 20 × 25 cm² in size) containing 10 holes of 0.2 mm diameter to create a passive modified atmosphere within the bags. The fruits were stored under ambient conditions (24–30°C), and analyses were conducted at three-day intervals throughout the storage period.

**Observations recorded**

***Physico-chemical quality attributes***

**Physiological loss in weight (%):**The initial weight of the litchi fruits was recorded immediately after coating, *i. e*., on day 0, and subsequently at each storage interval on the 3rd, 6th, 9th, 12th, and 15th days under ambient conditions. The physiological weight loss of the fruits was determined using the following formula:

$$\text{PLW (\%)} = \frac{[\text{Initial weight of the fruit} - \text{Weight of fruit on periodic interval (g)}]}{\text{Initial weight of the fruit (g)}} \times 100$$

**Per cent decay:**The percentage of fruit decay was calculated using the following formula (Ismail *et al.,* 2010):

$$\text{Decay (\%)} = \frac{\text{Number of spoiled fruits}}{\text{Total number of fruits}} \times 100$$

**Browning index (BI):**It was assessed using a scale from 0 to 5, where 0 denoted no browning (excel-

lent quality) and 5 indicated severe browning (poor quality). The intermediate scores represented varying degrees of browning: 1 for slight browning, 2 for browning less than 1/4 of the surface, 3 for 1/4 to 1/2 browning, and 4 for 1/2 to 2/3 browning. The browning index was calculated using the formula: Ó (browning score × percentage of fruits in each category). This index served as a quantitative indicator of the overall browning extent observed during the evaluation (Jiang, 2000; Kumar *et al.,* 2013).

**Total soluble solids (TSS):**TSS of the pulp was measured using an Erma handheld refractometer with a range of 0–90 °Brix. A drop of homogenized pulp was placed on the refractometer prism, and the TSS values were recorded in °Brix.

**Titratable acidity (TA):** It was determined following the procedure described by Ranganna (1986). The results were expressed as a percentage of citric acid equivalents and calculated using the following formula:

$$\text{Acidity (\%)} = \frac{\text{Titre value} \times \text{Normality} \times \text{Eq. weight of acid} \times \text{Volume made} \times 100}{\text{Volume of sample taken} \times \text{Volume of aliquot taken} \times 100}$$

**Ascorbic acid:**Ascorbic acid content in litchi fruits was determined using the visual titration method with 2,6-dichlorophenol-indophenol sodium salt, following the procedure outlined by Ranganna (2001). The results were expressed in milligrams per 100 grams of pulp, indicating the ascorbic acid concentration in the fruit with following formula.

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titre value} \times \text{Dye factor} \times \text{Volume made up}}{\text{Aliquot of extract} \times \text{Weight or volume of sample taken}} \times 100$$

**Total sugar content:**The total sugar content in litchi fruit was estimated using the "Lane and Eynon method" as described by Ranganna (1986). The total sugar percentage was calculated using the following formula:

$$\text{Total sugars (\%)} = \frac{\text{Fehlings factor (0.05)} \times \text{Dilution made} \times \text{Volume made}}{\text{Titre value} \times \text{Weight of sample}} \times 100$$

***Phytochemicals quality attributes and organoleptic characteristics***

**Total anthocyanin content:**The total anthocyanin content in litchi fruit was estimated using the "Colorimetric method" outlined by Ranganna (1977). The anthocyanin content was calculated using the following formula:

$$\text{Total OD/100g} = \frac{\text{O.D.} \times \text{Volume made up} \times 100}{\text{Weight of sample}}$$

$$\text{Total anthocyanin (mg/100g)} = \frac{\text{Total O.D./100g}}{98.2}$$

**Total antioxidants capacity:**The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity of the fruit was assessed following the method described by Hwang *et al.* (2016). The percentage of DPPH radical scavenging activity was calculated using the following formula:

$$\text{Antioxidant activity (\%)} = \frac{1 - \text{Absorbance of sample}}{\text{Absorbance of control}} \times 100$$

**Organoleptic evaluation:**The organoleptic qualities of litchi fruits—such as colour, taste, and overall acceptability were assessed during the storage period using a 9-point Hedonic scale. This method, outlined by Ranganna (2001), involved recording the judges' preferences and perceptions on a standardized scorecard.

9-point hedonic scale: 9- like extremely, 8- like very much, 7- like moderately, 6- like slightly, 5- neither like nor dislike, 4- dislike slightly, 3- dislike moderately, 2- dislike very much and 1- dislike extremely. Statistical analysis

The data were analyzed using a two-factor Completely Randomized Design with three replications, following the methodology of Snedecor and Cochran (1987). The results revealed significant differences among the treatments, with storage intervals showing significance at the $P<0.05$ level. The findings were visually presented through tables and graphs.

## RESULTS AND DISCUSSION

***Physiological loss in weight (PLW %)***

The weight loss of fruits during storage is primarily attributed to water loss through transpiration and its utilization during respiration. Result showed significant effect of *Aloe vera* (30%) gel-based coating and

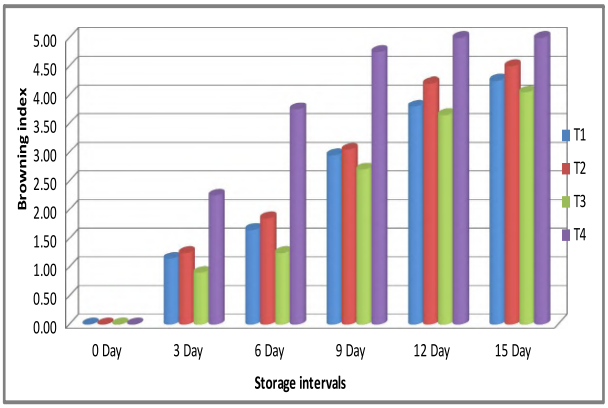
storage periods and their interaction on PLW (Table 1). Among the storage periods, weight reduction was observed to increase progressively with the extension of the storage period. The highest weight loss (14.41%) was observed at 15 days of storage. Among the *Aloe vera* gel (30%)-based, it was noted that AVG 30% + AA 1% + $H_2O_2$ 1% had the minimum PLW (5.15%) and the highest in control (12.0%). The interaction effect between storage periods and AVG showed that the highest PLW (24.23%) was observed in the control treatment on the 15$^{th}$day of storage at room temperature. In contrast, the treatment with 30% *Aloe vera* gel combined with 1% ascorbic acid and 1% $H_2O_2$ effectively minimized weight loss to 7.27% on the 12$^{th}$ day and 10.07% on the 15$^{th}$ day. This was closely followed by the treatment containing 30% *Aloe vera* gel and 1% ascorbic acid, which recorded weight losses of 8.22% and 11.03% on the 12$^{th}$ and 15$^{th}$ days, respectively (Table 1). The findings of the present study revealed that the *Aloe vera* gel (AVG) coating treatment significantly reduced the percentage of weight loss in litchi fruits compared to the control. This effect is likely due to the coating acting as a protective barrier around the fruit, minimizing external exchange and moisture loss (Sogvar *et al*., 2016). Factors such as light exposure, temperature, fruit maturity, and oxidation may also contribute to water loss from the fruits, thereby increasing weight loss (Parven *et al.,* 2020). According to Silva *et al*. (2017), edible coatings can help prevent water loss, limit sugar accumulation, and slow down starch degradation. Similar trends in reduced weight loss during storage were also observed with AVG coatings applied to apples (Khan *et al.,* 2019) and papaya (Parven *et al.,* 2020).

### *Per cent decay*

The results revealed a significant effect of 30% *Aloe vera* gel-based coating, storage duration, and their interaction on decay percentage (Table 1). A progressive increase in decay incidence was noted with the extension of the storage period, with the highest decay percentage (74.16%) recorded on the 15$^{th}$day of storage. Among the different *Aloe vera gel* (30%)-based coating treatments, the combination of AVG 30% + AA 1% + $H_2O_2$ 1% recorded the lowest decay percentageat 16.11%, whereas the highest decay percentage (51.38%) was observed in the untreated control. The interaction effect between storage periods and AVG showed that the lowest fruit decay percentage (58.33%) was recorded in the treatment with 30% *Aloe vera* gel combined with 1% ascorbic acid and 1% $H_2O_2$, followed by 65.00% decay in the treatment with 30% *Aloe vera* gel and 1% ascorbic acid. The highest decay percentage (100%) was observed in the control/uncoated fruits by the 15$^{th}$day of storage. The results of the decay assessment showed that fruits treated with *Aloe vera* gel (AVG) coating consistently had lower infection scores than the control throughout the storage period. This is likely due to the antimicrobial properties of AVG, which can effectively inhibit the growth of bacteria, fungi, and molds responsible for fruit rotting during storage. These findings align with earlier studies demonstrating that AVG coatings enhance resistance to decay in table grapes (Nia *et al.,* 2021), strawberries (Sogvar *et al.,* 2016), and oranges (Rasouli *et al.,* 2019).

### *Browning index*

The Browning Index (BI), which reflects the extent of surface browning in fruits, indicated that the browning process was effectively slowed during ambient storage, allowing the fruits to be stored for up to 15 days. The results indicated a significant ef-




*Where, T 1 = *Aloe vera* 30% + Ascorbic acid 1%, T 2 = *Aloe vera* 30% + $H_2O_2$ 1%, T 3 = *Aloe vera* 30% + Ascorbic acid 1% + $H_2O_2$ 1% and T 4 = Uncoated (control).

**Fig 1: Effect of coating formulation on the browning index in litchi fruits cv. Rose Scented**

**Table 1: Effect of coating formulation on the percentage of physiological loss in weight (PLW%) and per cent decay in litchi fruits cv. Rose Scented**

| Parameters | Day | AVG 30% + AA 1% | AVG 30% + $H_2O_2$ 1% | AVG 30% +AA 1% + $H_2O_2$ 1% | Control | Mean |
|---|---|---|---|---|---|---|
| PLW % | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 3 | 3.19 | 3.40 | 3.13 | 4.42 | 3.54 |
| | 6 | 5.21 | 5.53 | 4.48 | 8.58 | 5.94 |
| | 9 | 6.55 | 7.26 | 5.95 | 16.28 | 9.01 |
| | 12 | 8.22 | 8.73 | 7.27 | 18.49 | 10.68 |
| | 15 | 11.03 | 12.30 | 10.07 | 24.23 | 14.41 |
| | Mean | 5.70 | 6.20 | 5.15 | 12.00 | |
| | Factors | C. D. at 5% | | SE (m) | | |
| | Storage intervals (S. I. ) | 0.142 | | 0.050 | | |
| | Treatments (T) | 0.174 | | 0.061 | | |
| | Interaction (S. I. ×T) | 0.348 | | 0.122 | | |
| Decay % | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 3 | 0.00 | 0.00 | 0.00 | 6.66 | 1.66 |
| | 6 | 3.33 | 3.33 | 1.66 | 38.33 | 11.66 |
| | 9 | 10.00 | 11.67 | 6.66 | 70.00 | 24.58 |
| | 12 | 31.66 | 36.66 | 30.00 | 93.33 | 47.91 |
| | 15 | 65.00 | 73.33 | 58.33 | 100.00 | 74.16 |
| | Mean | 18.33 | 20.83 | 16.11 | 51.38 | |
| | Factors | C. D. at 5% | | SE (m) | | |
| | Storage intervals (S. I. ) | 0.549 | | 0.193 | | |
| | Treatments (T) | 0.673 | | 0.236 | | |
| | Interaction (S. I. ×T) | 1.346 | | 0.472 | | |

*Where, AVG= *Aloe vera* gel, AA= Ascorbic acid, $H_2O_2$= Hydrogen peroxide

**Table 2: Effect of coating formulation on the total soluble solids (°Brix) and titratable acidity (%) in litchi fruits cv. Rose Scented**

| Parameters | Day | AVG 30% + AA 1% | AVG 30% + $H_2O_2$ 1% | AVG 30% + AA 1% + $H_2O_2$ 1% | Control | Mean |
|---|---|---|---|---|---|---|
| TSS °Brix | 0 | 16.90 | 16.64 | 16.70 | 16.90 | 16.78 |
| | 3 | 17.30 | 17.20 | 17.14 | 19.05 | 17.67 |
| | 6 | 17.85 | 17.89 | 17.80 | 21.00 | 18.63 |
| | 9 | 19.70 | 19.55 | 19.65 | 18.14 | 19.26 |
| | 12 | 19.89 | 19.70 | 20.15 | 15.10 | 18.71 |
| | 15 | 17.40 | 16.45 | 18.10 | 11.70 | 15.91 |
| | Mean | 18.17 | 17.90 | 18.25 | 16.98 | |
| | Factors | C. D. at 5% | | SE (m) | | |
| | Storage intervals (S. I. ) | 0.305 | | 0.107 | | |
| | Treatments (T) | 0.373 | | 0.131 | | |
| | Interaction (S. I. ×T) | 0.746 | | 0.262 | | |
| Titratable acidity (%) | 0 | 0.40 | 0.39 | 0.39 | 0.42 | 0.40 |
| | 3 | 0.35 | 0.35 | 0.36 | 0.28 | 0.33 |
| | 6 | 0.26 | 0.27 | 0.29 | 0.20 | 0.25 |
| | 9 | 0.23 | 0.22 | 0.24 | 0.13 | 0.21 |
| | 12 | 0.18 | 0.17 | 0.19 | 0.13 | 0.17 |
| | 15 | 0.14 | 0.12 | 0.15 | 0.11 | 0.13 |
| | Mean | 0.26 | 0.25 | 0.27 | 0.21 | |
| | Factors | C. D. at 5% | | SE (m) | | |
| | Storage intervals (S. I. ) | 0.004 | | 0.001 | | |
| | Treatments (T) | 0.005 | | 0.002 | | |
| | Interaction (S. I. ×T) | 0.010 | | 0.004 | | |

*Where, AVG= *Aloe vera* gel, AA= Ascorbic acid, $H_2O_2$= Hydrogen peroxide

**Table 3: Effect of coating formulation on the ascorbic acid (mg/100g) and total sugars (%) in litchi fruits cv. Rose Scented**

| Parameters | Day | AVG 30% + AA 1% | AVG 30% + $H_2O_2$ 1% | AVG 30% +AA 1% + $H_2O_2$ 1% | Control | Mean |
|---|---|---|---|---|---|---|
| Ascorbic acid (mg/100g) | 0 | 44.89 | 44.90 | 44.95 | 47.35 | 45.52 |
| | 3 | 38.40 | 38.40 | 39.54 | 38.85 | 38.80 |
| | 6 | 32.74 | 31.79 | 33.05 | 29.70 | 31.82 |
| | 9 | 25.20 | 23.70 | 25.80 | 19.45 | 23.53 |
| | 12 | 22.35 | 20.95 | 23.14 | 15.15 | 20.39 |
| | 15 | 18.90 | 17.70 | 20.25 | 10.20 | 16.67 |
| | Mean | 30.41 | 29.57 | 31.12 | 26.78 | |
| | Factors | C. D. at 5% | | SE (m) | | |
| | Storage intervals (S. I. ) | 0.502 | | 0.176 | | |
| | Treatments (T) | 0.614 | | 0.215 | | |
| | Interaction (S. I. ×T) | 1.229 | | 0.431 | | |
| Total sugars (%) | 0 | 10.70 | 10.57 | 10.51 | 10.61 | 10.60 |
| | 3 | 11.13 | 10.87 | 11.01 | 13.27 | 11.57 |
| | 6 | 12.95 | 12.86 | 13.10 | 12.38 | 12.82 |
| | 9 | 14.55 | 14.16 | 15.07 | 12.22 | 14.00 |
| | 12 | 14.69 | 14.20 | 15.44 | 11.32 | 13.91 |
| | 15 | 14.20 | 13.52 | 14.89 | 10.13 | 13.18 |
| | Mean | 13.03 | 12.69 | 13.34 | 11.65 | |
| | Factors | C. D. at 5% | | SE (m) | | |
| | Storage intervals (S. I. ) | 0.225 | | 0.079 | | |
| | Treatments (T) | 0.276 | | 0.097 | | |
| | Interaction (S. I. ×T) | 0.552 | | 0.194 | | |

*Where, AVG= *Aloe vera* gel, AA= Ascorbic acid, $H_2O_2$= Hydrogen peroxide

**Table 4: Effect of coating formulation on the total anthocyanin content (mg/100g) and total antioxidants capacity (µmol/100g FW) in litchi fruits cv. Rose Scented**

| Parameters | Day | AVG 30% + AA 1% | AVG 30% + $H_2O_2$ 1% | AVG 30% +AA 1% + $H_2O_2$ 1% | Control | Mean |
|---|---|---|---|---|---|---|
| Total anthocyanin content (mg/100g) | 0 | 33.74 | 33.59 | 33.65 | 33.65 | 33.65 |
| | 3 | 32.25 | 32.15 | 32.23 | 25.99 | 30.65 |
| | 6 | 27.70 | 27.43 | 28.19 | 19.41 | 25.68 |
| | 9 | 23.95 | 22.94 | 25.21 | 13.96 | 21.52 |
| | 12 | 21.46 | 20.38 | 22.50 | 10.76 | 18.77 |
| | 15 | 18.86 | 18.32 | 19.60 | 8.01 | 16.20 |
| | Mean | 26.32 | 25.80 | 26.89 | 18.63 | |
| | Factors | C. D. at 5% | | SE (m) | | |
| | Storage intervals (S. I. ) | 0.431 | | 0.151 | | |
| | Treatments (T) | 0.528 | | 0.185 | | |
| | Interaction (S. I. ×T) | 1.056 | | 0.370 | | |
| Total antioxidants capacity (µmol/100g FW) | 0 | 68.51 | 67.86 | 67.82 | 68.61 | 68.20 |
| | 3 | 65.42 | 64.67 | 65.10 | 61.82 | 64.25 |
| | 6 | 54.53 | 53.26 | 55.20 | 45.64 | 52.16 |
| | 9 | 47.58 | 46.99 | 48.97 | 33.74 | 44.32 |
| | 12 | 36.15 | 35.31 | 38.13 | 23.74 | 33.33 |
| | 15 | 33.44 | 32.03 | 34.33 | 16.85 | 29.16 |
| | Mean | 50.94 | 50.02 | 51.59 | 41.73 | |
| | Factors | C. D. at 5% | | SE (m) | | |
| | Storage intervals (S. I. ) | 0.756 | | 0.265 | | |
| | Treatments (T) | 0.926 | | 0.325 | | |
| | Interaction (S. I. ×T) | 1.853 | | 0.649 | | |

*Where, AVG= *Aloe vera* gel, AA= Ascorbic acid, $H_2O_2$= Hydrogen peroxide

**Table 5: Effect of coating formulation on the sensory quality (SQ) evaluation in litchi fruits cv. Rose Scented**

| Parameters | Day | AVG 30% + AA 1% | AVG 30% + $H_2O_2$ 1% | AVG 30% +AA 1% + $H_2O_2$ 1% | Control | Mean |
|---|---|---|---|---|---|---|
| Skin appearance | 0 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 |
| | 3 | 6.80 | 6.70 | 7.00 | 6.00 | 6.62 |
| | 6 | 6.10 | 6.00 | 6.30 | 4.50 | 5.72 |
| | 9 | 5.30 | 4.90 | 5.30 | 1.90 | 4.35 |
| | 12 | 4.10 | 3.90 | 4.50 | 1.00 | 3.37 |
| | 15 | 3.10 | 2.90 | 3.50 | 1.00 | 2.62 |
| | Mean | 5.73 | 5.56 | 5.93 | 3.90 | |
| | Factors | | C. D. at 5% | | SE (m) | |
| | Storage intervals (S. I. ) | | 0.086 | | 0.030 | |
| | Treatments (T) | | 0.105 | | 0.037 | |
| | Interaction (S. I. ×T) | | 0.211 | | 0.074 | |
| Taste | 0 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 |
| | 3 | 7.00 | 7.00 | 7.20 | 6.30 | 6.90 |
| | 6 | 6.50 | 6.30 | 6.60 | 2.10 | 5.37 |
| | 9 | 5.50 | 5.30 | 6.00 | 1.00 | 4.44 |
| | 12 | 4.30 | 3.80 | 5.00 | 1.00 | 3.52 |
| | 15 | 3.30 | 3.00 | 3.50 | 1.00 | 2.70 |
| | Mean | 5.94 | 5.73 | 6.21 | 3.41 | |
| | Factors | | C. D. at 5% | | SE (m) | |
| | Storage intervals (S. I. ) | | 0.102 | | 0.036 | |
| | Treatments (T) | | 0.125 | | 0.044 | |
| | Interaction (S. I. ×T) | | 0.251 | | 0.088 | |
| Overall acceptability | 0 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 |
| | 3 | 7.00 | 6.80 | 7.00 | 6.00 | 6.70 |
| | 6 | 6.30 | 5.70 | 6.50 | 2.70 | 5.30 |
| | 9 | 5.20 | 4.90 | 5.50 | 1.20 | 4.20 |
| | 12 | 4.10 | 3.70 | 4.40 | 1.00 | 3.30 |
| | 15 | 3.10 | 3.00 | 3.20 | 1.00 | 2.57 |
| | Mean | 5.78 | 5.51 | 5.93 | 3.48 | |
| | Factors | | C. D. at 5% | | SE (m) | |
| | Storage intervals (S. I. ) | | 0.061 | | 0.022 | |
| | Treatments (T) | | 0.075 | | 0.026 | |
| | Interaction (S. I. ×T) | | 0.151 | | 0.053 | |

*Where, AVG= *Aloe vera* gel, AA= Ascorbic acid, $H_2O_2$= Hydrogen peroxide

fect of 30% *Aloe vera* gel-based coating, storage duration, and their interaction on the browning index (Fig.1). A steady increase in the browning index was observed with the extension of the storage period, with the highest value (4.45) recorded on the 15$^{th}$day. Among the different *Aloe vera* gel (30%)-based treatments, the combination of AVG 30% + AA 1% + $H_2O_2$ 1% exhibited the lowest browning index (2.09), while the highest index (3.45) was observed in the untreated control. The interaction effect between storage periods and AVG showed that the slight browning up to the 3$^{rd}$ day, followed by a gradual increase by the 15$^{th}$ day. Meanwhile, BI in non-coated fruits rose sharply, with complete browning observed by the 12$^{th}$ day of storage. Postharvest browning adversely affects the visual appeal of fruits and leads to substantial economic losses by diminishing their market value (Sivakumar *et al.,* 2010). In litchi, browning primarily results from desiccation induced degradation of anthocyanin pigments (Zhang *et al.,* 2015). The application of *Aloe vera* (ALV) coating helps reduce moisture loss by preserving the integrity of the fruit peel, thereby slowing down the degradation of anthocyanins (Sridevi *et al.,* 2018). Consequently, ALV-coated fruits exhibited reduced browning, likely due to better reten-

tion of anthocyanins.

***Total Soluble Solids (°Brix)***

The results demonstrated a significant effect of 30% *Aloe vera* gel-based coating, storage duration, and their interaction on total soluble solids (TSS) (Table 2). TSS values increased progressively with the extension of the storage period, reaching a peak of 19.26°Brix on the 9$^{th}$day, followed by a decline to 15.91°Brix on the 15$^{th}$day. Among the *Aloe vera* gel (30%)-based treatments, the combination of AVG 30% + AA 1% + $H_2O_2$ 1% recorded the highest TSS value (18.25°Brix), while the lowest TSS (16.98°Brix) was observed in the untreated control. The interaction effect of treatments over the storage period was found significant. The highestTSS value (20.15°Brix) was recorded on the 12$^{th}$ day in fruits treated with 30% *Aloe vera* gel combined with 1% ascorbic acid and 1% $H_2O_2$, followed closely by the treatment with 30% *Aloe vera* gel and 1% ascorbic acid (19.89°Brix). However, TSS levels in both treatments declined slightly by the 15$^{th}$ day*i. e*., 18.10 and 17.40°Brix, respectively. In contrast, the control fruits (uncoated) reached their peak TSS (21.00°Brix) on the 6$^{th}$ day, after which the TSS content declined rapidly through to the end of the storage period (15$^{th}$ day). The °Brix value of total soluble solids (TSS) plays a vital role in determining the flavour quality of litchi fruit (Jiang *et al.,* 2018). Postharvest senescence often leads to a decline in TSS, which in turn reduces the fruit's eating quality (Ali *et al.,* 2019). Studies have shown that applying *Aloe vera* (ALV) coating can slow down the degradation of TSS by delaying fruit senescence (Qamar *et al.,* 2018). Therefore, the use of ALV coating helped suppress senescence and preserved a higher concentration of TSS in coated litchi fruits.

***Titratable acidity (%)***

A significant influence of the 30% *Aloe vera* gel-based coating, storage duration, and their interaction was observed on titratable acidity (Table 2). As the storage period extended, titratable acidity showed a consistent declining trend, with the most substantial reduction (0.13%) recorded on the 15$^{th}$day. Among the various *Aloe vera* gel (30%)-based treatments, the combination of AVG 30% + AA 1% + $H_2O_2$ 1% exhibited the least decline in titratable acidity (0.27%), whereas the greatest reduction was observed in the untreated control (0.21%). The interaction effect between storage periods and AVG showed thatthe greatest reduction in TA (0.11%) was recorded in the control, followed by 0.12% in the treatment with 30% *Aloe vera* gel + 1% $H_2O_2$ . The lowest decrease in TA (0.15%) was observed in fruits treated with 30% *Aloe vera* gel + 1% ascorbic acid + 1% $H_2O_2$, closely followed by 0.14% in the treatment with 30% *Aloe vera* gel + 1% ascorbic acid, by the 15$^{th}$ day of storage. Titratable acidity (TA) in litchi fruits typically declines as the storage period increases (Shah *et al.,* 2017). This reduction is mainly attributed to oxidation processes associated with postharvest senescence (Mendy *et al.,* 2019). The application of *Aloe vera* (ALV) coating helps slow this decline by inhibiting senescence and reducing the oxidation of organic acids in the treated fruits (Song *et al.,* 2013). As a result, ALV coating likely minimized oxidation and delayed fruit senescence, thereby maintaining higher TA levels in the coated litchi fruits.

***Ascorbic acid (mg/100g)***

The data presented in Table 3 indicate that the coating treatments had a significant effect on ascorbic acid content (mg/100g) as storage progressed. A significant influence of the 30% *Aloe vera* gel-based coating, storage duration, and their interaction was observed on ascorbic acid levels. A progressive decline in ascorbic acid was noted with increasing storage time, with the lowest value (16.67mg/100g) recorded on the 15$^{th}$day. Among the *Aloe vera* gel (30%)-based treatments, the combination of AVG 30% + AA 1% + $H_2O_2$ 1% resulted in the least reduction in ascorbic acid content (31.12mg/100g), whereas the greatest loss was observed in the untreated control (26.78mg/100g). The interaction effect between storage period and *Aloe vera* gel (AVG) treatments was found to be statistically significant. By the 15$^{th}$ day, the greatest decrease in ascorbic acid content (10.20mg/100g) was recorded in the control. In contrast, the smallest declines were observed in

fruits treated with 30% *Aloe vera* gel + 1% ascorbic acid + 1% $H_2O_2$ and 30% *Aloe vera* gel + 1% ascorbic acid, which retained 20.25mg/100g and 18.90mg/100g of ascorbic acid, respectively. Ascorbic acid content generally decreases during storage as a result of oxidative degradation (Mditshwa*et al*., 2017). The application of *Aloe vera* (ALV) coating helps slow this decline by limiting oxidation during postharvest storage (Khaliq *et al.,* 2019). This protective effect is attributed to the coating's ability to restrict oxygen availability, thereby reducing oxidative breakdown and delaying fruit senescence (Sogvar*et al*., 2016; Khaliq *et al.,* 2019).

***Total sugars (%)***

The data presented in Table 3 indicate that the 30% *Aloe vera* gel-based coating, the storage duration, and their interaction had a significant effect on the total sugar content of litchi fruits. Over the course of storage, a gradual reduction in total sugar percentage was recorded, with the highest value (14.00%) on the 9$^{th}$day, followed by a decline to 13.18% by the 15$^{th}$day. Among the various coating treatments, the combination of AVG 30% + AA 1% + $H_2O_2$ 1% maintained the highest total sugar content (13.34%), whereas the lowest level was observed in the untreated control (11.65%). The interaction effect between storage periods and AVG showed that the highest total sugar content (15.44%) was observed on the 12$^{th}$ day in fruits treated with 30% *Aloe vera gel* + 1% ascorbic acid + 1% $H_2O_2$, followed by 14.69% in fruits coated with 30% *Aloe vera* gel + 1% ascorbic acid. By the 15$^{th}$ day, these values slightly declined to 14.89% and 14.20%, respectively. In contrast, the control fruits (uncoated) recorded their highest total sugar content (13.27%) on the 3$^{rd}$day, which subsequently declined as storage progressed. As reported by Campestre *et al*. (2000), the increase in total sugar content during storage is primarily due to the hydrolysis of polysaccharides into soluble sugars, or the breakdown of starch and other complex carbohydrates into simpler sugars. The subsequent decline in sugar content after reaching its peak may result from the complete utilization of sugars during respiration and fermentation over extended storage periods. These findings are in close agreement with those of Rani (2010) in litchi cv. Rose Scented. Similarly, Qamar *et al*. (2018) reported positive effects of *Aloe vera* gel coating, which effectively preserved the sugar content in strawberries.

***Total anthocyanin content (mg/100g)***

The findings indicated a significant influence of the *Aloe vera* gel-based coating, storage duration, and their interaction on anthocyanin content. A gradual increase in anthocyanin degradation was observed with the extension of the storage period (Table 4). The greatest decline in anthocyanin content (16.20) was observed at 15$^{th}$days of storage. Among the *Aloe vera* gel (30%)-based coating treatments, the combination of AVG 30% + AA 1% + $H_2O_2$ 1% retained the highest anthocyanin content (26.89), whereas the lowest was observed in the untreated control (18.63). The interaction effect between storage periods and *Aloe vera* gel showed that the highest anthocyanin content (19.60) was observed in fruits coated with *Aloe vera* gel 30% + ascorbic acid 1% + $H_2O_2$ 1%, whereas the lowest content (8.01) was recorded in the uncoated control fruits on the 15$^{th}$ day of storage at ambient condition. The red coloration of litchi fruit is primarily attributed to anthocyanins, which tend to degrade rapidly after harvest. This red hue is a key indicator of visual appeal and significantly influences the marketability of litchi (Sivakumar *et al.,* 2010). The degradation of anthocyanins is mainly caused by the breakdown of vacuoles, resulting in the loss of cellular compartmentation and the subsequent enzyme-mediated degradation of these pigments (Jiang *et al.,* 2018). *Aloe vera* (ALV) coating helps preserve cellular integrity by delaying senescence, thereby reducing the activity of pro-oxidant enzymes (Supapvanich *et al.,* 2016). As a result, ALV coating likely maintained cellular compartmentation in the litchi peel and helped retain higher levels of anthocyanin pigments.

***Total antioxidants capacity (DPPH) (µmoltrolex eq. /100g FW)***

The results demonstrated a significant effect of *Aloe vera* gel-based coating, storage duration, and their interaction on the antioxidant activity of litchi fruits

(Table 4). A progressive decline in antioxidant activity was observed with increasing storage time, with the lowest value (29.16 µmol/100g FW) recorded on the 15thday. Among the *Aloe vera* gel (30%)-based treatments, the combination of AVG 30% + AA 1% +$H_2O_2$ 1% exhibited the highest antioxidant activity (51.59 µmol/100g FW), while the lowest was found in the untreated control (41.73 µmol/100g FW). The interaction effect between storage periods and AVG showed that the highest antioxidant activity was recorded on the 15th day in $T_3$ (*Aloe vera* gel 30% + ascorbic acid 1% + $H_2O_2$ 1%) at 34.33 µmol/100g FW, followed by $T_1$ (*Aloe vera* gel 30% + ascorbic acid 1%) with 33.44 µmol/100g FW. In contrast, the control treatment ($T_4$) showed the lowest antioxidant level at 16.85 µmol/100g FW, with $T_2$ (*Aloe vera* gel 30% + $H_2O_2$ 1%) slightly higher at 32.03 µmol/100g FW. This finding is consistent with the earlier study by Kumari *et al*. (2015), which reported that applying an edible coating to litchi fruits helped preserve antioxidant activity during storage by reducing the activity of PPO and POD enzymes. Similarly, Kumar *et al*. (2017) demonstrated the effectiveness of *Aloe vera* gel coating in maintaining the total antioxidant capacity of guava fruits.

***Sensory quality (SQ) evaluation***

The primary qualities of fruits that influence consumer preference are skin appearance, taste, and aroma, as these elements greatly affect overall fruit acceptability. Among the assessed attributes, visual appearance was particularly important in determining the fruit samples' appeal and served as a key factor in the sensory assessment process. Result showed significant effect of *Aloe vera* (30%) gel-based coating, and storage periods and their interaction on sensory quality evaluation of litchi fruits (Table 5). A progressive decline in sensory evaluation scores for skin appearance, taste, and overall acceptability was observed with the extension of the storage period. The lowest scores were recorded on the 15thday, with values of 2.62 for skin appearance, 2.70 for taste, and 2.57 for overall acceptability. Among the *Aloe vera* gel (30%)-based coating treatments, the combination of AVG 30% + AA 1% + $H_2O_2$ 1% received the highest sensory scores *i. e*., 5.93 for skin appearance, 6.21 for taste, and 5.93 for overall acceptability, while the control showed the lowest scores (3.90, 3.41, and 3.48, respectively). A significant interaction effect between treatments and storage period was observed in the sensory evaluation. The fruits treated with *Aloe vera* gel 30% + ascorbic acid 1% + $H_2O_2$ 1% achieved the highest scores for skin appearance (6.3), taste (6.60), and overall acceptability (6.50) on the 6th day of storage, followed by the treatment with *Aloe vera* gel 30% + ascorbic acid 1%, which recorded scores of 6.1, 6.5, and 6.3, respectively. These scores declined on the 9th, 12th, and 15th days of storage. In contrast, uncoated fruits showed their peak scores for skin appearance (6.0), taste (6.3), and overall acceptability (6.0) on the 3rd day of storage, with a consistent decline observed during subsequent storage periods. Das *et al*. (2024) observed that lemons coated with *Aloe vera* gel retained their fresh appearance and resisted mould development for up to 20 days of storage. Comparable outcomes were noted by Parven *et al*. (2020) for papaya and Qamar *et al*. (2018) for strawberries, where *Aloe vera* gel (AVG) coatings helped minimize colour changes during storage. Furthermore, sensory evaluations of coated fruits indicated improvements in visual appeal without negatively impacting taste, aroma, or flavour. These findings are reinforced by Bhavana *et al*. (2018), who reported that *Aloe vera* coating yielded the highest skin colour scores in apple ber fruits. Similarly, Sophia *et al*. (2015) demonstrated that *Aloe vera* gel significantly prolonged colour retention in mangoes under ambient conditions. Kumar *et al*. (2017) also highlighted the effectiveness of sodium alginate and *Aloe vera* gel coatings in preserving guava quality and achieving optimal overall acceptability for up to 15 days.

## CONCLUSION

It is concluded that *Aloe vera* gel-based edible coatings effectively improved the postharvest quality of litchi fruits during storage periods. *Aloe vera* gel (30%) based with 1% ascorbic acid and 1% hydrogen peroxide notably reduced weight loss, browning, and decay and retained thephysicochemical, phytochemical, and sensory attributes up to 9thday as compared to control during ambient storage. This

eco-friendly, low-cost method offers a promising solution for extending shelf life and reducing postharvest losses of litchi fruits upto three times under ambient conditions.

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