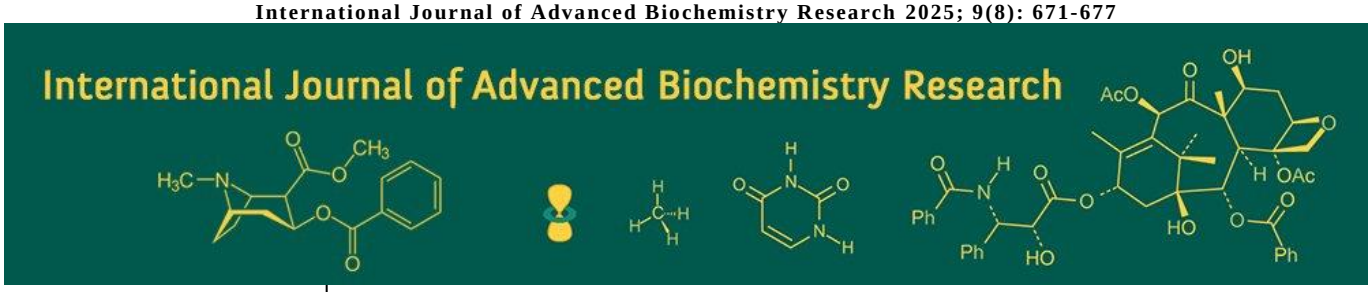

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Impact of *Aloe vera* gel edible coating on the quality of kinnow during storage

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Abstract
The study examines the effect of an edible coating derived from *Aloe vera* gel at four different concentrations mixed with water (0:1), (1:1), (2:1), and (3:1) on the preservation of kinnow quality. The kinnow was stored at 5 ± 0.5°C and 90 ± 2% relative humidity (RH) using LDPE packaging and without packing for 35 days. Quality criteria including firmness, physiological weight loss, colour alteration, titratable acidity, total soluble solids (TSS), TSS/acid ratio, ascorbic acid concentration, juice yield, and sensory attributes were assessed at 7-day intervals. After a 14-day storage period, the characteristics of the uncoated specimens degraded more rapidly than those of the treated specimens. The produce was not subjected to any visible pathogen attacks. The findings indicated that *Aloe vera* gel coating successfully preserved the quality of stored kinnows, with optimal results achieved at a (3:1) concentration, positioning it as a viable alternative coating for kinnow.

Keywords: Firmness, colour, physiological weight loss, juice content

Introduction
Kinnow mandarin, a first-generation hybrid of King × Willow leaf, is the most prevalent citrus fruit cultivated. Kinnow (*Citrus deliciosa* Ten.) has achieved significant popularity among cultivators and consumers in North India owing to its exceptional fruit quality, vigorous tree growth, higher yield potential, and superior performance relative to other citrus varieties. Eckert (1978) [16], Naqvi and Dass (1994) [31], and Singh and Jain (2004) [44] assert that qualitative losses become more severe when fungal infections and extensive rot penetration render the infected produce unsuitable for human consumption. Mandarin group fruits are especially susceptible to microbial attacks that lead to postharvest deterioration (Sharma *et al*., 2008) [42].

Edible coatings are thin films that improve food product quality and can be safely eaten as part of the product without inducing negative alterations (Baldwin, 1994; Ahvenainen, 1996; Díaz-Montes *et al*., 2021) [1, 2, 14]. Edible coatings provide a barrier against external agents, prolonging shelf life by minimising gas exchange, flavour degradation, moisture loss, aroma dissipation, and solute migration towards the cuticle (Tzia, C *et al*. 2016) [48]. They are secure due to the natural biocidal properties or incorporation of antimicrobial compounds (Petersen *et al*., 1999; Aloui, H *et al*., 2016) [35, 3]. *Aloe vera* is a tropical and subtropical plant recognised for its medical and therapeutic qualities (Eshun & He, 2004; Mditshwa *et al*., 2017) [17, 29]. It is an edible plant that poses no environmental risk and is readily available. *Aloe vera* gel serves as an antibacterial, antifungal, and anti-inflammatory agent (Danish *et al*., 2020) [13]. The efficacy of *Aloe vera* gel as an edible coating is contingent upon its composition (Dang *et al*., 2008) [12]. Its application provides an environmentally favourable alternative to film packaging (Rojas-Argudo *et al*., 2005) [38]. Martinez-Romero *et al*. (2006) [28] reported the use of *Aloe vera* gel as an edible covering to prolong shelf life and inhibit senescence in sweet cherries and table grapes. *Aloe vera* gel-based edible coatings have demonstrated effectiveness in preventing moisture loss, mitigating softening, regulating respiration and senescence rates, delaying oxidative browning, and inhibiting microorganism growth in diverse food products (Ahmed *et al*., 2009; Valverde *et al*., 2005; Martinez-Romero *et al*., 2006; Marpudi *et al*., 2011) [1, 49, 28, 27]. This novel method presents a viable substitute for postharvest chemical applications, prolonging the shelf life of food items.

Chitosan, a natural polymer derived from the deacetylation of chitin, presents benefits including biocompatibility, biodegradability, and non-toxicity relative to other polysaccharides. It possesses bacteriostatic and fungistatic characteristics (Dutta *et al*., 2009; Kumar, 2000) [15, 23]. Chitosan serves as an edible surface coating for fruits and vegetables owing to its superior film-forming characteristics (Han *et al*., 2004; Ribeiro *et al*., 2007) [21, 37]. Pectin is frequently used in diverse food formulations as a gelling and thickening ingredient. It is used in the manufacture of jams, jellies, and marmalades because of its capacity to gel in a sugar-acid solution. Pectin has emerged as a significant component in the food sector owing to its rising demand. Low-density polyethylene (LDPE) is extensively used in the food industry as a packaging material to preserve product quality and prolong shelf life by inhibiting weight loss and contamination. The objective of this investigation was to enhance the quality of kinnow by optimising the concentration of *Aloe vera* gel coating and to evaluate its influence on the qualitative characteristics of kinnow fruit during refrigerated storage. This study assessed the effectiveness of *Aloe vera* gel as an edible surface coating to enhance the shelf life and quality of kinnow fruit.

Materials and Methods

Kinnow fruits were procured from the university campus (Punjab Agricultural University, Ludhiana, Punjab) and the local market of Ludhiana. Fruits were selected based on dimensions, hue, and lack of exterior blemishes. Fresh *Aloe vera* leaves were procured from the university campus and the adjacent market. Chitosan and pectin were obtained from Global Traders in Ludhiana.

The *Aloe vera* plant's fresh leaves were cleaned using a 25% chlorine solution. The *Aloe vera* gel matrix was subsequently extracted from the outer cortex of the leaves, and the colourless hydroparenchyma was homogenised using a processor. The acquired matrix was filtered using cheesecloth to remove fibres. Pasteurisation was done at 70°C for 45 minutes to inhibit enzymatic degradation of the *Aloe vera* concentrate. Subsequently, the gel was promptly cooled to room temperature, and ascorbic acid (1.9-2.0 g/L) and citric acid (4.5-4.6 g/L) were incorporated to inhibit browning, enhance flavour, and stabilise the juice. The pH of *Aloe vera* juice was sustained at 4. It was then kept in brown amber bottles to avoid oxidation.

The edible *Aloe vera* gel coating solution was formulated using four distinct strengths of *Aloe vera* gel and water: (1:1), (2:1), (3:1), and (0:1) as the control. Pectin at a 1% (w/v) concentration was hydrated with the produced solution at ambient temperature and subsequently solubilised in a water bath at 50°C. Upon completion of solubilisation, glycerol at a concentration of 1% (w/v) was incorporated into the prepared coating solution, which was maintained in a water bath with gentle agitation for 30 minutes. A chitosan solution was prepared by dissolving 1% (w/v) chitosan in 0.5% acetic acid in distilled water. The pH of 5.6 was then adjusted with 0.1M NaOH. This prepared chitosan solution was mixed with the *Aloe vera* juice and water solutions of different concentrations. The fresh kinnow fruits were properly washed twice with chlorinated water and air-dried. The fruits were randomly grouped into four classes. The four groups were immersed in coating solutions of *Aloe vera* gel and water: C1 (1:1), C2 (2:1), C3 (3:1), and C0 (0:1) (control) for a duration of 5 minutes. They were then dried until their coatings were non-sticky to the touch. Treated fruits were maintained under refrigerated settings (5 ± 0.5°C and 90 ± 2% RH) both unwrapped (P0) and wrapped in LDPE bags (P1). The treated and untreated fruits underwent physical and chemical analysis over a 35-day storage duration. Prior to storage, three kinnow fruits per replication for each treatment were weighed using a digital balance, recording the initial weight of the kinnow. The identical fruits were weighed at weekly intervals throughout the storage duration. The physiological weight loss was determined as the percentage reduction of beginning weight (Han *et al*. 2004). The firmness of fruits was assessed using a texture analyser with a penetration test. A needle probe with a diameter of 5 mm was permitted to enter the fruit to a depth of 20 mm. Throughout the analysis, a 50 kg load cell was utilised, with a pre-test speed of 2.5 mm/sec, a test speed of 2.0 mm/sec, and a post-test speed of 10 mm/sec. The force necessary to breach the fruit's skin surface has been recorded in kilogrammes (Padmaja *et al*. 2015) [33].

The color of samples was measured using a Miniscan XE plus Hunter lab colorimeter. Before measuring the color, the colorimeter was adjusted using white and dark plates. Three measurements were taken on each fruit. The Hunter Lab color scale was used to measure color values: L* for lightness, a* from green to red, and b* from yellow to blue. Total color difference (ΔE) was calculated as:

$$\Delta E = \left(\sqrt{\Delta a^2 + \Delta b^2 + \Delta L^2}\right) \quad (1)$$

Where $\Delta L = L^*_{standard} - L^*_{sample}$, $\Delta a = a^*_{standard} - a^*_{sample}$ and $\Delta b = b^*_{standard} - b^*_{sample}$.

Total soluble solids (TSS) in kinnow juice were determined at ambient temperature using a hand refractometer calibrated from 0 to 32° Brix (Padmaja *et al*. 2015) [33]. Measurements were conducted in triplicate. Titratable acidity was determined by titrating 2 ml of juice in a conical flask with 0.1 N NaOH, utilising 2-3 drops of phenolphthalein as an indicator until a pink hue emerged. The outcome is expressed as % total acidity (titrated acidity) (AOAC 2000) [4]. The TSS/acid ratio was determined by dividing the °Brix value of the fruit by its titratable acidity.

Juice content was calculated by cutting the fruit and squeezing out all the juice with an extractor or a juice press. The extracted juice was then filtered through muslin cloth. Juice content was calculated as:

$$\text{Juice content (\%)} = \frac{W_1 - W_2}{W_1} \text{X } 100$$

W_1 = Total weight of juice (g)
W_2 = beaker weight (g).

Ascorbic acid (AA) was determined by visual titration technique using 2,6-dichlorophenol indophenol (Ranganna, 1999) [36]. The dye, which is blue in alkaline solution and red in acid solution, was reduced by ascorbic acid.

$$AA(mg/100g) = \frac{0.5mg \times V_1 \times 100ml}{V_2 \times 5ml \times \text{weight of sample}} \times 100$$

The specimens underwent inspection by a randomly selected panel for sensory evaluation. They were informed about the sensory attributes to be evaluated. Each panel member received a sensory evaluation rating scale, which was used to assess various samples. The mean values of assessments derived from the individuals were subsequently calculated. The evaluation of physio-organoleptic qualities was conducted based on colour, appearance, texture, and general acceptability using a 9-point hedonic scale.

Results and Discussion

Firmness

Firmness is crucial for consumer acceptability of fresh fruits, influencing texture and shelf life. Statistical data indicated that storage duration and treatment interactions significantly impacted fruit firmness. Over-ripening and skin pitting lead to changes in fruit weight and size. Coated fruits retained firmness as degradation of insoluble protopectines to soluble pectin and pectin acid is reduced. As fruit ripens the pectic depolymerized and activity pectinesterase and polygalacturonase increase. (Yaman and Bayoindirli 2002) [51]. High carbon-dioxide gas and low oxygen gas also helps in reducing activity of enzyme, retaining firmness during storage (Salunkhe *et al*. 1991) [40]. Results are shown is fig 1a, 1b and 1c

At harvest, mean fruit firmness was 1.919 kgf, similar for both control and coated fruits, but it decreased during storage. Control fruits showed a higher loss in firmness than coated samples, as the coating delayed softening. Under refrigerated conditions, control and unpacked fruits gradually lost firmness, while properly packed with coating fruits maintained better firmness. A decay in fruit notices after 56 days, but fruits with coating showed slight softeness, with significant differences ($p \leq 0.05$). Firmness of 1.648 kgf was noted in C4P1D3T1, 1.632 kgf in C4P1D2T1 and 1.617 kgf in C4P1D1T1 at 77 days. Minimum firmness (0.874 kgf) was observed in C0P0T1 at 56 days. Kinnow coated C1P0D1T1 with C1 concentration decayed after 35 days, was having firmness 0.904 kgf.

Aloe vera coating effectively maintained kinnow firmness after 77 days, while control fruits stayed for 56 days. Similar findings by Lerdthanangkul (1996) [24] and Hagenmaeir (1995) [20] indicated that coatings significantly affect fruit firmness. *Aloe vera* coatings also increased pineapple shelf life by maintaining firmness and less mechanical damage and reducing decay (Vidrih *et al*. 1998; Batisse *et al*. 1996) [50, 6]. The statistical analysis proved that coatings and packaging has significant effect on firmness.

As illustrated in Figures 2a, 2b, and 2c, both control and unpackaged kinnow fruits exhibited a decline in firmness from the initial measurement of 1.919 kgf, whereas coated and packaged fruits retained firmness more effectively throughout the storage period. By the sixth day, control samples had decayed, while coated ones remained marginally acceptable, demonstrating statistically significant differences ($p \leq 0.05$). Appendices A4, A5, and A6 further supported that fruits treated with coating and stored in LDPE bags maintained firmness better across all three dipping durations (D1, D2, D3) during a 10-day storage period. Among all treatments, the highest average firmness (1.378 kgf) was recorded in the C4P1D3T0 group, followed by C4P1D2T0 (1.355 kgf). In contrast, the lowest firmness value (0.803 kgf) was observed in C1P0D1T0 after six days. Control fruits had significantly degraded by this time, with a minimum firmness of 0.854 kgf in the C0P0T0 group. Fruits treated with the C1 coating concentration and control samples were no longer viable after six days. *Aloe vera* coatings proved particularly effective in preserving firmness over 10 days, aligning with earlier research by Lerdthanangkul and Krochta (1996) [24] and Hagenmaier and Baker (1995) [20], who highlighted the role of edible coatings in maintaining fruit texture. Similar observations were reported by Batisse *et al*. (1996) [9] and Vidrih *et al*. (1998) [50], noting *Aloe vera*'s potential to delay decay and firmness loss. Additionally, Shelton (1991) [46] found that *Aloe vera* gel exhibits antibacterial properties against various foodborne pathogens such as *Bacillus cereus*, *Salmonella typhimurium*, *Escherichia coli*, and *Klebsiella pneumoniae*, contributing to its preservation effect on fruit firmness.

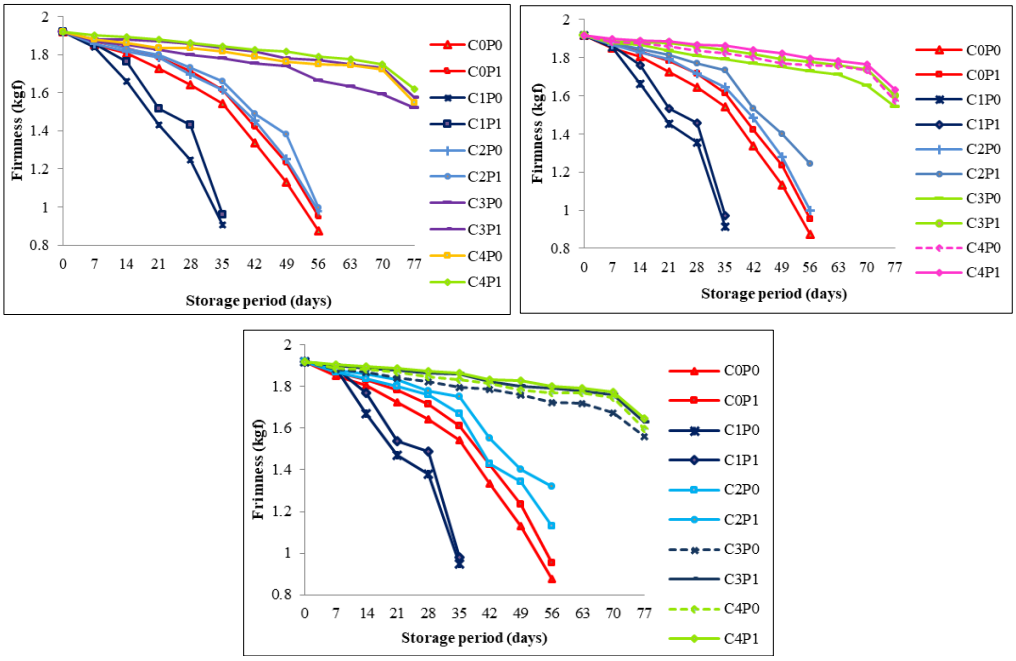

Fig 1: Effect of *Aloe vera* gel coating on kinnow firmness (kgf) with (a) Dipping time D1 (3 min) (b) Dipping time D2 (5 min) (c) Dipping time D3 (7 min) packed and unpacked stored under refrigerated conditions (T1).

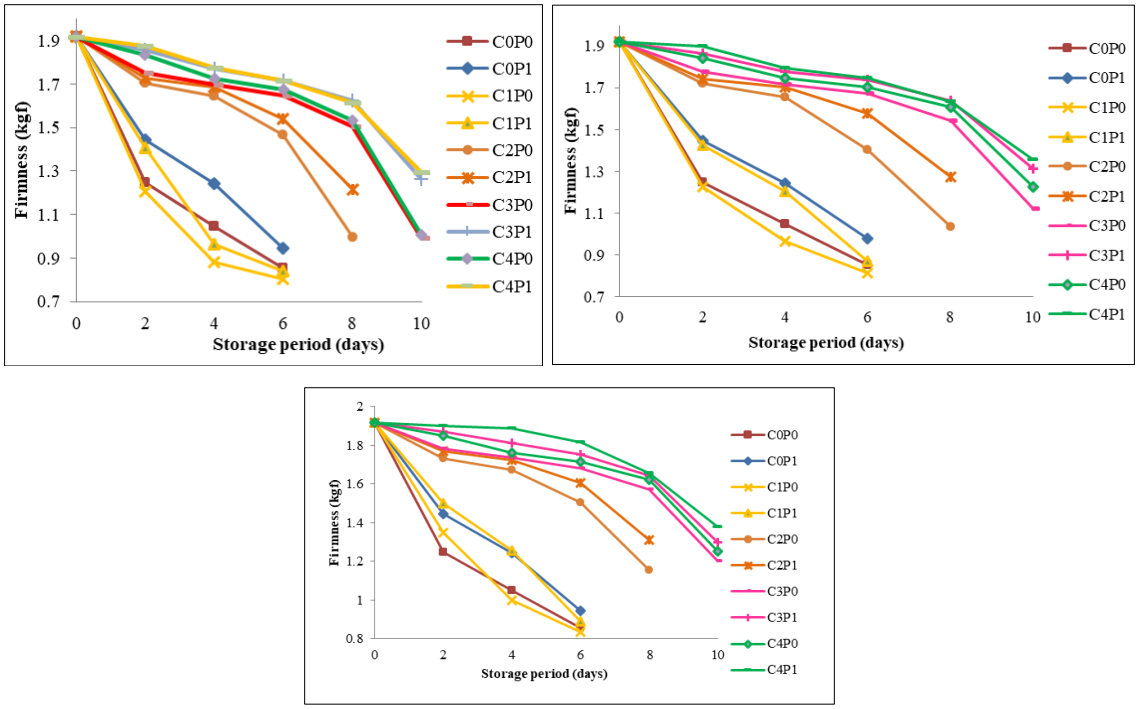

Fig 2: Effect of *Aloe vera* gel coating on kinnow firmness (kgf) with (a) Dipping time D1 (3 min) (b) Dipping time D2 (5 min) (c) Dipping time D3 (7 min) packed and unpacked stored under ambient conditions (T0).

Physiological Weight Loss (PLW)

Physiological weight loss is a key indicator of postharvest deterioration, mainly resulting from water loss via transpiration and the depletion of stored carbon through respiration. Water loss depends on the vapor pressure gradient between the fruit surface and the external atmosphere. Additionally, during respiration, carbon is lost as CO_2, contributing to overall weight reduction. Applying coatings helps minimize both water and carbon loss by forming a semi-permeable film that restricts gas exchange.

In this study, statistical evaluation revealed that factors such as *Aloe vera* gel coatings, packaging type, storage duration, and dipping intervals, along with their interactions, significantly influenced the weight loss in kinnow fruits. After 56 days, uncoated (control) fruits exhibited the highest average PLW of 14.9%, whereas the lowest PLW of 4.02% was observed in coated fruits stored in LDPE packaging (C4P1D3T1) for 77 days (Appendix A9). These results emphasize the moisture retention ability of coated and LDPE-packed kinnows.

Further analysis confirmed that *Aloe vera*-coated fruits stored for 10 days had significantly reduced weight loss compared to controls. Specifically, C4P1D3T0-treated fruits showed the lowest weight loss (3.75%), while control fruits (C0P0T0) had the highest (10.43%) after 6 days (Appendix A12). Other effective treatments included C4P1D2T0 (3.98%) and C3P1D3T0 (3.99%). The least effective treatment was C1P0D1T0, with a PLW of 6.35%, and fruit decay occurred after 6 days. C2-treated fruits also deteriorated within 8 days with a PLW of 5.46% in C2P0D1T0. These outcomes highlight the effectiveness of *Aloe vera* coatings combined with LDPE packaging in reducing moisture loss. Similar observations have been made in previous studies, where edible coatings retained water content and limited spoilage in fruits like grapes (Valverde *et al*., 2005; Avena-Bustillos *et al*., 1997) [49, 6]. *Aloe vera* gel also showed antimicrobial effects, particularly against yeasts and molds, which contributed to extended shelf life (Tripathi *et al*., 2004) [47].

Colour Change (ΔE)

Fruit color was analyzed using the 'L', 'a', and 'b' parameters, and the overall change in color (ΔE) was computed. The results indicated a significant ($p \leq 0.05$) difference in color development between treated and untreated fruits. Uncoated and unpackaged fruits exhibited the most pronounced color changes, with ΔE values reaching 8.54±0.058% by day 35, while the least change (2.54±0.058%) was noted in fruits treated with 3:1 *Aloe vera* gel and packed in LDPE bags. The coating slowed ripening by delaying pigment transformation. Similar outcomes were reported in strawberries and tomatoes, where moisture loss and gas composition affected the rate of color change (Nunes *et al*., 2005; Yang and Chinnan, 1987). *Aloe vera*'s ability to suppress ethylene production played a role in delaying chlorophyll degradation and pigment formation (Carrillo-Lopez *et al*., 2000) [10].

Total Soluble Solids (TSS)

A consistent increase in TSS was observed during storage, starting from 10.2±0.058ºBrix. Coated fruits (3:1 *Aloe vera* concentration) packed in LDPE maintained TSS values better, recording 10.5±0.058ºBrix after 14 days and 11.4±0.058ºBrix after 35 days. Control fruits without packaging exhibited a faster rise in TSS, reaching 11.9±0.058ºBrix after 14 days and peaking at 13.8±0.058ºBrix at 35 days. This rapid increase could be attributed to higher water loss, leading to sugar concentration. Prior research with *Aloe vera* gel-coated nectarines also showed lower TSS increments compared to untreated fruits (Ahmed *et al*., 2009) [1].

Titratable Acidity (TA)

Titratable acidity showed a statistically significant decline over time. The highest TA level (0.86±0.0058%) was

observed in coated and LDPE-packed fruits (3:1 concentration), whereas the lowest (0.66±0.0058%) was found in control samples. The reduction in acidity as storage progressed is typical as fruits mature, converting organic acids to sugars. These findings are consistent with patterns observed in apples and guavas during cold storage (Sadler & Murphy, 1998; Olivas *et al*., 2007) [39, 32].

TSS/Acid Ratio

This ratio, a marker of citrus fruit taste, increased progressively from an initial value of 10.74±0.0058. The highest ratio (20.91±0.0058) was observed in control and unpackaged fruits, indicating advanced ripening. Meanwhile, the lowest ratio (13.26±0.012) was found in *Aloe vera*-treated and LDPE-packed kinnows, highlighting the delayed ripening process. Earlier work on citrus fruits stored under similar conditions also reported comparable trends (Medlicott & Thompson, 1985; Arowora *et al*., 2013) [30, 5].

Juice Content

Juice yield declined throughout the storage period. The initial value of 52.8±0.058% dropped to 51.5±0.058% in coated and packed fruits and further to 46.1±0.058% in control fruits by day 35. The retention of juice was better in *Aloe vera*-coated kinnows, reinforcing its effectiveness in reducing dehydration.

Ascorbic Acid (AA) Content

Vitamin C levels significantly declined over time, with clear differences between treatments ($p \leq 0.05$). Control fruits showed the sharpest drop, reaching 15.2±0.058 mg/100g, while *Aloe vera*-coated and LDPE-packed fruits retained higher levels (22.03±0.058 mg/100g) by day 35. The slower decline in treated fruits is due to reduced oxidation and better moisture retention.

Overall Acceptability (OA)

Sensory evaluation based on appearance, flavor, and texture revealed that control fruits remained acceptable only up to 21 days, while coated kinnows were rated acceptable even at day 35. The best sensory ratings were recorded for 3:1 coated and packed kinnows, with an overall acceptability score of 79.8±0.58%, compared to 48.4±0.58% for control fruits. The slower decline in quality attributes under *Aloe vera* treatment supports earlier findings on coated guava fruits (Singh & Yadav, 2011) [45].

Table 1: Effect of dipping time, coating concentration, packaging and storage period on kinnow physiological weight loss (PLW%) stored under refrigerated conditions.

Quality Parameter	Dipping time (A)			Storage(B)						Coatings (C)					Packaging (D)	
	D1	D2	D3	0	7	14	21	28	35	C0	C1	C2	C3	C4	P0	P1
PLW (%)	2.74	2.54	2.33	0	0.72	1.35	2.23	3.64	4.74	3.89	4.19	1.96	1.43	1.21	2.79	2.28
LSD	0.02			0.026						0.026					0.016	
(p=0.05)	AB: 0.045 AC: 0.045 AD: 0.028 BC: 0.058 BD: 0.037 CD: 0.037 ABCD: 0.14															

Table 2: Effect of dipping time, coating concentration, packaging and storage period on kinnow physiological weight loss (PLW%) stored under ambient conditions.

Quality Parameter	Dipping time (A)			Storage(B)				Coatings (C)					Packaging (D)	
	D1	D2	D3	0	2	4	6	C0	C1	C2	C3	C4	P0	P1
PLW (%)	3.5	3.4	3.2	0	1.74	3.6	4.8	6.83	4.58	2.32	1.67	1.46	3.66	3.09
LSD	0.018			0.018				0.024					0.015	
(p=0.05)	AB: 0.032 AC: 0.041 AD: 0.026 BC: 0.041 BD: 0.026 CD: 0.034 ABCD : 0.101													

Table 3: Effect of dipping time, coating concentration, packaging and storage period on kinnow colour change (ΔE) stored under ambient conditions.

Quality Parameter	Dipping time (A)			Storage(B)				Coatings (C)					Packaging (D)	
	D1	D2	D3	0	2	4	6	C0	C1	C2	C3	C4	P0	P1
Colour change	2.4	2.35	2.32	0	0.8	2.06	4.22	5.45	2.0	1.9	1.27	1.16	2.44	2.27
LSD	0.029			0.029				0.037					0.023	
(p=0.05)	AB: 0.051 AC: 0.065 AD: NS BC: 0.065 BD: 0.041 CD: 0.053 ABCD : NS													

Table 4: Effect of dipping time, coating concentration, packaging and storage period on kinnow colour change (ΔE) stored under ambient conditions.

Quality Parameter	Dipping time (A)			Storage(B)				Coatings (C)					Packaging (D)	
	D1	D2	D3	0	2	4	6	C0	C1	C2	C3	C4	P0	P1
Colour change	2.4	2.35	2.32	0	0.8	2.06	4.22	5.45	2.0	1.9	1.27	1.16	2.44	2.27
LSD	0.029			0.029				0.037					0.023	
(p=0.05)	AB: 0.051 AC: 0.065 AD: NS BC: 0.065 BD: 0.041 CD: 0.053 ABCD : NS													

Conclusion

The results of this study demonstrate that *Aloe vera* gel-based coatings significantly enhance the postharvest quality of kinnow fruits. By minimizing physiological weight loss, delaying color and texture degradation, and retaining nutritional parameters such as TSS and ascorbic acid, *Aloe vera* gel proved to be an effective natural preservative. Among the various concentrations, the 3:1 *Aloe vera* and water combination gave the best results, especially when paired with LDPE packaging. Treated fruits remained free from fungal contamination and showed superior marketability for up to 35 days under refrigerated conditions.

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Conceptualization and designing of the research work (Satish Kumar Gupta); Execution of field/lab experiments and data collection (Surpreet Kaur); Analysis of data and interpretation (M S Alam); Preparation of manuscript (Preeti Birwal).

Declaration: The authors should declare that they do not have any conflict of interest.

References
1. Ahmed MJ, Singh Z, Khan AS. Postharvest *Aloe vera* gel-coating modulates fruit ripening and quality of 'Arctic Snow' nectarine kept in ambient and cold storage. International Journal of Food Science and Technology. 2009;44(5):1024-1033.
2. Ahvenainen R. New approaches in improving the shelf life of minimally processed fruit and vegetable. Trends in Food Science and Technology. 1996;7:79-87.
3. Aloui H, Khwaldia K. Natural antimicrobial edible coatings for microbial safety and food quality enhancement. Comprehensive Reviews in Food Science and Food Safety. 2016;15(6):1080-1103.
4. AOAC. Methods of analysis. 16th ed. Washington, DC: Association of Official Analytical Chemists; 2000.
5. Arowora KA, Williams JO, Adetunji CO, Fawole OB, Afolayan SS, Olaleye OO, *et al*. Effects of *Aloe vera* coatings on quality characteristics of oranges stored under cold storage. Greener Journal of Agricultural Sciences. 2013;3(1):39-47.
6. Avena-Bustillos RJ, Krochta JM, Saltveit ME. Water vapour resistance of Red Delicious apples and celery sticks coated with edible caseinate-acetylated monoglyceride films. Journal of Food Science. 1997;62:351-354.
7. Baldwin EA. Edible coatings for fresh fruits and vegetables: past, present, and future. In: Krochta JM, Baldwin EA, Nisperos-Carriedo MO, editors. Edible coatings and films to improve food quality. Lancaster, PA: Technomic Publishing Company; 1994. p. 25-64.
8. Baldwin EA, Burns JK, Kazokas W, Brecht JK, Hagenmaier RD, Bender RJ, *et al*. Effect of two edible coatings on mango (*Mangifera indica* L.) ripening during storage. Postharvest Biology and Technology. 1999;17(3):215-226.
9. Batisse C, Buret M, Coulomb PJ. Biochemical differences in cell wall of cherry fruit between soft and crisp fruit. Journal of Agricultural and Food Chemistry. 1996;44:453-457.
10. Carrillo-Lopez A, Ramirez-Bustamante F, Valdez-Torres J, Rojas-Villegas R, Yahia E. Ripening and quality changes in mango fruit as affected by coating with an edible film. Journal of Food Quality. 2000;23(5):479-486.
11. Castillo S, Navarro D, Zapata PJ, Guillen F, Valero D, Serrano M, *et al*. Antifungal efficacy of *Aloe vera in vitro* and its use as a preharvest treatment to maintain postharvest table grape quality. Postharvest Biology and Technology. 2010;57(3):183-188.
12. Dang KT, Singh Z, Swinny EE. Edible coatings influence fruit ripening, quality and aroma biosynthesis in mango fruit. Journal of Agricultural and Food Chemistry. 2008;56(4):1361-1370.
13. Danish P, Ali Q, Hafeez MM, Malik A. Antifungal and antibacterial activity of *Aloe vera* plant extract. Biological and Clinical Sciences Research Journal. 2020;1:1-8.
14. Díaz-Montes E, Castro-Muñoz R. Edible films and coatings as food-quality preservers: an overview. Foods. 2021;10(2):249.
15. Dutta PK, Tripathi S, Mehrotra GK, Dutta J. Perspectives for chitosan-based antimicrobial films in food applications. Food Chemistry. 2009;114(4):1173-1182.
16. Eckert JW. Post-harvest diseases of citrus fruits. Outlook on Agriculture. 1978;9:225-232.
17. Eshun K, He Q. *Aloe vera*: a valuable ingredient for the food, pharmaceutical and cosmetic industries - a review. Critical Reviews in Food Science and Nutrition. 2004;44(2):91-96.
18. Grewal AG, Hafiz IA, Chaudhary AH, Khan MI, Chaudhary MI. Quality estimation during marketing of kinnow and Feutrell's Early. International Journal of Agriculture and Biology. 2000;2:328-330.
19. Gangwar LS, Singh D, Singh D. Estimation of post-harvest losses in Kinnow mandarin in Punjab using a modified formula. Agricultural Economics Research Review. 2007;20(2):315-331.
20. Hagenmaier RD, Baker RA. Layered coatings to control weight loss and preserve gloss of citrus fruit. Horticultural Science. 1995;30(2):296-298.
21. Han JH, Floros JD. Casting antimicrobial packaging films and measuring their physical properties and antimicrobial activity. Journal of Plastic Film and Sheeting. 1997;13:287-298.
22. Krochta JM, Baldwin EA, Nisperos-Carriedo MO. Edible coatings and films to improve food quality. Lancaster, PA: Technomic Publishing; 1994.
23. Kumar MNV. A review of chitin and chitosan applications. Reactive and Functional Polymers. 2000;46:1-27.
24. Lerdthanangkul S, Krochta JM. Edible coating effects on postharvest quality of green bell peppers. Journal of Food Science. 1996;61:176-179.
25. Lidster PO, Tung MA, Garland MR, Porritt SW. Texture modification of processed apple slices by a postharvest heat treatment. Journal of Food Science. 1979;44(4):998-1000.
26. Gounga ME, Xu SY, Wang Z. Whey protein isolate-based edible films as affected by protein concentration, glycerol ratio and pullulan addition in film formation. Journal of Food Engineering. 2007;83:521-530.
27. Marpudi SL, Ramachandran P, Srividya N. *Aloe vera* gel coating for postharvest quality maintenance of fresh fig fruits. Research Journal of Pharmaceutical, Biological and Chemical Sciences. 2013;4(1):878-887.
28. Martinez-Romero D, Alburquerque N, Valverde JM, Guillén F, Castillo S, Valero D, *et al*. Postharvest sweet cherry quality and safety maintenance by *Aloe vera* treatment: a new edible coating. Postharvest Biology and Technology. 2006;39(1):93-100.
29. Mditshwa A, Magwaza LS, Tesfay SZ, Opara UL. Postharvest factors affecting vitamin C content of citrus

fruits: a review. Scientia Horticulturae. 2017;218:95-104.
30. Medlicott AP, Thompson AK. Analysis of sugars and organic acids in ripening mango fruit (*Mangifera indica* L. var. Keitt) by high performance liquid chromatography. Journal of the Science of Food and Agriculture. 1985;36:561-566.
31. Naqvi SAMH, Dass HC. Assessment of post-harvest losses in Nagpur mandarin: a pathological perspective. Plant Disease Research. 1994;9(2):215-218.
32. Olivas GI, Mattinson DS, Barbosacanovas GV. Alginate coatings for preservation of minimally processed '*Gala*' apples. Postharvest Biology and Technology. 2007;45(2):89-96.
33. Padmaja N, Don Bosco SJ, Rao JS. Physico-chemical analysis of sapota (*Manilkara zapota*) coated by edible *Aloe vera* gel. International Journal of Applied Sciences and Biotechnology. 2015;3:20-25.
34. Park HJ. Development of advanced edible coatings for fruits. Trends in Food Science and Technology. 1999;10:250-260.
35. Petersen K, Nielsen PV, Bertelsen G, Lawther M, Olsen MB, Nilsson NH, *et al*. Potential of biobased materials for food packaging. Trends in Food Science and Technology. 1999;10(2):52-68.
36. Ranganna S. Handbook of analysis and quality control for fruits and vegetable products. 3rd ed. New Delhi: Tata McGraw-Hill Publishing Co. Ltd; 1999.
37. Ribeiro C, Vicente AA, Teixeira JA, Miranda C. Optimization of edible coating composition to retard strawberry fruit senescence. Postharvest Biology and Technology. 2007;44:63-70.
38. Rojas-Argudo C, Perez-Gago MB, Del Rio MA. Postharvest quality of coated cherries 'Burlat' as affected by coating composition and solids content. Food Science and Technology International. 2005;11(6):306-311.
39. Sadler GD, Murphy PA. pH and titrable acidity. In: Nielsen SS, editor. Food analysis. Gaithersburg: Aspen Publishers Inc.; 1998. p. 99-118.
40. Salunkhe DK, Boun HR, Reddy NR. Storage, processing and nutritional quality of fruits and vegetables. Vol. 1. Boston: CRC Press Inc.; 1991.
41. Sarker A, Grift TE. Bioactive properties and potential applications of *Aloe vera* gel edible coating on fresh and minimally processed fruits and vegetables: a review. Journal of Food Measurement and Characterization. 2021;15:2119-2134.
42. Sharma RN, Maharshi RP, Gaur RB. Biorational approach to manage the core rot disease incidence in kinnow fruits (*Citrus deliciosa* Ten.). Plant Disease and Research. 2008;23(1):1-5.
43. Sinclair WB, Ramsey RC. Changes in the organic acid content of *Valencia Orange* during development. Botanical Gazette. 1944;106:140-148.
44. Singh D, Jain RK. Post-harvest losses in distant marketing of kinnow. Plant Disease and Research. 2004;15(1):36-39.
45. Singh Y, Yadav YK. Evaporative cool chambers using alternative materials for storage of horticultural produce. Journal of Dairying Foods and Home Science. 2011;30(4):302-306.
46. Shelton RM. *Aloe vera*: its chemical and therapeutic properties. International Journal of Dermatology. 1991;30(10):679-683.
47. Tripathi P, Dubey N. Exploitation of natural products as an alternative strategy to control postharvest fungal rotting of fruit and vegetables. Postharvest Biology and Technology. 2004;32(3):235-245.
48. Tzia C, Tasios L, Spiliotaki T, Chranioti C, Giannou V. Edible coatings and films to preserve quality of fresh fruits and vegetables. In: Food preservation. 2016. p. 531.
49. Valverde JM, Valero D, Martinez-Romero D, Guillen F, Castillo S, Serrano M. Novel edible coating based on *Aloe vera* gel to maintain table grape quality and safety. Journal of Agricultural and Food Chemistry. 2005;53(20):7807-7813.
50. Vidrih R, Zavrtanik M, Hribar J. Effect of low O_2, high CO_2 or added acetaldehyde and ethanol on postharvest physiology of cherries. Acta Horticulturae. 1998;2:693-695.
51. Yaman O, Bayindirli L. Effects of an edible coating and cold storage on shelf-life and quality of cherries. Lebensmittel-Wissenschaft und -Technologie. 2002;35:146-150.
52. Zhao P, Ndayambaje JP, Liu X, Xia X. Microbial spoilage of fruits: a review on causes and prevention methods. Food Reviews International. 2022;38(suppl 1):225-246.