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Post-harvest application of coating materials on physio-chemical properties and shelf life of papaya (*Carica papaya* L.) *cv*. Red Lady

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Abstract
The present investigation was conducted to evaluate the "Post-Harvest Application of Coating Materials on Physio-Chemical Properties and Shelf Life of Papaya (*Carica papaya* L.) cv. Red lady". The experiment comprised 10 treatments: T_0 (Control), T_1 (Coconut oil), T_2 (Calcium chloride 2%), T_3 (Calcium chloride 4%), T_4 (Honey 10%), T_5 (Honey 20%), T_6 (Sodium chlorite 0.2%), T_7 (Sodium chlorite 0.4%), T_8 (*Aloe vera* gel 30%) and T_9 (*Aloe vera* gel 60%). Physical parameters such as fruit weight, length, diameter, physiological loss in weight (PLW) and retention of marketable fruits were recorded along with quality parameters like total soluble solids (TSS), titratable acidity, total sugar, reducing sugar and non-reducing sugar. Sensory attributes including colour and appearance, texture, taste, flavour and overall acceptability were also evaluated. Results indicated that *Aloe vera* gel 60% (T_9) exhibited the lowest PLW maximum retention of marketable fruits, highest sensory scores and extended shelf life followed by Calcium chloride 4% (T_3). The untreated control fruits (T_0) showed rapid deterioration and the shortest storage life. The study demonstrates that edible coatings, particularly *Aloe vera* gel at 60% can effectively maintain the quality and extend the shelf life of papaya fruits under ambient storage conditions.

Keywords: *Aloe vera* gel, calcium chloride, honey, physico-chemical properties, shelf life, sodium chlorite

Introduction
Papaya (*Carica papaya* L.), commonly known as papaw or pawpaw is a tropical fruit of significant economic and nutritional importance. It belongs to the family Caricaceae and is widely cultivated in tropical and subtropical regions for its sweet, aromatic fruit. The botanical name of papaya is *Carica papaya* L., and it is a diploid species with a chromosome number of 2n = 18.

To extend shelf life and preserve quality during storage and transportation, various edible coating materials have been explored. These coatings act as semi-permeable barriers to gases and moisture, thereby slowing down respiration, delaying ripening, reducing weight loss, and maintaining fruit firmness and visual appeal.

Materials such as aloe vera gel, honey, calcium chloride, chitosan and carboxymethyl cellulose (CMC) have been evaluated for their effectiveness in post-harvest preservation of papaya (Kohli *et al*., 2018 and Maringgal *et al.*, 2022) [2, 6].

Papaya is a delicious, nutritious, and refreshing fruit, valued for its digestive benefits. Every 100 g of ripe papaya contains, among other nutrients, about 91 % moisture, 4.1 % carbohydrates, 0.4 % protein, 2472 IU vitamin A, and 43.1 mg vitamin C.

Materials and Methods
The study was carried out in the Post-Harvest Laboratory, Department of Fruit Science, College of Horticulture and Research station Durg (C.G), during the year 2024-25. Papaya fruits at the mature-green stage were harvested from uniform plants, sorted for size and free from defects, and immediately subjected to treatments. Fruits were washed, air-dried, and dipped in respective coating solutions for 3-5 minutes, then air-dried and stored at ambient conditions (25 ± 2 °C; 70-75% RH).

Colour & appearance, texture, taste, flavour, overall acceptability. Coconut, Calcium chloride 2%, Calcium chloride 4%, Honey 10%, Honey 20%, Sodium Chlorite 0.2%, Sodium chlorite 0.4%, *Aloe vera* gel 30%, *Aloe vera* gel 60%. were taken for Coating materials of papaya fruits and kept under the ambient condition.

Aloe vera gel Solution

Aloe vera Gel at 30% *Aloe vera* solution was made by extracting 300 ml of fresh gel from mature *Aloe vera* leaves. After blending the gel well, 700 ml of distilled water were added to dilute it. To create a uniformly smooth solution that could be used for fruit coating, the resultant mixture was run through a muslin cloth. *Aloe vera* Gel 60% 400 ml of distilled water and 600 ml of *Aloe vera* gel were combined to create the 60% solution. The mixture was then filtered to remove any coarse particles before application.

Calcium Chloride ($CaCl_2$%) Solution

Solution of 2% $CaCl_2$ to guarantee total solubility 2 grams of analytical-grade calcium chloride were precisely weighed and dissolved in one liter of distilled water while being constantly stirred. Solution of 4% $CaCl_2$ the same conditions were used to dissolve 4 grams of calcium chloride in 1 liter of distilled water for this concentration (Patel *et al*. 2017).

Sodium Chlorite ($NaClO_2$) Solution

A solution of 0.2% $NaClO_2$. After dissolving two grams of sodium chlorite in one liter of distilled water a 0.2% solution was created. A solution of 0.4% $NaClO_2$. 1 liter of distilled water was used to dissolve four grams of sodium chlorite, yielding a 0.4% solution. Yadav, Singh *et al.* (2019).

Honey Solution

A 10% solution of honey 100 ml of pure, unprocessed honey was combined with 900 ml of lukewarm distilled water that had been kept between 30 °C and 40 °C to create a 10% honey solution. Until it was completely homogeneous, the mixture was constantly stirred. Solution of 20% Honey Here, 800 ml of distilled water and 200 ml of honey were combined and the mixture was well stirred to create a homogenous mixture. Before every use, all coating solutions were made from scratch. The fruits were left to air dry naturally after being immersed in their respective solutions for five to ten minutes. They were then stored at room temperature for further analysis (Sharma *et al.*, 2021) [11].

Results and Discussion

According to preliminary analysis, coatings had a significant impact on papaya fruit storage quality. In comparison to the control, aloe vera gel 60% (T_9) continuously decreased physiological weight loss, maintained higher TSS, moderated the decline in titratable acidity and increased sugar accumulation. T_9 received the highest ratings from the sensory panel for colour, texture, flavour and taste. The next best treatment was calcium chloride 4% (T_3). Fruits in the untreated control (T_0) group had the shortest shelf life due to rapid weight loss, shrivelling and low sensory scores. Aloe vera coatings function as semi-permeable barriers to gases and moisture, lowering respiration rate and postponing ripening in climacteric fruits reported by (Shankhu *et al*., 2022 and Sharma *et al.*, 2023) [23].

Physical parameters of papaya

Papaya fruit weight (g), length (cm), diameter (cm), physiological weight loss (%) and marketable (%) fruit retention were the physical characteristics of the fruits that were measured.

Fruit weight (g)

The fruit weight of papaya decreased progressively from 0 DAS during the storage period across all treatments. The highest average fruit weight was recorded under T_9 (Calcium chloride 4%). g followed by T_3 (Aloe vera gel 60%) with 640 g. Fruits under the remaining treatments were discarded due to spoilage by microorganisms or overripening and no observations were recorded at 15 DAS. However, no fruit was found to be kept for observational recording under the remaining treatments as the fruits were thrown out after 15 days of storage because they had overripened or spoiled due to microorganisms Sharmin *et al.* (2015).

Fruit length (cm)

The length of papaya fruits decreased progressively from 0 DAS during the storage period at 15 DAS. The maximum fruit length (21.73 cm) was observed under treatment T_9 (Calcium chloride 4%). while the minimum length (20.81 cm) was recorded under T_3 (Aloe vera gel 60%) No fruits were retained under the remaining treatments for observation due to spoilage. After 15 days fruits of all treatments except T_9 and T_4 were spoiled and no further observations were recorded. However, no fruits were found to be kept for observation under the other treatments because they were spoiled Kuwad *et al.* (2015).

Fruit diameter (cm)

The fruit diameter of papaya fruits decreased progressively from 0 DAS during storage At 15 DAS. The highest fruit diameter (12.60 cm) was retained under treatment T_9 (Aloe vera gel 60%) performing better than the other treatments while the lowest diameter (10.78 cm) was recorded under T_3 (Calcium chloride 4%). No fruits were retained under the remaining treatments. However, since the fruits were spoiled and thrown away, none of them were discovered to have been preserved for observation under the other treatments Islam *et al.* (2020) [13].

Physiological loss in weight (%)

Significant variations were observed in physiological loss in weight (PLW) of papaya fruits under different treatments during storage. Compared to 0 DAS. The minimum PLW (5.02%) was recorded under T_9 (Aloe vera gel 60%) at 15 DAS. Followed by T_3 (Calcium chloride 4%) with a PLW of 10.50%. Fruits under the remaining treatments were completely discarded due to spoilage. However, because they had spoiled fruits kept under the other treatments were thrown out completely (Singh *et al*., 2012 and Sharmin *et al.*, 2015) [8, 12].

Retention of marketable fruits (%)

Among the various coating material treatments, the percentage of marketable fruits showed a decline from 0 DAS during storage. At 15 DAS. The maximum marketable fruit percentage (36.42%) was recorded under T_3 (Calcium chloride 4%), followed closely by T_9 (Aloe vera gel 60%) with 35.10%. Fruits under the remaining treatments were completely discarded due to spoilage or over ripening at 15th

days of storage period. Whereas remaining treatments (Kumar *et al.*, 2019 and Ming *et al*., 2008)

Chemical composition of papaya

The following variables were used to record the chemical composition of papaya fruits: total soluble solids (°Brix), titrable acidity, total sugar, reducing sugar and non-reducing sugar.

Total soluble solids (°Brix)

The total soluble solids (TSS) of papaya fruits showed an increasing trend from 0 DAS during storage up to the 15th day. After which a slight decline was observed. The fruits treated with T_9 (Aloe vera gel 60%) recorded the highest TSS value (15.60 ºBrix), while the minimum TSS (15.30 ºBrix) was observed under T_3 (Calcium chloride 4%). No fruits were retained under the remaining treatments for observation at 15 days after storage and no fruits were found to be kept for observation under the other treatments Sharmin *et al*. (2015) [14].

Total sugar (%)

The total sugar content of papaya fruits showed a significant increase from 0 day onwards and continued to rise up to the 15th day of storage, after which it declined. Compared to 0 DAS. The maximum total sugar (9.25%) was recorded under treatment T_9 (Aloe vera gel 60%), while the minimum (9.40%) was observed under treatment T_3 (Calcium chloride 4%) at the 15th for the percentage of total sugar was noted under treatment T_3 (calcium chloride 4%) Mendy *et al.* (2019).

Titratable acidity (%)

The longer the papaya fruits were stored, the lower their titratable acidity became. No fruit The titratable acidity (%) of papaya fruits showed a significant decrease from 0 DAS onwards with the increase in storage period. Compared to the initial acidity at 0 DAS. The lowest acidity (0.07%) was observed under treatment T_9 (Aloe vera gel 60%), while the highest (0.10%) was recorded under treatment T_3 (Calcium chloride 4%) at the 15th day of storage. No fruits were retained under the remaining treatments for recording observations, as they were discarded due to spoilage by microorganisms or overripening during 15 days of storage. while the highest acidity (0.29%) was recorded under treatment T_3 (calcium chloride 4%) Ali *et al.* (2016).

Reducing sugar (%)

The percentage of reducing sugar in papaya fruits showed a significant increase from 0 DAS up to the 15th day of storage after which it started to decline. Compared to the initial value at 0 DAS. The highest reducing sugar (9.86%) was recorded under treatment T_9 (Aloe vera gel 60%) at 15 DAS. While the lowest (9.64%) was observed under treatment T_3 (Calcium chloride 4%) at 15 DAS and no fruits were found to be kept for observation under the other treatments Kuwar *et al.* (2015) [4].

Non-reducing sugar (%)

The percentage of non-reducing sugar in papaya fruits showed a significant increase from 0 DAS up to the 15th day of storage, after which it started to decline. Compared to the initial value at 0 DAS, the highest non-reducing sugar (5.85%) was recorded under treatment T_3 (Calcium chloride 4%) at 15 DAS, while the lowest (5.10%) was observed under treatment T_9 (Aloe vera gel 60%) at 15 DAS days after storage and no fruits were found to have been kept for observation under the other treatments during this trial Marappan *et al.* (2024) [5].

Table 1: Effect of different coating materials on the fruit weight and fruit length of Papaya cv. Red Lady.

Treatments Notation	Treatments Details	Fruit weight (g)					Fruit Length (cm)				
		3 DAS	6 DAS	9 DAS	12 DAS	15 DAS	3 DAS	6 DAS	9 DAS	12 DAS	15 DAS
T_0	Control	710	695	680	0.00*	0.00*	18.15	18.09	17.13	0.00*	0.00*
T_1	Coconut oil	720	705	690	0.00*	0.00*	18.71	18.24	18.12	0.00*	0.00*
T_2	Calcium chloride 2%	730	715	700	685	0.00*	20.61	20.86	20.78	20.06	0.00*
T_3	Calcium chloride 4%	740	725	710	695	680	21.73	21.48	20.67	20.18	19.31
T_4	Honey 10%	750	735	720	705	0.00*	20.42	20.45	20.36	19.39	0.00*
T_5	Honey 20%	760	745	730	715	0.00*	19.22	19.14	19.01	18.12	0.00*
T_6	Sodium chloride 0.2%	770	755	740	725	0.00*	19.44	19.25	19.09	18.87	0.00*
T_7	Sodium Chloride 0.4%	780	765	750	735	0.00*	19.68	19.55	19.47	19.10	0.00*
T_8	Aloe vera gel 30%	690	675	660	645	0.00*	20.30	20.37	20.16	19.67	0.00*
T_9	Aloe vera gel 60%	700	685	670	655	640	21.64	21.42	21.19	20.96	20.81
	SE (m) ±	4.86	4.32	3.95	4.01	3.88	0.08	0.12	0.17	0.07	0.03
	C.D. at 5%	14.75	13.12	12.54	12.86	12.45	0.25	0.37	0.54	0.23	0.11

Table 2: Effect of different coating materials on the Fruit Diameter and Physiological loss in weight (%) of Papaya cv. Red Lady.

Treatments Notation	Treatments Details	Fruit Diameter (cm)					Physiological loss in weight (%)				
		3 DAS	6 DAS	9 DAS	12 DAS	15 DAS	3 DAS	6 DAS	9 DAS	12 DAS	15 DAS
T_0	Control	11.30	11.01	9.57	0.00*	0.00*	6.39	11.10	12.80	0.00	0.00
T_1	Coconut oil	11.60	11.19	9.31	0.00*	0.00*	5.03	7.85	10.18	0.00	0.00
T_2	Calcium chloride 2%	12.20	12.15	11.98	11.20	0.00*	4.10	6.20	7.56	8.23	0.00
T_3	Calcium chloride 4%	12.41	12.24	12.05	11.35	10.78	1.89	4.29	5.25	6.29	10.50
T_4	Honey 10%	12.30	11.78	11.59	10.44	0.00*	2.50	5.42	8.12	11.67	0.00
T_5	Honey 20%	12.21	12.10	11.95	11.03	0.00*	3.32	6.46	10.28	13.31	0.00
T_6	Sodium chloride 0.2%	11.69	11.60	11.37	9.75	0.00*	5.07	6.50	10.22	14.42	0.00
T_7	Sodium Chloride 0.4%	11.70	11.50	11.30	10.01	0.00*	4.03	6.05	7.10	8.44	0.00
T_8	Aloe vera gel 30%	12.10	12.02	11.60	11.02	0.00*	2.84	5.32	6.34	8.06	0.00
T_9	Aloe vera gel 60%	13.10	13.00	12.90	12.80	12.60	1.22	1.83	3.08	3.76	5.02
	SE (m) ±	0.05	0.07	0.11	0.06	0.09	0.07	0.09	0.06	0.04	0.02
	C.D. at 5%	0.17	0.24	0.37	0.20	0.30	0.17	0.29	0.20	0.14	0.08

Table 3: Effect of different coating materials on the Retention of marketable fruits (%) and Total soluble solids (°Brix) of Papaya cv. Red Lady

Treatments Notation	Treatments Details	Retention of marketable fruits (%)					Total soluble solids (°Brix)				
		3 DAS	6 DAS	9 DAS	12 DAS	15 DAS	3 DAS	6 DAS	9 DAS	12 DAS	15 DAS
T_0	Control	71.20	58.10	47.55	0.00*	0.00*	8.05	11.53	12.40	0.00*	0.00*
T_1	Coconut oil	76.45	68.32	55.28	0.00*	0.00*	8.51	11.83	13.20	0.00*	0.00*
T_2	Calcium chloride 2%	73.60	65.14	54.53	41.25	0.00*	9.00	12.20	13.71	14.10	0.00*
T_3	Calcium chloride 4%	78.90	70.40	63.25	50.16	36.42	9.70	13.07	14.20	15.03	15.30
T_4	Honey 10%	75.32	66.12	56.15	44.80	0.00*	8.77	12.23	13.40	13.80	0.00*
T_5	Honey 20%	77.15	68.44	59.28	46.35	0.00*	8.90	12.00	13.70	14.20	0.00*
T_6	Sodium chloride 0.2%	72.85	63.10	52.44	40.89	0.00*	8.33	12.11	12.03	12.50	0.00*
T_7	Sodium Chloride 0.4%	79.42	70.12	60.35	47.85	0.00*	8.50	12.52	13.10	13.60	0.00*
T_8	Aloe vera gel 30%	74.95	66.20	55.44	43.15	0.00*	8.30	12.22	13.01	13.50	0.00*
T_9	Aloe vera gel 60%	79.55	71.34	62.15	49.58	35.10	10.58	13.33	14.40	15.37	15.60
	SE (m) ±	0.04	0.07	0.05	0.03	0.02	0.04	0.06	0.07	0.09	0.05
	C.D. at 5%	0.12	0.21	0.15	0.09	0.60	0.11	0.16	0.20	0.27	0.15

Table 4: Effect of different coating materials on the Titrable acidity (%) and Total sugar (%) of Papaya cv. Red Lady

Treatments Notation	Treatments Details	Titrable acidity (%)					Total Sugar (%)				
		3 DAS	6 DAS	9 DAS	12 DAS	15 DAS	3 DAS	6 DAS	9 DAS	12 DAS	15 DAS
T_0	Control	0.72	1.05	1.25	0.00*	0.00*	7.85	10.95	12.40	0.00*	0.00*
T_1	Coconut oil	0.70	0.98	1.18	0.00*	0.00*	7.60	10.70	12.15	0.00*	0.00*
T_2	Calcium chloride 2%	0.60	0.85	0.95	0.10	0.00*	7.35	10.40	11.85	10.85	0.00*
T_3	Calcium chloride 4%	0.58	0.74	0.80	0.61	0.10	7.20	10.20	11.60	10.65	9.40
T_4	Honey 10%	0.55	0.68	0.72	0.36	0.00*	7.10	10.00	11.45	10.50	0.00*
T_5	Honey 20%	0.65	0.82	0.90	0.52	0.00*	7.55	10.60	12.05	10.95	0.00*
T_6	Sodium chloride 0.2%	0.64	0.80	0.88	0.48	0.00*	7.40	10.30	11.75	10.75	0.00*
T_7	Sodium Chloride 0.4%	0.60	0.75	0.82	0.44	0.00*	7.25	10.15	11.55	10.60	0.00*
T_8	Aloe vera gel 30%	0.62	0.78	0.85	0.46	0.00*	7.30	10.25	11.65	10.70	0.00*
T_9	Aloe vera gel 60%	0.55	0.70	0.78	0.38	0.07	7.05	9.95	11.35	10.45	9.25
	SE (m) ±	0.006	0.005	0.007	0.005	0.003	0.03	0.04	0.05	0.07	0.04
	C.D. at 5%	0.019	0.015	0.022	0.015	0.009	0.12	0.13	0.15	0.21	0.12

Table 5: Effect of different coating materials on the Reducing sugar (%) and non-reducing sugar (%) of Papaya cv. Red Lady.

Treatments Notation	Treatments Details	Reducing sugar (%)					Non-reducing sugar (%)				
		3 DAS	6 DAS	9 DAS	12 DAS	15 DAS	3 DAS	6 DAS	9 DAS	12 DAS	15 DAS
T_0	Control	2.25	5.90	6.54	0.00*	0.00*	2.38	3.97	3.59	0.00*	0.00*
T_1	Coconut oil	3.65	6.16	8.48	0.00*	0.00*	2.45	4.29	2.87	0.00*	0.00*
T_2	Calcium chloride 2%	4.03	6.25	9.02	7.12	0.00*	2.77	4.55	5.09	0.00*	0.00*
T_3	Calcium chloride 4%	4.09	6.62	9.27	9.41	9.64	2.98	4.98	7.17	7.40	5.10
T_4	Honey 10%	3.55	5.32	7.57	6.13	0.00*	2.87	5.04	5.44	0.00*	0.00*
T_5	Honey 20%	3.63	6.03	8.52	6.16	0.00*	3.07	5.02	5.71	0.00*	0.00*
T_6	Sodium chloride 0.2%	4.01	6.11	9.11	7.18	0.00*	3.09	5.03	6.31	0.00*	0.00*
T_7	Sodium Chloride 0.4%	3.80	6.24	8.58	6.24	0.00*	3.14	5.06	5.97	0.00*	0.00*
T_8	Aloe vera gel 30%	4.02	6.13	8.43	6.15	0.00*	3.15	5.09	5.10	0.00*	0.00*
T_9	Aloe vera gel 60%	4.21	6.64	8.54	9.45	9.86	3.17	5.71	6.76	6.92	5.85
	SE (m) ±	0.07	0.02	0.08	0.06	0.03	0.02	0.04	0.01	0.03	0.007
	C.D. at 5%	0.26	0.07	0.25	0.20	0.10	0.06	0.12	0.03	0.09	0.021

Conclusion

The present investigation revealed that the application of edible coatings significantly influenced the post-harvest quality and shelf life of papaya cv. Red Lady during ambient storage. Among all the treatments, *Aloe vera* gel 60% (T_9) consistently recorded the lowest physiological weight loss, slower ripening rate, better firmness retention, higher total soluble solids to acidity balance, and superior sensory scores throughout the storage period. The natural film-forming ability, antimicrobial compounds (aloin, saponins) and moisture barrier properties of *Aloe vera* gel 60 % were found to effectively delay senescence, maintain attractive fruit appearance, and extend marketability up to 15 days compared to 8-9 days in the control.

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