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Pre-harvest treatments enhances the post-harvest quality of papaya (*Carica papaya* L.) cv. Red Lady

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ABSTRACT

Papaya stands as a significant fruit crop in India, ranking fifth in importance after banana. The Red Lady variety, particularly thriving in Tamil Nadu, has gained widespread popularity domestically and in export markets. However, ensuring consistent high-quality fruit reaching consumers remains a challenge. Addressing this issue, an experiment conducted at a farmer's field, Ammampalayam, Attur taluk, Salem district during 2020-2021 aimed to assess pre-harvest chemical treatments' impact on post-harvest papaya quality. Papaya plants were subjected to a series of spray treatments including NAA, potassium chloride, potassium nitrate (as a potassium source), calcium chloride, calcium nitrate and calcium sulfate (as a calcium source). Additionally, a combination treatment of NAA @ 100 ppm with potassium and calcium sources at 1.5% was applied at 21 days after flower anthesis onto the fruits. A control group was sprayed with plain water. These treatments were repeated six times every two weeks. The application of 1.5% calcium chloride ($CaCl_2$) significantly enhanced fruit quality, leading to increased total soluble solids and ascorbic acid levels. Treatment with 1.5% calcium chloride (T_5) significantly increased the quality parameters, showing higher total soluble solids and ascorbic acid content, while acidity significantly decreased compared to the control. Throughout the storage period, all treatments maintained a low pH, suggesting papaya fruits had a low degree of acidity. However, the treatment with 1.5% calcium chloride stood out for its comprehensive enhancement of post-harvest quality parameters.

Keywords: Calcium chloride, fruit quality, ascorbic acid, shelf-life, storage.

INTRODUCTION

Papaya (*Carica papaya* L.) is an economically and nutritionally important tropical fruit crop cultivated widely in India and other tropical and subtropical regions. It was introduced to India from Malacca in the 16th century (Kumar and Abraham, 9). Taxonomically, papaya belongs to the family Caricaceae, which comprises approximately 48 species; however, *Carica papaya* L. is the only species in this family that produces edible fruits (Chadha, 3). Although papaya is often referred to as a "tree," it is botanically classified as a large, fast-growing herbaceous plant with a soft, hollow stem and a sparse branching habit. The leaves are palmately lobed and spirally arranged at the crown, giving the plant its characteristic appearance. Native to tropical America, the species is believed to have originated in the lowland regions of Southern Mexico and Central America. Papaya plants exhibit diverse floral morphologies, primarily dioecious and gynodioecious, with some cultivars showing hermaphroditic characteristics, which is important for fruit production and crop improvement programs.

Improving the postharvest quality and extending the shelf life of papaya remains a critical concern due to its highly perishable nature. Pre-harvest treatments using plant growth regulators (PGRs) and essential mineral nutrients have emerged as effective strategies to enhance fruit quality attributes such as firmness, sweetness, antioxidant levels, and resistance to physiological disorders. Foliar application of calcium and potassium salts, in combination with synthetic auxins like naphthalene acetic acid (NAA), has shown promising results in improving physiological and biochemical properties of various fruit crops, including papaya.

Several studies have reported that these pre-harvest interventions can delay ripening, reduce postharvest decay, and improve overall fruit quality (Zoffoli *et al.,* 22; Domínguez *et al.,* 5; Zhu *et al.,* 21). However, the effectiveness of such treatments may vary depending on the species, cultivar, application method, and environmental conditions (Lara, 11). Therefore, it is imperative to optimize treatment protocols specific to the crop and cultivar for maximizing postharvest benefits. In this context, the cultivar 'Red Lady' a widely grown papaya variety in India serves as a suitable candidate for evaluating the influence of pre-harvest foliar applications on postharvest quality enhancement.

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MATERIALS AND METHODS

Research investigations were undertaken at a farmer's field located in Ammampalayam, Attur taluk of Salem district, spanning the period from 2020 to 2021. The experiment employed a Randomized Block Design (RBD) to evaluate the effects of various treatments on the post-harvest quality of the Red Lady papaya variety. The RBD comprised 12 treatments, replicated three times, resulting in a total of 360 plants chosen for the study. Plant spacing was maintained at 2 × 2 meters to facilitate optimal growth and development. The experiment involved the preparation of specific concentrations of pre-harvest sprays, which were applied 21 days after flower anthesis. Spraying occurred every two weeks over a span of six times, with the final application executed four days before the scheduled fruit harvesting. Observations were conducted on the 3rd, 6th and 9th days post-harvest. Data collected underwent analysis following the standard methodology outlined by Panse and Sukhatme (14), with the critical difference determined at a significance level of 5 percent probability. The analysis was carried out using the IRRISTAT package on a personal computer platform.

RESULTS AND DISCUSSION

The total soluble solids (TSS) and ascorbic acid content of papaya are significantly impacted by pre-harvest treatments, as demonstrated by the data in Table 1. Fruits that were treated with T_5 ($CaCl_2$ @ 1.5%) showed the highest TSS content on 3rd, 6th and 9th of storage; the corresponding measurements were 10.79 °Brix, 12.34 °Brix and 13.32 °Brix. T_2 (NAA @ 100 ppm) had the lowest TSS content, with values of 10.57 °Brix, 12.14 °Brix and 13.17 °Brix on the 3rd, 6th and 9th, respectively. T_1 (Control) had the lowest TSS content, with readings of 8.34 °Brix, 10.14 °Brix and 11.64 °Brix at the third, sixth and ninth days, respectively. Significant variations were observed in the TSS content over the course of the storage days, with a gradual increase from 9.60 °Brix on the third day to a peak of 12.50 °Brix on the ninth day and then a decline (Fig. 1).

According to research by Wills *et al.*, (19) over ripening causes sugar degradation into CO_2 as a result of respiration, while the rise in total soluble solids during ripening is linked to starch breakdown

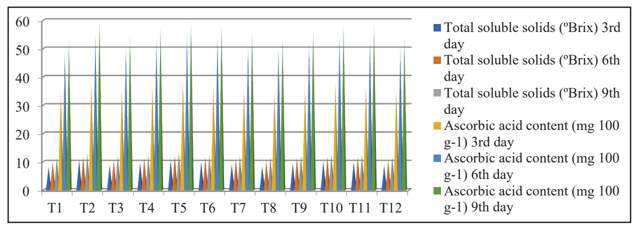

Fig. 1. Effect of pre-harvest treatments on total soluble solids (ºBrix) and ascorbic acid content (mg 100 g^{-1}) of papaya fruits cv. Red Lady.

Table 1. Effect of pre-harvest treatments on total soluble solids (ºBrix) and ascorbic acid content (mg 100 g^{-1}) of papaya fruits cv. Red Lady.

Treatment	Total soluble solids (ºBrix)			Ascorbic acid content (mg 100 g^{-1})		
	3rd day	6th day	9th day	3rd day	6th day	9th day
T_1 - Control	8.34	10.14	11.64	34.45	49.27	53.26
T_2 - NAA @ 100 ppm	10.57	12.14	13.17	38.37	55.07	59.22
T_3 - KCl @ 1.5%	9.07	10.82	12.14	35.62	51.13	55.08
T_4 - KNO_3 @ 1.5%	9.78	11.45	12.61	37.03	53.14	57.18
T_5 - $CaCl_2$ @ 1.5%	10.79	12.34	13.32	38.74	55.64	59.82
T_6 - $CaNO_3$ @ 1.5 %	10.01	11.67	12.76	37.46	53.77	57.84
T_7 - $CaSO_4$ @ 1.5 %	9.31	11.01	12.30	36.11	51.82	55.8
T_8 - (T_2 + T_3)	8.58	10.39	11.83	34.76	49.87	53.8
T_9 - (T_2 + T_4)	9.55	11.23	12.46	36.58	52.49	56.5
T_{10} - (T_2 + T_5)	10.34	11.93	13.01	37.98	54.48	58.6
T_{11} - (T_2 + T_6)	10.11	11.72	12.86	37.57	53.87	57.96
T_{12} - (T_2 + T_7)	8.83	10.62	11.99	35.2	50.51	54.43
Mean	9.60	11.28	12.50	36.65	52.58	56.62
S.Ed	0.100	0.091	0.070	0.120	0.200	0.220
C.D (p=0.05)	0.20	0.18	0.14	0.24	0.40	0.44

into sugars. Additionally, Karemera and Habimana (8) discovered that spraying 1.5% $CaCl_2$ 30 days prior to harvest maximized the number of days for mango fruit ripening and increased its shelf life. By reducing respiration rate and microbial fermentation, calcium reduces senescence and improves fruit quality by increasing TSS content. Calcium also regulates intercellular and extracellular processes. The conversion of organic compounds to soluble solids under the influence of calcium chloride may be the cause of the increase in TSS during storage (Mason *et al*., 12).

Among the treatments, papaya fruits treated with T_5 ($CaCl_2$ @ 1.5%) exhibited the highest ascorbic acid content, measuring at 38.74 mg 100 g^{-1}, 55.64 mg 100 g^{-1} and 59.82 mg 100 g^{-1} on the 3rd, 6th and 9th day of storage respectively. This was followed by T2 (NAA @ 100 ppm), with values of 38.37 mg 100 g^{-1}, 55.07 mg 100 g^{-1} and 59.22 mg 100 g^{-1} on the respective days. Conversely, the untreated fruits (T1) showed the lowest ascorbic acid content, recording values of 34.45 mg 100 g^{-1}, 49.27 mg 100 g^{-1} and 53.26 mg 100 g^{-1} on the same respective days. Notable variations were observed in ascorbic acid content across the storage period, with levels escalating from 36.65 mg 100 g^{-1} on the 3rd day to 56.62 mg 100 g^{-1} on the 9th day, followed by a decline towards the end of the storage period.

In papaya, ascorbic acid content typically increases during ripening and then decreases during senescence, in accordance with findings by Selvaraj *et al*. (16). This study corroborates with Lal *et al*. (10), who reported the highest ascorbic acid content in fruits treated with $CaCl_2$ @ 1.5%. Calcium chloride is believed to delay oxidation in fruits, consequently leading to higher levels of ascorbic acid. Similar outcomes were observed by Singh *et al*. (17) in papaya, Desai (4) and Patel *et al*. (15) in sapota, as well as Bisen *et al*. (2) in guava.

Table 2 presents data on titratable acidity influenced by various pre-harvest treatments, revealing notable disparities in fruit acidity content. The highest titratable acidity was recorded in T_5 ($CaCl_2$ @ 1.5%), with values of 0.38%, 0.34% and 0.28% on the 3rd, 6th and 9th day of storage respectively. Following closely was T_2 (NAA @ 100 ppm), exhibiting values of 0.36%, 0.32% and 0.27% on the same days. Conversely, untreated fruits (T_1) displayed the lowest acidity content, registering values of 0.23%, 0.20% and 0.17% on the respective days (Fig. 2). Notably, the acidity content of fruits demonstrated a significant variation across the storage period, displaying a declining trajectory from 0.31% on the 3rd day to 0.22% on the 9th day and continuing until the end of the storage period.

The decrease in acidity could be attributed to fermentation or the breakdown of acids into sugars during fruit respiration (Singh *et al*., 18). Pre-harvest calcium treatments were found to enhance the post-harvest quality of papaya, significantly reducing acidity content after harvest. Calcium played a role in inhibiting acid degradation, thereby preserving cell

Table 2. Effect of pre-harvest treatments on titratable acidity (%) and pH of papaya fruits cv. Red Lady.

Treatment	Titratable acidity (%)			pH		
	3rd day	6th day	9th day	3rd day	6th day	9th day
T_1 - Control	0.23	0.20	0.17	5.30	5.40	5.50
T_2 - NAA @ 100 ppm	0.36	0.32	0.27	5.39	5.49	5.59
T_3 - KCl @ 1.5%	0.27	0.24	0.20	5.34	5.45	5.53
T_4 - KNO_3 @ 1.5%	0.32	0.28	0.23	5.36	5.47	5.56
T_5 - $CaCl_2$ @ 1.5%	0.38	0.34	0.28	5.40	5.50	5.60
T_6 - $CaNO_3$ @ 1.5%	0.33	0.29	0.24	5.37	5.48	5.57
T_7 - $CaSO_4$ @ 1.5%	0.29	0.25	0.21	5.35	5.46	5.54
T_8 - (T_2 + T_3)	0.24	0.21	0.18	5.32	5.43	5.52
T_9 - (T_2 + T_4)	0.30	0.27	0.22	5.36	5.46	5.55
T_{10} - (T_2 + T_5)	0.35	0.31	0.26	5.38	5.49	5.58
T_{11} - (T_2 + T_6)	0.34	0.30	0.25	5.38	5.48	5.58
T_{12} - (T_2 + T_7)	0.26	0.22	0.19	5.33	5.44	5.53
Mean	0.31	0.26	0.22	5.35	5.46	5.55
S.Ed	0.006	0.005	0.004	-	-	-
C.D (p=0.05)	0.012	0.011	0.009	NS	NS	NS

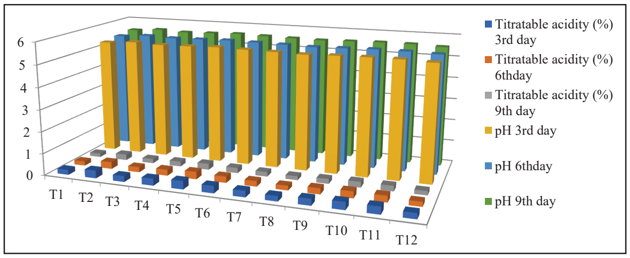

Fig. 2. Effect of pre-harvest treatments on titratable acidity (%) and pH of papaya fruits cv. Red Lady.

integrity. These findings align with studies conducted by Hussain *et al*. (6), Wojcik (20), Asgharzade *et al*. (1) and Moor *et al*. (13) in apple, Ismail *et al*. (7) in guava and Lal *et al*. (10) in apricot.

Table 2 indicated that there were no notable differences in the pH of fruits resulting from the various pre-harvest treatments, as all treatments maintained a consistently low pH level, confirming the inherently low acidity of papaya. Moreover, there were no significant fluctuations observed in the pH of papaya fruits over the storage duration. The differences among the treatment means regarding papaya pH remained insignificant throughout the storage period.

The pre-harvest treatment of 1.5% calcium chloride was found to be improving the quality and shelf life of papaya cv. Red Lady, according to the findings of the current investigation. Superior levels of quality parameters, such as total soluble solids and ascorbic acid, were obtained from this treatment. This treatment also resulted in a decrease in fruit acidity. Throughout the duration of storage, no discernible impact of the treatments on the pH of the papaya fruit was found. Thus, it can be said that papaya cv. Red Lady's overall quality was significantly enhanced and its shelf life was prolonged by the pre-harvest application of calcium chloride at a rate of 1.5%.

AUTHOR'S CONTRIBUTION

Writing - original draft, formal analysis, software, data curation (SCT); Investigation, Writing – review & editing, supervision, validation (KR); writing – review & editing (SS).

DECLARATION

There are no competing interests for the writers.

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