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Effect of different post-harvest treatments on quality and shelf life of papaya

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Abstract
An experiment was conducted to study the effect of different post harvest treatments on quality and shelf life of papaya. Eleven treatments post harvest treatments viz. GA_3 100 ppm, 200 ppm, 300 ppm, $CaCl_2$ 1.0%, 2.0%, 3.0%, 4.0% wax emulsion, 5.0% wax emulsion, BA 150 ppm, BA 250 ppm and control were used in the experiment.

Keywords: Growth regulators, quality, shelf life, papaya, wax emulsion

Introduction
Papaya (*Carica papaya* L.) is evergreen herbaceous commercial fruit crop of tropical and subtropical region. In India it is grown area of 133 lakh ha, with a production of 5699 M.T (NHB, 2015-16). Papaya fruit has occupied a place of pride in human diet because of its striking nutritional and medicinal values. It is one of the richest source of carotene (pro - vitamin) and a fair source of vitamin-C, besides being high in sugars and pectin. Its delicious fruit are not only palatable, nutritive, digestive and also act as a mild laxative. Papaya is highly perishable fruit and can be stored only for four days at room temperature. Ripening in fleshy fruits is preceded by a shift in metabolism which leads to characteristic changes in their composition, texture and colour. The compositional changes include an increase in reducing sugars and aroma compounds and decline in acidity, astringency and chlorophylls (Selvaraj *et al.*, 1982) [10]. Post-harvest loss of papaya fruit up to 75 and 90 percent have been reported in India and Costarica (Cerbez and Seenz, 1993) [2].

Within the same species, different varieties respond differently to post - harvest chemical treatments in extending the shelf life and in hastening the ripening process. The cv. Red Lady has emerged as a leading commercial variety. Hence increasing the shelf life of fruits by using various technologies like post harvest treatments. Keeping this view it is proposed to study Post harvest treatments quality and shelf life of papaya

Materials and Methods
The experiment was conducted at college of horticulture, Rajendranagar. Treatmental details: T_1 - Fruits dipped in GA_3@ 100 ppm, T_2 - Fruits dipped in GA_3 @ 200 ppm, T_3 - Fruits dipped in GA_3 @ 300 ppm, T_4 - Fruits dipped in $CaCl_2$ @ 1.0%, T_5 - Fruits dipped in $CaCl_2$ @2.0%, T_6 - Fruits dipped in $CaCl_2$ @ 3.0%, T_7 - Fruits dipped in Wax emulsion @ 4.0%, T_8 - Fruits dipped in Wax emulsion @ 5.0%, T_9- Fruits dipped in BA @ 150 ppm, T_{10} - Fruits dipped in BA @ 250 ppm, T_{11} - Control (without any dipping). After dipping for 5 minutes the fruits were taken out gently and spread on the table separately for air drying. The fruits were stored at room temperature. From each replication some of fruits were marked for observing physical changes and the rest of kept for chemical analysis. The experiment was statically laid out as per completely randomized design. There were 11 treatments including control and they were replicated thrice. The weight of the fruits was recorded on every third day and subtracted from the initial weight. The loss of weight in grams in relation to initial weight was calculated and expressed as percentage. The fruit firmness was measured by using Penetrometer by pressing at the center of the fruit. The extent of rot was determined by weighing the decayed fruits on each day of observation and the percentage was calculated on the basis of total weight of the fruits stored. Total soluble solids of the fruits were measured with the help of hand refractometer (EMRA make) in expressed in degree brix (^{O}Brix). The total sugars, ascorbic acid and titrable acidity were estimated by the standard method of AOAC (1980) [1].

Results and Discussion

a) Physical characteristics

Physiological loss in weight (PLW) increased considerably in all the treatments with increase in storage period. Physiological loss in weight was reduced in fruit treated with 5% wax and $CaCl_2$ 3% over control (Table 1). Minimum PLW (14.97%) at 15 days of storage was recorded in fruit treated with 5% wax treatment. Less physiological loss in weight in fruits treated with 5% wax during storage at normal ambient temperature. The wax coating retarded the rate of respiration, transpiration, decay and reduced the enzymatic activates responsible for disorganization of cellular structure, thus, delay senescence and thereby, reduce weight loss. The similar results are reported by Singh *et al*. (2012) [11] and Raj kumar and Manivannam (2007) [9].

Fruit firmness gradually declined with increase days of storage; however, it was visibly checked with various with different growth regulators and chemicals treatments. Maximum (2.03 kg cm^{-2}) fruit firmness was recorded in papaya fruits treated with $CaCl_2$ 3.0% and followed by fruits treated with wax 4.0% treated fruit. Calcium treatments significantly retained higher fruit firmness after 15 days of storage than other treatments. Higher fruit firmness observed in calcium treated fruits may be due to delay in ripening process. Solubilization of insoluble pectins by increased pectinesterase activity appears to be one of the reasons for the development of fruit softening which is associated with ripening (Selvaraj and Pal, 1982) [10]. The retention of higher fruit firmness in calcium treated fruits was also due to higher mechanical strength offered by the calcium as it was a part of the cell wall as calcium pectate. There may also be a possibility that, lignification mediated by calcium may serve to prevent membrane deterioration by restricting rapid peroxidation and its autocatalytic production. Retention of high fruit firmness with $CaCl_2$ 3.0% was reported in papaya by (Chen and Paull, 1986) [3] and in lemon by (Tsantili *et al.*, 2002) [17]. Spoilage gradually increases with increase days of storage. Lowest spoilage (33.49%) of fruits was recorded in $CaCl_2$@ 3.0% and followed by wax emulsion @ 5.0%. This may be due to controlled transpiration and respiration rates which might have delayed the disintegration of ripening of fruits. The similar findings were reported by Yadav *et al.* (2006) [19] in mandarin, Patel *et al*. (2011) [8] in custard apple.

Fruit quality

The data regarding the effect of different post harvest treatments on TSS content papaya fruits are presented in (Table 2). Fruit treated with $CaCl_2$@ 3.0% had maintained maximum TSS (11.28 ^{O}Brix) during ambient storage. Total soluble solids content of the fruits reached maximum at the ripe stage and started declining towards the end of shelf life. The increase in the total soluble solids during ripening is due to breakdown of starch into sugars. Further due to over ripening / senescence the sugar are degraded to CO_2 because of respiration (Wills *et al.,* 1989) [18]. Similar results were reported in Sapota (Singh *et al.,* 2000) [5-13]. It was further reported that, a very low cellulose activity was recorded in papaya fruit pulp during ripening (Pal and Selvaraj, 1987) [7].

The tritable acidity affects by different post harvest treatments shown in (Table. 3). Minimum titrable acidity was recorded (Table 3) in fruits treated with $CaCl_2$@ 1.0% (0.03%). The reduction in titrable acidity during storage might be associated with the conversion of organic acid into sugar and their derivatives or their utilization in respiration. Similar results have also been reported by Singh *et al.* (2008) [12] and Hoda *et al.* (2000) [5] in Mango, Sudha *et al.* (2007) [16] in Sapota. There were significant differences in reducing sugars among different days of storage period. The initial reducing sugars content was increased gradually upto 12th day and there after declined trend follows upto end of shelf life. The highest reducing sugars were recorded in fruits treated with GA_3 100 ppm (8.65%). It was also found that sugars were increase with increasing the storage period up to 12th days of storage, but at 15th days of storage it reduced drastically. The initial raise in sugars content may be due to conversion of starch into sugars, while later the decrease was due to consumption of sugars for respiration during storage. The results are also conformation with those of Patel *et al.* (2011) [8] in Custard apple and Yuvraj *et al*. (1999) [20] in Mango. The changes in non reducing sugars during storage in papaya cv. Red lady treated with various chemicals and growth regulators treatments are presented in (Table - 4). The highest non reducing sugars were recorded (Table. 4) in fruit treated with 4.0% Wax emulsion (2.75%). The changes in total sugars during storage in papaya cv. Red lady treated with various chemicals and growth regulators treatments are presented in table - 4. The total sugars increased from 3rd day to 12th day and then declined to by 15th day of storage period. The highest total sugars were recorded in fruits treated with GA_3 200 ppm (11.00%). It was also found that total sugars were increased with increasing the storage period up to 12th days of storage, but at 15th days of storage it reduced drastically. It may be due to break down of physiological process. The results are also conformation with those of Patel *et al.* (2011) [8] in Custard apple and Yuvraj *et al*. (1999) [20] in Mango. Singh *et al.* (1988) [15] in Mango.

The higher ascorbic acid (Table. 5) content was observed in fruits treated with $CaCl_2$ 3.0% (44.66 mg/100g pulp). It may be due to break down of physiological process. As the results is also conformation with those of Yuvraj *et al*. (1999) [20] in Mango and Patel *et al.* (2011) [8] in custard apple. The effect of different chemicals and growth regulators on shelf life of papaya cv. Red lady stored at room temperature was presented in table - 5. The fruits treated with different treatments differed significantly and highest shelf life (15.32 days) observed in fruits treated with $CaCl_2$ @ 3.0% and which was followed by GA_3 @200 ppm (14.02 days) and 5.0% wax emulsion (13.32 days). Lowest shelf life was recorded in Control (9.78 days). Reduction in water loss of papaya fruits during storage with application of calcium chloride was expected as calcium sprays play an important role in maintaining cellular organization and regulating enzyme activities and thereby helping in reducing water loss. Similar results were reported by Singh *et al*. (1987) [14] and Garg and Ram (1976) [4].

Table 1: Effect of various treatments on physiological loss in weight and fruit firmness in papaya cv. red lady

Treatments	Physiological loss in weight (%)					Firmness (kg cm^{-2})				
	3rd day	6th day	9th day	12th day	15th day	3rd day	6th day	9th day	12th day	15th day
T_1 - GA_3 100 ppm	1.98	4.07	7.02	15.57	16.48	5.26	4.92	4.61	3.20	1.05
T_2 - GA_3 200 ppm	1.94	3.62	6.77	13.12	15.83	6.81	6.34	6.07	4.77	1.45
T_3 - GA_3 300 ppm	2.42	3.97	7.78	15.02	17.83	6.00	5.72	5.04	3.82	1.65
T_4 - $CaCl_2$ 1.0%	2.48	3.82	7.55	15.22	17.82	6.25	6.1	5.92	3.14	1.68
T_5 - $CaCl_2$ 2.0%	2.65	3.55	7.31	14.78	18.01	6.74	6.45	6.07	4.03	1.32
T_6 - $CaCl_2$ 3.0%	1.06	2.97	6.34	12.88	15.12	7.15	6.51	6.30	5.10	2.03
T_7 - 4.0% Wax emulsion	1.53	3.34	7.92	15.83	17.61	6.31	6.28	5.97	3.94	1.81
T_8 - 5.0% Wax emulsion	1.27	3.03	6.64	12.34	14.97	6.78	6.45	6.15	4.05	1.74
T_9 - BA 150 ppm	2.75	3.07	7.85	-	-	6.70	6.28	6.07	-	-
T_{10} - BA 250 ppm	2.85	5.55	7.96	16.75	-	5.57	5.42	5.19	4.01	-
T_{11} - Control	3.12	7.55	8.13	-	-	4.98	4.59	4.10	-	-
Mean	2.19	4.05	7.39	14.61	16.70	6.23	5.91	5.59	4.00	1.59
SE.m±	0.06	0.08	0.17			0.14	0.09	0.12		
CD at 5%	0.17	0.24	0.51			0.42	0.26	0.34		

- Fruit spoiled

Table 2: Effect of various treatments on spoilage and total soluble solids in papaya cv. red lady

Treatments	Spoilage (%)					Total soluble solids (^{O}Brix)				
	3rd day	6th day	9th day	12th day	15th day	3rd day	6th day	9th day	12th day	15th day
T_1 - GA_3 100 ppm	0.00	14.04	20.38	34.12	58.88	9.30	10.33	10.55	11.05	10.86
T_2 - GA_3 200 ppm	0.00	10.62	17.41	23.65	51.86	9.90	10.54	11.07	12.36	11.08
T_3 - GA_3 300 ppm	0.00	13.15	18.93	21.27	54.88	9.19	9.66	10.27	10.79	10.21
T_4 - $CaCl_2$ 1.0%	0.00	14.29	18.85	27.87	58.93	9.59	10.27	10.65	11.17	11.09
T_5 - $CaCl_2$ 2.0%	0.00	13.87	19.45	29.81	54.04	9.33	9.99	10.44	10.87	10.65
T_6 - $CaCl_2$ 3.0%	0.00	11.32	15.56	20.94	33.49	10.09	10.74	10.84	12.14	11.28
T_7 - 4.0% Wax emulsion	0.00	13.74	17.92	31.85	51.77	9.06	10.21	10.55	11.07	10.55
T_8 - 5.0% Wax emulsion	0.00	12.12	16.73	21.29	49.48	9.97	10.18	10.65	11.63	10.95
T_9 - BA 150 ppm	0.00	13.24	19.87	-	-	9.15	10.12	10.41	-	-
T_{10} - BA 250 ppm	0.00	13.38	17.71	22.52	-	9.04	10.21	10.43	11.22	-
T_{11} - Control	0.00	15.94	20.21	-	-	9.26	9.6	11.76	-	-
Mean	0.00	13.25	18.46	25.92	51.66	9.44	10.17	10.69	11.36	10.83
SE.m±	0.00	0.29	0.49			0.27	0.16	0.11		
CD at 5%	0.00	0.85	1.44			NS	0.46	0.34		

- Fruit spoiled

Table 3: Effect of various treatments on titrable acidity and reducing sugars in papaya cv. red lady

Treatments	Titrable acidity (%)					Reducing sugars (%)				
	3rd day	6th day	9th day	12th day	15th day	3rd day	6th day	9th day	12th day	15th day
T_1 - GA_3 100 ppm	0.37	0.32	0.23	0.12	0.04	7.65	8.77	8.98	9.26	8.65
T_2 - GA_3 200 ppm	0.43	0.40	0.26	0.13	0.05	7.80	8.65	9.01	9.18	8.62
T_3 - GA_3 300 ppm	0.51	0.50	0.32	0.12	0.04	6.98	7.82	8.55	8.78	8.19
T_4 - $CaCl_2$ 1.0%	0.46	0.42	0.23	0.13	0.03	7.16	8.33	8.85	9.12	8.55
T_5 - $CaCl_2$ 2.0%	0.41	0.37	0.21	0.14	0.05	6.97	7.89	8.78	8.83	8.16
T_6 - $CaCl_2$ 3.0%	0.53	0.47	0.31	0.13	0.11	6.98	7.82	8.85	9.05	8.55
T_7 - 4.0% Wax emulsion	0.39	0.36	0.27	0.17	0.09	6.85	7.75	8.56	8.78	8.26
T_8 - 5.0% Wax emulsion	0.52	0.48	0.29	0.15	0.05	6.83	7.81	8.48	8.80	8.33
T_9 - BA 150 ppm	0.40	0.35	0.27	-	-	6.30	7.54	8.62	-	-
T_{10} - BA 250 ppm	0.42	0.40	0.24	0.19	-	7.01	7.83	8.41	9.04	-
T_{11} - Control	0.30	0.27	0.19	-	-	7.10	7.85	8.45	-	-
Mean	0.43	0.40	0.26	0.14	0.05	7.06	8.00	8.70	8.98	8.41
SE.m±	0.01	0.01	0.02			0.12	0.09	0.07		
CD at 5%	0.06	0.02	0.04			0.34	0.27	0.22		

- Fruit spoiled

Table 4: Effect of various treatments on non reducing sugars and total sugars in papaya cv. red lady

Treatments	Non reducing sugars (%)					Total sugars (%)				
	3rd day	6th day	9th day	12th day	15th day	3rd day	6th day	9th day	12th day	15th day
T_1 - GA_3 100 ppm	1.57	1.47	1.17	2.80	2.33	8.02	9.24	10.15	10.68	10.08
T_2 - GA_3 200 ppm	1.54	1.05	1.33	2.94	2.58	8.34	9.70	10.34	12.13	11.00
T_3 - GA_3 300 ppm	1.51	1.16	1.64	2.77	2.36	8.48	8.98	10.19	10.55	10.05
T_4 - $CaCl_2$ 1.0%	1.71	1.30	1.57	2.56	2.27	8.87	9.64	10.42	11.08	10.02
T_5 - $CaCl_2$ 2.0%	1.78	1.74	1.46	2.78	2.83	8.75	9.63	10.24	10.62	10.98
T_6 - $CaCl_2$ 3.0%	1.54	1.69	1.44	2.92	2.32	8.52	9.52	10.29	11.97	10.87
T_7 - 4.0% Wax emulsion	1.80	1.88	1.93	2.83	2.75	8.65	9.63	10.49	10.62	10.00
T_8 - 5.0% Wax emulsion	1.33	1.96	1.63	3.11	2.73	8.16	9.76	10.12	11.01	10.06
T_9 - BA 150 ppm	1.64	1.25	2.13	-	-	7.94	8.79	10.75	-	-
T_{10} - BA 250 ppm	1.10	1.20	1.63	2.84	-	8.11	9.03	10.04	11.08	-
T_{11} - Control	2.08	2.24	2.53	-	-	9.17	10.09	10.98	-	-
Mean	1.50	1.54	1.68	2.83	2.52	8.46	9.45	10.36	11.08	10.37
SE.m±	0.17	0.12	0.11			0.09	0.14	0.09		
CD at 5%	0.50	0.36	0.31			0.26	0.41	0.27		

- Fruit spoiled

Table 5: Effect of various treatments on ascorbic acid and shelf life in papaya cv. red lady

Treatments	Ascorbic acid (mg/100g pulp)					Shelf life
	3rd day	6th day	9th day	12th day	15th day	(Days)
T_1 - GA_3 100 ppm	26.70	29.97	31.48	38.42	40.77	12.53
T_2 - GA_3 200 pp	31.85	32.98	35.14	40.36	43.57	14.02
T_3 - GA_3 300 ppm	30.44	32.87	34.29	38.23	41.08	12.84
T_4 - $CaCl_2$ 1.0%	28.14	30.53	36.81	39.95	40.65	12.43
T_5 - $CaCl_2$ 2.0%	30.41	30.84	31.96	39.73	38.68	11.03
T_6 - $CaCl_2$ 3.0%	32.07	35.74	39.91	40.94	44.66	15.32
T_7 - 4.0% Wax emulsion	30.73	29.51	35.83	39.95	40.73	10.87
T_8 - 5.0% Wax emulsion	31.88	34.41	35.78	41.25	43.52	13.32
T_9 - BA 150 ppm	30.45	30.94	32.45	-	-	10.97
T_{10} - BA 250 ppm	28.98	30.92	31.86	37.81	-	11.75
T_{11} - Control	30.36	33.24	37.85	-	-	9.00
Mean	30.18	31.99	34.85	39.62	41.70	
SE.m±	0.61	1.04	1.01			0.32
CD at 5%	1.78	3.05	2.97			0.94

- Fruit spoiled

Conclusions

The physical and quality parameters of fruits were significantly influenced by the various post harvest treatments on quality and shelf life of papaya. Higher fruit firmness, lowest spoilage, maximum TSS and higher storage life was recorded in fruit treated with $CaCl_2$ 3.0% when compare to other treatments.

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