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Effect of Post Harvest Treatments on the Shelf life and Quality of Guava [*Psidium guajava* (L.)] cv. Allahabad Safeda

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A B S T R A C T

An experiment was conducted to determine the effect of different post harvest treatments on the shelf life and quality of guava. Different chemicals such as Gibberellic acid, Calcium chloride, Salicylic acid and Potassium permanganate were used, individually and in combinations. The different concentrations of GA_3 at 25 and 50 ppm and combination with $KMnO_4$ (5g/kg sachet), $CaCl_2$ at 1 and 2% and in combination with $KMnO_4$ (5g/kg sachet) and Salicylic acid at 70 & 140 ppm and in combination with $KMnO_4$ (5g/kg sachet) was used. Guava fruits of cv. Allahabad Safeda were treated with chemicals and stored at ambient temperatures. Fruits which were treated with 140 ppm salicylic acid *i.e.*, T_6 were significant among all the treatments and recorded lowest PLW (1.79%), minimum fruit rotting (3.69%), highest shelf life (7 days) over control (4 days). The 2[nd] best treatment which was found to be significant was, fruits treated with salicylic acid at 70 ppm *i.e.*, T_5. Biochemical parameters such as total sugars (6.75%), reducing sugars (3.83) and TSS (11.68°brix) were found to be significant and highest in the fruits treated with salicylic acid at 140 ppm. It was concluded that fruits treated with salicylic acid were found be effective in increasing the shelf life and quality of guava fruits.

Introduction

Guava is the 4[th] most important fruit after Mango, Banana and Citrus and it is popularly known as the "Apple of the tropics". In India, the most important guava growing states are Uttar Pradesh, Bihar, Madhya Pradesh, Maharashtra and Gujarat etc. Uttar Pradesh is one of the most important states of India where, half of the total area is under guava production and district Allahabad has the reputation of growing the best guava in the country as well as in the world.

Salicylic acid is a plant hormone which inhibits ethylene biosynthesis and delays the senescence (Ozeker, 2005). It has been shown to inhibit the conversion of ACC into ethylene (Leslie and Romani, 1988) by suppressing ACC oxidase activity (Fan *et al.,* 1996). It is also involved in local and systemic resistance to pathogens (Yalpani *et al.,* 1994; Kang *et al.,* 2003). Exogenous application of SA has been reported to delay the ripening of Peach (Han *et al.,* 2003), Banana (Srivastava and Dwivedi, 2000).

Gibberellins (GA_3) are a group of growth substances, known to retard ripening and senescence of fruits. The effects of GA_3 seem to be mainly on colour development, although other aspects of ripening processes are also affected. GA_3 delays chlorophyll degradation and fruit softening (Vendrell, 1970) and decreases sugar accumulation, TSS and sugar/acid ratio in Banana (Ahmed and Tingwa, 1995) and Mango (Murthy and Rao, 1982).

Pre and post harvest application of calcium may delay senescence in fruits with no detrimental effect on consumer acceptance (Lester and Grusak, 2004). Exogenously applied Calcium stabilizes the plant cell wall and protects it from cell wall degrading enzymes (White and Broadley, 2003). Studies have shown that the rate of senescence often depends on the calcium status of the tissue and by increasing calcium levels, various parameters of senescence such as respiration, protein, chlorophyll content and membrane fluidity are altered (Poovaiah, 1984). It is also involved in reducing the rate of senescence and fruit ripening (Ferguson, 1984).

The inclusion of potassium permanganate, which is an ethylene absorbent, aims an extension of storage period (Salunkhe and Desai, 1984). It is quite effective in reducing ethylene levels by oxidizing it to carbon dioxide and water. It is a chemical which has been used to remove ethylene from storage atmosphere. The use of $KMnO_4$ in conjunction with modified atmosphere in polyethylene films delayed fruit ripening, maintained quality and extended shelf life in Mango and Banana. Several studies have shown that $KMnO_4$ applications delay fruit softening and increase post-harvest life (Illeperuma and Jayasuriya, 2002).

Materials and Methods

A lab experiment to investigate the effect of post harvest treatments on the shelf life and quality of guava (*Psidium guajava* L.) was carried out in Completely Randomized Design with three replications at Laboratory of fruit science, Department of Fruit Science, Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad, during 2017-18. The experimental material comprised of fruits of cultivar Allahabad Safeda obtained from Fruit Research Station, Sangareddy, Hyderabad.

Treatments

T_1 - Gibberellic acid @ 25 ppm
T_2 - Gibberellic acid @ 50 ppm
T_3 - Calcium chloride @ 1%
T_4 - Calcium chloride @ 2%
T_5 - Salicylic acid @ 70 ppm
T_6 - Salicylic acid @ 140 ppm
T_7 - Gibberellic acid (25 ppm) + $KMnO_4$ (5g/kg sachet)
T_8 - Gibberellic acid (50 ppm) + $KMnO_4$ (5g/kg sachet)
T_9 - Calcium chloride (1%) + $KMnO_4$ (5g/kg sachet)
T_{10} -Calcium chloride (2%) + $KMnO_4$ (5g/kg sachet)
T_{11} -Salicylic acid (70 ppm) + $KMnO_4$ (5g/kg sachet)
T_{12} - Salicylic acid (140 ppm) + $KMnO_4$ (5g/kg sachet)
T_{13} – Control

Observations were recorded at 0 (initial), 2, 4 and 6 days interval. Observations on physico-chemical characters and sensory evaluation of guava fruits with different treatments were recorded as per the standard methods given for different characters.

Physiological loss in weight

For determination of Physiological Loss in Weight (PLW), three fruits from each replication were marked and labeled. The marked and labeled fruits in each treatment were weighed prior to storage. Their weight was determined on 0(initial), 2^{nd}, 4^{th} and 6^{th} day of storage. PLW was expressed on percent basis (on the basis of original weight of fruit).

Rotting

It was calculated by counting the number of decayed fruits from carton boxes at different intervals. Decayed fruits were weighed on the day of each observation. The percent rotting was estimated using the following formula:

Shelf life

After treating the guava fruits as per the treatments, they are whipped by muslin cloth and wrapped in double layer of newspaper and stored in carton boxes at room conditions up to 6 days. On the basis of fruit decay (%), shelf life is considered.

Sugars

The sugars were estimated as per the method advocated by Ranganna (1979). 5g of pulp was macerated and transferred to 250 ml volumetric flask, with 100 ml of distilled water. 2 ml saturated lead acetate was added to precipitate the tannin present in the sample. In the next step 25 ml of saturated disodium hydrogen phosphate Na_2HPO_4 was added to precipitate excess amount of lead acetate. It was then shaked well and then filtered in 250 ml volumetric flask to make the volume 250 ml. The extract (Aliquot) was then used for the estimation of sugars, as follows.

Total sugars

Total sugars were also estimated by the same method. After acid hydrolysis of 50 ml aliquot with 5 ml concentrated HCl, it is mixed well and kept for 24 h. It is then followed by neutralization with Sodium hydroxide using phenolphthalein indicator. Finally it is titrated against Fehling's solution using methylene blue indicator. The total sugars percentage was calculated using standard formula.

$$\text{Total sugars (\%)} = \frac{\text{Glucose equivalent (0.05)} \times \text{Vol. made up} \times 100}{\text{Titrate value} \times \text{Weight of the sample}}$$

Reducing sugars

The prepared aliquot was then titrated against boiling standard Fehling's mixture (5ml each Fehling's A and B solution) using methylene blue as an indicator until the sample has changed its colour to brick red precipitate. Reducing sugars percentage was calculated using standard formula.

$$\text{Reducing sugars (\%)} = \frac{\text{Glucose equivalent (0.05)} \times \text{Vol. made up} \times 100}{\text{Titrate value} \times \text{Weight of the sample}}$$

Total soluble solids

Total soluble solids of the pulp was recorded using a hand refractometer in the range of 0 – 32 percent. The juice was extracted from the fruit of guava and filtered through a cheese cloth and then the sample was taken on the prism of the hand refractometer. Three reading were taken for each replication and the average was considered. The results were expressed in terms of degree brix.

Results and Discussion

The Physiological loss in weight was significantly affected by various post harvest treatments in guava cv. Allahabad Safeda (Table 1). Under ambient conditions of storage, minimum average physiological loss in weight (1.79%) was observed in the fruits which were treated with salicylic acid at 140 ppm (T_6) which was on par with T_5 *i.e.*, the fruits treated with salicylic acid at 70 ppm (1.88%). The maximum mean PLW (2.48%) was recorded in T_{13} *i.e.*, control. It is observed that SA treated fruits have positive effects in maintaining membrane integrity. Abbasi *et al.*, (2010) observed less chilling injury and less weight loss than other treatments in fruits of peach treated with 1mM SA. Brar *et al.*, (2014) found that 200 ppm SA significantly reduced the PLW loss in peach fruit under cold storage condition.

Table.1 Effect of different post harvest treatments on physiological loss in weight (%) in Guava cv. Allahabad Safeda

S.No.	Treatments	PLW (%)			
		Days after storage			
		2	4	6	Mean
1.	T_1 (GA_3 @ 25 ppm)	0.95	2.70	3.47	2.37
2.	T_2 (GA_3 @ 50ppm)	0.94	2.64	3.38	2.32
3.	T_3 ($CaCl_2$ @ 1%)	0.85	2.47	2.92	2.08
4.	T_4 ($CaCl_2$ @ 2%)	0.87	2.42	2.87	2.05
5.	T_5 (SA @ 70 ppm)	0.80	2.30	2.54	1.88
6.	T_6 (SA @ 140 ppm)	0.72	2.24	2.41	1.79
7.	T_7 GA_3 (25ppm) + $KMnO_4$ (5g)	0.93	2.70	3.32	2.32
8.	T_8 GA_3 (50 ppm) + $KMnO_4$ (5g)	0.90	2.60	3.24	2.25
9.	T_9 $CaCl_2$ (1%) + $KMnO_4$ (5g)	0.89	2.55	3.14	2.19
10.	T_{10} $CaCl_2$ (2%) + $KMnO_4$ (5g)	0.87	2.50	3.04	2.14
11.	T_{11} SA (70ppm) + $KMnO_4$ (5g)	0.84	2.32	2.64	1.93
12.	T_{12} SA (140 ppm) + $KMnO_4$ (5g)	0.86	2.38	2.69	1.98
13.	T_{13} (Control)	0.97	2.70	3.76	2.48
Mean		0.88	2.50	3.03	2.14
		2	4	6	
SE(m) ±		0.01	0.02	0.04	
CD at 5%		0.04	0.08	0.13	

Table.2 Effect of different post harvest treatments on fruit rotting (%) in Guava cv. Allahabad Safeda

S.No.	Treatments	Fruit rotting (%)			
		Days after storage			
		2	4	6	Mean
1.	T_1 (GA_3 @ 25 ppm)	0.00	7.89	11.26	6.38
2.	T_2 (GA_3 @ 50 ppm)	0.00	7.47	10.73	6.07
3.	T_3 ($CaCl_2$ @ 1%)	0.00	5.54	8.62	4.72
4.	T_4 ($CaCl_2$ @ 2%)	0.00	5.29	8.58	4.62
5.	T_5 (SA @ 70 ppm)	0.00	4.72	7.23	3.98
6.	T_6 (SA @ 140ppm)	0.00	4.06	7.00	3.69
7.	T_7 GA_3 (25ppm) +$KMnO_4$ (5g)	0.00	7.29	10.99	6.09
8.	T_8 GA_3 (50 ppm) +$KMnO_4$ (5g)	0.00	7.01	10.56	5.86
9.	T_9 $CaCl_2$ (1%) +$KMnO_4$ (5g)	0.00	5.93	9.01	4.98
10.	T_{10} $CaCl_2$ (2%) +$KMnO_4$ (5g)	0.00	5.84	8.94	4.93
11.	T_{11} SA (70ppm) +$KMnO_4$ (5g)	0.00	4.82	8.07	4.30
12.	T_{12} SA (140 ppm) +$KMnO_4$ (5g)	0.00	4.88	8.32	4.40
13.	T_{13} (Control)	0.00	9.64	14.62	8.09
Mean		0.00	6.18	9.53	5.24
		2	4	6	
SE(m) ±		0.00	0.01	0.02	
CD at 5%		0.00	0.04	0.07	

Table.3 Effect of different post harvest treatments on fruit shelf life (days) in Guava cv. Allahabad Safeda

S.No.	Treatments	Shelf life (days)
1.	T_1 (GA_3 @ 25 ppm)	5.10
2.	T_2 (GA_3 @ 50 ppm)	5.22
3.	T_3 ($CaCl_2$ @ 1%)	5.20
4.	T_4 ($CaCl_2$ @ 2%)	5.50
5.	T_5 (SA @ 70 ppm)	6.50
6.	T_6 (SA @ 140 ppm)	7.00
7	T_7 GA_3 (25 ppm) + $KMnO_4$ (5g)	5.10
8.	T_8 GA_3 (50 ppm) + $KMnO_4$ (5g)	5.20
9.	T_9 $CaCl_2$ (1%) + $KMnO_4$ (5g)	5.50
10.	T_{10} $CaCl_2$ (2%) + $KMnO_4$ (5g)	5.60
11.	T_{11} SA (70ppm) + $KMnO_4$ (5g)	6.00
12.	T_{12} SA (140 ppm) + $KMnO_4$ (5g)	6.00
13.	T_{13} (Control)	4.00
Mean		5.53
SE(m) ±		0.160
CD at 5%		0.465

Table.4 Effect of different post harvest treatments on total sugars (%) in Guava cv. Allahabad Safeda

S.No.	Treatments	Total sugars (%)				
		Days after storage				
		0	**2**	**4**	**6**	**Mean**
1.	T_1 (GA_3 @ 25 ppm)	5.70	5.78	6.02	5.60	5.78
2.	T_2 (GA_3 @ 50 ppm)	5.76	5.79	5.98	5.70	5.81
3.	T_3 ($CaCl_2$ @ 1%)	6.11	6.19	6.46	6.30	6.27
4.	T_4 ($CaCl_2$ @ 2%)	6.19	6.30	6.61	6.42	6.38
5.	T_5 (SA @ 70 ppm)	6.42	6.57	6.81	6.72	6.63
6.	T_6 (SA @ 140 ppm)	6.53	6.73	6.96	6.77	6.75
7.	T_7 GA_3 (25 ppm) + $KMnO_4$ (5g)	5.82	5.84	5.99	5.79	5.86
8.	T_8 GA_3 (50 ppm) + $KMnO_4$ (5g)	5.82	5.93	6.15	5.90	5.95
9.	T_9 $CaCl_2$ (1%) + $KMnO_4$ (5g)	5.96	6.07	6.33	6.15	6.13
10.	T_{10} $CaCl_2$ (2%) + $KMnO_4$ (5g)	6.06	6.17	6.47	6.29	6.25
11.	T_{11} SA (70 ppm) + $KMnO_4$ (5g)	6.39	6.50	6.80	6.61	6.58
12.	T_{12} SA (140 ppm) + $KMnO_4$ (5g)	6.28	6.36	6.67	6.46	6.44
13.	T_{13} (Control)	5.60	5.74	5.88	5.59	5.70
Mean		6.05	6.15	6.39	6.18	6.19
		0	2	4	6	
SE(m) ±		0.02	0.02	0.05	0.02	
CD at 5%		0.05	0.07	0.17	0.07	

Table.5 Effect of different post harvest treatments on reducing sugars (%) in Guava cv. Allahabad Safeda

S.No.	Treatments	Reducing sugars (%)				
		Days after storage				
		0	**2**	**4**	**6**	**Mean**
1.	T_1 (GA_3 @ 25 ppm)	3.38	3.40	3.49	3.30	3.39
2.	T_2 (GA_3 @ 50 ppm)	3.40	3.45	3.62	3.41	3.47
3.	T_3 ($CaCl_2$ @ 1%)	3.48	3.52	3.67	3.62	3.57
4.	T_4 ($CaCl_2$ @ 2%)	3.52	3.58	3.79	3.68	3.64
5.	T_5 (SA @ 70 ppm)	3.62	3.68	3.84	3.83	3.74
6.	T_6 (SA @ 140 ppm)	3.71	3.75	3.98	3.87	3.83
7.	T_7 GA_3(25ppm) + $KMnO_4$(5g)	3.35	3.39	3.51	3.42	3.42
8.	T_8 GA_3(50 ppm) + $KMnO_4$(5g)	3.40	3.44	3.58	3.47	3.47
9.	T_9 $CaCl_2$(1%) +$KMnO_4$(5g)	3.44	3.50	3.64	3.59	3.54
10.	T_{10} $CaCl_2$(2%) + $KMnO_4$(5g)	3.49	3.54	3.72	3.66	3.60
11.	T_{11} SA(70ppm) + $KMnO_4$(5g)	3.60	3.66	3.84	3.78	3.72
12.	T_{12} SA(140 ppm) + $KMnO_4$(5g)	3.56	3.60	3.78	3.70	3.66
13.	T_{13} (Control)	3.32	3.38	3.41	3.29	3.35
Mean		3.48	3.53	3.68	3.59	3.57
		0	2	4	6	
SE(m) ±		0.01	0.02	0.05	0.03	
CD at 5%		0.029	0.06	0.16	0.08	

Table.6 Effect of different post harvest treatments on total soluble solids (°Brix) in Guava cv. Allahabad Safeda

S.No.	Treatments	Total soluble solids (°Brix)				
		Days after storage				
		0	2	4	6	Mean
1.	T_1 (GA_3 @ 25 ppm)	11.54	11.61	11.69	11.51	11.59
2.	T_2 (GA_3 @ 50 ppm)	11.55	11.62	11.71	11.52	11.60
3.	T_3 ($CaCl_2$ @ 1%)	11.58	11.65	11.73	11.55	11.63
4.	T_4 ($CaCl_2$ @ 2%)	11.59	11.64	11.74	11.56	11.63
5.	T_5 (SA @ 70 ppm)	11.62	11.68	11.77	11.58	11.66
6.	T_6 (SA @ 140 ppm)	11.63	11.69	11.79	11.59	11.68
7.	T_7 GA_3 (25 ppm) + $KMnO_4$ (5g)	11.55	11.62	11.70	11.53	11.60
8.	T_8 GA_3 (50 ppm) + $KMnO_4$ (5g)	11.57	11.63	11.71	11.55	11.62
9.	T_9 $CaCl_2$ (1%) + $KMnO_4$ (5g)	11.58	11.64	11.72	11.55	11.62
10.	T_{10} $CaCl_2$ (2%) + $KMnO_4$ (5g)	11.59	11.64	11.73	11.57	11.63
11.	T_{11} SA (70 ppm) + $KMnO_4$ (5g)	11.61	11.67	11.76	11.58	11.66
12.	T_{12} SA (140 ppm) + $KMnO_4$ (5g)	11.60	11.66	11.75	11.57	11.65
13.	T_{13} (Control)	11.54	11.60	11.68	11.50	11.58
Mean		11.58	11.64	11.73	11.55	11.63
		0	2	4	6	
SE(m) ±		0.006	0.009	0.011	0.004	
CD at 5%		0.017	0.027	0.032	0.012	

Fatemi *et al.,* (2013) observed that Salicylic acid application significantly decreased weight loss percentage and increased storage life of kiwi fruits. Similar results were reported by Abbasi *et al.,* (2010), Brar *et al.,* (2014) and Fatemi *et al.,* (2013).

The rotting percent was significantly affected by various post harvest treatments in guava cv. Allahabad Safeda (Table 2). Under ambient conditions of storage, minimum rotting (3.69%) was observed in the fruits treated with salicylic acid at 140 ppm *i.e.* T_6 which was on par with T_5 *i.e.* fruits treated with salicylic acid at 70 ppm (3.98%). The maximum rotting (8.09%) was recorded in control. A rapid decay in control fruits at both room and low temperature storage conditions was reported (Ray *et al.,* 2004). Fatemi *et al.,* (2013) observed that SA at all concentrations inhibited grey mould growth in kiwi fruits. Litchi fruits kept at ambient storage conditions have got rotten after 4 days of storage (Marboh, 2009). Similar results were reported by Ray *et al.,* 2004, Fatemi *et al.,* 2013 and Marboh, 2009. The shelf life of fruits had significant difference on the post harvest treatments in guava fruits (Table 3). Highest shelf life (7 days) was recorded in fruits treated with salicylic acid at 140 ppm *i.e.* T_6 which was on par with T_5 *i.e.* fruits treated with salicylic acid at 70 ppm (6.5 days). Lowest shelf life (4 days) was recorded in control *i.e.* T_{13}. The post harvest treatment with 5.0 mM SA delayed the occurrence of IB in pineapple, extended its shelf life (Lu *et al.,* (2010). Treatment of strawberry plants with SA at vegetative stage and fruit development stage followed by post harvest treatment of fruits with 1 and 2 mmol L^{-1} effectively controlled the total decay and increased shelf life (Babalar *et al.,* 2007). Similar results were reported by Lu *et al.,* (2010) and Babalar *et al.,* (2007).

The total sugars had significant difference among various treatments in the fruits. The total sugars increased gradually from 0 to 4th day of storage, by reaching its peak at 4th day and then gradually declined from 6th day onwards (Table 4). Highest total sugars (6.75%) were recorded in T_6 *i.e.* when the fruits were treated with salicylic acid at 140 ppm which was on par with T_5 *i.e.* when the fruits were treated with salicylic acid at 70 ppm (6.63). Lowest total sugars were recorded in T_{13} *i.e.* in control. There was a sharp decline in total sugars in untreated fruits. Similar results were reported by Lu *et al.,* (2011) in Pineapple and Sayyari *et al.,* (2009) in Pomegranate.

Among all the treatments maximum reducing sugars (3.83%) were recorded in T_6 *i.e.* fruits treated with salicylic acid at 140 ppm followed by T_5 *i.e.* fruits treated with salicylic acid at 70 ppm. while minimum reducing sugars were recorded in T_{13} *i.e.* in control (Table 5). Reduction in reducing sugars level in untreated fruits was mainly due to higher rate of respiration which leads to unchecked progression of ripening and senescence. SA is well known phenol that can prevent ACO activity was suggested by Paliyath and Subramanian (2008). Salicylic acid treated fruits increased the reducing sugars in concentration manner in banana (Manoj and Upendra 2000). Similar results were reported by Manoj and Upendra (2000).

Highest Total soluble solids (11.68 °B) was recorded in the fruits treated with salicylic acid at 140 ppm *i.e.* T_6 which was on par with T_5 *i.e.* fruits treated with salicylic acid at 70 ppm (11.66 °B). Lowest TSS was recorded in control (11.58 °B) (Table 6). Increase in the TSS of fruits may be due to reduction of the activities of various enzymes and by delaying senescence, disorganization of cellular structure and checking of microbial activities (Lougheed *et al.,* 1979). The TSS and sugars increase during storage due to hydrolysis of starch into sugars as on complete hydrolysis of starch no further increase occurs and subsequently a decline in TSS is predictable as they along with other organic acids are primary substrate for respiration (Wills *et al.*, 1980). Similar results were recorded by Fatemi *et al.*, (2013) in kiwi fruits, when the fruits treated with SA at 5 mM concentration had highest TSS. Hajilou *et al.*, (2013) recorded highest TSS in 2.0 mM and 3.0 mM SA treatments in apricot.

It can be concluded that salicylic acid at 140 ppm was found to be the best among all the treatments in extending the shelf life and quality of guava cv. Allahabad Safeda.

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