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Effect of Salicylic Acid as Papaya Post-Harvest Treatment in Ambient Condition

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Abstract For determining the effect of salicylic acid (SA) on post harvest life and quality of papaya fruits six different concentrations (0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 mM L^{-1}) were applied to papaya fruits cv Red Lady. Fruits harvested at mature green stage were washed, dipped for five minutes in respective SA solutions and stored at 20-25^{0}C with 75-80% relative humidity. After 7 days of storage (DAS), it was found that fruits treated with SA at 2.5 mM L^{-1} had least percentage weight loss (11.46%) of fruits. Moreover, fruits under this treatment showed low TSS (7.75 ^{0}Brix), TSS : Acid ratio (33.70), carotenoids content (1.06 mg $100g^{-1}$) and peel color score (2.08), which marked delayed ripening and thus had maximum shelf life (14 days) with having least decay percentage (6.25%) of fruits.

Keywords Salicylic acid, Papaya, Shelf life, Carotenoids.

Introduction

Papaya is one of the important tropical fruit of Caricaceae family having good market demand as table fruit and also for its papain content. Besides, the fruit is rich in vitamin A and has mild laxative property. For successful marketing of the crop, the main drawback is, it has very short shelf life. It was reported that papaya faced post harvest loss up to 75% by wholesaler and retailers in USA [1]. In India, it was reported that total post harvest loss in papaya trading is 25.49% [2]. However, cold storage though increased shelf life but generally with chilling injury. Salicylic acid is reported as a natural and safe phenolic compound which has been found to generate a wide range of metabolic and physiological responses in plants and act as potential bio agent in controlling post harvest loss of horticultural crops and delay in ripening through inhibition of ethylene biosynthesis or action [3]. Therefore, present experiment was taken up to evaluate the impact of post harvest application of SA on quality and shelf life of papaya fruits at ambient storage condition.

Materials and Methods

Mature green fruits of papaya cv Red Lady obtained from fifteen months old papaya plants cultivated under open field condition by a local papaya grower of Tanhril, Aizawl were used and kept at Research Laboratory, Department of Horticulture, Aromatic and

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Table 1. Effect of selected post-harvest treatments on percentage weight loss, decay and shelf life of papaya fruits.

Treatments	Percentage of weight loss (%) 7 DAS	Fruit decay (%) 7 DAS	Shelf life (Days)
T_1 : SA at 0.5 mM	15.34ab	31.25	9.25ab
T_2 : SA at 1.0 mM	14.72a	25.00	10.50ab
T_3 : SA at 1.5 mM	13.21a	25.00	11.25bc
T_4 : SA at 2.0 mM	14.37a	18.75	11.50bc
T_5 : SA at 2.5 mM	11.46a	6.25	14.00c
T_6 : SA at 3.0 mM	11.62a	12.50	13.75c
T_7 : Control	18.75b	43.75	8.00a
SEm (±)	1.1776	-	0.9402
CD at 5%	3.4639	-	2.7656

Table 2. Effect of selected post-harvest treatments on total soluble solids (TSS), titrable acidity and TSS : Acid ratio of papaya fruits.

Treatments	TSS (^{0} Brix) 7 DAS	Titrable acidity (%) 7 DAS	TSS : Acid ratio 7 DAS
T_1 : SA at 0.5 mM	11.25e	0.12a	93.75e
T_2 : SA at 1.0 mM	10.14d	0.15ab	70.00d
T_3 : SA at 1.5 mM	9.80 cd	0.18abc	53.70c
T_4 : SA at 2.0 mM	9.45c	0.20bcd	46.67b
T_5 : SA at 2.5 mM	7.75a	0.23cd	33.70a
T_6 : SA at 3.0 mM	8.45b	0.25d	33.80a
T_7 : Control	12.70f	0.14ab	94.07e
SEm (±)	0.1816	0.0191	2.0587
CD at 5%	0.5342	0.0561	6.0557

Medicinal Plants, Mizoram University at 23 ± 2 ^{0}C temperature and relative humidity 75 ± 5% for the experiment. Seven post harvest treatments viz., fruit dipping in salicylic acid (SA) at 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 mM L^{-1} and control (treated with water) with four replications were used and statistical analysis was done by following complete randomized design [4]. Five fruits were kept per replication to record different physical (skin color, texture and fruit weight loss) and biochemical (TSS, titrable acidity, TSS/acid ratio, total and reducing sugar, ascorbic acid and carotenoids) parameters after seven days interval through standard procedures [5, 6]. Fruits were visually observed and scored for skin color using the following standard color index [7]. Score 0 : Green skin without yellow stripe, Score 1 : Green skin with light yellow stripe, Score 2 : Green skin with well-defined yellow stripe, Score 3 : One or more orange-colored stripes in skin, Score 4 : Clearly orange-colored skin with some light green areas. Score 5 : Characteristic orange-colored skin of papaya, and Score 6 : Fruit color similar to stage 5, but more intense. Fruits were visually observed and score for fruit firmness was following standard index [8]. Scorel : Soggy and soft, Score 2 : Slightly firm, Score 3 : Moderately firm, Score 4 : Very firm. Decay percentage of papaya fruits was calculated as the number of decayed fruit divided by initial number of all fruits [9]. Optimum shelf life (days) of fruit under different treatment in room condition were evaluated depending on the visual observation of fruit decay, fruit physico-chemical parameters; edible and marketable quality [9, 10].

Results and Discussion

Skin color

Under the present study, papaya fruits stored at ambient condition showed significant peel color variation among the selected treatments. It was reported that papaya skin color intensified as the fruits ripened [7]. In this study fruits at control showed maximum peel color score (4.67) at 7 DAS (Table 4). Earlier report suggested that papaya cv Pusa Delicious fruit got reasonable high skin color (average score : 6.90) under control treatment at 6 DAS of ambient condition [11]. Results showed that fruits treated with comparatively higher SA concentration (2.5-3.0 mM) resulted in low skin color score (2.08-2.50) at 7 DAS. It was reported that SA treated strawberry fruit showed delaying in color development at post-harvest storage because of its anti-senescent effect [12].

Fruit texture

Firmness or texture of papaya fruits decreased significantly during storage at ambient condition. Earlier study described that fruits firmness decreased as fruit ripening and softening of vegetative tissues are usually accompanied by catabolism of cell wall polysaccharides [8]. At 7 DAS fruits at control showed minimum texture score (1.75 : Soggy and Soft). It was reported that firmness of non-treated fruits when fully ripe (100% skin yellow) was quite low (15.1N) at 10 DAS at 22^{0}C [13]. Fruit treated with SA at 2.5 and

Table 3. Effect of selected post-harvest treatments on total sugar, reducing sugar and ascorbic acid content of papaya fruits.

Treatments	Total sugar (%) 7 DAS	Reducing sugar (%) 7 DAS	Ascorbic acid (mg 100 g^{-1}) 7 DAS
T_1 : SA at 0.5 mM	10.17d	8.59c	23.42a
T_2 : SA at 1.0 mM	9.83cd	8.09bc	29.65b
T_3 : SA at 1.5 mM	4.79cd	6.49ab	32.55c
T_4 : SA at 2.0 mM	8.56bc	5.74a	35.56d
T_5 : SA at 2.5 mM	6.38a	4.86a	39.84e
T_6 : SA at 3.0 mM	7.21ab	6.07a	40.83e
T_7 : Control	12.44e	10.78d	22.42a
SEm (±)	0.4649	0.5699	1.6227
CD at 5%	1.3674	1.6765	4.7353

3.0mM showed comparatively higher texture score (3.75, 3.42 : moderately firm) at 7 DAS (Table 4). Positive influence of SA was found on fruit firmness of strawberry when dipped in SA solution [12].

Physiological weight loss

At 7 DAS, it was recoded that fruits at control showed maximum loss of weight (18.75%) compared with the fruits treated with SA at 2.5 mM (11.46%) or 3.0mM (11.62%) (Table 1). It was reported that weight loss of papaya fruit was found maximum (16.16 ± 0.87%) at 8 DAS in control stored at ambient condition (27 ^{0}C, 80% relative humidity) [14]. SA can also decrease respiration rate and fruit weight loss by stomata closing [15].

TSS content

Current study showed that TSS content of the stored papaya fruits was found maximum in control (12.70^0 Brix) at 7 DAS (Table 2). It was reported that fruits at control had high TSS (11.73 ^{0}Brix) at 6 DAS of ambient storage [11]. Present study revealed that SA at 2.5- 3.0 mM caused significant reduction in TSS (7.75, 8.45 ^{0}Brix) accumulation in papaya fruits at 7 DAS. Treatment of kiwi fruit with MeSA of 32µIL^{-1} maintained lower TSS content than the control fruits at the end of storage [16].

Table 4. Effect of selected post-harvest treatments on carotenoids, peel color and texture fruits.

Treatments	Carotenoids (mg 100 g^{-1}) 7 DAS	Peel color score 7 DAS	Texture score 7 DAS
T_1 : SA at 0.5 mM	2.79c	4.08	1.83
T_2 : SA at 1.0 mM	2.34bc	3.83	2.25
T_3 : SA at 1.5 mM	2.12bc	3.42	2.75
T_4 : SA at 2.0 mM	2.23bc	3.58	2.33
T_5 : SA at 2.5 mM	1.06a	2.08	3.75
T_6 : SA at 3.0 mM	1.88b	2.50	3.42
T_7 : Control	2.93c	4.67	1.75
SEm (±)	0.2455	-	-
CD at 5%	0.7221	-	-

Titrable acidity, TSS : Acid ratio, total and reducing sugar content

Fruits at control showed faster ripening compared with other and thus titrable acidity was recorded minimum (0.14%) at 7 DAS (Table 2). Organic acids normally decreased in several fruits as they were respired or converted to sugar. SA at 2.5mM showed maximum titrable acidity (0.25%) of fruits followed by SA at 3.0mM (0.23%). It was already stated that fruits at control showed maximum TSS value (12.70 ^{0}Brix) with minimum titrable acidity (0.14%) that caused highest value for TSS : Acid ratio (94.07) at 7 DAS. This may be because the fruits at control got faster ripening than other treatments. On the contrary, fruits treated with SA at 2.5mM and 3.0mM showed low TSS : Acid ratio (33.70 and 33.80) which signified that SA has potential anti-ripening effect [3]. Ambient storage of papaya fruit caused rapid accumulation of sugars. It was found that fruits at control had maximum total (12.44%) and reducing (10.78%) sugar content at 7 DAS (Table 3). It was reported that papaya fruit got 10.03% total sugar after 9 days of storage at ambient condition [17]. At 7 DAS, SA at 2.5mM showed minimum total sugar (6.38%) and reducing sugar (4.86%) content of fruits. It was reported that SA can decrease the degradation rate of starch to soluble sugar, which may have caused lower accumulation of sugars in SA treated fruits [18].

Ascorbic acid content

It is evident from the present study that fruits at con-

trol showed minimum ascorbic acid content (22.20 mg 100 g^{-1}) at 7 DAS (Table 3). It was reported that fruits at control had minimum ascorbic acid content (27.20 mg 100g^{-1}) at 3 DAS at ambient condition [11]. Ascorbic acid content generally reduced during storage because of its oxidative process [19]. It was found that SA at 2.5 and 3.0 mM significantly reduced loss of ascorbic acid and was found high (39.84 and 40.83 mg 100g^{-1}) at 7 DAS. It was reported that application of SA was found effective in reducing the rate of respiration and ethylene production and maintained higher amount of ascorbic acid [20].

Carotenoids content

Carotenoids content was also recorded maximum (2.93 mg 100 g^{-1}) under control treatment because of chlorophyll degradation. It was reported that fruit at control had carotenoids content of 2.89 mg 100 g^{-1} at 6 DAS [11]. It was observed that fruits treated with SA at 2.5mM showed minimum carotenoids (1.06 mg 100g^{-1}) at 7 DAS (Table 4). Storage study on tomato fruit recorded low carotenoids and lycopene accumulation when treated with SA at 0.4mM [21].

Fruit decay

At 7 DAS, fruits at control showed maximum decay (43.75%) whereas, it was found minimum (6.25%) at T_5 (SA at 2.5mM) followed by T_6 (12.50%). It was observed that SA treated fruits had significant reduction in fruit decay (Table 1). SA at 0.8 mM decreased the fruit decay index and in turn improved preservation of banana fruit during storage at 25 ^{0}C and 85% relative humidity [18].

Shelf life

From the present study, it was evident that SA treated fruits showed higher shelf life (>8 days) than fruits at control (Table 1). It was reported that fruits at control had the minimal post – harvest life only of 7.00 days when stored at ambient condition [14]. SA treatments delayed ripening and adjoining physico- chemical changes in papaya may be because it delayed respiration climacteric and reduced ethylene production. Moreover, decaying was found less in SA treated fruits. These are to be considered behind the high shelf life of SA treated fruits.

Conclusion

The result of the present experiment showed that SA at 2.5 to 3.0 mM may be the effective post harvest treatment to extend shelf life while maintaining the physico-chemical qualities of papaya cv Red Lady during storage at room temperature.

References

1. Paull RE, Chen NJ (2014) Recent advances in post harvest management of papaya. Acta Hort 1024: 321—327.
2. Gajanana TM, Sudha M, Saxena AK, Dakshinamoorthy V (2010) Post harvest handling marketing and assessment of losses in papaya. Acta Hort 851 : 519—526.
3. Asghari M, Aghdam MS (2010) Impact of salicyclic acid on post harvest physiology of horticultural crops. Trends Food Sci Technol 21 : 501—509.
4. Rangaswamy R (2010) A textbook of agricultural statistics. 2nd edn. New Age Int (P) Ltd, New Delhi, India.
5. AOAC (2012) Official methods of analysis. 19th edn. Assoc of Anal Chem, Rockville MD, USA.
6. Sadasivam S, Manickam A (2008) Biochemical methods. 3rd edn. New Age Int (P) Ltd, New Delhi, India.
7. Basulto FS, Duch ES, Gil FF, Plaza RD, Saavedra AL, Santhamaria JM (2009) Post harvest ripening and maturity indices for *Maradol papaya*. Interciencia 34 : 583—588.
8. Othman Z (2008) Effect of post harvest coatings and heat treatment on quality of stored pineapple fruits. PhD thesis. Univ of Putra, Malaysia.
9. Mahmud TMM, Al Eryani-Raqeeb A, Syed Omar SR, Mohamed Zaki AR, Al Eryani AR (2008) Effects of different concentrations and applications of calcium on storage life and physico-chemical characteristics of papaya (*Carica papaya* L.). Amer J Agric Biol Sci 3 : 526—533.
10. Mandal D, Lalremruata, Hazarika TK, Nautiyal BP (2015) Effect of post- harvest treatments on quality and shelf life of pineapple (*Ananas comosus* L. Merr. Giant Kew) fruits at ambient storage condition. Int J Bio-Resource and Storess Mgmt 6 : 490—496.
11. Singh P, Kumar S, Maji S (2012) Effect of ethrel on post harvest changes in papaya (*Carica papaya* L.) fruits. Hort Flora Res Spect 1 : 225—230.
12. Shafiee M, Taghavi TS, Babalar M (2010) Addition of salicylic acid to nutrient solution combined with post harvest treatments (hot water, salicylic acid, and calcium dipping) improved post harvest fruit quality of strawberry. Scientia Hort 124 : 40—45.
13. Manenoi A, Bayogan ERV, Thumdee S, Paull RE (2007) Utility of l-methylcyclopropenre as a papaya post har

vest treatment. Postharv Biol Technol 44 : 55—62.
14. Chutichudet B, Chutichudet P (2014) Effect of chitosan or calcium chloride on external post harvest qualities and shelf life of Holland papaya fruit. J Agric Sci 6 : 160—177.
15. Zheng Y, Zhang Q (2004) Effects of polyamines and salicylic acid post harvest storage of Ponkan mandarin. Acta Hort 632 : 317—320.
16. Aghdam MSM, Motallebiazar A, Mostofi Y, Moghaddam JF, Ghasemneghad M (2010) Effect of MeSA vapor treatment on the post harvest quality of Hayward kiwi fruit. Acta Hort 877 : 743—748.
17. Alam MS, Hossain MM, Ara MI, Amanullah ASM,Mondal MF (2010) Effects of packaging materials and growth regulators on quality and shelf life of papaya. Bangladesh Res Publ J 3 : 1052—1061.
18. Hu H, Mo Y, Xie J, Zhang L, Gu H, Gong D (2009) Effect of salicylic acid on antioxidation capacity and preservation of post-harvested banana fruits. Food Sci 2 : 239—244.
19. Cantwell M, Nie X, Hong G (2009) Impact of storage condition on grape tomato quality (http://ucce.ucdavis.edu/files/datastore/234-1531.pdf visited on 10.02.2015).
20. Renhua H, Renxue X, Yunel L, Liming H, Yongjie X (2008) Effect of pre harvest salicylic acid spray treatment on post harvest antioxidant in the pulp and peel of Cara cara navel orange (*Citrus sinensis* L. Osbeck). J Sci Food Agric 88 : 229—236.
21. Pila N, Gol NB, Ramana Rao TV (2010) Effect of post-harvest treatments on physico-chemical characteristics and shelf life of tomato (*Lycopersicon esculentum* Mill.) fruits during storage. Am Euras J Agric & Environ Sci 9 : 470—479.