FOLIAR APPLICATION OF SALICYLIC ACID RETAINS QUALITY OF APRICOT FRUIT DURING STORAGE AND MARKETING

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ABSTRACT: *The apricot fruits were sprayed with 0, 0.5, 1.0, 1.5, 2 and 2.5 mM salicylic acid (SA) at pale green stage and harvested at light yellow stage of maturity. The fruits were analyzed for quality attributes at day 0 (fresh fruits), 15 and 30 days storage at refrigerated temperature (7-9°C) followed by 24 hours simulated marketing (25-30°C). The quality attributes of apricot fruit declined with increasing storage duration. However, the application of salicylic acid retarded the senescence related changes during storage and marketing. The fruit firmness (3.29 kg.cm^{-2}), acidity (0.76%) and ascorbic acid content (10.45 mg. 100g^{-1}) in fresh fruits declined to 3.02 kg.cm^{-2} fruit firmness, 0.69% acidity and 9.27 mg. 100g^{-1} ascorbic acid with 15 days refrigerated storage; and further to 1.09 kg.cm^{-2} fruit firmness , 0.49% acidity, and 7.12 mg. 100g^{-1} ascorbic acid in fruits stored for 30 days. By contrast, the weight loss (0.51%), TSS (8.86%) and TSS/acid ratio (11.74) of fresh fruits, increased to 1.62%, 10.99% and 15.95 with 15 days storage and increased to the maximum of 1.92, 13.11% and , 27.24, respectively with 30 days storage + 24 hours marketing at warmer temperature. The foliar application of salicylic acid significantly declined the loss of fruit quality during storage and marketing. The control fruit had the maximum mean weight loss (1.50%) and TSS/Acid ratio (21.29), but the minimum fruit firmness (2.22 kg.cm^{-2}), acidity (0.61%) and ascorbic acid content (7.40 mg. 100g^{-1}), By contrast fruit sprayed with 2.5 mM salicylic acid had the minimum mean weight loss (1.10%), the highest fruit firmness (2.69 kg.cm^{-2}), acidity (0.67%) and ascorbic acid content (10.27 mg. 100g^{-1}). The interaction of SD × SA concentration revealed that the increase in weight loss, TSS and TSS/Acid ratio of apricot fruit was significantly lower in apricot fruits treated with SA. It can be concluded that apricot could be pre harvest foliar sprayed with 2.5 mM salicylic acid to retain the quality attributes for 30 days followed by 48 hours simulated marketing.*

Keywords: Apricot, Quality attributes, Salicylic acid, simulated marketing, storage duration

1. INTRODUCTION

Apricot *(Prunus armeniaca L.)* belongs to family Rosaceae [1]. The apricot is, generally, grown in sub-temperate climates of the world. The total production of apricot in the world is 3.37 million tons [2]. Pakistan with an annual production of 1.71 million tons ranks sixth in apricot production in the world. Apricot is a climacteric fruit and highly perishable fruits, therefore, has high rates of respiration and ethylene production that result in a short (2-4 weeks) storage life [3]. The fruit maturation follows fruit softening which results in fruit senescence. The apricot fruit is also susceptible to physiological disorders such as internal browning and flesh break down [4]. Attempts have been made to extend the storage life of apricot fruit [4]. Cold storage is one of the most commonly used techniques to increase the storage life of fruits and vegetables, which decrease the rate of respiration of respiration and ethylene production [5, 6]. The efficiency of cold storage can be enhanced by modifying the storage atmosphere [7] and application of postharvest chemicals such as potassium permanganate, salicylic acid [8], calcium [9] and 1-methylcyclopropene (1-MCP) [10].

Salicylic acid is natural product, which is known to regulate the growth and development of the plants [11]. Preharvest application of salicylic acid may increase the fruit size and, hence, yield as well as fruit quality [12]. Salicylic acid (SA) is potent inhibitor of ethylene biosynthesis and, thus, delays the senescence of fruits during storage [13]. It has been reported that fruit treated with salicylic acid have lower ethylene production and hence slow ripening [14]. The loss fruit quality and ascorbic acid, during storage, is decreased by the application of salicylic acid [15]. The application of SA also lowers the weight loss and retains fruit firmness and hence enhances the storage life [16]. The current research was, therefore, conducted to evaluate the influence of preharvest salicylic acid application on the quality of apricot fruit during storage and subsequent marketing.

2. MATERIALS AND METHODS

Experimental site and plant material

The experiment "Foliar application of salicylic acid retains quality of apricot fruit during storage and marketing" was carried out during 2014. The fruits were collected from Horticultural Farm of The University of Agriculture Peshawar, Pakistan. Apricot trees (*Prunus armeniaca*, L.) aging 17 years old of uniform size, planted at 7×7 m distance having Peshawar Local as rootstock, were selected for the experiment. The apricot orchard had clay loam soil with a pH range of 7.8-8.2. All the cultural practices were carried uniformly in the apricot orchard.

Salicylic acid application

The fruit were sprayed with different concentrations of salicylic acid at pale green stage of maturity. Salicylic acid solutions were prepared as described by [17]. The trees were sprayed with 0, 0.5, 1.0, 1.5 2.0 and 2.5 mM salicylic acid at pale green stage of maturity. The control trees were sprayed with distal water only. Complete wetting was achieved by applying 5-6 liters of solution per tree. Tween-20 (0.1%) was added to salicylic acid solution as surfactant. The spraying operation was carried out early in the morning.

The fruits were hand harvested at light yellow stage. The fruits free from physical injuries are disease symptoms were selected.

The selected fruits in each treatment and replication were divided into three lots. The first lot (fresh fruits) were transferred to warmer temperature (25-30°C) for 48 hours as

simulated marketing time. The other two lots were shifted to cold storage (5±1°C) for 15 and 30 days. At completion of each storage interval, the fruits were shifted warmer marketing temperature for 48 hours. The fresh and stored fruits were incubated for 48 hours at 25-30°C as simulated marketing time.

After completion of simulated marketing, the fruits were analyzed for different quality attributes at the Horticulture Lab, The University of Agriculture Peshawar.

The experiment was planned as two factorial Completely Randomized Design with 18 treatments repeated three times. For chemical analysis, 10 fruits were taken at random for each treatment and replication.

Study parameter:

The apricot fruits were studied for the following parameters during storage.

Weight Loss (%)

For weight loss 10 fruits for each treatment and replication were packed separately. The fruit weight was measured after simulated marketing for each storage interval with an electrical balance. The difference between the initial and final fruit weight for each treatment and replication was converted to percent weight loss [18].

Fruit firmness (kg.cm^{-2})

Hand held penetrometer (Effigi, FT-11) was used to measure the fruit firmness of the randomly taken 5 fruits for each treatment in each replication. For this, purpose a small portion of skin at the equatorial region of apricot fruit was peeled to expose the flesh. The penetrometer was set to 0 and the probe was gently pressed into the flesh. The reading was recorded when the probe was penetrated to the specified level [19].

Total Soluble Solids (%), Acidity and TSS/Acid ratio

The total soluble solids content of apricot juice was recorded by randomly taking the fruits from treatment in each replication with the help of a hand held Refractometer. A few drops of fruit juice was placed on clean dry prism of the hand refractometer and the reading was taken. The prism of refractometer was clean with distilled water and dried with tissue paper between successive readings [20].

The titratable acidity (%) of the fruit juice was determined by the method described in [21] by titration with solution of 0.1N sodium hydro oxide (NaOH). Phenolphthalein was used as an indicator for the completion of the reaction. The TSS/acid ratio was determined by dividing the values for TSS over acidity.

Ascorbic acid (mg. 100g^{-1})

The ascorbic acid content of the fruit was determined by the dye method of [22]. The juice from known weight of randomly taken fruits in each replication for all the treatments.

Statistical Procedures

Statistix 8.1 package was used for analysis of variance (ANOVA) of different parameter for detecting the differences among the factors as well as their interactions. Least significant differences (LSD) test was used in such situations where the differences were significant [23].

3. RESULTS AND DISCUSSION

Tables of analysis of variance (ANOVA) the means value regarding quality attributes of apricot fruit during storage are presented in this section.

Weight loss (%)

Weight loss of apricot was significantly influenced by storage duration, salicylic acid concentrations and their interaction (Table 1). The weight loss of apricot fruits increased significantly with increasing storage duration. The mean minimum weight loss (0.51%), after 48 hours simulated marketing, was recorded for fresh fruits, which increased to 1.62 and 1.92% in apricot fruit stored for 15 and 30 days respectively. The application of salicylic acid decreased the weight loss significantly. The maximum mean weight loss in control fruits (1.50%) decreased with increasing salicylic acid concentration. Thus, the minimum weight loss (1.10%) was recorded in fruits treated with 2.5 mM salicylic acid (Table 2). The interaction of storage duration and salicylic acid also significantly affected the weight loss of apricot fruit during storage and marketing. The weight loss of fresh apricot fruit after 48 hours simulated marketing ranged from the maximum of 0.70% with 0 mM SA application to the minimum of 0.50% with foliar application of 2.5mM SA (Figure 1). The weight loss in stored fruit and vegetable, generally, increases with increasing storage duration due to transpiration and respiration [24]. The fruit lose weight due to moisture loss and respiration plant is prone to considerable weight loss during storage. The rate of water loss depends on skin thickness and surface waxes [25]. The apricot fruit has non-waxy skin, that provides little barrier to moisture loss, hence the fruit lose significant moisture after harvest [4], hence it is likely to observe increased weight loss with increasing storage duration. The application of salicylic acid decreased the weight loss [26], probably by retarding the rate of respiration [27]. However, the influence of salicylic acid was concentration dependent.

Fruit Firmness (kg.cm^{-2})

The firmness of apricot fruit was significantly affected by the storage duration, salicylic acid application but the SD×SA interaction was not significant (Table 1). Whereas, increasing storage duration decreased the fruit firmness, salicylic acid application retained higher fruit firmness than the control fruits. The firmness of fresh fruit + 48 hours simulated marketing was 3.29 kg.cm^{-2} which decreased to 3.02 and 1.09 kg.cm^{-2} with extending storage duration to 15 and 30 days. The control fruits had the least mean fruit firmness (2.22 kg.cm^{-2}), which was significantly higher in fruits treated with salicylic acid. The maximum fruit firmness (2.69 kg.cm^{-2}) was recorded in fruits treated with 2.5 mM SA. The difference in firmness of fruit treated with 2.0 and 2.5 mM SA was, however, not significant (Table 2). The fruit firmness usually decline during storage. The loss of firmness during storage is attributed to changes in primary cell wall during ripening, that results in textural changes texture [28, 29]. However, the application of salicylic acid decrease the rate of respiration and ethylene production [13], it therefore inhibit the ripening related cell wall breakdown and hence retained greater firmness as compared to control fruit (Table 2)

Total Soluble Solids (%)

The total soluble solids (TSS) content of apricot fruits increased significantly with increasing the storage duration. The least TSS (8.86%) was recorded in fresh apricot fruits + 48 hours simulated, which increased to 10.99 and 13.11% when apricot fruits were stored for 15 and 30 days + 48 hours simulated marketing (Table 2). The application of salicylic acid had no significant effect (Table 1). The SD×SA interaction, however, had significant effect on TSS content of apricot fruit (Table 1). While, the TSS content of apricot fruit increased with storage duration, the increase was less in salicylic acid treated fruits. The application of salicylic acid retained high TSS content in fresh fruit and retarded the increase in TSS content of fruit stored for 15 or 30 days. Whereas, in control fruit the TSS content increased from 7.27 to 14.86% with 30 days storage and 48 hours simulated marketing, the increase in fruits treated with 2.5 mM SA was from 10.78% in fresh fruits to 11.67 in fruits stored for 30 days + simulated marketing (Figure 2). The total soluble solids content is major factor in the taste and quality of fruits. The TSS, generally, increases during storage and subsequent marketing due to breakdown of starch into sugar [30]. The application of salicylic acid, however, resulted in less TSS than the control fruits. It indicates that, SA retarded the ripening of fruits during storage and marketing and hence the SA treated fruit had lower TSS than the control fruit (Table 1). These results are in agreement with [31]. The conversion of starches and pectins into simple sugar during ripening might be responsible for the increasing of total soluble solid. [30] stated that more starch and pectin content is present at early mature stage as compared to mid and late mature stage due to which total soluble solid increases with delaying harvesting. Thus, the salicylic acid treated fruit had lower TSS due to slow ripening [32].

Acidity

The titratable acidity of apricot fruit decreased significantly with increasing storage duration. However, the decrease in acidity of apricot fruit was significantly lower by salicylic acid application. The highest acidity (0.76%) decreased significantly to 0.69 and 0.49% with increasing storage duration to 15 and 30 days + 48 hours simulated marketing (Table 2). By contrast, the mean across salicylic acid concentration revealed the was the least acidity (0.61%) in untreated control, which increased significantly with increasing salicylic acid concentration and was the highest (0.68%) in fruits treated with 2.0 mM salicylic acid (Table 2). The difference in 1.0-2.5 mM salicylic acid concentrations was, however, non-significant. The interaction of SD × SA was also not significant (Table 1). The acidity of fruits decreases during storage due to loss of organic acid especially citric acid [33] in respiratory metabolism [34]. These results are comparable to the findings of [35], who reported higher acidity in grapes with application of SA.

TSS/Acid Ratio

The TSS/acid ratio of apricot fruit varied significantly with storage duration and salicylic acid concentrations as well as the SD×SA interaction (Table 1). Increasing the storage duration resulted in significant increase in TSS/acid ratio of apricot fruit. The TSS/acid ratio of fresh fruit after 48 hours simulated marketing was 11.74 which increased to 15.95 and 27.24 with 15 and 30 days storage + 48 hours simulated marketing. The application of salicylic acid retained lower TSS/acid ratio. The highest TSS ratio in control fruit (21.29) decreased with increasing salicylic acid concentrations and was the least (16.42) with 2.0 mM salicylic acid. The difference in 1.5, 2.0 and 2.5 mM salicylic acid concentrations was not significant (Table 2). The SD×SA interaction also had significant effect on TSS/acid ratio of apricot fruit (Table 1). Whereas, increasing storage duration increased the TSS/acid ratio, application SA decreased the increase in TSS/acid ratio. The TSS/acid ratio of fresh fruit after 24 hours simulated was (9.75), which increased to 16.99 and 37.14 in fruit stored for 15 and 30 days. By contrast the TSS/acid ratio of fruits treated with 2.5 mM salicylic acid increased from 14.09 in fresh fruit to 14.18 and 21.361 with the 15 and 30 days storage + 48 hours simulated marketing (Figure 3). The starch is converted to soluble sugars in most fruits during the storage, which results in increased TSS content [36]. On the other hand, the organic acids are utilized in respiration [34]. Hence, the TSS/acid ratio increased during ripening or storage and marketing [36]. The increase in total soluble solid and decrease in acidity of fruits with storage and simulated marketing resulted in higher TSS/acid ratio [37]. However, the increase in TSS/acid ratio was less in SA treated fruits indicating that foliar SA application suppressed the increase in TSS and loss of acidity. The SA treated fruits, therefore had lower TSS/acid ratio [27, 26]. Since, the increase in TSS was lower in SA treated fruits and the acidity was retained at higher levels as compared to control fruits, it resulted in lower TSS/acid ratio. It demonstrates that SA at 2mM concentration was effective in retarding the ripening [27].

Ascorbic Acid content (mg. $100g^{-1}$)

The ascorbic acid content of apricot fruit varied significantly with storage duration and salicylic acid concentrations but the SD×SA interaction was not significant (Table 1). The ascorbic acid content of fresh fruit + 48 hours simulated marketing was 10.45 mg. $100g^{-1}$, which decreased to 9.27 and 7.12 mg. $100g^{-1}$ with storage for 15 and 30 days. Salicylic acid application retained higher ascorbic acid content of the fresh and stored fruit at higher levels than the control fruits. The ascorbic acid content of fresh fruit + 48 hours simulated marketing was 7.40 mg. $100g^{-1}$ which increased significantly with salicylic acid application. The maximum ascorbic acid content (10.27 mg. $100g^{-1}$) was recorded in fruits treated with 2.5 mM SA (Table 2). The ascorbic acid is highly sensitive to degradation and gradually declines during storage of fruits [30] due to rapid oxidation [38]. The foliar application of salicylic acid, however, retained higher ascorbic acid content as compared to control fruits (Table 2). The higher ascorbic acid content in SA treated fruits indicates that SA application delayed the ripening and senescence [39].

4. CONCLUSIONS

It can be concluded that salicylic acid at 2.5 mM as a preharvest foliar spray significantly reduced weight loss and retained all the studied attributes except total soluble solids for 30 days followed by 48 hours simulated marketing hence recommended for storing apricot fruits.

Table 1: Analysis of variance of the quality attributes of apricot as affected by salicylic acid during storage

SoV	DF	Weight loss	Fruit firmness	TSS	Acidity	TSS/Acid ratio	Ascorbic acid
				MS			
Storage duration (SD	2	8.47*	27.500*	81.196*	0.335*	1158.550*	51.280*
Salicylic acid (SA)	5	0.54*	0.205*	0.215ns	0.006*	30.840*	10.348*
SD x SA	10	0.10*	0.010^{ns}	5.869*	0.003^{ns}	47.381*	0.301^{ns}
Error	36						
Total	53						

Table 2. Influence of foliar application of salicylic acid and storage duration on the quality attributes of apricot fruit. Means in a column followed by different are significant at $p \leq 0.05$.

Storage Duration (Days)	Weight Loss (%)	Fruit Firmness ($kg.cm^{-2}$)	TSS (%)	Acidity (%)	TSS/Acid Ratio	Ascorbic Acid ($mg.\ 100g^{-1}$)
0	0.51 c	3.29 a	8.86 c	0.76 a	11.74 c	10.45 a
15	1.62 b	3.02 b	10.99 b	0.69 b	15.95 b	9.27 b
30	1.92 a	1.09 c	13.11 a	0.49 c	27.24 a	7.12 c
LSDs	0.0705	0.054	0.489	0.041	1.776	0.358
Salicylic Acid Concentrations (mM)						
0.0	1.50 a	2.22 c	11.20	0.61b	21.29 a	7.40 e
0.5	1.58 a	2.32 bc	11.05	0.62 b	19.48 b	8.12 d
1.0	1.45 b	2.45 b	11.03	0.64 ab	18.38 bc	8.71 c
1.5	1.27 c	2.49 b	11.02	0.66 a	17.64 c	9.44 b
2.0	1.18 c	2.61 a	10.83	0.68 a	16.42 c	9.73 b
2.5	1.10 cd	2.69 a	10.78	0.67 a	16.63 c	10.27 a
LSDs	0.098	0.077	ns	0.040	1.548	0.506
		SD×SA				
Significance	*	Ns	*	ns	*	Ns

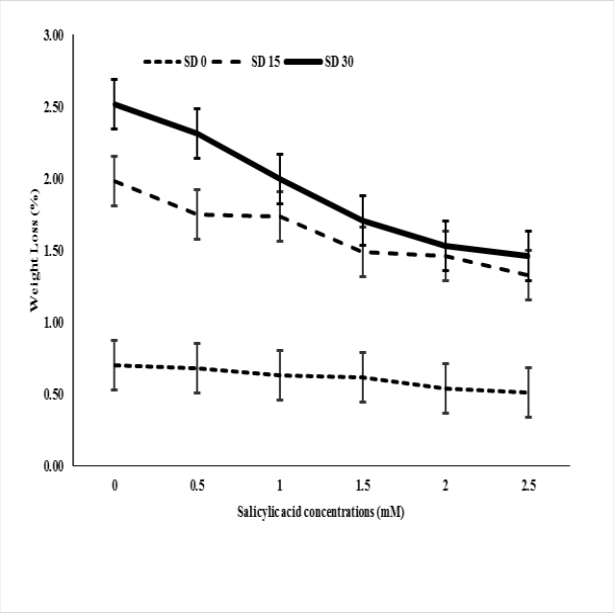

Figure 1. The effect of pre-harvest salicylic acid application on the weight loss of apricot fruits after storage and 48 hours simulated marketing. The vertical error bars represents LSD at $p \leq 0.05$.

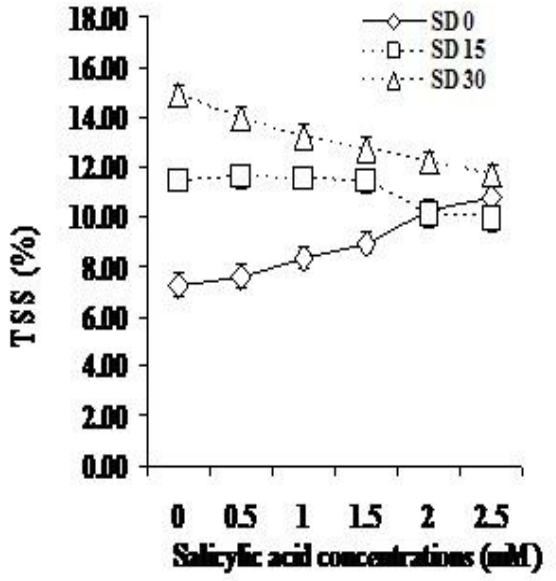

**Figure 2. The effect of pre-harvest salicylic acid application on the TSS/acid ratio of apricot fruits stored for 0, 15 and 30 days and incubated at marketing temperature for 48 hours. The vertical error bars represents standard error for each series. **

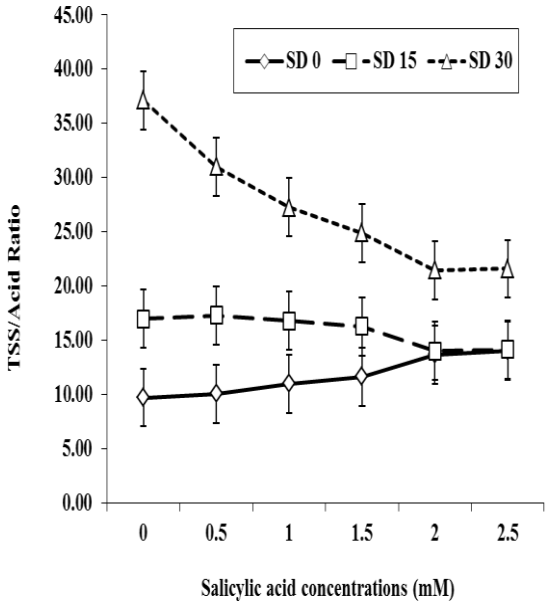

Figure 3. The effect of pre-harvest salicylic acid application on the TSS/acid ratio of apricot fruits stored for 0, 15 and 30 days and incubated at marketing temperature for 48 hours. The vertical error bars represents standard error for each series.

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5. REFERENCES

[1] Shahnawaz, M., & Khan, T.U., "Determination of yield and fruit characteristics of various Baltistan dried apricot cultivars," *Pakistan Journal of Food Science*, 15(4), 47-50 (2005)

[2] FAO., "Food and Agriculture Organization of the United Nations," Available at http://faostat.fao. org/site/339/default.aspx. Retrieved on 13-3-2014 (2010)

[3] Demartino, G., Massantini, R., & Botondi, R., "Temperature affects impact injury on apricot fruit," *Postharvest Biology and Technology*, 25:145-149 (2002)

[4] Alil, S., Masud, T., Abbasi, K. S., Mahmood, T., & Hussain, I., "Influence of $CaCl_2$ on biochemical composition, antioxidant and enzymatic activity of apricot at ambient storage," *Pakistan Journal of Nutrition*, 12 (5), 476-483 (2013)

[5] Kader, A. A., "Post-harvest Technology of Horticultural Crops," University of California, Agriculture and Natural Resources. Pub. 3311 (2002)

[6] Fatahi, J., Fitfall, R., & Bari., M., "Postharvest quality of Kiwi fruit (*Actinidia deliciosa* cv. Hayward) affected by pre-storage application of salicylic acid,". *South- Western Journal of Horticulture, Biology and Environment*, 1, 175-186 (2010)

[7] Scetar, M., Kurek, M. & Galic, K., "Trends in fruit and vegetable packaging," *Croatian Journal of Food Technology, Biotechnology and Nutrition*, 5(4), 69-86 (2010)

[8] Bal, E., & Celik, S. "The effects of postharvest treatments of salicylic acid and potassium permanganate on the storage of kiwifruit," *Bulgarian Journal of Agricultural Science*, 16, 576-584 (2010)

[9] Jan, I., Rab, A., & Sajid, M. "Influence of calcium chloride on physical characteristics and soft rot incidence on fruit of apple cultivars," *The Journal of Animal and Plant Science*, 23, 1353 1359 (2013)

[10] Ozkaya, O., Yildirimb, D., Dundar, O., & Tukel, S. S., "Effects of 1- methylcyclopropene (1-MCP) and modified atmosphere packaging on postharvest storage quality of nectarine fruit," *Scientia Horticulturae*, 198, 454– 461 (2016)

[11] Asgharia, M., & Aghdam, M. S., "Impact of salicylic acid on post-harvest physiology of horticultural crops," *Trends in Food Science and Technology*, 21, 502-509 (2010)

[12] Champa, W. A. H., Gill, M. I. S., Mahajan, B. V. C., & Arora, N. K., "Preharvest salicylic acid treatments to improve quality and postharvest life of table grapes (*Vitis vinifera* L.) cv. Flame Seedless," *Journal of Food Science and Technology*, 52, 3607- 3616 (2015)

[13] Ozeker, E., "Salicylic acid and its effects on plants," *Ege University Faculty of Agriculture Journal*, 42(1), 213-223(Tr) (2005)

[14] Fatemi, H., Mohammadi, S., & Aminifard, M. H., "Effect of postharvest salicylic acid treatment on fungal decay and some postharvest quality factors of kiwi fruit. *Archives of Phytopathology and Plant Protection*, 46, 1338-1345 (2013)

[15] Sahar, M., & Wahab, A. E., "Apricot postharvest fruitq quality, storability and marketing in response to preharvest application," *Middle East Journal of Agriculture Research*, 3: 347-358 (2015)

[16] Khademi, Z., & Ershadi, A., "Postharvest application of salicylic acid improves storability of peach (*Prunus persica* cv. Elberta) Fruits," *International Journal of Agriculture and Crop Sciences*, 5, 651- 655 (2013)

[17] Ranjbaran, E., Sarikhani, H., Wakana, A., & Bakhshi, D., "Effect of salicylic acid on storage life and postharvest quality of grape (*Vitis vinifera* L. cv. Bidaneh Sefid)," *Journal of the Faculty of Agriculture, Kyushu University*, 56, 263-269 (2011)

[18] Amayogi, R. K., & Alloli, T. B., "Studies on integrated nutrient and postharvest management of fig (*Ficus carica* L.)," Ph.D. Thesis. Department of Horticulture College of Agriculture Dharwad University Agriculture Science Dharwad. 580, 005-143 (2007)

[19] Pocharski, W. J., D. Knopacka, J. Zweirz., "Comparison of Magnees Tayler pressure test with mechanical non-destructive method of apple and pear firmness measurements," *International Agrophysics*, 14, 311-331 (2000)

[20] Ranganna, S., "Hand book of analysis and quality control for fruit and vegetable products," Tata McGraw-Hill Publishing Co. Ltd., New Delhi, India. p. 1112 (1986)

[21] AOAC (Association of official Analytical Chemists), "Official methods of analysis," 15th Ed, (Ed. Helrich, K.) Arlington, Virginia USA. 513 (2000)

[22] AOAC., "Official methods of analysis of the Association of Official Analytical Chemists, 15th ed., Association of Official Analytical Chemists, Arlington VA, pp. 1058-1059 (1990)

[23] Steel, R. G. D., & Torrie, J. H., "Principles and procedures of statistics," MC. Graw Hill Pub. Comp. Inc. New York (1997)

[24] Hardenburg, R. E., Watada, A. E., & Wang, C. Y., "The commercial storage of fruits, vegetables and florist and nursery stocks," *Agriculture. Hand book Number 66, USDA*, p. 19 (1990)

[25] Veravrbeke, E. A., Verboven, P., Oostveldt, P., & Nicolai, B. M., "Predication of moisture loss across the cuticle of apple (*Malus sylvestris* sp. Mitis (Wallr.) during storage: part 2. Model simulations and practical applications," *Postharvest Biology and Technology*, 30, 89-97 (2003)

[26] Babalar, M., Asghari, M., Talaei, A., & Khosroshahi, A., "Effect of pre- and postharvest salicylic acid treatment on ethylene production, fungal decay and overall quality of selva strawberry fruit," *Food Chemistry*, 105, 449–453 (2007)

[27] Srivastava, M. K., & Dwivedi, U. N., "Delayed ripening of banana by salicylic acid," *Plant Science*, 158, 87-96 (2000)

[28] Kov, E., & Felf, E., "Investigating the firmness of stored apples by non-destructive method," *Acta Horticulturae (ISHS)*, 59: 257-260 (2003)

[29] Kov, E., Hertog E., & Vanstreels, E., "Relationship between physical and biochemical parameters in apple softening," *Acta Horticulturae*, 68, 573-578 (2005)

[30] Jan, I., A. Rab and M. Sajid., "Storage performance of apple cultivars harvested at different stages of maturity," *Journal of Animal and Plant Science*, 22(2), 438- 447 (2012)

[31] Nasrin, T. A. A., Molla, M. M., Hossaen, M. A., Alam M. S., & Yasmin, L., "Effect of postharvest treatments on shelf life and quality of tomato," *Bangladesh Journal of Scientific and Industrial Research*, 33(3), 579-585 (2008)

[32] Tareen, M. J., Abbasi N. A., & Hafiz, I. A., "Effect of salicylic acid treatments on storage life of peach fruits cv. 'Florda King'," *Pakistan Journal of Botany*, 44(1), 119-124 (2012)

[33] Marsh, K., Rossiter, K., Lau, K., Walker, S., Gunson A., & Macrae, E. A., "The use of fruit pulps to explore flavour in kiwifruit," In: H. Huang (Editor), *V International Symposium on Kiwifruit, Acta Horticulturae*, 610, 229-237 (2003)

[34] Shafique, M. Z., Ibrahim, M., Helali M. O. H., & Biswas, S. K., "Studies on the physiological and biochemical composition of different mango

cultivars at various maturity levels," *Bangladesh Journal of Scientific and Industrial Research*, 41(1-2), 101-108 (2006)

[35] Bal, E., & Kok, D., "Effects of uv-c and salicylic acid on quality of 'muskule' table grapes during cold storage,". *Journal of Applied Horticulture*, 9 (2), 127-131 (2007)

[36] Tariq, M.A., Tahir, F. M., Asif A. A., & Pervez, M. A., "Effect of controlled atmosphere storage on damaged citrus fruit quality," *International Journal of Agriculture and Biology*, 03(1), 9-12 (2001)

[37] Hussain, I., Asif, M., Ahmed, M., Khan M., & Shakir, M., "Effect of uni- packaging on the post harvest behavior of Citrus fruits in NWFP Pakistan," *Journal of Nutrition*, 3(6), 336-339 (2004)

[38] Lee, S. K., & Kader**,** A. A., "Pre-harvest and postharvest factors influencing vitamin C content of horticultural crops," *Post harvest Biology and Tecnology*, 20**,** 207-220 (2000)

[39] Davarynejad, G. H., Zarei, M., Nasrabadi, M. E., & Ardakani, E., "Effects of salicylic acid and putrescine on storability, quality attributes and antioxidant activity of plum cv. 'Santa Rosa'," *Journal of Food Science and Technology*, 52, 2053-62 (2015)