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Effects of Foliar Spraying with Salicylic Acid on Some Quantity and Quality Characteristics of Pear Fruits

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ABSTRACT

A factorial experiment with randomized complete block design carried out in Erbil governorate, Iraq during 2015 and 2016 seasons on pear (*Pyrus Communis* L.) Spadona and Compote cvs. to investigate the effects of spraying trees with (0, 0.5, 1.0 and 1.5%) salicylic acid (SA) on some fruits quantity and quality characteristics. The results show that Compote fruits had the highest weight and firmness significantly compared to Spadona fruits in both seasons, whereas Spadona variety records the highest total acidity. Fruits of Compote variety records higher chlorophyll a , chlorophyll b and total carotenoids content significantly compared to Spadona variety in 2015, in the opposite of the results of 2016 in respect to chlorophyll a and chlorophyll b. Spraying trees with SA increased fruit weight and firmness compare to control treatment for both seasons, and total acidity in 2015 and total sugars in 2016, whereas the differences were not significant in 2016 and 2015 for the last two properties. In 2015 spraying 1.5% SA increased each of chlorophyll a and b content significantly compared to other concentrations, whereas significant decrease in total carotenoids content observed with increasing SA concentration, whereas the differences between SA treatments were not significant in 2016 in respect to chlorophyll a, b and total carotenoids.

Keywords Foliar spraying, Pear fruit quality, *Pyrus Communis* L., Salicylic acid, Total acidity, Total sugars.

INTRODUCTION

Pear (*Pyrus communis* L.) is an important fruit which is grown in temperate zone throughout the world. It is cultivated in the middle and Northern parts of Iraq depending upon cold requirement for breaking dormancy [1]. In Iraq pear tress cultivated in 2400 hectare area giving 14326 ton per year [2].

Pear is a climacteric fruit [3] had a rapid ripening that shortens their storage life and decreased the efficiency of their handling and transporting [4], especially in Iraq where some of its varieties are harvested during August, therefore it is very important to search for active applying in order to improve fruits qualities especially storability characteristics.

Recently salicylic acid (SA) is used in order to improve fruits quality and prolong storage period. These treatments are conducted either pre-harvest or postharvest [5, 6 and 7]. SA is considered as a plant hormone [8], inhibiting ethylene biosynthesis and delaying fruits senescence [9], and it is considered as safe for human health [10].

There are several studies indicating beneficial influences of SA on fruits, such as the study conducted by [11] on apple trees cv. Anna, whom found that spraying trees with 50, 100, 200 or 400 ppm SA for 1, 2, 3 or 4 times increased fruits total acidity and sugars and decreased fruits TSS with increasing SA concentration and numbers of spraying during 2009 and 2010 seasons. [12] found that spraying peach trees cv. Florida king with 1, 2 and 3 mM SA in three different stages increased fruits weights, firmness and total acidity compared to control treatment. [13] found that spraying mango trees cv. Kesra with 1500, 2000 and 2500 ppm SA, the treatment 2500 ppm increased fruit yield and keeps fruits TSS, acidity and sugars compared to control treatment. [14] and [15] show that saying apple and peach trees with SA increased chlorophyll a and b in fruits compare to control.

As it shown in the previous studies the good effects of SA on quantity and quality characteristics of different fruits were conducted, but a little on pear. Because of this reason and attention to the risk of improper use of chemicals in pre and post-harvest technology and consumer's demand for healthy products, this study was conducted in order to improve quantity and quality of two pear fruits varieties (Spadona and Compote cvs.) by spraying trees with different concentration of SA at the condition of Northern region of Iraq.

2. MATERIAL AND METHODS

2.1 Plant Material

A study was carried out in a private orchard in Erbil governorate, 414m altitude, and 36.41° North latitude during 2015 and 2016 seasons on pear (*Pyrus communis* L.), 48 trees of 5 years old of Spadona and Compote cvs. were selected and sprayed at sun set to runoff with SA (0 (only water), 0.5, 0.1 and 1.5 %) in two different times the first was a month after full bloom (18th and 28th of May 2015 and 2016 respectively), whereas the second spray was two weeks later.

2.2 Studies Characteristics

Firm, yellow-green fruits were harvested from the trees of each experimental unit in 4th of July for Spadona variety and the 1st of November for Compote vareity, and the following characteristics were performed in the laboratories of Koya University as follows: average fruit weight, fruits firmness by using hand-penetrometer with 7.9 mm head diameter and

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remove part of the fruit peel [16], total soluble solids (TSS) by using hand-refractometer according to [17], total sugars was estimated by using spectrophotometer at 490 nm as it mention in [18], total acidity estimated by titrating against 0.1N sodium hydroxide using phenolphthalein as indicator and expressed as mg of malic acid per gram, each of chlorophylls and carotenoids pigments were determined by using acetone as solvent according to [19].

Meteorological data in the field condition during the growing seasons were measured by the Directorate of Weather and Earthquakes/ Erbil/ Iraq- Kurdistan Region as it shown in Table 1.

Table1. Maximum and minimum temperature, the relative humidity and the amount of rain fall during growing seasons.

Month	Average of Temperature		Relative Humidity (%)		Falling Rain (mm)	
	2015	2016	2015	2016	2015	2016
January	8.4	7.5	61.5	79.3	52	71.8
February	9.8	11.5	62.2	79.7	48.1	61.9
March	12.9	13.8	58.4	87.3	95.7	110.2
April	17.3	18.9	50.8	77.8	29.2	61.4
May	25.4	24.5	34.9	63.6	4.6	1.1
June	30.3	31.2	43.8	51.9	-	-
July	35.2	34.5	59.0	50.8	-	-
August	34.3	35.8	80.1	51.3	-	-
September	31.3	28.6	84.1	54.3	12.5	-
October	23.5	23.9	86.4	52.6	98.9	0.4
November	14.7	15.2	82.1	52.2	102.7	21
December	9.5	8.3	83.2	67.2	121.8	128.9

2.3 Statistical Analysis

Factorial experiment in randomized complete block design with 3 replicates was used in this study. Data subjected to analysis of variance using SAS program. Treatments means were compared using Duncan`s multiple range test ($p \leq 0.05$) [20].

3. RESULTS

3.1 Effects on average fruit weight (g)

Results in table 2 show that Compote fruits weight was significantly higher than Spadona fruits in both seasons. Spraying trees with 0.5% SA increased fruit weight significantly compared to other treatments in 2015, whereas in 2016 compared to control and 1.5% treatments, when the lowest values were recorded in 1.5% SA for both seasons. All interactions between Compote variety and SA concentrations were superior in fruit weight especially 0.5% SA in 2015 and each of 0.5 and 1% SA in 2016.

3.2 Effects on fruit firmness (Kg/cm^3)

Firmness of Compote variety fruits was significantly higher than Spadona variety in both seasons (Table 2). SA concentration had non-significant effects on fruits firmness in 2015, whereas in 2016 the firmness increased with increasing the acid concentration significantly for 1 and 1.5% concentrations compare to the control. The interaction between variety and SA concentration on fruit firmness showed that spraying trees of Compote variety with 0.5% SA increased the fruit firmness significantly compared to all interactions between Spadona and SA concentrations, whereas in 2016 fruits firmness increased significantly in all interactions of Compote variety compared to Spadona variety.

3.3 Effects on fruit total soluble solids (TSS) (%)

Each of the variety of pear fruits, SA concentration and there interactions had non-significant effects on fruits TSS in 2015, whereas in 2016 Compote fruits TSS increased significantly compared to Spdona variety, while the SA had non-significant effects on the percent of fruits TSS. In respect to interaction between the two factors, results in table 3 show significant increases in the percent of TSS content in the all interactions of Compote fruits with SA concentrations compared to Spadona interactions except the 0.5% SA treatment.

3.4 Effects on fruit total sugars (%)

Variety had non-significant effects on fruits content of total sugars in both seasons. Same effect was observed by SA factor in 2015, whereas in 2016 fruits total sugars increased with increasing SA concentration, were the highest value 11.12% was recorded in 1.5% SA treatment. The interactions between Spadona variety with 1% SA and Compote variety with 0.5% SA increased fruits total sugars significantly to 14.21 and 14.11% respectively compared to the interaction between Spadona variety and spraying 0.5% SA in 2015, whereas in 2016 the interactions between varieties and SA concentrations had non-significant effects on fruits total sugars (Table 3).

3.5 Effects on fruit total acidity (%)

Results in table 3 show that fruits of Spadona variety record the highest total acidity for both seasons compare to Compote variety. Increasing SA to 1.0 and 1.5% increased the fruit total acidity compared to 0 and 0.5% treatments in 2015, whereas in 2016 the differences were not significant. Interactions between the varieties and spraying SA show that total acidity decreased significantly in Compote variety interactions compare to Spadona in both seasons, whereas higher value were record in the interaction between Spadona variety with 1.5% SA which reached to 2.03 and 2.16% for both seasons 2015 and 2016 respectively.

3.6 Effects on fruits peel pigments (mg/cm^3 sol)

Results in table 4 show that fruits of Compote variety records higher chlorophyll a, b and total carotenoids content significantly compared to Spadona variety in 2015, in the opposite of the results of 2016 in respect to chlorophyll a and chlorophyll b. Spraying 1.5% SA increased each of chlorophyll a and b content significantly to 0.34 and 0.41 mg/cm3 sol compared to other concentrations, in contrast, increasing SA concentration leads to significant decrease in total carotenoids content in 2015, whereas the differences between SA treatments were not significant in 2016 in respect to chlorophyll a, b and total carotenoids. Interactions between varieties and spraying SA show that most of Compote variety with SA increased chlorophyll a and b in 2015 in the opposite of 2016 when most interactions of Spadona variety record the highest values, whereas total carotenoids was higher in compote interactions for both seasons.

TABLE 2. Effects of tree spraying with salicylic acid (SA) on fruits weight and firmness for Spadona and Compote pear fruits at harvesting during two seasons.

Treatments	Fruit weight (g)		Fruit firmness (Kg/ cm^2)	
	2015	2016	2015	2016
Varieties				
Spadona	90.45 b	93.38 b	13.42 b	17.58 b
Compote	139.51 a	190.78 a	15.88 a	22.75 a
Concentration of SA (%)				
0	114.10 b	138.34 ab	14.92 a	19.33 b
0.5	134.94 a	153.00 a	15.33 a	20.00 ab
1.0	109.71 bc	152.17 a	13.83 a	20.50 a
1.5	101.17 c	124.80 b	14.50 a	20.83 a
Interaction between variety and SA				
Spadona x 0	90.67 d	101.2 c	14.50 bcd	16.3 c
Spadona x 0.5	92.87 d	91.6 c	13.50 bc	16.7 c
Spadona x 1.0	88.82 d	85.5 c	12.50 d	18.7 b
Spadona x 1.5	89.43 d	95.2 c	13.17 cd	18.7 b
Compote x 0	137.53 b	175.4 b	15.33 abc	22.3 a
Compote x 0.5	177.00 a	214.4 a	17.17 a	23.3 a
Compote x 1.0	130.60 b	218.9 a	15.17 abc	22.3 a
Compote x 1.5	112.90 c	154.4 b	15.83 ab	23.0 a

Means followed by the same letters within column for variety, SA concentration and their interactions are not significantly different at $p \leq 0.05$ according to the Duncan`s Multiple Range test.

TABLE 3. Effects of tree spraying with salicylic acid (SA) on fruit TSS, total sugars and total acidity for Spadona and Compote pear fruits at harvesting during two seasons.

Treatments	TSS (%)		Total Sugars (%)		Total acidity (%)	
	2015	2016	2015	2016	2015	2016
Varieties						
Spadona	12.31 a	11.32 b	12.50 a	11.18 a	1.36 a	2.09 a
Compote	12.29 a	12.95 a	12.96 a	9.73 a	0.86 b	1.38 b
Concentration of SA (%)						
0	12.29 a	12.03 a	12.87 a	9.50 b	0.88 b	1.76 a
0.5	12.34 a	11.93 a	12.58 a	10.63 ab	0.73 c	1.63 a
1.0	12.46 a	12.60 a	13.56 a	10.59 ab	1.43 a	1.78 a
1.5	12.11 a	11.97 a	11.91 a	11.12 a	1.40 a	1.77 a
Interaction between variety and SA						
Spadona x 0	12.34 a	11.2 bc	12.92 ab	9.70 a	0.98 d	2.14 a
Spadona x 0.5	12.00 a	11.1 bc	11.06 b	12.13 a	0.80 e	1.91 b
Spadona x 1.0	12.80 a	12.1 ab	14.21 a	11.36 a	1.61 b	2.13 ab
Spadona x 1.5	12.11 a	10.9 c	11.81 ab	11.56 a	2.03 a	2.16 a
Compote x 0	12.23 a	12.9 a	12.82 ab	9.29 a	0.78 e	1.38 c
Compote x 0.5	12.69 a	12.7 a	14.11 a	9.14 a	0.65 e	1.34 c
Compote x 1.0	12.11 a	13.1 a	12.92 ab	9.83 a	1.25 c	1.43 c
Compote x 1.5	12.11 a	13.1 a	12.00 ab	10.68 a	0.76 e	1.38 c

Means followed by the same letters within column are not significantly different at $p \leq 0.05$ according to the Duncan`s Multiple Range test.

TABLE 4. Effects of tree spraying with salicylic acid (SA) on fruit peels content of chlorophyll a, b and total carotenoids for Spadona and Compote pear at harvesting during two seasons.

Treatments	Chlorophyll a		Chlorophyll b		Total carotenoids	
	(mg/cm^3 sol)					
	2015	2016	2015	2016	2015	2016
Varieties						
Spadona	0.23 b	0.32 a	0.18 b	0.52 a	0.08 b	0.09 b
Compote	0.28 a	0.15 b	0.47 a	0.23 b	0.297 a	0.27 a
Concentration of SA(%)						
0	0.24 b	0.24 a	0.30 b	0.46 a	0.191 a	0.20 a
0.5	0.22 b	0.19 a	0.29 b	0.30 a	0.144 ab	0.17 a
1.0	0.23 b	0.28 a	0.29 b	0.36 a	0.143 ab	0.18 a
1.5	0.34 a	0.25 a	0.41 a	0.35 a	0.133 b	0.16 a
Interaction between variety and SA						
Spadona x 0	0.20 c	0.29 ab	0.12 d	0.58 a	0.08 c	0.07 b
Spadona x 0.5	0.19 c	0.29 ab	0.16 cd	0.52 ab	0.09 c	0.09 b
Spadona x 1.0	0.20 c	0.40 a	0.17 cd	0.52 ab	0.08 c	0.11 b

Spadona x 1.5	0.35 a	0.30 ab	0.26 c	0.47 ab	0.08 c	0.08 b
Compote x 0	0.29 ab	0.18 bc	0.49 ab	0.34 ab	0.374 a	0.33 a
Compote x 0.5	0.25 bc	0.10 c	0.42 b	0.15 b	0.280 b	0.25 a
Compote x 1.0	0.25 bc	0.15 bc	0.42 b	0.20 ab	0.278 b	0.25 a
Compote x 1.5	0.33 a	0.19 bc	0.56 a	0.24 ab	0.258 b	0.24 a

Means followed by the same letters within column are not significantly different at $p \leq 0.05$ according to the Duncan`s Multiple Range test.

4. DISCUSSIONS

Most of the differences in quantity and quality characteristics of a fruit varieties are controlled by the genetic factors as a result of differences in tissues, internal hormones and enzymes activities [21], which reflects on characteristics of the varieties of same species to a significant levels, as it shown in weight loss, fruit firmness and total sugars (Table 2 and 3). Decreases in fruits TSS and increases in total sugars in Spadona fruits (Table 3) may due to late maturing of this variety compared to Compote.

The increase in fruits weight for 0.5% SA came from the positive effects of SA on increasing the bio-productivity as a result increasing photosynthesis pigments and increasing photosynthesis process [22], these results agree with [23] on grapefruits.

Firmness of any fruit variety depends mainly on cell wall tenacity and storage materials like pectin, starch, etc. , so decreasing fruit firmness due to transforming non-soluble pectin to soluble pectin [24] as a result of reaction of polygalacturonase, lipoxygenase, cellulose and pectin methyl esterase enzymes which analyzed cell wall and increased fruit softness [7]. So the different between Compote and Spadona varieties in these reactions may due to difference in their fruits firmness in both seasons. According to [25], the sudden decrease in fruits firmness during ripening is concise with rapid decrease in fruits content of salicylic acid, so the external application of this acid will retards fruit firmness, and this is clear in graduate increases in fruits firmness with increasing SA concentration in 2016 (Table 2).[26] returns the softening of climacteric fruits to ethylene production, and added SA retards the activity of enzymes that analyses cell wall, such as galacturonase, lipoxofygenase, cellulase and pectin methyl esterase which decreased fruit softening [7]. This confirm the results of [27] on peach and [28] on grapefruits.

TSS increase is considered as a ripening marker. Decreasing fruits TSS in SA treatments due to delaying ripening, inhibiting catalysis enzymes and controlling water loss from fruits surfaces [22], decrease in ethylene production as a result to decrease in activity of enzymes that synthesis sucrose phosphate, which consider as the key enzyme for sucrose metabolism [7]. The study results agree with those of[29] on pear and [30] on kiwifruits.

Increasing total sugars in fruits from trees treated with 1.5% SA due to the effects of SA in production and transporting sugars and pigments [8], and metabolism processes were organized by SA sprayed on trees [31].

Keeping high acidity in fruits from trees treated with SA due to decreasing in respiration and ethylene production [26, 32 and 33], and its role in decrease pectin dissolving [34] and delaying fruits ripening. The results agree with [31, 35 and 36].

The significant increase in chlorophyll a and b in the treatment of spraying 1.5% SA in the fruits of two varieties (Table 4) may due to decreasing in ethylene production which is leads to decreasing chlorophyllase enzyme [26] in the fruits of both varieties. The decrease in carotenoids content in Spadona variety in addition to genetic factors may due to increase in temperature before harvest in June and July, where high temperature (Table 1) due to inhibiting carotenoids accumulation in fruits [37]. The study results agree with [14] and [15] on apple and peach fruits.

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REFERENCES

1. Abbas, S.A. and K.S. Adel. 1989. Apple Fruits Production. Higher Education Printing. Salah-Eldin University, Erbil, Iraq.
2. FAOSTAT, Food Agriculture Organization STAT. 2013. http//faostat.fao.org.
3. Tarabih, M.E. 2014. Improving storability of Le-Conte pear fruit using Aminoethoxyvinylglycine (AVG) and oxalic acid (OA) under cold storage conditions. Asian Journal of Crop Science, 6: 320-333.
4. Zerbini, P.E. 2002. The quality of pear fruit. Acta Hortic., 596: 805-810.
5. Sandhu, S.S.; A.P. Singh. 2000. Effect of harvesting dates and individual seal packaging on the pear fruit cv. Le-Conte during cold storage. Haryana J. Hortic. Sci., 29:48–52.
6. ShiJuan, D.; C. KunSong; L. JunLiang and J.T. Zheng. 2002. The storability and its regulatory mechanism of Huanghua pear (*Pyrus pyrifolia* Nakai.) fruit as influenced by postharvest treatments. Agric. Sci. China, 1:1238–1245.

7. Asghari, M. and M.S. Aghdam. 2010. Impact of salicylic acid on postharvest physiology of horticultural crops. Trends Food Sci. Technol., 2: 502–509.
8. Raskin, I. 1992. Role of salicylic acid in plants. Ann. Rev. Plant Physiol. Plant Mol. Bio.l, 43: 439–463.
9. Khademi, O.; Z. Zamani; Y. Mostofi; S. Kalantari and A. Ahmadi. 2012. Extending storability of persimmon fruit cv. "Karaj" by postharvest application of salicylic acid. J.Agri. Sci. Tech. 14: 1067-1074.
10. Hooper, L. and A. Cassidy. 2006. A review of the health care potential of bioactive compounds, J. Sci. Food Agric., 86: 1805-1813.
11. Shaaban, M.M., M.K. A. Abed El-Aal and, F. A. Faissal. 2011. Insight into effect of salicylic acid on apple trees growing under saline soil. Res. J. Agri. and Biol. Sci., 7 (2): 150-156.
12. Ali, I., N.A. Abbasi and I.A. Hafiz. 2014. Physiological response and quality attributes of peach fruit cv. Florida King as affected by different treatments of calcium chloride, purerscine and salicylic acid. Pak. J. Agri., 51(1): 33-39.
13. Ngullie, C.R., R.V. Tank and D.R. Bhanderi. 2014. Effect of salicylic acid and humic acid on flowering, fruiting, yield and quality of mango (*Mangifera indica* L.) cv. Kesar. Adva. Res. J. crop. Improv, 5: 136-139.
14. Hussein, M. A., T. K. Mahdy and Asmaa A. Ibrahim. 2001. Effect of calcium chloride and gibberllic acid treatments on Anna and Dorsett Golden apples during storage.B–Chemical characteris-tics of fruits. J. Agric. Sci., 32(2): 185-200.
15. El-Shazly, S.M., A.M. Eisa, A.M.H. Moåtamed and H.R.M. Kotb. 2013. Effect of some agro-chemicals preharvest foliar application on yield and fruit quality of "Swelling" peach trees. Alex. J. Agric. Res., 58(3): 219-229.
16. Kader, A.A. and F.G. Mitchill. 1989. Maturity and quality, peaches, plums and nectarines growing and handling for fresh market. Publication no. 3331. Publications, Div Agr. Nat. Res., Univ. of California, Okland.
17. A.O.A.C. 2002. Association of Official Agricultural Chemists. Official and Tentative Methods of Analysis. 17th ed. Washington D.C.,U.S.A.
18. Joslyn, M.A. 1970. Methods in Food Analysis (2).Acad. Press, N.Y. London.
19. Ranganna, S. 1977. Manual of Analysis of Fruit and Vegetable Products. Tata McGraw Hill Publishing Company Limited, New Delhi.
20. Reza, A. H. 2006. Design of Experiments for Agriculture and the Natural Sciences. Chapman & Hall IC RC . New York. 437 Pp.
21. Afzadi, M.A. 2012. Genetic and biochemical properties of apples that affect storability and nutritional value. Introductory Paper at the Faculty of Landscape Planning, Horticulture and Agricultural Science. Swedish University of Agricultural Sciences Balsgård. Pp. 41.
22. Hayat, S.; Q. Fariduddin; B. Ali and A. Ahmad. 2005. Effect of salicylic acid on growth and enzyme activities of wheat seedlings. Acta. Agronomica Hungarica. 53: 433-437.
23. Harindra Champa, W. A., M. I. S. Gill ; B. V. C. Mahajan and N. K. Arora. 2014. Preharvest salicylic acid treatments to improve quality and postharvest life of table grapes (*Vitis vinifera* L.) cv. Flame Seedless.
24. Ahmed, W.; S. Ahmed; L. Ali and H. Hussan. 2015. Effect of pre-harvest spray of Salicylic (SA) and Methyl jasmonate (MeJA) on the phyrtochemicals and physiological changes during the storage of grapefruit cv. Ray ruby. Int. J. Biosci., 6(1): 269- 282.
25. Wang, L.J.; S.J. Chen; W.F. Kong; S.H. Li and D.D. Archbold. 2006. Salicylic acid pretreatment alleviates chilling injury and effects the anti-oxidant system and heat shock proteins of peaches during cold storage, Postharvest Biol. Technol., 41: 244-251.
26. Babalar, M.; M. Asghari; A. Talaei and A. Khosroshahi. 2007. Effect of pre and post-harvest salicylic acid treatment on ethylene production fungal decay and overall quality of selva strawberry fruit. Food chem., 105: 449-453.
27. Razavi, F.; J. Hajilou; G. Dehgan; R. N-B. Hassani and M. Turchi. 2014. Enhancement of postharvest quality of peach fruit by salicylic acid treatment. Int. J. Biosci. 4(1): 177-184.
28. Samra, B.N. 2015. Impact of postharvest salicylic acid and jasmonic acid treatments on quality of "Crimson Seedless" grapes during cold storage and shelf life. Int. J. of Advanced Res., 3(5): 483-490.
29. Jiankang, C.; Z. Kaifang and J. Weibo 2006. Enhancement of postharvest disease resistance in Ya Li pear (*pyrus bretschneideri*) fruit by salicylic acid sprays on the trees during fruit growth, European J. Plant Pathol., 114: 363-378.
30. Bal, E. and S. Celik. 2010. The effects of postharvest treatments of salicylic acid and potassium permanganate on the storage of kiwifruit. Bulg. J. Agric. Sci., 16: 576-584.

31. Ahmed, S.; Z. Sengh; A. Sattar Khan and Z. Iqbal. 2013. Pre-harvest applicaton of salicylic acid maintain the rind textural properties and reduce fruit rot and chilling injury of sweet orange during cold storage, Pak. J. Agri. Sci., 50(4): 559-569.

32. Srivastava, M.K. and U.N. Dwivedi. 2000. Delayed ripening of banana fruit by salicylic acid, Plant Sci., 158: 87-96.

33. Zhang, Y.; K. Chen; S. Zhang; I. Ferguson. 2003. The role of salicylic acid in postharvest ripening of kiwifruit. Postharvest Biol. Technol., 28: 67-74.

34. Pressey, R. and J.K. Avants. 1973. Separation and characterization of endopolygalacturonase and exopolygalacturonase from peaches. Plant Physiol. 52: 252-256.

35. Lolaei, A.; B. Kaviani; M.A. Rezaei; M.K. Raad and R. Mohammadipour. 2012. Effect of pre- and postharvest treatment of salicylic acid on ripening of fruit and overall quality of Strawberry (*Fragaria ananasa* Duch cv. Camarosa) fruit. Ann. Biol. Res., 3(10): 4680-4684.

36. Al-Obeed, R.S. 2012. Jujube post-harvest fruit quality and storagability in response to agro-chemicals preharvest application. Afr. J. Aagric. Res., 7(36): 5099-5107.

37. Ivan, S. and T. A. Wheaton. 1971. Effects of ethylene and temperature on carotenoid pigmentation of citrus peel. Florida State Horticulture Society, 264-266.

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