



Full Length Article

Preharvest salicylic acid and delay ripening of 'superior seedless' grapes



A.A. Lo'ay

Pomology Department, Faculty of Agriculture, Mansoura University, 35516 Box, El-Mansoura, Egypt

ARTICLE INFO

Article history:

Received 7 December 2016

Received in revised form 30 March 2017

Accepted 30 April 2017

Available online 11 May 2017

ABSTRACT

The experiment was conducted to study the effect of salicylic acid (SA) treatment (0, 1, 2, 4 mM SA) on *Vitis vinifera* L. 'Superior seedless' which conducted during two seasons 2014 and 2015. The study aims to delay cluster repining during shelf-life at room temperature for four days. The results showed that SA treatments were significantly effective in reducing weight loss. Berry shatter, rachis browning index, while it preserved another quality parameter high such as berry firmness, separation force, total phenol content (TPC) and color hue angle during shelf-life for four days. The previous results were significantly observed with SA at 4 mM compared to control and other SA concentrations. However, total solid content (SSC%), titratable acidity (TA%), SSC/TA ratio was significantly affected by SA at 4 mM up to end the shelf-life period. In contrast, the lowest values of carotenoid content and membrane electrolyte leakage (IL%) during shelf-life compared with other SA concentrations. Therefore, SA is effective for delaying fruit ripening and maintain cluster quality of 'Superior seedless' grapes.

© 2017 Mansoura University. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

'Superior seedless' is one of the earlier seedless table grapes grown under Mediterranean climate and it is well adapted to Egyptian conditions. It harvested at yellow-white flesh and green skin color stage as European market requests [1]. The table grape is a non-climacteric fruit with low physiological activity. Also, it is sensitive to water loss and fungal infection during handling [2]. Even it is one of the major sources of polyphenols among fruit. It being relevant to appearance, test, and flavor as well as to the health maintaining fruit quality [1]. Therefore, it is imperative to develop a compatible strategy that would improve physical and chemical quality features alongside maintaining postharvest quality during subsequent shelf-life [3].

Salicylic acid (SA) is an endogenous plant growth regulator of phenolic nature. It plays some important roles in the regulation of plant growth development and enhances plant vigor under biotic and abiotic stresses [4]. SA plays an essential role in controlling berry quality such as color, flavor, astringency and bitterness [5], and enhance berry size [6], weight [7] and berry firmness [8]. Mainly, SA positively effects on reducing fruit respiration and ethylene biosynthesis [9] weight loss, berry decay and softening rate during storage and shelf-life [8].

The present study was conducted to investigation the effect of preharvest treatment of SA on delaying berry ripening during the marketing of Superior Seedless grapes.

2. Materials and methods

2.1. Experimental procedure

The experiment was performed on 9-year-old own rooted grapevines (*Vitis vinifera* L.) cv. Superior Seedless planted 2 × 3 meter in sandy soil in a commercial orchard near Monufia Gov. Egypt. 36 vines were selected to be as uniform as possible. It's distributed at four treatments, each 9 vines were divided at three replicates. All treatments were sprayed three times a year after fruit set, at berry variation and 14 days before harvesting time. Also. All vines received the same agricultural practices as productive program design. Triton B as a wetting agent at 0.1% was added to SA solution. Vines were sprayed by SA solution at the first light. Superior seedless vines were treated by SA at four concentrations 0, 1, 2, and 4 mM [10].

This investigation was carried out during two seasons 2014 and 2015. To study the effect of foliar salicylic acid (SA) application on physical and chemical quality attribute of berries of Superior Seedless grapes. Samples were picked when the soluble solid content (SSC%) in berry juice at 17% in average. Cluster samples (220 clusters) were divided into two main patches. The first patch was formed with 120 clusters, each treatment 24 clusters for measuring physical and chemical quality attitude analysis during shelf-life for four days. The second cluster sample patch (100 clusters) for non-distractive measurements such as rachis browning index, water losses%, and berry shuttering%. Samples were handled to Pomology depart. Fac. of Agric. Mansoura Univ. and its stored at room temperature (28 ± 1 °C and air humidity average during shelf-life period 44 ± 2).

E-mail address: Loay_arafat@mans.edu.egURLs: <http://www.mans.edu.eg>

2.2. Physical properties evaluation

Quality elements were determined, berries were randomly removed from several cluster samples and were divided into three replicates to measure soluble solid content (SSC%) using Carlzeiss hand refractometer, acidity as tartaric acid (TA) was determined by titration with 0.1N NaOH [11], and SSC/TA ratio was calculated as defined maturity index. Berry firmness and separation force were recorded using fruit texture Effegi-penetrometer supplemented with a plunger 2 mm diameter penetrator. Firmness and separation force of berries were expressed as *N*. weight losses percentage was measured. Berry shattering percentage and rachis browning index [12]. The color was recorded as described by [13]. Thereafter, all images were analyzed by using software ImageJ Ver. 1.43u USA to get RGB signals to calculate hue angle of clusters according to [14].

2.3. Chemical properties evaluation

Rachis membrane electrolyte leakage was measured using a conductivity meter and the results were expressed as a percentage as described by [15]. Total phenols were determined by Folin-Ciocalteu method, based on colorimetric oxidation/reduction reaction of phenols [16]. Total carotenoids content was spectrophotometrically measured at wavelength 452.5 nm using spectrophotometer [17].

2.4. Statistical analysis

Data for evaluation of parameters in time were analyzed using analysis of variance (ANOVA) when shelf-life time and treatment factors are considered. The means were compared using the least significant differences (LSD) at $P < 0.05$ level of probability. The statistical software package GenStat Ver. 11 (Lawes Agriculture Trust, Rothamsted Experimental station, UK) was used.

3. Result and discussions

3.1. Physical quality analysis

The physiological water losses of all SA treatments during 4 days of shelf-life, but the weight losses of increase in different among the treatments (Table 1). Both SA treatments 2 and 4 mM exhibited a comparatively lower weight loss compared with 0 and 1 mM SA at end of shelf-life period. It was at 4th day of shelf-life: 0 mM = 26.16%; 1 mM = 27.84%; 2 mM = 14.27% and 4 mM = 14.60% of the initial weight. SA is considering as an electron donor produce free radicals which prevent normal respiration thus leading to lower weight loss [8]. Further SA inhibits ethylene biosynthesis or action by decreasing respiration [9].

The percentage berry shatter was significantly affected by SA treatments (Table 1) increased during shelf-life and decreased with vines treated by 4 mM SA at 4th day (3.06%) compared with all treatments (0 mM = 11.97%; 1 mM = 6.83% and 2 mM = 4.66%). It might be that SA was delayed ripening tissues of pedicels of berries during shelf-life. So, the quality was maintained with a higher level of SA [18]. Moreover, SA treatments increased the activity of antioxidants enzymes capacity in plant cell after harvesting leading to delay fruit ripening process in mango [19] and peach [20].

Rachis quality of bunches has been investigating extensively among producers and exporters because of its high impact on the cluster freshness that determines consumers [21]. SA treatment 4 mM (RBI = 1.90 slight browning incidence) presented a significant reduction in rachis browning during shelf-life up to 4th day compared with 2 mM (RBI = 2.57), 1 mM (RBI = 3.43 Moderate incidence) and 0 mM (RBI = 4 severe incidence). It is clear that SA treatment at 4 mM has a good potential beneficial against rachis browning of detached grape clusters by reducing water loss and suppression of polyphenol oxidase enzymes activity, it might also maintaining rachises healthy [20].

Superior seedless grapes harvested in yellow-white flesh and green skin color which is becoming in high demand to Europe from Egyptian market. Data in Table 1 present the changes in degrees of clusters h° during shelf-life. All SA treatments decreased significantly during the shelf-life period. It was at 0 mM ($h^{\circ} = 49$) com-

Table 1
Cluster weight losses, berry shattering%, rachis browning index, Hue angle (h°), Berry firmness (*N*) and separating force (*N*) of 'Superior Seedless' grapes during four-day shelf-life at 2014 and 2015 seasons.

Measurements	Shelf-life time (days)								
	D1	D2	D3	D4	D1	D2	D3	D4	
Cluster weight losses %					Hue angle (h°)				
Treatments					Treatments				
0	0.00	8.66	20.14	26.16	0	112	93	64	49
1	0.00	9.50	18.81	27.84	1	118	108	87	63
2	0.00	5.20	10.51	14.27	2	119	115	107	73
4	0.00	5.75	8.50	13.60	4	120	119	115	98
LSD ($P < 0.05$)	...	6.76	6.19	4.44	LSD ($P < 0.05$)	1.80	7.00	4.90	4.30
Berry shattering %					Berry firmness (N)				
Treatments					Treatments				
0	1.10	3.09	7.69	11.97	0	11.37	9.90	4.20	2.13
1	0.81	2.13	3.18	6.83	1	11.93	10.10	8.13	5.30
2	0.68	0.84	2.09	4.66	2	11.07	11.20	9.67	7.73
4	0.47	0.69	1.81	3.06	4	12.93	11.30	10.4	9.57
LSD ($P < 0.05$)	0.13	0.51	0.86	1.07	LSD ($P < 0.05$)		1.74		
Rachis browning index					Berry separating force (N)				
Treatments					Treatments				
0	1.00	1.4	2.07	4.00	0	9.83	8.07	5.00	3.40
1	1.00	1.17	1.47	3.43	1	10.83	9.70	7.87	6.97
2	1.00	1.03	1.27	2.57	2	11.50	11.17	10.33	9.23
4	1.00	1.00	1.20	1.90	4	11.70	11.13	10.53	10.20
LSD ($P < 0.05$)	...	0.14	0.45	0.75	LSD ($P < 0.05$)		1.02		

Means in a column are significantly different at ($P < 0.05$) according to LSD. Each value represent mean of 3 replicates during two seasons of 2014 and 2015.

Table 2
Effect of postharvest salicylic acid (SA) application on SSC%, AT%, SSC/AT ratio, total carotenes, total phenol content and membrane electrolyte leakage of 'Superior Seedless' grapes during four-day shelf-life at 2014 and 2015 seasons.

Measurements	Shelf-life time (days)			
	D1	D2	D3	D4
SSC% (Total soluble solid content)				
Treatments				
0	16.66	17.00	17.33	18.00
1	17.00	17.33	17.66	17.33
2	16.00	17.43	17.67	17.76
4	16.00	16.76	17.33	18.00
LSD ($P < 0.05$) 0.891				
TA (total titratable acidity%)				
Treatments				
0	0.54	0.53	0.50	0.43
1	0.58	0.56	0.47	0.41
2	0.66	0.60	0.53	0.63
4	0.78	0.67	0.63	0.59
LSD ($P < 0.05$) 0.062				
SSC/TA ratio				
Treatments				
0	32.70	24.59	20.77	4.33
1	29.12	28.89	24.89	2.67
2	37.47	33.89	27.57	2.33
4	42.00	34.06	29.00	2.00
LSD ($P < 0.05$) 3.932				
Total carotenes (mg 100 g ⁻¹ FW)				
Treatments				
0	2.87	3.23	3.17	2.90
1	2.37	2.87	2.70	2.80
2	2.00	2.80	2.17	2.67
4	1.80	2.10	1.83	1.27
LSD ($P < 0.05$) 0.391				
TPC (mg GAR 100 g ⁻¹ FW)				
Treatments				
0	39.24	32.99	27.87	20.20
1	38.43	36.26	28.20	21.81
2	46.04	41.85	39.07	32.44
4	53.75	48.88	46.30	36.78
LSD ($P < 0.05$) 5.464				
IL% (ion leakage percentage)				
Treatments				
0	3.33	4.33	13.00	22.33
1	2.33	2.67	5.00	11.67
2	2.00	2.33	3.67	8.33
4	1.33	2.00	2.67	6.00
LSD ($P < 0.05$) 1.936				

Means in a column are significantly different at ($P < 0.05$) according to LSD. Each value represent mean of 3 replicates during two seasons of 2014 and 2015.

pared with 4 mM ($h^0 = 98$). The color (Hue angle) changes in the clusters were also related to aging cluster tissue. Moreover, the change in hue angle value is related to water loss during shelf-life as reported to [22].

Firmness and separation force are considered the main indicators in judging the table grape quality from customers. Both parameters declined significantly during shelf-life (4 days) in all SA treatments (Table 1). However, berry firmness and separation force were significantly always higher in SA application compared with control (0 mM only water). It was higher in SA (4 mM) at 4th days of (9.57N) shelf-life and berry separation force was (10.20N) compared with other applications. These changes in firmness and separation force were related to clusters lose their water content and physiological in their structure during the shelf-life period. SA prevents fruit softening by affecting activities of enzymes cell wall degrading (cellulose, polygalacturonase, and xylanase). Rapid softening in fruit during shelf-life was related to a rapid decrease in endogenous SA [3].

3.2. Chemical quality analysis

The SSC and TA in berries were significantly affected by SA treatments. The value in the fresh cluster as important flavor and quality parameters. All SA treatments presented lower SSC contents compared to control at harvest time (Table 2). The higher reduction in SSC was with vines treated SA at 4 mM at harvest time. The SSC content increased slightly during the shelf-life period in all treatments. It could be illustrated that increasing water losses during shelf-life [3]. TA content of the berries initially declined during 4 days of shelf-life. Higher two concentration (2 and 4 mM) of SA presented high content of TA at 1st up to 4th day compared to control. SSC/TA ratio was observed higher in 4 mM SA compared to other concentration of SA and control. It might be that SA suppresses the rate of respiration and ethylene biosynthesis [9] which might account for retardation of ripening-related to changes.

All berries samples treated and nontreated SA treatment, carotene was increased at 2nd day of and decreased up to 4th day. The highest carotene content was observed in (Table 2) control and decreased with increasing SA concentration it might be explained that SA stimulates synthesis of carotenoids and xanthophylls [23]. Accordingly, SA as a treatment for grapevines berries delayed or inhibited ripening when applied at variation stage [24].

The changes of TPC in grape skins during shelf-life are presented in Table 2. All treatment presented higher TPC at 1st day and it decreased continually up to 4th day of shelf-life. Control treatment presented highly decreases in TPC when vine treated by SA (4 mM) presented higher content of TPC at harvest time (1st day). The different was observed which might be illustrated that higher concentration of SA maintained the highest TPC [25].

One of the common parameter during cold storage and shelf-life is increased membrane permeability which is used as an indicator of membrane damage. SA at 4 mM treated vine clusters presented a significantly lower MEL at 1st day (1.33%) up to a 4th day (6.00%) of the shelf-life period compared to control (3.33% up to 22.33%) and other SA concentrations during shelf-life. SA treatment delayed the respiration, and also inhibited ethylene production [26].

In general, SA experiment showed the effectiveness of all postharvest treatments on the 'Superior seedless' table grapes quality during shelf-life. It improved the physical and chemical characteristics such as berry firmness and separation force possibly through inhibition of ethylene biosynthesis. Chemically, SA treatment maintained TPC amount during shelf-life with a high level of SA. This reaction may decrease the cell wall degradation by decreasing the cell wall hydrolases enzymes during ripening fruits

and less IL%. So, no breakdown of cluster rachis tissue occurred, therefore, browning incidence becomes less (moderate level; browning index) and lower rate water loss during the shelf-life. On the other hand, total phenol decreased slightly according to inhibit PPO by SA during ripening that reflects to increase fruit color quality (h°). Completely, SA treatment can be easily and safe usage to delaying/shifting ripening processes of grape with improving cluster fruits quality during shelf-life.

References

- [1] Artés-Hernández F, Tomás-Barberán FA, Artés F. Modified atmosphere packaging preserves quality of SO_2 -free 'Superior seedless' table grapes. *Postharvest Biol Technol* 2006;39:146–54.
- [2] Kader AA. *Postharvest Technology of Horticulture Crops*. Third Edition, ISBN 6-87996-51-1, 2002.
- [3] Champa WAH, Gill MIS, Mahajan BVC, Arora NK. Preharvest salicylic acid treatments to improve quality and postharvest life of table grapes (*Vitis vinifera* L.) cv. Flame Seedless. *J Food Sci Technol* 2015;52:3607–16.
- [4] Hayat Q, Hayat S, Irfan M, Ahmad A. Effect of exogenous salicylic acid under changing environment: a review. *Environ Exp Bot* 2010;68:14–25.
- [5] Chamkha M, Cathala B, Cheynier V, Douillard R. Phenolic composition of champagnes from Chardonnay and Pinot Noir vintages. *J Agric Food Chem* 2003;51:3179–84.
- [6] Marzouk HA, Kassem HA. Improving yield, quality, and shelf life of Thompson seedless grapevine by preharvest foliar applications. *Sci Hortic* 2011;130:425–30.
- [7] Elwan MWM, El-Hamahmy MAM. Improved productivity and quality associated with salicylic acid application in greenhouse pepper. *Sci Hortic* 2009;122:521–6.
- [8] Shafiee M, Taghavi TS, Babalar M. Addition of salicylic acid to nutrient solution combined with postharvest treatments (hot water, salicylic acid, and calcium dipping) improved postharvest fruit quality of strawberry. *Sci Hortic* 2010;124:40–5.
- [9] Srivastava MK, Dwivedi UN. Delayed ripening of banana fruit by salicylic acid. *Plant Sci* 2000;158:87–96.
- [10] 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). *J Fac Agric Kyushu Univ* 2011;56:263–9.
- [11] A.O.A.C. Association of Official of Analytical Chemist 15th Ed. Published by the A.O.A.C., Washington., USA; 1995.
- [12] Lo'ay AA. Biological indicators to minimize berry shatter during handling of "Thompson seedless" grapevines. *World Appl Sci J* 2011;12:1107–13.
- [13] Lo'ay AA, El Khateeb AY. Delaying guava ripening by exogenous salicylic acid. *J Plant Prod Mans Univ* 2011;2:715–24.
- [14] Khojastehnazhand M, Omid M, Tabatabaeefar A. Development of a lemon sorting system based on color and size. *Afr J Plant Sci* 2010;4:122–7.
- [15] Lo'ay AA. Chilling injury in mangoes (Ph.D. thesis). Wageningen University; 2005. p. 1–224. ISBN:90-8504-309-3.
- [16] Slinkard K, Singleton VL. Total phenol analysis: automation and comparison with manual methods. *Am J Enol Vitic* 1977;28:49–53.
- [17] Mackinney G. Absorption of light by chlorophyll solutions. *J Biol Chem* 1941;104:315–22.
- [18] Wang Z, Ma L, Zhang X, Xu L, Cao J, Jiang W. The effect of exogenous salicylic acid on antioxidant activity, bioactive compounds and antioxidant system in apricot fruit. *Sci Hortic* 2015;181:113–20.
- [19] Mo Y, Gong D, Liang G, Han R, Xie J, Li W. Enhanced preservation effects of sugar apple fruits by salicylic acid treatment during post-harvest storage. *J Agric Food* 2008;88:2693–9.
- [20] Tareen MJ, Abbasi NA, Hafiz IA. Postharvest application of salicylic acid enhanced antioxidant enzyme activity and maintained quality of peach cv. 'Flordaking' fruit during storage. *Sci Hortic* 2012;142:221–8.
- [21] Balic I, Moreno A, Sanhueza D, Huerta C, Orellana A, Defilippi BG, et al. Molecular and physiological study of postharvest rachis browning of table grape cv Red Globe. *Postharvest Biol Technol* 2012;72:47–56.
- [22] Harman Y, Sen F. The effect of different concentrations of pre-harvest gibberellic acid on the quality and durability of 'Obilnaja' and 'Black Star' plum varieties. *Food Sci Technol* 2016;36:362–8.
- [23] Moharekar ST, Lokhande SD, Hara T, Tanaka R, Tanaka A, Chavan PD. Effect of salicylic acid on chlorophyll and carotenoid contents of wheat and moong seedlings. *Photosynthetica* 2003;41:315.
- [24] Abdel-Salam M. Effect of foliar application of salicylic acid and micronutrients on the berries quality of "Bez El Naka" local grape cultivar middle east. *J Appl Sci* 2016;6:178–88.
- [25] Jamali B, Eshghi S, Taffazoli E. Vegetative growth, yield, fruit quality and fruit and leaf composition of strawberry cv. 'pajaro' as influenced by salicylic acid and nickel sprays. *J Plant Nutr* 2013;36:1043–55.
- [26] Luo Z, Chen C, Xie J. Effect of salicylic acid treatment on alleviating postharvest chilling injury of 'Qingnai' plum fruit. *Postharvest Biol Technol* 2011;62:115–20.