

## Effect of Pre-Harvest Treatments on Cluster Quality of "Flame Seedless" Table Grape Cultivar During Cold Storage

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**Abstract:** To improve fruit quality and storability of "Flame seedless" table grape cultivar (*Vitis vinifera*, L.), potassium (0.15%), glucose (0.15%) and potassium (0.15%) plus glucose (0.15%) were applied as spraying vegetative growth and clusters at Veraison (stage 1) or spraying vegetative growth and clusters or clusters only at 20% berry coloring (stage 2) by ethrel 250 or 500 ppm through 2007 and 2008 seasons in private farm at Eltayara area, Belbeis, El-Sharkia Governorate, Egypt. Results revealed that, the highest texture value was obtained by potassium followed by potassium plus glucose. Spraying clusters by ethrel at 500 ppm decreased berry texture and achieved the lowest value of texture. All concentrations of ethrel either on cluster or foliar application treatment reduced berry hue angle color (increased red skin color) and increased anthocyanin percentage more than control, potassium and glucose treatments. All concentrations of ethrel treatments and control increased significantly berry weight loss % more than glucose or potassium either alone or in combination with glucose. Ethrel at 500 ppm exhibited the highest values of berries decay percentages compared with untreated fruits. Potassium plus glucose or glucose treatments recorded the least values of berries decay percentages. Potassium plus glucose recorded the highest contents of TSS, TSS/acid ratio and sugars content and the lowest total acidity in grape berries. In brief, the application of potassium plus glucose or glucose treatments as foliar application at (Veraison) had more pronounced positive effect on quality of "Flame seedless" berries during storage at 0°C. Sprayed clusters alone or clusters and foliar application at 20% berry coloring stage by ethrel at 500 ppm gave the highest anthocyanin and sugars content and least value of hue angle skin color (from reddish orange to red) at harvest date.

**Key words:** Table grapes • Flame seedless • Ethrel • Potassium • Glucose • Foliar application • Berry quality • Cold storage

### INTRODUCTION

Grapes (*Vitis vinifera*, L.) ranks as the second major fruit crop in Egypt following citrus. Vineyards have increased in the last years especially in the newly reclaimed lands [1]. Grapes are considered as one of the promising exported crops in Egypt. The exported quantity of the Egyptian grapes is still 1.4% of the total grapes production through the period of 2001-2006 [2]. Red table grape "Flame seedless" is early-season grape variety in Egypt with a firm, crispy texture and sweet, neutral taste and have the ability of exporting and marketing.

Shelf-life is important only in grapes intended for table use. Decreasing quality during post-harvest handling of table grapes is often associated with water loss and decay. Browning of the cluster stem and shelling

of berries is another problem. Potassium improves drought resistance and increase the shelf life of fruits [3]. On the other hand, Cant'in, *et al.* [4] reported that, treating "Crimson seedless" grapes with 250 ppm ethephon did not affect decay and berry shattering percentages as a pre-harvest application. Moreover, Rizk-Alla and Meshrake [5] found that, pre-harvest application by GA<sub>3</sub> plus glucose on 'Crimson seedless' resulted in the highest berry shattering percentages. Ethrel treatments may cause undesirable softening of grape berries [6]. Meanwhile, Potassium foliar application enhanced berry firmness [7]. On the other hand, pre-harvest application by GA<sub>3</sub> plus glucose resulted in softer "Crimson seedless" berries [5]. Rizk-Alla and Meshrake [5] worked on "Crimson seedless" table grape and found that spraying with potassium alone or with

glucose lead to an increase color, total soluble solids also, TSS% gradually increased till the end of the storage period. It increases juice TSS% with the enhancement of K levels since it promotes the translocation of photosynthesis products in the plant [8-10].

Decreases in juice titratable acidity percentages with the enhancement of K levels were due to interacts with tartaric acid at form of potassium tartrate which has limited solubility [11]. The role of potassium fertilization in reducing the acid levels in berries could be due to the reduction in tartaric acid when it was converted into potassium tartrate [10]. Color is an important aspect of grape quality, especially for red, blue or black processed grapes. Coloration is due to anthocyanin accumulation in the skin begins at veraison stage (the point in the growing season when ripening grapes begin to soften and change color from green to either red or yellow, depending on the variety) [12]. Also, Human and Bindon [13] reported that, pre-harvest treatment with ethephon, allowed grapes to be harvested 10 days before non-treated fruits by improving the color of the grapes.). On the other hand, sugar is a major enhancer of anthocyanin production [14-16].

This study, focus on red table grapes "Flame seedless" as an early grape variety in Egypt and have the ability for exporting, was done for increasing the competitive ability to enhance the quality and to increase ability for storage and marketing.

## MATERIALS AND METHODS

The present investigation was carried out during the two successive seasons 2007 and 2008 in a private farm at Eltayara area, Belbeis, El-Sharkia Governorate, Egypt. Five-years old of cultivar "Flame seedless" grape vines were used as the plant material for this study. Plants devoted for this work were healthy, carefully selected as being representative of the chosen cultivar and as uniform as possible in vigor and shape. All selected vines were grown in sandy soil, planted at 1.5 × 3 meters apart, gable system, grown in sandy soil and received regularly the same horticultural care adopted in this orchard.

Seventy two vines were selected in a completely randomized design and divided into six groups. Each group was replicated three times and each replicate was represented by three vines.

Spraying was conducted on the vegetative growth and clusters at:

Veraison (stage1):

- Potassium 0.15%.
- Glucose 0.15%.
- Potassium 0.15% plus glucose 0.15%.

20% Berry Coloring (stage 2):

- Ethrel 250 ppm.
- Ethrel 500 ppm.

Spraying was conducted on clusters only at 20% berry coloring (stage 2):

- Ethrel 250 ppm.
- Ethrel 500 ppm.

Unsprayed (Control)

After 2 weeks of stage 2 (20% berry coloring), 36 clusters for each treatment (12 clusters for each replicate) uniform in size, color and free from any visible blemishes were picked at random in the early morning and immediately transferred in refrigerated trucks at 5°C to the laboratory of Horticultural Research Institute at Giza to be evaluated for their physical and chemical characteristics.

On arrival, clusters of each replicate were placed in carton boxes (2 boxes for each), lined with ventilated low-density polyethylene (LDPE) layer (50±5 µm. in thickness and 2% ventilation). Each box contained a single layer (approximate 3 Kg) with SO<sub>2</sub> sheet placed on the top of the clusters. The first box of each replicate was used to determine the physical properties while the second one was used to determine the chemical properties changes during storage. All boxes were stored for 4 weeks at 0°C and 90-95% relative humidity. Cluster quality parameters of all treatments were analyzed weekly as follows:

**Physical Characteristics:** Berry texture was determined by using Flfra texture analyzer instrument by penetrating cylinder 2 mm diameter to a constant distance with a constant speed 2 mm/second. The results were expressed as a resistance force of the skin or flesh (gm/ cm<sup>2</sup>).

Skin color (Hue angle) was determined by using a Hunter colorimeter type (DP-9000) for the estimation of a, b and hue angle (h°). In this system of color representation the values a\* and b\* describe a uniform two-dimensional color space, where a\* is negative for green and positive for red and b\* is negative for blue and positive for yellow. From a and b values, were calculated Hue angle (h°= arc tan b\*/a\*) determines the red, yellow, green, blue, purple, or intermediate colors between adjacent pairs of these basic colors Hue

angle (0°= red-purple, 90° = yellow, 180°=bluish-green, 270°= blue), as described by McGuire [17].

Weight loss% was calculated as the following equation:

$$\text{Weight loss \%} = \frac{A - B}{A} \times 100$$

Where:

A = The initial weight of box.

B = Weight at inspect date

Decay % was determined according to the following equation:

$$\text{Decay \%} = \frac{A}{B} \times 100$$

Where:

A = Decayed berries weight at time of sampling.

B = The initial berries weight.

**Chemical Characteristics:** Total Soluble Solids (TSS %) of the berry juice was estimated by A'bbe digital refractometer, according to A.O.A.C. [18].

Titrate acidity % of the berry juice was determined in terms of anhydrous tartaric acid percentage after titration against 0.1 N sodium hydroxide using phenolphthalein as an indicator according to A.O.A.C. [18].

T.S.S./Acid ratio was calculated by dividing the value of T.S.S. over the value of titrate acidity for each sample.

Anthocyanin one gram from berry skin was blended with 95% ethyl alcohol and 1% HCl. The mixture was then filtered through a centered glass funnel G-3 and the extract was transferred to 25ml volumetric flask and completed to volume with the acidified alcohol then measured on spectrophotometer at wavelength 535nm according to the method of Husia *et al.* [19].

Total sugars were determined by using the phenol-sulphuric acid method according to Dubois *et al.* [20]. A standard curve was carried out using pure glucose with a suitable concentration. The concentration of total sugars was calculated and expressed as mg/g fresh weight of peels and flesh of Flame seedless grape tissues.

**Statistical Analysis Procedure:** All data parameters were analyzed as Factorial Completely Randomized Design in factorial arrangement with three replications. All data were subjected to statistical analysis as

described by Snedecor and Cochran [21]. The differences between means were differentiated using Duncan multiple range test [22].

## RESULTS AND DISCUSSION

### Physical Characteristics

**Berry Texture (g/cm<sup>2</sup>):** As shown in Table 1 data revealed that, berry texture decline towards the end of storage period (4 weeks). At the end of storage period, the highest texture value (25.70, 24.40 g/cm<sup>2</sup>) was obtained by potassium, followed by potassium plus glucose (25.70, 23.90 g/cm<sup>2</sup>) and control (25.30, 23.90 g/cm<sup>2</sup>), in both seasons, respectively. In contrast, spraying table grape cluster by ethrel 500 ppm decreased berry texture and achieved the lowest value (22.90 and 20.70 g/cm<sup>2</sup>) of texture in the first and second seasons, respectively. In this respect, Dokoozlian [23] on 'Red Malaga' grapes, Cantin, *et al.* [4] and Jayasena and Cameron [6] on 'Crimson seedless' cv. accepted that, ethrel treatments may cause undesirable softening of grape berries. On the other hand, potassium foliar application enhanced berry firmness. These results are in agreement with those obtained on grape berries by Abdel-Mohsen [24] on 'Crimson seedless' and Nofal and Rezk [7] on table grapes.

**Skin Color (Hue Angle):** As shown in Table 2, all concentrations of ethrel either on cluster or as foliar application treatments reduced berry hue angle color (increased red skin color) more than the control. The differences within ethrel treatments were not significant, in both seasons. Moreover, spraying cluster by ethrel at 500 ppm recorded the least value of hue angle skin color (36.04 and 23.62) from reddish orange to red at harvest date (initial time of storage period). The pre-mentioned results, however, found support in work of Nikolaou, *et al.* [25] on "Cardinal" table grape and Lombard, *et al.* [26] on "Flame seedless" which hasten berry maturity, Chroma (C\*) and improve skin color when spraying bunch and foliar with ethephon. Also, Cantin, *et al.* [4] and Human and Bindon [13] using pre-harvest treatment with ethephon, allowed grapes to be harvested 10 days before non-treated fruits by improving the color of the grapes. On the other hand, control treatment recorded the highest significant value of skin hue angle (63.94 and 54.80) from yellow to reddish orange at harvest date. Potassium plus glucose, glucose also potassium treatments recorded 50.62, 53.96 and 55.12 of skin hue angle in the first season and 28.40, 33.30 and 37.40 in the second one at harvest date.

Table 1: Effect of pre-harvest treatments on texture (g/cm<sup>2</sup>) of 'Flame seedless' table grape berries stored at 0°C during 2007 and 2008 seasons

Treatments	Storage period (weeks)									
	Initial		1		2		3		4	
<b>2007 season</b>										
Ethrel (250ppm) foliar + cluster	30.80	ab	29.00	a-c	27.40	a-c	25.40	bc	24.80	a-c
Ethrel (250ppm) cluster	29.40	ab	27.70	a-c	26.10	bc	25.30	bc	23.70	b-d
Ethrel (500ppm) foliar + cluster	28.50	ab	27.20	bc	25.50	c	25.10	bc	23.40	cd
Ethrel (500ppm) cluster	27.60	b	25.50	c	25.40	c	24.20	c	22.90	d
Potassium (0.15%)	32.80	a	31.40	a	29.90	a	28.40	ab	25.70	a
Glucose (0.15%)	31.60	ab	29.60	ab	27.50	a-c	26.50	ab	25.10	ab
Potassium (0.15%) + Glucose (0.15%)	32.10	ab	30.90	ab	29.80	a	27.30	ab	25.70	a
Control	32.00	ab	30.70	ab	28.70	ab	26.90	ab	25.30	a
<b>2008 season</b>										
Ethrel (250ppm) foliar + cluster	27.90	bc	27.00	a	24.70	a	24.40	ab	22.40	b
Ethrel (250ppm) cluster	27.70	bc	26.60	a	24.40	a	24.30	ab	21.90	b
Ethrel (500ppm) foliar + cluster	26.70	bc	25.30	a	24.30	a	24.10	ab	21.80	b
Ethrel (500ppm) cluster	26.50	c	25.30	a	24.10	a	23.70	b	20.70	c
Potassium (0.15%)	32.40	a	28.70	a	26.00	a	25.70	ab	24.40	a
Glucose (0.15%)	28.50	a-c	27.10	a	24.70	a	24.40	ab	23.80	a
Potassium (0.15%) + Glucose (0.15%)	30.60	ab	27.90	a	25.90	a	24.80	ab	23.90	a
Control	29.80	a-c	27.10	a	25.70	a	24.70	ab	23.90	a

Values followed by the same letter (s) are not significantly differed at 0.05 level of probability

Table 2: Effect of pre-harvest treatments on skin color (Hue angle) of 'Flame seedless' table grape berries stored at 0°C during 2007 and 2008 seasons

Treatments	Storage period (weeks)									
	Initial		1		2		3		4	
<b>2007 season</b>										
Ethrel (250ppm) foliar + cluster	36.94	d	36.46	c	32.68	cd	31.56	cd	28.20	cd
Ethrel (250ppm) cluster	36.72	d	34.30	c	32.20	cd	29.00	de	27.18	de
Ethrel (500ppm) foliar + cluster	36.46	d	33.80	c	31.84	d	27.54	e	25.36	e
Ethrel (500ppm) cluster	36.04	d	32.88	c	26.96	e	26.32	e	24.68	e
Potassium (0.15%)	55.12	b	44.10	b	42.20	b	40.44	b	36.06	b
Glucose (0.15%)	53.96	b	43.58	b	37.72	c	37.70	b	30.78	c
Potassium (0.15%) + Glucose (0.15%)	50.62	c	37.08	c	36.28	c	34.02	cd	30.78	c
Control	63.94	a	61.60	a	61.58	a	57.02	a	40.60	a
<b>2008 season</b>										
Ethrel (250ppm) foliar + cluster	27.98	de	27.40	d	25.68	c	23.96	cd	23.42	c
Ethrel (250ppm) cluster	25.92	de	25.20	d	25.01	c	22.70	d	22.38	c
Ethrel (500ppm) foliar + cluster	25.12	de	24.24	d	21.30	d	19.54	e	17.06	d
Ethrel (500ppm) cluster	23.62	e	19.18	e	18.62	d	17.08	f	14.20	e
Potassium (0.15%)	37.40	b	35.44	b	33.48	b	27.16	b	26.30	b
Glucose (0.15%)	33.30	bc	31.54	bc	28.56	c	25.38	bc	24.72	bc
Potassium (0.15%) + Glucose (0.15%)	28.40	b	27.86	cd	27.16	c	25.28	bc	24.48	bc
Control	54.80	a	54.06	a	52.44	a	46.86	a	36.94	a

Values followed by the same letter (s) are not significantly differed at 0.05 level of probability

Table 3: Effect of pre-harvest treatments on weight loss percentage of 'Flame seedless' table grape berries stored at 0°C during 2007 and 2008 seasons

Treatments	Storage period (weeks)							
	1		2		3		4	
<b>2007 season</b>								
Ethrel (250ppm) foliar + cluster	1.49	a	3.56	a	5.20	a	9.00	a
Ethrel (250ppm) cluster	1.49	a	3.70	a	5.39	a	9.06	a
Ethrel (500ppm) foliar + cluster	1.55	a	3.85	a	5.49	a	9.19	a
Ethrel (500ppm) cluster	1.75	a	3.98	a	5.77	a	9.22	a
Potassium (0.15%)	0.78	b	2.15	b	4.10	b	7.05	b
Glucose (0.15%)	0.85	b	2.29	b	4.31	b	7.39	b
Potassium (0.15%) + Glucose (0.15%)	0.86	b	2.79	b	4.77	b	7.14	b
Control	1.45	a	3.97	a	5.37	a	9.01	a
<b>2008 season</b>								
Ethrel (250ppm) foliar + cluster	1.31	a	3.43	a	5.72	a	9.22	a
Ethrel (250ppm) cluster	1.43	a	3.45	a	5.82	a	9.33	a
Ethrel (500ppm) foliar + cluster	1.59	a	3.77	a	6.14	a	10.37	a
Ethrel (500ppm) cluster	1.66	a	3.82	a	6.42	a	10.74	a
Potassium (0.15%)	0.75	b	2.20	b	4.57	b	7.20	b
Glucose (0.15%)	0.96	b	2.61	b	4.64	b	7.46	b
Potassium (0.15%) + Glucose (0.15%)	0.81	b	2.81	b	4.66	b	7.84	b
Control	1.37	a	3.69	a	6.02	a	10.00	a

Values followed by the same letter (s) are not significantly differed at 0.05 level of probability

These results are in agreement with Meshrake [27] on Anna apple and Rizk-Alla and Meshrake [5] on "Crimson seedless" table grape, since they found that, spraying with potassium or/and glucose lead to increase color.

**Weight Loss Percentage:** Results in Table 3 indicated a gradual increase in weight loss was shown towards the end of the storage period (4 weeks). All concentrations of ethrel either on cluster or as foliar application treatments and control increased significantly berry weight loss % of "Flame seedless" grape cultivar more than glucose (0.15%) and potassium (0.15%) either alone or in combination with glucose as a pre-harvest treatment. Moreover, spraying cluster by ethrel at 500 ppm recorded highest berry weight loss (9.22 and 10.74%), while spraying potassium (0.15%) recorded least berry weight loss (7.05 and 7.20%) after 4 weeks of storage at 0°C in first and second seasons, respectively. The differences between all ethrel treatments and control were not significant in both seasons. The same was found between glucose (0.15%) and potassium (0.15%) either alone or in combination with glucose. Potassium improved drought resistance and increased the shelf life of fruits [3]. Potassium treatments increased berry weight loss percentage and shattering percentage at the end of room storage period [28].

**Decay Percentage:** All used treatments increased discarded berries (decay percentage) until the end of storage periods (Table 4). After 4 weeks of cold storage, table grape cluster and foliar treated by ethrel at 500 ppm exhibited the highest value of berries decay percentage (9.73, 9.53% for cluster spray and 8.88, 8.32% for foliar spray) compared with the untreated fruits (Control) which had 5.03 and 5.86% in the first and second seasons, respectively. On the other hand, pre-harvest spraying with potassium plus glucose and glucose treatments recorded the least values of berries decay percentage (4.73, 4.08%) and (4.71, 4.03%), while potassium treatment recorded (4.79, 4.78%) of berries decay percentage in the first and second seasons, respectively. These results are in agreement with El-Oraby and Ekbal [29] on "Thompson seedless" since they found that, decay percentage was increased by prolonged storage period at 0°C. Moreover, Cant'in, *et al.* [4] observed that, pre-harvest with ethephon was not effect on decay percentages of Crimson seedless grapes.

#### Chemical Characteristics

**Total Soluble Solids (TSS):** At harvest date (initial time of cold storage), pre-harvest foliar application treatment by potassium plus glucose recorded the highest berry TSS (19.40, 20.23 %) followed by potassium

Table 4: Effect of pre-harvest treatments on decay percentage of 'Flame seedless' table grape berries stored at 0°C during 2007 and 2008 seasons

Treatments	Storage period (weeks)							
	1		2		3		4	
2007 season								
Ethrel (250ppm) foliar + cluster	0.60	ab	2.41	d	3.48	d	7.02	d
Ethrel (250ppm) cluster	0.66	a	2.74	c	3.77	c	8.04	c
Ethrel (500ppm) foliar + cluster	0.67	a	2.93	b	4.79	b	8.88	b
Ethrel (500ppm) cluster	0.71	a	3.16	a	5.64	a	9.73	a
Potassium (0.15%)	0.42	c	1.63	f	2.79	e	4.79	e
Glucose (0.15%)	0.05	d	1.07	g	2.40	f	4.71	e
Potassium (0.15%) + Glucose (0.15%)	0.40	c	1.14	g	2.44	f	4.73	e
Control	0.52	bc	1.82	e	2.85	e	5.03	e
2008 season								
Ethrel (250ppm) foliar + cluster	0.58	b	1.17	bc	3.67	c	6.70	c
Ethrel (250ppm) cluster	0.61	ab	1.33	a-c	3.92	c	7.64	b
Ethrel (500ppm) foliar + cluster	0.68	ab	1.50	ab	4.47	b	8.32	b
Ethrel (500ppm) cluster	0.69	a	1.63	a	4.97	a	9.53	a
Potassium (0.15%)	0.24	c	0.45	de	2.27	e	4.78	d
Glucose (0.15%)	0.02	d	0.20	e	1.37	f	4.03	d
Potassium (0.15%) + Glucose (0.15%)	0.04	d	0.28	e	1.49	f	4.08	d
Control	0.33	c	1.13	c	2.95	d	5.86	c

Values followed by the same letter (s) are not significantly differed at 0.05 level of probability

Table 5: Effect of pre-harvest treatments on total soluble solids (TSS %) of 'Flame seedless' table grape berries stored at 0°C during 2007 and 2008 seasons

Treatments	Storage period (weeks)									
	Initial		1		2		3		4	
2007 season										
Ethrel (250ppm) foliar + cluster	18.03	d	18.23	de	18.77	a	20.10	cd	19.37	ab
Ethrel (250ppm) cluster	18.20	d	18.37	cd	18.80	a	20.30	cd	19.57	a
Ethrel (500ppm) foliar + cluster	18.33	cd	19.17	bc	19.27	a	20.90	bc	19.77	a
Ethrel (500ppm) cluster	18.53	b-d	19.23	ab	19.67	a	21.03	a-c	20.17	a
Potassium (0.15%)	19.17	ab	19.67	a	20.23	a	21.83	ab	20.50	a
Glucose (0.15%)	19.10	a-c	19.40	ab	20.10	a	21.53	ab	20.43	a
Potassium (0.15%) + Glucose (0.15%)	19.40	a	19.77	a	20.30	a	21.97	a	20.80	a
Control	17.13	e	17.37	e	17.70	a	19.27	d	17.77	b
2008 season										
Ethrel (250ppm) foliar + cluster	18.00	cd	18.97	cd	18.97	cd	20.07	bc	19.60	bc
Ethrel (250ppm) cluster	18.23	cd	19.17	bc	19.17	bc	20.13	bc	19.83	bc
Ethrel (500ppm) foliar + cluster	18.63	b-d	19.53	bc	19.53	bc	20.47	b	20.03	bc
Ethrel (500ppm) cluster	19.20	a-c	19.83	bc	19.83	bc	20.90	ab	20.47	ab
Potassium (0.15%)	19.70	ab	20.00	a-c	20.00	a-c	21.67	a	21.47	a
Glucose (0.15%)	20.07	a	20.07	ab	20.13	ab	21.33	ab	21.13	a
Potassium (0.15%) + Glucose (0.15%)	20.23	a	20.93	a	20.93	a	21.87	a	21.73	a
Control	17.83	d	18.03	d	18.03	d	19.13	c	18.93	c

Values followed by the same letter (s) are not significantly differed at 0.05 level of probability

Table 6: Effect of pre-harvest treatments on titratable acidity percentage of 'Flame seedless' table grape berries stored at 0°C during 2007 and 2008 seasons

Treatments	Storage period (weeks)									
	Initial		1		2		3		4	
<b>2007 season</b>										
Ethrel (250ppm) foliar + cluster	1.23	ab	1.20	ab	1.13	ab	1.03	ab	1.00	ab
Ethrel (250ppm) cluster	1.22	a-c	1.20	ab	1.03	ab	1.00	ab	0.98	ab
Ethrel (500ppm) foliar + cluster	1.20	a-c	1.08	b	1.00	ab	0.95	ab	0.95	ab
Ethrel (500ppm) cluster	1.22	a-c	1.10	ab	1.03	ab	1.00	ab	0.95	ab
Potassium (0.15%)	1.05	bc	1.03	b	0.98	b	0.95	ab	0.88	bc
Glucose (0.15%)	1.13	bc	1.03	b	0.98	b	0.95	ab	0.93	ab
Potassium (0.15%) + Glucose (0.15%)	1.03	c	1.00	b	0.98	b	0.93	b	0.80	c
Control	1.35	a	1.33	ab	1.15	ab	1.13	a	1.03	ab
<b>2008 season</b>										
Ethrel (250ppm) foliar + cluster	1.00	ab	0.98	ab	0.95	a	0.83	b	0.73	ab
Ethrel (250ppm) cluster	0.98	ab	0.90	a-c	0.90	a	0.80	b	0.73	ab
Ethrel (500ppm) foliar + cluster	0.98	ab	0.88	b-d	0.88	a	0.78	ab	0.68	ab
Ethrel (500ppm) cluster	0.98	ab	0.90	a-c	0.88	a	0.80	b	0.70	ab
Potassium (0.15%)	0.90	bc	0.85	cd	0.80	a	0.75	ab	0.55	a
Glucose (0.15%)	0.95	b	0.88	b-d	0.88	a	0.78	ab	0.60	a
Potassium (0.15%) + Glucose (0.15%)	0.78	c	0.78	d	0.73	a	0.68	a	0.53	a
Control	1.10	a	1.00	a	0.98	a	0.83	b	0.80	b

Values followed by the same letter (s) are not significantly differed at 0.05 level of probability

(19.17, 19.70 %) and glucose (19.10, 20.07 %), while the lowest TSS (17.13, 17.83 %) was recorded by control berries in the first and second seasons, respectively (Table 5). Moreover, spraying table grape cluster with ethrel at 500 ppm increased berry TSS and recorded.

On the other hand, an initial intensive increase in berry total soluble solids percentage (TSS %) of 'Flame seedless' table grape cultivar that continued up to 3 weeks under cold storage conditions, was followed by a period of a slight decrease that continued up to 4 weeks in both seasons for all treatments used. On discussing the previous results, increasing juice TSS% with the enhancement of K levels could be due to the K promotion for the translocation of products of photosynthesis in the plant [8-10].

**Titratable Acidity Percentage:** As shown in Table 6, pre-harvest foliar application treatment by potassium plus glucose recorded the lowest contents of titratable acidity (1.03, 0.78 %) followed by potassium (1.05, 0.90 %) and glucose (1.13, 0.95 %), while the highest titratable acidity (1.35, 1.10 %) was recorded by control berries at harvest date in 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively. Additionally, spraying table grape cluster by ethrel at 250 and 500 ppm increased berry titratable acidity as it

recorded 1.23, 1.00 % and 1.22, 0.98 % at initial time of cold storage in 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively. On the other side, a decrease in berry titratable acidity percentage of "Flame seedless" table grape was observed up to 4 weeks under cold storage conditions, in both seasons, for all treatments used. On discussing the previous results, decreasing in juice titratable acidity percentage with the enhancement of K levels could be due to the interacts with tartaric acid to form of potassium tartrate which limited solubility [11]. Furthermore, Omar [8]; Rühl [30]; Al-Moshileh and Al-Rayes [9] and Saleh *et al.* [10] on "Thompson seedless" grapevines mentioned the role of potassium fertilization in reducing the acid levels in berries. This could be due to the reduction in tartaric acid which might be converted into potassium tartrate.

**TSS/Acid Ratio:** An increase in berry TSS/acid ratio of "Flame seedless" table grapes was observed up to 4 weeks under cold storage conditions, in both seasons for all treatments (Table 7). On the other side, pre-harvest foliar application treatment by potassium plus glucose recorded the highest berry TSS/acid ratio (19.29, 26.88 and 24.25, 38.53) followed by potassium (18.73, 22.41 and 21.91, 35.82) and glucose (17.24, 21.13 and 20.65, 33.55),

Table 7: Effect of pre-harvest treatments on T.S.S./acid ratio of 'Flame seedless' table grape berries stored at 0°C during 2007 and 2008 seasons

Treatments	Storage period (weeks)									
	Initial		1		2		3		4	
<b>2007 season</b>										
Ethrel (250ppm) foliar + cluster	15.32	c	16.75	c	17.22	c	17.79	c	18.03	c
Ethrel (250ppm) cluster	15.45	c	16.92	c	19.09	b	18.37	bc	18.67	c
Ethrel (500ppm) foliar + cluster	15.98	c	19.44	b	19.77	b	20.28	ab	19.29	bc
Ethrel (500ppm) cluster	15.80	c	19.12	b	19.68	b	19.67	b	19.51	bc
Potassium (0.15%)	18.73	a	21.30	a	21.03	a	21.29	a	21.91	b
Glucose (0.15%)	17.24	ab	21.00	a	20.95	ab	21.16	a	20.65	bc
Potassium (0.15%) + Glucose (0.15%)	19.29	a	21.97	a	21.33	a	21.95	a	24.25	a
Control	13.11	d	14.54	d	15.45	d	15.44	d	16.71	d
<b>2008 season</b>										
Ethrel (250ppm) foliar + cluster	18.40	c	20.58	c	20.63	c	22.99	bc	24.83	cd
Ethrel (250ppm) cluster	19.31	bc	22.37	bc	22.03	bc	23.96	bc	25.14	cd
Ethrel (500ppm) foliar + cluster	19.49	bc	23.39	bc	22.89	bc	25.20	b	27.60	c
Ethrel (500ppm) cluster	20.28	b	23.22	bc	23.39	bc	24.79	b	27.43	c
Potassium (0.15%)	22.41	b	25.49	bc	26.84	ab	26.67	b	35.82	b
Glucose (0.15%)	21.13	b	24.15	bc	24.38	b	25.90	b	33.55	bc
Potassium (0.15%) + Glucose (0.15%)	26.88	a	28.22	a	29.97	a	31.01	a	38.53	a
Control	15.85	d	19.13	d	19.42	d	21.85	c	22.29	d

Values followed by the same letter (s) are not significantly differed at 0.05 level of probability

Table 8: Effect of pre-harvest treatments on anthocyanin gm/100gm of 'Flame seedless' table grape berries stored at 0°C during 2007 and 2008 seasons

Treatments	Storage period (weeks)									
	Initial		1		2		3		4	
<b>2007 season</b>										
Ethrel (250ppm) foliar + cluster	15.11	cd	21.57	c	26.43	b	31.57	ab	34.92	a
Ethrel (250ppm) cluster	17.96	c	26.24	b	30.19	a	32.43	ab	35.13	a
Ethrel (500ppm) foliar + cluster	24.41	b	29.23	a	30.67	a	32.59	ab	35.57	a
Ethrel (500ppm) cluster	28.91	a	29.63	a	31.74	a	33.00	ab	35.85	a
Potassium (0.15%)	13.45	d	16.34	e	19.29	d	22.25	c	28.89	b
Glucose (0.15%)	14.71	cd	19.03	d	19.50	d	28.37	b	29.77	b
Potassium (0.15%) + Glucose (0.15%)	14.78	cd	19.35	cd	22.75	c	28.42	b	30.35	b
Control	5.16	e	7.91	f	9.06	e	12.41	d	14.03	c
<b>2008 season</b>										
Ethrel (250ppm) foliar + cluster	26.45	b	32.29	c	32.41	c	35.80	b	37.88	bc
Ethrel (250ppm) cluster	27.54	b	34.38	b	35.66	b	37.57	a	38.02	bc
Ethrel (500ppm) foliar + cluster	33.34	a	35.93	ab	36.26	ab	37.70	a	39.01	ab
Ethrel (500ppm) cluster	35.32	a	37.16	a	37.21	a	38.29	a	40.18	a
Potassium (0.15%)	19.41	c	23.41	f	29.44	e	31.54	c	34.90	d
Glucose (0.15%)	21.72	c	25.89	e	30.95	d	32.48	c	35.03	d
Potassium (0.15%) + Glucose (0.15%)	22.18	c	28.91	d	31.86	cd	34.93	b	36.53	cd
Control	9.22	d	13.29	g	15.22	f	15.53	d	17.60	e

Values followed by the same letter (s) are not significantly differed at 0.05 level of probability

Table 9: Effect of pre-harvest treatments on total sugars percentage of 'Flame seedless' table grape berries stored at 0°C during 2007 and 2008 seasons

Treatments	Storage period (weeks)									
	Initial		1		2		3		4	
<b>2007 season</b>										
Ethrel (250ppm) foliar + cluster	13.47	de	14.40	de	15.46	bc	16.07	c	16.34	bc
Ethrel (250ppm) cluster	13.97	cd	14.51	c-e	15.49	bc	16.14	c	17.16	ab
Ethrel (500ppm) foliar + cluster	14.34	b-d	14.84	cd	15.84	bc	16.21	c	17.18	ab
Ethrel (500ppm) cluster	14.35	b-d	15.19	bc	15.95	b	16.33	c	17.21	ab
Potassium (0.15%)	14.77	a-c	15.60	b	16.10	ab	16.52	bc	17.28	ab
Glucose (0.15%)	15.03	ab	15.71	b	16.12	ab	17.01	ab	17.47	a
Potassium (0.15%) + Glucose (0.15%)	15.43	a	16.56	a	16.88	a	17.05	a	17.57	a
Control	12.76	e	14.09	e	15.13	c	15.55	d	16.09	c
<b>2008 season</b>										
Ethrel (250ppm) foliar + cluster	16.07	ab	16.95	ab	17.44	ab	17.58	bc	17.98	d
Ethrel (250ppm) cluster	16.54	ab	17.02	ab	17.54	a	17.79	a-c	18.15	cd
Ethrel (500ppm) foliar + cluster	16.86	a	17.18	a	17.58	a	17.84	a-c	18.19	b-d
Ethrel (500ppm) cluster	17.00	a	17.21	a	17.61	a	17.85	a-c	18.31	a-d
Potassium (0.15%)	17.02	a	17.27	a	17.75	a	17.89	ab	18.81	a-c
Glucose (0.15%)	17.31	a	17.30	a	17.87	a	17.96	ab	18.84	ab
Potassium (0.15%) + Glucose (0.15%)	17.41	a	17.36	a	17.99	a	18.15	a	18.91	a
Control	15.01	b	16.59	b	16.78	b	17.42	c	17.98	d

Values followed by the same letter (s) are not significantly differed at 0.05 level of probability

while the least berry TSS/acid ratio (13.11, 15.85 and 16.71, 22.29) was recorded by control berries at harvest date (initial time of storage period) and at the end of the storage period (4 weeks at 0°C) in 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively. Additionally, spraying table grape as foliar or cluster alone by ethrel at 500 ppm recorded high berry TSS/acid ratio (15.98, 19.49 and 15.80, 20.28) at harvest date (initial time of cold storage) and at the end of storage period (19.29, 27.43 and 19.51, 27.43) in 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively. While, spraying table grape as foliar or cluster alone by ethrel at 250 ppm recorded 15.32, 18.40 and 15.45, 19.31 as berry TSS/acid ratio at harvest date also, 18.03, 24.83 and 18.67, 25.14 were recorded at the end of the storage period in 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively. These results are in agreement with Omar [8] on "Thompson seedless" where that, TSS/acidity increased significantly with the increased level used of K<sub>2</sub>O. Moreover, Rizk-Alla and Meshrake [5] found that, pre-harvest application on "Crimson seedless" cv. of potassium (K 0.15%) and glucose (G 0.15%) and their combination lead to increase TSS / acid ratio. In the same line, Nikolaou, *et al.* [25] treating "Cardinal" cv. by ethephon (post-veraison) on bunch plus foliar spray and found that treatment increased Brix / titratable acidity.

**Anthocyanin Percentage:** Anthocyanin (gm/100gm f.w.) was increased with the advance in cold storage up to 4 weeks. Spraying table grape clusters at veraison stage by ethrel at 500 ppm give the highest percentage of anthocyanin (28.91, 35.32 gm/100gm f.w.), followed by foliar application of ethrel at 500 ppm (24.41, 33.34 gm/100gm f.w.), while the least value was recorded by control treatment (5.16, 9.22 gm/100gm f.w.) in the 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively (Table 8). On the other side, spraying table grape as foliar application by potassium, glucose and their combination increased berry anthocyanin. It recorded 13.45, 19.41 gm/100gm f.w., 14.71, 21.72 gm/100gm f.w. and 14.78, 22.18 gm/100gm f.w. at the initial time of cold storage in 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively. On discussing the previous results, in case of grape the coloration is due to anthocyanin accumulation in the skin, begging at veraison stage (the onset of maturation stages). Coloration is due to anthocyanin accumulation in the skin, sprayed red seedless cultivars at or near veraison stage by ethrel increasing berry anthocyanin percentage for color improvement Jensen [31] on "Flame seedless", Dokoozlian [23] on "Crimson seedless", Lombard, *et al.* [26] on "Flame seedless" and "Bonheur" table grapes and Human and Bindon [13] on "Crimson seedless".

On the other hand, sugar is a major enhancer of anthocyanin production [14-16]. Moreover, Rizk-Alla and Meshraake [5] found that, pre-harvest application on "Crimson seedless" cv. by potassium, glucose and their combination lead to anthocyanin increasing.

**Total Sugars Percentage:** As shown in Table 9 pre-harvest foliar application treatment by potassium plus glucose recorded the highest berry sugars percentage (8.43, 10.41 %) followed by glucose (8.03, 10.31 %) and potassium (7.77, 10.02 %), while the lowest sugars percentages (5.76, 8.01 %) were recorded by control berries at initial time of cold storage, through the first and second seasons, respectively. Moreover, spraying table grape clusters by ethrel at 500 ppm increased berry sugars percentage more than control and recorded (7.35, 10.00 %) at initial time of cold storage. On the other hand, a slight increase in berry total sugars percentage of 'Flame seedless' grapes continued up to the end of cold storage conditions in both seasons for all treatments used. These results are in harmony with Nofal and Rezk [7] who reported that, potassium influences the flavor and taste of table grapes by increasing the sugar content and the sweetness of the berries. In the same line, Abd El-Moneim [32] found that, potassium application on "Valencia" orange increased the total sugar contents in fruit juice.

## CONCLUSION

Based on the results of this study, it can be concluded that, the application of potassium plus glucose and glucose treatments as foliar applications at veraison had more pronounced positive effect on berry quality of "Flame seedless" table grapes during storage at 0°C. Meanwhile, spraying clusters alone or clusters and foliar applications at 20% berry coloring stage by ethrel at 500 ppm gave the highest anthocyanin and sugars content and the least value of hue angle skin color (from reddish orange to red) at harvest date.

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