Improving Coloration, quality and Storability of "Kelsey" Plum Fruits by some Pre-Harvest Applications

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Abstract

Kelsey" plum is one of the late season cultivars in Egypt, but under environmental conditions, the fruit suffering from poor color development, causing economic losses. This experiment was conducted during 2018 and 2019 seasons on 5-years-old “Kelsey” plum cultivar budded on Nemaguard rootstock and located in a private orchard at El-Nubaria district, El-Behira governorate to study the effect of pre-harvest spraying with ProTone (Active ingredient, Abscisic acid (ABA 10 %)) at 50 and 100 ppm and jasmonic acid at 1000 and 2000 ppm in comparison to the control treatment on coloration, quality and storability. The fruits were stored for 30 days at (0±1°C and 90-95% relative humidity) then, evaluated in each treatment at 0, 10, 20 and 30 days to determine the changes in fruit quality characteristics during cold storage. Results showed that exogenous application of jasmonic acid at 2000 ppm was the best treatment for improving some fruit quality properties in terms of fruit weight, size, flesh weight, flesh/stone ratio. Moreover, under cold storage this treatment increased fruit anthocyanin, total sugars contents and TSS/Acid ratio, simultaneously reduced fruit weight loss and fruit disorders percentage, in addition gave the intermediate values of fruit firmness.

Key words: ProTone, jasmonic acid, coloration, quality, storability, "Kelsey" plum

Introduction

In Egypt, The cultivated area with plum reached 1120 hectares in 2018 produced 14775 tons (FAO, 2018). The Low-chilling plum cultivars grow well under the Egyptian environmental conditions like Kelsey cultivar which classified as climacteric fruits. This cultivar faced many problems related with worse of some fruit quality attributes as fruit color, low storing ability and some difficulties with handling in the market (Farag and Attia, 2018).

The previous studies indicated the importance of some factors affected on anthocyanin accumulation in peel fruit such as fruit position on the tree, leaf-fruit ratio, shading fruit, nutrition and foliar application with some growth regulators (Creelman and Mullet, 1997; Martinez-Romero, et al 2003; Murray et al., 2005 and Roberto et al.,2012). On the other hand, Growth regulators could be used for alleviating the quality losses at the cold storage (Meheriuk et al., 1995 and Sayyari et al., 2011).

Using Ethrel for enhancing the fruit coloration has drawbacks as leaves defoliation and low yield in the next season (Roberto et al., 2012). While, exogenous application with Abscisic acid (ABA) or Jasmonic acid (JA) enhance anthocyanin synthesis, chlorophyll degradation (Lichter et al., 2006; Wang et al., 2006 and Francescato, 2013) and does not cause excessive senescence. In addition, reduced the sensitivity to fungal decay during storage with the ProTone (ABA) treatments (Lichter et al., 2006) and Jasmonic application (Moline et al., 1997 and Cao et al., 2008). Furthermore, Jasmonic acid (JA) reduces post-harvest quality losses of fruits and prolongs shelf life (Fan et al., 1998).

Therefore, this research aimed to study the effects of spraying ProTone and Jasmonic acid on coloration, quality and storability of "kelsey" plum fruits stored at (0±1°C with 90-95% R.H.).
Materials and Methods

Five-years-old of "Kelsey" plum (*Prunus salicina* L.) budded on Nemaguard rootstock was used in this trial during 2018 and 2019 seasons. The trees were spaced at 3.5×4 m, planted in sandy soil under fertigation system and located in a private orchard at El-Nubaria district, El-Behira governorate, Egypt. Fifteen uniform trees were similar vigor; healthy and free from defects were used for this investigation. This experiment consisted of five treatments arranged in factorial analysis in a randomized complete block design. Three replicates were chosen for each treatment with one tree in each replicate. The trees were sprayed two times at (1st and 7th July during 2018 and 2019, respectively) by using the following treatments:

T₁: Control (water only).
T₂: ProToneat 50 ppm (Active ingredient, ABA 10 %, Shoura Chemicals Company).
T₃: ProTone at (100 ppm).
T₄: Jasmonic acid at 1000 ppm, obtained from (Sigma-Aldrich Company).
T₅: Jasmonic acid at (2000 ppm).

Random samples were collected from each tree two weeks after the application, and then placed into cardboard boxes in single rows and stored for 30 days at 0±1°C with 90-95% R.H. The treated fruits were evaluated in each treatment at 0, 10, 20 and 30 days of treatment.

Measurements

At harvest

Fruit weight (g), fruit size (cm³), fruit length (cm), fruit diameter (cm), flesh weight (g), stone weight (g) and flesh/stone ratio were measured.

At cold storage

Fruit firmness was determined as (Ib/inch²) using Effigi Pressure Tester (mod. Ft327). TSS% was estimated in fruit juice using a digital refractometer. Titratable acidity was determined as a malic acid by titration with 0.1 N of NaOH according to (A.O.A.C, 1985). Fruit TSS/Acid ratio was calculated as a ratio between TSS (%) and acidity (%). Total sugars were estimated by using the phenol sulfuric acid method described by (Smith, 1956), and the concentration was calculated from a standard curve of glucose (mg. per g. fresh weight of fruit tissue). Chlorophylls a & b were determined according to (Wintermans and Mat, 1965). Anthocyanin was determined on the fruit as (mg/100g fresh weight) according to the method described by Rabino et al. (1977). A carotene pigment in fruit pulp was expressed as mgs / 100 gm fresh weight and determined according to the procedure outlined by Wensttein (1957) and expressed as mg/100 g fresh weight. Fruit weight loss percentage was calculated as follows:

\[
\text{Fruit weight at the beginning storage} - \text{Fruit weight at sampling date} \times 100 \\
\text{Fruit weight at the beginning storage}
\]

Fruits affected with either pathological or physiological disorders were counted by visual and calculated as a percentage to the initial number of fruits per each sample (replicate) and treatment too.

Statistical analysis:

The obtained data were statistically analyzed for some parameters at harvest time as a Randomized Complete Block Design by analysis of variance (ANOVA) using Statistical Analysis System (CoStat) program.

In the other side, for some parameters at cold storage, as a factorial Randomized Complete Block Design by analysis of variance (ANOVA) using Statistical Analysis System (CoStat) program. Where the first factor was five treatments mentioned before, the second factor was storage period. The means of treatments were compared using LSD at 0.05 according to Snedecor and Cochran (1989).
Results and Discussion

Fruit weight, fruit length, fruit diameter and fruit size:

The results in Table 1 represented the effect of pre harvest spraying of ProTone and jasmonic acid treatments on fruit weight, fruit length, fruit diameter and fruit size of “Kelsey” plums in both seasons. Data indicated that, ProTone at (50 & 100 ppm) caused a significant decrease in fruit weight, fruit diameter and fruit size as compared with the untreated fruits (control). On the contrary, both concentration of Jasmonic acid caused a marked increase in fruit weight, fruit length, diameter and fruit size comparing with the untreated fruits (control). The significant increases in fruit size obtained with the higher concentration could be ascribed to mitigating the influence of ethylene on the processes of fruit ripening which delay harvest while the assimilation and translocation of carbohydrate is going on which could reflect on increasing fruit size (Farag et al., 2015).

Similar results obtained by (Ağlar and Öztürk, 2018) on Fuji Apple. This positive effect by Jasmonic acid treatments on fruit weight, fruit length, diameter and fruit size could be due to its role in enhancing auxin (IAA) biosynthesis (Hentrich et al., 2013).

Table 1: Effect of pre-harvest spraying of ProTone and jasmonic acid on fruit weight (g), fruit length (cm), fruit diameter (cm) and fruit size (cm³) of “kelsey” plum in 2018 and 2019 seasons.

| Treatments              | Fruit weight (g) | Fruit length (cm) | Fruit diameter (cm) | Fruit size (cm³) |
|-------------------------|------------------|-------------------|---------------------|------------------|
|                         | 2018  | 2019  | 2018  | 2019  | 2018  | 2019  | 2018  | 2019  |
| Control                 |       |       |       |       |       |       |       |       |
| ProTone at 50 ppm       | 72.05 | 73.74 | 3.91  | 3.88  | 3.71  | 3.80  | 65.31 | 66.51 |
| ProTone at 100 ppm      | 70.65 | 72.51 | 3.82  | 3.30  | 3.64  | 3.76  | 63.86 | 64.62 |
| Jasmonic acid at 1000 ppm| 81.96 | 87.04 | 4.38  | 4.32  | 4.07  | 4.19  | 80.18 | 82.42 |
| Jasmonic acid at 2000 ppm| 87.38 | 89.56 | 4.54  | 4.44  | 4.20  | 4.28  | 84.01 | 86.22 |
| LSD at 0.05             | 3.03  | 2.07  | 0.31  | 0.15  | 0.07  | 0.06  | 1.44  | 1.33  |

Flesh weight, stone weight and flesh/stone ratio:

Data illustrated in Table 2 showed the effect of pre harvest spraying of ProTone and jasmonic acid treatments on flesh weight, stone weight and flesh/stone ratio. Data revealed that, ProTone at (50 & 100 ppm) decreased flesh weight, while, jasmonic acid at (1000 & 2000 ppm) increased flesh weight and the differences of all treatments were significant when compared with control.

Moreover, as for stone weight, data showed that, ProTone at 100 ppm, jasmonic acid at (1000 & 2000 ppm) treatments increased stone weight, while, ProTone at 50 ppm tended to a significant reduction in stone weight compared with control.

Furthermore, results in Table 2 showed that, ProTone at 50 ppm, jasmonic acid at 1000 ppm and jasmonic acid at 2000 ppm treatments significantly increased flesh/stone ratio, except for jasmonic acid at 1000 ppm in 2019 season, where the difference is not big enough to be significant as compared with control. On contrary, ProTone at 100 ppm significantly decreased flesh/stone ratio compared with control in two season of study.

These increase in flesh weight and flesh/stone ratio by exogenous application with jasmonic could be attributed to the increase in fruit size (Table 1) led to higher proportionate fresh weight. These conclusions support the results of (Zayan et al., 2016) who reported increase in peach fruit size is often accompanied by a decrease in firmness.
Table. 2: Effect of pre-harvest spraying of ProTone and jasmonic acid on flesh weight (g), stone weight (g) and flesh/stone ratio of "kelsey" plum in 2018 and 2019 seasons.

| Treatments               | Flesh weight (g) 2018 | Stone weight (g) 2018 | Flesh weight (g) 2019 | Stone weight (g) 2019 | Flesh/stone ratio 2018 | Flesh/stone ratio 2019 |
|--------------------------|-----------------------|-----------------------|-----------------------|-----------------------|------------------------|------------------------|
| Control                  | 74.15                 | 76.27                 | 2.14                  | 2.11                  | 32.43                  | 36.21                  |
| ProTone at 50 ppm        | 70.18                 | 71.89                 | 1.87                  | 1.85                  | 37.74                  | 39.52                  |
| ProTone at 100 ppm       | 68.50                 | 70.34                 | 2.15                  | 1.17                  | 31.93                  | 32.52                  |
| Jasmonic acid at 1000 ppm| 78.90                 | 84.95                 | 2.32                  | 2.26                  | 34.46                  | 39.15                  |
| Jasmonic acid at 2000 ppm| 85.71                 | 87.03                 | 2.27                  | 2.22                  | 38.33                  | 39.23                  |
| LSD at 0.05              | 1.64                  | 1.16                  | 0.30                  | 0.27                  | 4.23                   | 4.52                   |

**Fruit firmness:**
In both season, all treatments significantly decreased fruit firmness compared with control. In addition, both concentration of jasmonic acid significantly gave the best fruit firmness values compared with ProTone at 50 & 100 ppm (Table 3).

Regarding storage periods, data in Table 3 showed that, in both seasons of study, fruit firmness significantly decreased gradually with the progress of cold storage.

The reducing in fruit firmness affecting by spraying ProTone and jasmonic acid treatments in comparison to control may be explained by their inhibitor effect on some enzymes causing decrease in flesh firmness particular lypolygalacturonase biosynthesis (Fan et al., 1998 and Moustakime et al., 2017). These results are in harmony with those obtained by (Balbontín et al., 2018) on sweet cherry reported pre harvest applications of abscisic acid (ABA), methyl jasmonate (MeJA) gave higher fruit firmness than the control.

Krishna et al. (2012) showed the role of growth regulators in preservation the fruit firmness during cold storage. Also, Gonzalez-Aguilar et al. (2003); Janoudi and Flore (2003); Rudell et al. (2005) and Altuntas et al. (2012) confirmed this trend for peach and apple fruits. MeJA dose produced higher fruit firmness than control because the effect of methyl jasmonate on enzymes caused softening of fruit flesh (Fan et al., 1998). Contrarily, Khan and Singh (2007) reported that methyl jasmonate application enhanced plum fruit softening.

**Fruit weight loss:**
Data concerning the effect of pre harvest spraying of ProTone and jasmonic acid on weight loss of “Kelsey” plums fruits in 2018 and 2019 seasons are reported in Table (4). Statistical analysis showed that fruit weight loss percentages increased with increasing storage periods, and the differences among all tested storage periods were significant comparing with the initial date in the two seasons of study.

Furthermore, ProTone at 50 ppm in both seasons and ProTone at 100 ppm in first season caused a non-significant increase in fruit weight loss compared with control. On the other hand, ProTone at 100 ppm in the second season and both concentrations of jasmonic acid at (1000 & 2000 ppm) in both seasons caused a significant decreased in fruit weight loss.

Loss fruit moisture through transpiration and respiration is the main factor for loss in fruit weight (Srivastava and Dwivedi, 2000 and Wang et al., 2006). Moreover, The decrease in fruit weight loss observed in trees treated with jasmonic acid due to its antioxidant capacity ability to overcome free radicals as hydrogen peroxide (H₂O₂) and malondialdehyde (MDA) levels (Kovacik et al., 2011 and Dar et al., 2015).

These results are agreed with those obtained by Kucuker and Ozturk (2014) investigated the effect of pre-harvest methyl jasmonate treatment (MeJA) on different plum fruit cultivars during the
cold storage. They reported that, methyl jasmonate treatment decreased plum fruit weight loss than the control through the cold storage.

Resistance of fruit to moisture loss, due to its low water vapor pressure in comparison to water at the same temperature because of dissolved substances, mostly sugars. More reasons caused loss in fruit weight not water loss alone like changes in cell wall, respiration and ethylene production especially in climacteric fruits during cold storage (Singh and Khan, 2010; Paul et al., 2012). In addition, storage conditions, pre-storage treatments (growth regulators), ripening level of fruits and cultivar are the main factors affected on weight loss degree (Valero et al., 2003; Casquero and Guerra, 2009; Krishna et al., 2012).

| Treatments                      | Storage Periods (Days) | Means (A) |
|--------------------------------|------------------------|-----------|
|                                | 0          | 10        | 20        | 30        |
| Control                        | 9.90       | 9.61      | 9.22      | 8.67      | 9.35      |
| ProTone at 50 ppm              | 8.11       | 7.57      | 7.24      | 6.92      | 7.46      |
| ProTone at 100 ppm             | 7.92       | 7.38      | 6.98      | 6.74      | 7.25      |
| Jasmonic acid at 1000 ppm      | 8.74       | 7.79      | 7.37      | 7.20      | 7.77      |
| Jasmonic acid at 2000 ppm      | 8.85       | 7.98      | 7.54      | 7.33      | 7.92      |
| Means                          | **9.55**   | **8.86**  | **8.47**  | **8.22**  |
| LSD at 0.05                    |            |           |           |           |
| Treatments (T): 0.22           |           |           |           |           |
| Storage Periods (S): 0.19      |           |           |           |           |
| Interaction (T×S): 0.44        |           |           |           |           |

| Treatments                      | Storage Periods (Days) | Means (A) |
|--------------------------------|------------------------|-----------|
|                                | 0          | 10        | 20        | 30        |
| Control                        | 9.48       | 9.22      | 8.72      | 8.10      | 8.88      |
| ProTone at 50 ppm              | 7.64       | 7.23      | 6.93      | 6.68      | 7.12      |
| ProTone at 100 ppm             | 7.53       | 7.19      | 7.21      | 6.62      | 7.14      |
| Jasmonic acid at 1000 ppm      | 9.05       | 8.84      | 8.01      | 7.59      | 8.37      |
| Jasmonic acid at 2000 ppm      | 9.44       | 8.99      | 8.51      | 7.76      | **8.67**  |
| Means                          | **9.82**   | **9.39**  | **9.03**  | **8.50**  |
| LSD at 0.05                    |            |           |           |           |
| Treatments (T): 0.19           |           |           |           |           |
| Storage Periods (S): 0.17      |           |           |           |           |
| Interaction (T×S): 0.37        |           |           |           |           |
Table 4: Effect of pre-harvest spraying of ProTone and jasmonic acid on weight loss percentage of "kelsey" plum fruits during cold storage at (0±1° C and 90-95% R.H.) in 2018 and 2019 seasons.

| Treatments                      | Storage Periods (Days) | Means (A) |
|---------------------------------|------------------------|-----------|
|                                 | 0          | 10        | 20        | 30        |           |
| **Season 2018**                  |            |           |           |           |           |
| Control                         | 0.00       | 3.80      | 4.39      | 4.84      | 3.26      |
| ProTone at 50 ppm                | 0.00       | 3.89      | 4.46      | 4.91      | 3.32      |
| ProTone at 100 ppm               | 0.00       | 3.84      | 4.43      | 4.87      | 3.28      |
| Jasmonic acid at 1000 ppm        | 0.00       | 3.69      | 4.22      | 4.51      | 3.10      |
| Jasmonic acid at 2000 ppm        | 0.00       | 3.58      | 4.14      | 4.26      | 2.99      |
| Means                           | **0.00**   | **3.76**  | **4.33**  | **4.68**  |           |
| LSD at 0.05                      |            |           |           |           |           |

| Treatments (T): 0.13 | Storage Periods (S): 0.12 | Interaction (T×S): 0.26 |

| **Season 2019**                  |            |           |           |           |           |
| Control                         | 0.00       | 3.48      | 4.18      | 5.11      | 3.19      |
| ProTone at 50 ppm                | 0.00       | 3.58      | 4.30      | 4.87      | 3.18      |
| ProTone at 100 ppm               | 0.00       | 3.53      | 4.24      | 5.15      | 3.23      |
| Jasmonic acid at 1000 ppm        | 0.00       | 3.22      | 3.32      | 4.87      | 2.85      |
| Jasmonic acid at 2000 ppm        | 0.00       | 3.06      | 3.14      | 4.03      | 2.56      |
| Means                           | **0.00**   | **3.37**  | **3.83**  | **4.81**  |           |
| LSD at 0.05                      |            |           |           |           |           |

| Treatments (T): 0.14 | Storage Periods (S): 0.12 | Interaction (T×S): 0.27 |

**Fruit disorders:**

Fruit disorders percentage during cold storage at 0±1° C and 90-95% R.H. of "kelsey" plum are shown in (Table 5). Data indicate that, a significant increases in fruit disorders percentage were observed with the advancement of cold storage period at 0±1ºC in both seasons.

Our results reveal that, pre harvest spraying of ProTone at (50 & 100 ppm) significantly increased fruit disorders compared with the control. On other hand, jasmonic acid at 1000&2000 ppm caused a significant decrease in "kelsey" plum fruit disorders as compared with control in two seasons of study. Reducing post-harvest diseases, chilling injury and prolong shelf life by MeJA, is considered important natural compound, may attributed to the role of JA in increasing plant tolerance against biotic and abiotic stress (Dar et al., 2015) or reducing in ion leakage and an increase in PAL activity (Cao et al., 2009 and Nilprapruck et al., 2008).
Table 5: Effect of pre-harvest spraying of ProTone and jasmonic acid on disorders percentage of “kelsey” plum fruits during cold storage at (0±1° C and 90-95% R.H.) in 2018 and 2019 seasons.

| Treatments                      | Storage Periods (Days) | Means (A) |
|---------------------------------|------------------------|-----------|
|                                 | 0  | 10  | 20  | 30  |     |
| **Season 2018**                 |    |     |     |     |     |
| Control                         | 0.00 | 6.80 | 7.25 | 7.77 | 5.45 |
| ProTone at 50 ppm               | 0.00 | 7.08 | 7.38 | 7.97 | 5.61 |
| ProTone at 100 ppm              | 0.00 | 7.24 | 7.45 | 8.08 | 5.69 |
| Jasmonic acid at 1000 ppm       | 0.00 | 6.45 | 6.80 | 7.44 | 5.17 |
| Jasmonic acid at 2000 ppm       | 0.00 | 6.29 | 6.55 | 7.31 | 5.04 |
| Means                           | 0.00 | **6.77** | **7.09** | **7.71** |     |
| **LSD at 0.05**                 |    |     |     |     |     |
| Treatments (T): 0.12            |    |     |     |     |     |
| Storage Periods (S): 0.11       |    |     |     |     |     |
| Interaction (T×S): 0.24         |    |     |     |     |     |
| **Season 2019**                 |    |     |     |     |     |
| Control                         | 0.00 | 7.09 | 7.34 | 7.89 | 5.58 |
| ProTone at 50 ppm               | 0.00 | 7.20 | 7.41 | 8.07 | 5.67 |
| ProTone at 100 ppm              | 0.00 | 7.34 | 7.47 | 8.26 | 5.77 |
| Jasmonic acid at 1000 ppm       | 0.00 | 6.38 | 6.65 | 7.38 | 5.10 |
| Jasmonic acid at 2000 ppm       | 0.00 | 6.27 | 6.45 | 7.29 | 5.00 |
| Means                           | 0.00 | **6.85** | **7.06** | **7.78** |     |
| **LSD at 0.05**                 |    |     |     |     |     |
| Treatments (T): 0.09            |    |     |     |     |     |
| Storage Periods (S): 0.08       |    |     |     |     |     |
| Interaction (T×S): 0.19         |    |     |     |     |     |

Total soluble solids:
With respect to the effect of various applied treatments on total soluble solids contents of "kelsey" plum fruit, in both experimental seasons, the data in Table 6 showed that, fruit total soluble solids contents significantly increased as the storage period extended till the end of storage period 30 days compared with initial time. Moreover, all treatments caused a significant increase in total soluble solids percentage compared with control in two seasons of study. Also, jasmonic acid at 2000 ppm was more effective on increasing total soluble solids contents compared with other treatments.

These results are in harmony with those obtained by Kucuker and Ozturk (2014) investigated the effect of pre-harvest methyl jasmonate treatment on different plum fruit cultivars during the cold storage. They reported that, plum fruit SSC values was better in the methyl jasmonate treatments than the control on entire analysis storage periods. In contrast, Rudell et al. (2005) cleared in ‘Fuji’ apple cultivar the negative effect of methyl jasmonate on conversion of starch into sugar. Higher fruit SSC content as a result of methyl jasmonate treatments, possibly, its inhibition effect on pectin and polygalacturonase enzyme activities leading to glucose, fructose and sucrose-like sugars accumulation.
Table 6: Effect of pre-harvest spraying of ProTone and jasmonic acid on total soluble solids percentage of "kelsey" plum fruits during cold storage at (0±1° C and 90-95% R.H.) in 2018 and 2019 seasons.

| Treatments                      | Storage Periods (Days) | Means (A) |
|---------------------------------|------------------------|-----------|
|                                 | 0  | 10  | 20  | 30  |          |
| **Season 2018**                 |    |     |     |     |          |
| Control                         | 10.09 | 10.70 | 11.38 | 11.99 | 11.04 |
| ProTone at 50 ppm               | 13.08 | 13.81 | 14.64 | 14.80 | 14.08 |
| ProTone at 100 ppm              | 13.51 | 13.95 | 15.07 | 15.33 | 14.46 |
| Jasmonic acid at 1000 ppm       | 13.81 | 14.17 | 14.67 | 15.12 | 14.44 |
| Jasmonic acid at 2000 ppm       | 14.35 | 14.45 | 14.82 | 15.33 | 14.74 |
| Means                           | 12.97 | 13.42 | 14.11 | 14.51 |          |
| LSD at 0.05                     |   |     |     |     |          |
| Treatments (T): 0.24 Storage Periods (S): 0.21 Interaction (T×S): 0.47 |
| **Season 2019**                 |    |     |     |     |          |
| Control                         | 10.66 | 11.35 | 11.80 | 12.35 | 11.54 |
| ProTone at 50 ppm               | 13.57 | 13.96 | 14.92 | 15.00 | 14.36 |
| ProTone at 100 ppm              | 13.86 | 14.13 | 15.18 | 15.55 | 14.68 |
| Jasmonic acid at 1000 ppm       | 14.00 | 14.26 | 14.93 | 15.38 | 14.64 |
| Jasmonic acid at 2000 ppm       | 14.51 | 14.67 | 15.07 | 15.43 | 14.94 |
| Means                           | 13.32 | 13.67 | 14.38 | 14.74 |          |
| LSD at 0.05                     |   |     |     |     |          |
| Treatments (T): 0.19 Storage Periods (S): 0.17 Interaction (T×S): 0.37 |

Acidity:

The response of acidity content of "kelsey" plum fruits during cold storage to pre harvest spraying of ProTone and jasmonic acid in 2018 and 2019 seasons was reported in (Table 7). The data revealed that there was a significant decrease in acidity contents as the storage period prolonged. Also, all treatments significantly decreased acidity percentages compared with untreated fruits during both seasons. In addition, ProTone at 100 ppm treatment was more effective in decreasing fruit acidity contents compared with other treatments in both seasons. This reduction in fruit acidity during cold storage could be due to the delaying in physiological ageing and alteration in metabolism, which ultimately resulted in higher retention of acidity. Meanwhile, decrease acidity in control fruits had high changes of acidity probably due to high respiratory rate and therefore acids consumption quickly and related to increases in metabolic activity.

In agreement with these results are those obtained by Kucuker and Ozturk (2014) investigated the effect of pre-harvest methyl jasmonate treatment (MeJA) on different plum varieties during the cold storage and they reported that, the MeJA application reduced fruit TA values than the control in different plum varieties. Consumption organic acids through respiration process leads to lower TA (Jan et al., 2012).
Table 7: Effect of pre-harvest spraying of ProTone and jasmonic acid on acidity percentage of “kelsey” plum fruits during cold storage at (0±1° C and 90-95% R.H.) in 2018 and 2019 seasons.

| Treatments                  | Storage Periods (Days) | Means (A) |
|-----------------------------|------------------------|-----------|
|                             | 0  | 10  | 20  | 30  |         |
| **Season 2018**             |    |     |     |     |         |
| Control                     | 1.27 | 1.97 | 1.13 | 1.09 | **1.17** |
| ProTone at 50 ppm           | 1.23 | 1.19 | 1.09 | 1.06 | **1.14** |
| ProTone at 100 ppm          | 1.20 | 1.15 | 1.04 | 1.00 | **1.09** |
| Jasmonic acid at 1000 ppm   | 1.24 | 1.19 | 1.15 | 1.11 | **1.17** |
| Jasmonic acid at 2000 ppm   | 1.21 | 1.16 | 1.11 | 1.07 | **1.14** |
| Means                       | **1.23** | **1.18** | **1.10** | **1.07** |         |
| **LSD** at 0.05             |    |     |     |     |         |
| Treatments (T): 0.02        |    |     |     |     |         |
| Storage Periods (S): 0.03   |    |     |     |     |         |
| Interaction (T×S): 0.05     |    |     |     |     |         |
| **Season 2019**             |    |     |     |     |         |
| Control                     | 1.61 | 1.54 | 1.49 | 1.43 | **1.52** |
| ProTone at 50 ppm           | 1.33 | 1.21 | 1.16 | 1.12 | **1.20** |
| ProTone at 100 ppm          | 1.23 | 1.87 | 1.13 | 1.09 | **1.16** |
| Jasmonic acid at 1000 ppm   | 1.44 | 1.44 | 1.41 | 1.27 | **1.39** |
| Jasmonic acid at 2000 ppm   | 1.29 | 1.24 | 1.15 | 1.14 | **1.21** |
| Means                       | **1.38** | **1.32** | **1.27** | **1.21** |         |
| **LSD** at 0.05             |    |     |     |     |         |
| Treatments (T): 0.03        |    |     |     |     |         |
| Storage Periods (S): 0.03   |    |     |     |     |         |
| Interaction (T×S): 0.06     |    |     |     |     |         |

**TSS/Acid ratio:**

Data illustrated in (Table 8) showed that all treatments caused a significantly increase in fruit TSS/Acid ratio compared with control in the two seasons of study. In addition, ProTone at 100 ppm and jasmonic acid at 2000 ppm were more effective on increasing TSS/Acid ratio and significant compared with other treatments.

As for the effect of storage periods on the changes in fruit TSS/Acid ratio, data in Table 8 showed that, TSS/Acid ratio increased gradually and significantly with the progress of cold storage in both seasons of study.

**Total sugars:**

Tabulated data in Table 9 declared that all used treatments increased fruit total sugars than the control fruits and the differences were big enough to be significant in both seasons. Fruit total sugars contents significantly increased with prolonging cold storage period as a compared with initial time in two seasons of study. The increase in sugars content of fruits could be due to ripening process that led to the transformation of some carbohydrates components as starch to sugars by the enzymatic activities (Karemera and Habimana, 2014).

In general, from abovementioned results, in comparison to control all treatments improved fruit total soluble solids and total sugars content in addition the TSS/Acid ratio meanwhile, reduced fruit acidity % during cold storage. These positive effects of ProTone and jasmonic acid due to their role in increasing ethylene production through inducing the expression of genes involved in its biosynthesis (Fan et al., 1998). These results are in harmony with those obtained by Kucuker and Ozturk (2014) on different plum cultivars mentioned that fruit SSC content increased, while acidity decreased during storage as a result of MeJA application.
Table 8: Effect of pre-harvest spraying of ProTone and jasmonic acid on TSS/Acid ratio of “kelsey” plum fruits during cold storage at (0±1° C and 90-95% R.H.) in 2018 and 2019 seasons.

| Treatments                  | Storage Periods (Days) | Means (A) |
|-----------------------------|------------------------|-----------|
|                             | 0    | 10   | 20   | 30   |         |
| Season 2018                 |      |      |      |      |         |
| **Control**                 | 7.95 | 8.97 | 10.10| 10.97| 9.50    |
| ProTone at 50 ppm           | 10.66| 11.64| 13.39| 14.01| 12.42   |
| ProTone at 100 ppm          | 11.26| 12.13| 14.58| 15.34| 13.33   |
| Jasmonic acid at 1000 ppm   | 11.14| 11.91| 12.75| 13.58| 12.35   |
| Jasmonic acid at 2000 ppm   | 11.82| 12.42| 12.31| 14.41| 12.99   |
| Means                       | **10.57** | **11.41** | **12.83** | **13.66** |         |
| LSD at 0.05                 |      |      |      |      |         |
| Treatments (T): 0.38 Storage Periods (S): 0.34 Interaction (T×S): 0.75 |
| Season 2019                 |      |      |      |      |         |
| **Control**                 | 6.62 | 7.35 | 7.90 | 8.64 | 7.63    |
| ProTone at 50 ppm           | 10.25| 11.50| 12.82| 13.39| 11.99   |
| ProTone at 100 ppm          | 11.27| 11.92| 13.40| 14.22| 12.70   |
| Jasmonic acid at 1000 ppm   | 9.72 | 9.90 | 10.58| 12.05| 10.56   |
| Jasmonic acid at 2000 ppm   | 11.22| 11.83| 13.06| 13.54| 12.41   |
| Means                       | **9.82** | **10.50** | **11.55** | **12.37** |         |
| LSD at 0.05                 |      |      |      |      |         |
| Treatments (T): 0.26 Storage Periods (S): 0.23 Interaction (T×S): 0.51 |

Table 9: Effect of pre-harvest spraying of ProTone and jasmonic acid on total sugars percentage of "kelsey" plum fruits during cold storage at (0±1° C and 90-95% R.H.) in 2018 and 2019 seasons.

| Treatments                  | Storage Periods (Days) | Means (A) |
|-----------------------------|------------------------|-----------|
|                             | 0    | 10   | 20   | 30   |         |
| Season 2018                 |      |      |      |      |         |
| **Control**                 | 7.46 | 7.72 | 7.80 | 7.88 | 7.72    |
| ProTone at 50 ppm           | 8.64 | 8.83 | 9.16 | 9.35 | 8.99    |
| ProTone at 100 ppm          | 8.77 | 8.92 | 9.35 | 9.60 | 9.16    |
| Jasmonic acid at 1000 ppm   | 8.81 | 8.94 | 9.30 | 9.64 | 9.17    |
| Jasmonic acid at 2000 ppm   | 8.89 | 9.07 | 9.44 | 9.73 | 9.28    |
| Means                       | **8.51** | **8.69** | **9.01** | **9.24** |         |
| LSD at 0.05                 |      |      |      |      |         |
| Treatments (T): 0.05 Storage Periods (S): 0.04 Interaction (T×S): 0.10 |
| Season 2019                 |      |      |      |      |         |
| **Control**                 | 7.29 | 7.54 | 7.69 | 7.75 | 7.65    |
| ProTone at 50 ppm           | 8.51 | 8.77 | 8.93 | 9.16 | 8.87    |
| ProTone at 100 ppm          | 8.69 | 8.83 | 9.25 | 9.56 | 9.08    |
| Jasmonic acid at 1000 ppm   | 8.63 | 8.83 | 9.20 | 9.52 | 9.04    |
| Jasmonic acid at 2000 ppm   | 8.82 | 9.09 | 9.41 | 9.65 | 9.17    |
| Means                       | **8.39** | **8.60** | **8.89** | **9.13** |         |
| LSD at 0.05                 |      |      |      |      |         |
| Treatments (T): 0.06 Storage Periods (S): 0.04 Interaction (T×S): 0.12 |
Anthocyanin, carotene and chlorophyll a, b:

Results of the present investigation, presented in Tables (10, 11, 12 and 13) showed the effect of pre harvest spraying of ProTone and jasmonic acid treatments on fruit anthocyanin, carotene and chlorophyll a, b contents of “Kelsey” plum fruits in 2018 and 2019 seasons. Data showed that, ProTone and jasmonic acid treatments significantly increased anthocyanin and carotene contents of “Kelsey” plums fruits as compared with control in both seasons of study. In addition, jasmonic acid at 2000 ppm was more effective on increasing anthocyanin and carotene contents and the differences are big enough to be significant compared with other treatments. Moreover, the statistical analysis showed that, ProTone at (50 & 100 ppm) and jasmonic acid at (1000 & 2000 ppm) treatments significantly decreased chlorophyll a and b compared with control. In addition, spraying jasmonic acid at 2000 ppm significantly decreased fruit chlorophyll a and b contents compared with other treatments in both seasons.

As for the effect of storage periods, data proved that, fruit anthocyanin contents significantly increased with prolonging storage periods as compared with initial time. Where, it was declared that, carotene and chlorophyll a, b contents decreased significantly increased with prolonging storage periods as compared with initial time.

Pre harvest applications of MeJA enhanced apple and strawberry fruit color (Rudell et al., 2005 and Concha et al., 2013). Also, Kondo (2006) there were increasing in the expression of anthocyanin biosynthesis-related genes in cherry. In another study, Kucuker and Ozturk (2015) reported that, MeJA have a positive effect on the color of cherry fruit. Nevertheless, Saracoglu et al. (2017) stated that the lightness were higher in MeJA and/or ABA treatments in comparison to the control. In general, chlorophyll degradation and anthocyanin's and total carotenoids, appearance are responsible for the plum coloration. In this study, an increase in fruit anthocyanin and carotene content at the same time decrease in chlorophyll values were observed with the ProTone (ABA) and jasmonic acid treatments as compared to control. This positive effect of JA and ABA in enhancing chlorophyll degradation and stimulates color pigments find support from the previous studies (Perez et al., 1993) on Golden Delicious’ apple (Khan and Singh, 2007) on plum and (Omran, 2011) on grapevine.

Table. 10: Effect of pre-harvest spraying of ProTone and jasmonic acid on anthocyanin (mg/100g F.W) of “Kelsey” plum fruits during cold storage at (0±1° C and 90-95% R.H.) in 2018 and 2019 seasons.

| Treatments                        | Storage Periods (Days) | Means (A) |
|-----------------------------------|------------------------|-----------|
|                                   | 0   | 10  | 20  | 30  |       |
| Season 2018                       |     |     |     |     |       |
| Control                           | 3.64 | 4.10 | 4.54 | 5.12 | 4.35  |
| ProTone at 50 ppm                 | 24.06 | 24.75 | 25.29 | 25.77 | 24.97 |
| ProTone at 100 ppm                | 25.22 | 25.86 | 26.18 | 26.90 | 26.04 |
| Jasmonic acid at 1000 ppm         | 25.06 | 25.27 | 26.00 | 26.26 | 25.65 |
| Jasmonic acid at 2000 ppm         | 26.01 | 26.13 | 26.53 | 26.29 | 26.28 |
| Means                             | 20.79 | 21.26 | 21.71 | 22.07 |       |
| LSD at 0.05                       | 3.06 | 3.54 | 4.11 | 4.86 | 3.89  |
| Treatments (T): 0.31              | Storage Periods (S): 0.28 | Interaction (T×S): 0.62 |
| Season 2019                       |     |     |     |     |       |
| Control                           | 23.16 | 24.21 | 24.73 | 25.49 | 24.39 |
| ProTone at 50 ppm                 | 24.51 | 25.09 | 25.83 | 26.37 | 25.45 |
| ProTone at 100 ppm                | 25.41 | 25.45 | 26.36 | 26.52 | 25.93 |
| Jasmonic acid at 1000 ppm         | 26.54 | 26.86 | 26.96 | 26.97 | 26.83 |
| Means                             | 20.54 | 21.03 | 21.57 | 22.04 |       |
| LSD at 0.05                       | 3.06 | 3.54 | 4.11 | 4.86 | 3.89  |
| Treatments (T): 0.36              | Storage Periods (S): 0.32 | Interaction (T×S): 0.72 |
Table. 11: Effect of pre-harvest spraying of ProTone and jasmonic acid on carotene (mg/100g) of “kelsey” plum fruits during cold storage at (0±1° C and 90-95% R.H.) in 2018 and 2019 seasons.

| Treatments                        | Storage Periods (Days) | Means (A) |
|-----------------------------------|------------------------|-----------|
|                                   | 0  | 10 | 20 | 30 |         |
| Season 2018                       |    |    |    |    |         |
| Control                           | 0.57 | 0.36 | 0.24 | 0.16 | 0.33 |
| ProTone at 50 ppm                 | 0.61 | 0.42 | 0.28 | 0.19 | 0.38 |
| ProTone at 100 ppm                | 0.64 | 0.49 | 0.31 | 0.23 | 0.42 |
| Jasmonic acid at 1000 ppm         | 0.63 | 0.84 | 0.33 | 0.22 | 0.42 |
| Jasmonic acid at 2000 ppm         | 0.66 | 0.52 | 0.37 | 0.27 | 0.45 |
| Means                             | 0.62 | 0.46 | 0.30 | 0.21 |       |
| LSD at 0.05                       |     |    |    |    |         |
| Treatments (T): 0.03               |     |    |    |    |         |
| Storage Periods (S): 0.03          |     |    |    |    |         |
| Interaction (T×S): 0.06            |     |    |    |    |         |

Season 2019

| Control                           | 0.56 | 0.32 | 0.22 | 0.15 | 0.31 |
| ProTone at 50 ppm                 | 0.59 | 0.44 | 0.33 | 0.22 | 0.39 |
| ProTone at 100 ppm                | 0.66 | 0.53 | 0.37 | 0.25 | 0.45 |
| Jasmonic acid at 1000 ppm         | 0.63 | 0.56 | 0.36 | 0.24 | 0.45 |
| Jasmonic acid at 2000 ppm         | 0.69 | 0.54 | 0.42 | 0.31 | 0.49 |
| Means                             | 0.63 | 0.48 | 0.34 | 0.23 |       |
| LSD at 0.05                       |     |    |    |    |         |
| Treatments (T): 0.02               |     |    |    |    |         |
| Storage Periods (S): 0.02          |     |    |    |    |         |
| Interaction (T×S): 0.04            |     |    |    |    |         |

Table. 12: Effect of pre-harvest spraying of ProTone and jasmonic acid on chlorophyll a(mg/100g) of “kelsey” plum fruits during cold storage at (0±1° C and 90-95% R.H.) in 2018 and 2019 seasons.

| Treatments                        | Storage Periods (Days) | Means (A) |
|-----------------------------------|------------------------|-----------|
|                                   | 0  | 10 | 20 | 30 |         |
| Season 2018                       |    |    |    |    |         |
| Control                           | 0.154 | 0.114 | 0.099 | 0.094 | 0.115 |
| ProTone at 50 ppm                 | 0.136 | 0.107 | 0.097 | 0.091 | 0.108 |
| ProTone at 100 ppm                | 0.133 | 0.104 | 0.091 | 0.088 | 0.104 |
| Jasmonic acid at 1000 ppm         | 0.130 | 0.104 | 0.093 | 0.086 | 0.103 |
| Jasmonic acid at 2000 ppm         | 0.127 | 0.093 | 0.087 | 0.078 | 0.096 |
| Means                             | **0.136** | **0.105** | **0.094** | **0.087** |       |
| LSD at 0.05                       |     |    |    |    |         |
| Treatments (T): 0.004              |     |    |    |    |         |
| Storage Periods (S): 0.004         |     |    |    |    |         |
| Interaction (T×S): 0.007           |     |    |    |    |         |

Season 2019

| Control                           | 0.131 | 0.113 | 0.097 | 0.091 | 0.108 |
| ProTone at 50 ppm                 | 0.133 | 0.106 | 0.093 | 0.089 | 0.105 |
| ProTone at 100 ppm                | 0.129 | 0.103 | 0.087 | 0.086 | 0.101 |
| Jasmonic acid at 1000 ppm         | 0.129 | 0.101 | 0.089 | 0.085 | 0.101 |
| Jasmonic acid at 2000 ppm         | 0.124 | 0.092 | 0.085 | 0.077 | 0.094 |
| Means                             | **0.129** | **0.103** | **0.090** | **0.086** |       |
| LSD at 0.05                       |     |    |    |    |         |
| Treatments (T): 0.004              |     |    |    |    |         |
| Storage Periods (S): 0.004         |     |    |    |    |         |
| Interaction (T×S): 0.008           |     |    |    |    |         |
### Table. 13: Effect of pre-harvest spraying of ProTone and jasmonic acid on chlorophyll b (mg/100g) of “kelsey” plum fruits during cold storage at (0±1° C and 90-95% R.H.) in 2018 and 2019seasons.

| Treatments                      | Storage Periods (Days) | Means (A) |
|---------------------------------|------------------------|-----------|
|                                 | 0          | 10        | 20        | 30        |           |
| **Season 2018**                 |            |           |           |           |           |
| Control                         | 0.197      | 0.101     | 0.092     | 0.086     | **0.119** |
| ProTone at 50 ppm               | 0.181      | 0.096     | 0.085     | 0.081     | **0.111** |
| ProTone at 100 ppm              | 0.162      | 0.091     | 0.083     | 0.078     | **0.103** |
| Jasmonic acid at 1000 ppm       | 0.177      | 0.091     | 0.078     | 0.073     | **0.105** |
| Jasmonic acid at 2000 ppm       | 0.155      | 0.088     | 0.074     | 0.069     | **0.097** |
| Means                           | **0.174**  | **0.093** | **0.082** | **0.077** |
| LSD at 0.05                     |            |           |           |           |           |
| **Season 2019**                 |            |           |           |           |           |
| Control                         | 0.213      | 0.105     | 0.089     | 0.085     | **0.123** |
| ProTone at 50 ppm               | 0.207      | 0.094     | 0.086     | 0.084     | **0.118** |
| ProTone at 100 ppm              | 0.180      | 0.090     | 0.083     | 0.079     | **0.108** |
| Jasmonic acid at 1000 ppm       | 0.180      | 0.092     | 0.081     | 0.075     | **0.107** |
| Jasmonic acid at 2000 ppm       | 0.167      | 0.089     | 0.077     | 0.073     | **0.101** |
| Means                           | **0.189**  | **0.094** | **0.083** | **0.079** |
| LSD at 0.05                     |            |           |           |           |           |

### Conclusion

Depending on the obtained results, it could be concluded that exogenous application of jasmonic acid at 2000 ppm was the best treatment for improving some fruit quality properties in terms of fruit weight, fruit size, flesh weight, flesh/stone ratio. Moreover, under cold storage this treatment increased fruit anthocyanin, total sugars contents and TSS/Acid ratio, simultaneously reduced fruit weight loss and fruit disorders percentage, in addition gave the intermediate values of fruit firmness.

### References

A.O.A.C., 1985. Official Methods of Analysis of the Association of Official Analytical Chemists. Washington D C, USA, 14Th Ed.

Ağlar, E. and B. Öztürk, 2018. Effects of Pre-Harvest Methyl Jasmonate Treatments on Fruit Quality of Fuji Apples during Cold Storage.International Journal of Agriculture and Wildlife Science (IJAWS). 4(1): 13-19.

Altuntas, E., B. Ozturk, Y. Ozkan and K. Yildiz, 2012.Physico-mechanical properties and color characteristics of apple as affected by methyl jasmonate treatments. International Journal of Food Engineering, 1: 1-16.

Balbontín, C., Gutiérrez, C., Wolff, M., and Figueroa, C.R., 2018. Effect of abscisic acid and methyl jasmonate preharvest applications on fruit quality and cracking tolerance of sweet cherry.Chilean journal of agricultural research, 78(3), 438-446.

Cao, S., Y. Zheng, K. Wang, P. Jin, H. Rui, 2009. Methyl jasmonate reduces chilling injury and enhances antioxidant enzyme activity in postharvest loquat fruit. Food Chem., 115, 1458–1463.

Cao, S.F., Y.H. Zheng Z.F. Yang, S.S. Tang and P.Jin, 2008. Control of anthracnose rot and quality deterioration in loquat fruit with methyl jasmonate. Journal of Science of Food and Agriculture, 88: 1598-1602.
Casquero, P.A., and M. Guerra, 2009. Harvest parameters to optimize storage life of European plum ‘Oullins Gage’. International Journal of Food Science and Technology, 44: 2049-2054.

Concha, C.M., N.E. Figueroa, L.A. Poblete, F.A. Oñate, W. Schwab, and C.R. Figueroa, 2013. Methyl jasmonate treatment induces changes in fruit ripening by modifying the expression of several ripening genes in *Fragaria chiloensis* fruit. Plant Physiology and Biochemistry 70:433-444. doi:10.1016/j.plaphy.2013.06.008.

Creelman, R.A. and J.E. Mullet. 1997. Biosynthesis and action of jasmonates in plants. Annu. Rev. Plant Physiol. Plant Mol. Biol. 48:355–381.

Dar T.A., M. Uddin M.M.A. Khan K.R. Hakeem and H. Jaleel, 2015. Jasmonates counter plant stress: a review. Environmental and Experimental Botany, 115: 49-57.

Fan, X., J.P. Mattheis, and J.K. Fellman. 1998. A role for jasmonates in climacteric fruit ripening. Planta 204:444-449.

FAO, (2018). Food and Agriculture Organization of the United Nation. The statistics of food and agriculture organization of the United Nations. http://www.fao.org.

Farag, K.M. and S.M. Attia, 2018. The Effect of Post-Harvest Treatments of Packaged "Kelsey" Plum Fruits with Oleic Acid Kept in Light, Dark or at Low Temperature International Journal of ChemTech Research, 11(05): 45-51

Farag, K.M., Neven M.N. Nagy, A.M. Haikal and S.S. Derhab, 2015. Mitigation of Ethephon and Protone Influence While Improving "Anna" Apples Coloration, Fruit Quality and Storability by Preharvest Application of Sprayable1-MCP. J. Agric. and Environ. Sciences, 14(2): 1-23.

Francescatto, P. Report on the use of prohydrojasmon (Blush™) to enhance fruit color in apples. Ohio: Ohio Agricultural Research and Development Center, The Ohio State University, 2013. 8p.

Gonzalez-Aguilar, G.A., J.G. Buta, and C.Y. Wang, 2003. Methyl jasmonate and modified atmosphere packaging (MAP) reduce decay and maintain postharvest quality of papaya ‘Sunrise’. Postharvest Biology and Technology, 28: 361-370.

Henrich,M., Christine,B., Petra, D., Youfa, C., Yunde, Z., Oliver, B., Josette, M., Joaquín, M., and Stephan, P., 2013. The jasmonic acid signaling pathway is linked to auxin homeostasis through the modulation of YUCCA8 and YUCCA9 gene expression. Plant J.; 74(4): 626–637.

Jan, I., A.Rab and M.Sajid, 2012. Storage performance of apple cultivars harvested at different stages of maturity. The Journal of Animal and Plant Sciences, 22: 438-447.

Janoudi, A. and J.A. Flor, 2003. Effects of multiple applications of methyl jasmonate on fruit ripening, leaf gas exchange and vegetative growth in fruit trees. The Journal of Horticultural Science and Biotechnology, 78: 793-797.

Karemera1, N.J and U. Habimana, 2014. Effect of pre-harvest calcium chloride on post-harvest behavior of Mango fruits (*Mangifera indica* L.) cv. Alphonso. Universal Journal of Agricultural Research, 2(3): 119 - 125.

Khan, A.S. and Z. Singh, 2007. Methyl jasmonate promotes fruit ripening and improves fruit quality in Japanese plum. The Journal of Horticultural Science and Biotechnology, 82: 695-706.

Kondo, S. 2006. The roles of jasmonates in fruit color development and chilling injury. ActaHorticulutae 727:45-56. doi:10.17660/ActaHortic.2006.727.3.

Kovacik J., B. Klej dus, F. Štork, J. Heddbavny and M. Backor, 2011. Comparison of methyl jasmonate and cadmium effect on selected physiological parameters in Scenedesmusquadricauda (chlorophyta, chlorophyceae). Journal of Phycolgy, 47: 1044-1049.

Krishna, H., B. Das, B.L. Attri, A. Kumar and N. Ahmed, 2012.Interaction between different pre and postharvest treatment on shelf life extension of ‘Oregon Spur’ apple. Fruits, 67: 31-40.
Kucuker, E., and B. Ozturk, 2015. The effects of aminoethoxyvinylglycine and methyl jasmonate on bioactive compounds and fruit quality of 'North Wonder' sweet cherry. African Journal of Traditional, Complementary and Alternative Medicines 12:114-119. doi:10.21010/ajtcam.v12i2.17.

Kucuker, E., and B. Ozturk, 2014. Effects of pre-harvest methyl jasmonate treatment on post-harvest fruit quality of Japanese plums. African Journal of Traditional, Complementary and Alternative Medicines, 11(6), 105-117.

Lichter, A., F.M. Gabler, and J.L. Smilanick, 2006. Control of spoilage in table grapes. (http://www.stewartpostharvest.com/ December 2006/ Lichter.pdf)

Martinez-Romero, D., E. Dupille, F. Guillen, J.M. Valverde, M. Serrano and D. Valero, 2003. 1-Methylcyclopropene increases storability and shelf life in climacteric and nonclimacteric plums. Journal of Agricultural and Food Chemistry, 51(16): 4680-4686.

Meheriuk M., B. Girard, L. Moys, H.J.T. Beveridge, D.L. McKenzie, J. Harrisson, S. Weintraub and R. Hocking, 1995. Modified atmosphere packing of lapins sweet cherry. Food Research International, 28: 239-244.

Moline, H.E., J.G. Buta, R.A. Saftner and J.L. Maas, 1997. Comparison of three volatile natural products for the reduction of postharvest decay in strawberries. Advances in Strawberry Research, 16: 43-48.

Moustakime, Y., Z. Hazzoumi, and K.A. Joutei, 2017. Effect of the exogenous application of abscisic acid (ABA) at fruit set and at veraison on cell ripeness of olives Oleaeuropaea L. and the extractability of phenolic compounds in virgin olive oil. Chemical and Biological Technologies in Agriculture, 4(1), 23.

Murray, X.J., D.M. Holcroft, N.C. Cook and S.J. Wand, 2005. Postharvest quality of 'Laetitia' and 'Songold' (Prunus salicina Lindell) plums as affected by preharvest shading treatments. Postharvest Biology and Technology, 37(1), 81-92.

Nilprapruck, P., N. Pradisthakarn, F. Authanithee, P. Keebjan, 2008. Effect of exogenous methyl jasmonate on chilling injury and quality of pineapple (Ananas comosus L.) cv. Pattavia. Silpakorn Univ. Sci. Technol. J., 2, 33–42.

Omran, Y.A. 2011. Enhanced yield and fruit quality of Redglobe grapevines by abscisic acid (ABA) and ethanol applications. OENO One, 45(1), 13-18.

Paul, V., R. Pandey and G.C. Srivastava, 2012. The fading distinctions between classical patterns of ripening in climacteric and non-climacteric fruit and the ubiquity of ethylene—an overview. Journal of Food Science and Technology, 49: 1-21.

Perez, A.G., C. Sanz, D.G. Richardson and J.M. Olias. 1993. Methyl jasmonate vapor promotes β-carotene synthesis and chlorophyll degradation in ‘Golden Delicious’ apple peel. J. Plant Growth. Regulat. 12:163–167.

Rabino, L. L.; Alberto and M. K. Monrad. 1977. Photocontrol of synthesis. Journal of Plant Physiology, 59: 569-573.

Roberto, S.R., A. Marinho de Assis, L.Y. Yamamoto, L.C.V. Miotto, A.J. Sato, K. Renata and G. Werner, 2012. Application timing and concentration of abscisic acid improve colour of ‘Benitaka’ table grape. Sci. Hort., 142: 44 - 48.

Rudell, D.R. and J.P. Mattheis, 2002. Methyl Jasmonate Enhances Anthocyanin Accumulation and Modifies Production of Phenolics and Pigments in ‘Fuji’ Apples. J. AMER. SOC. HORT. SCI. 127(3):435-441.

Rudell, D.R., J.K. Fellman and J.P. Mattheis, 2005. Preharvest application of methyl jasmonate to 'Fuji' apples enhances red coloration and affects fruit size splitting, and bitter pit incidence. HortScience 40:1760-1762.
Saracoglu, O., B. Ozturk, K. Yildiz, and E. Kucuker, 2017. Pre-harvest methyl jasmonate treatments delayed ripening and improved quality of sweet cherry fruits. Scientia Horticulturae 226:19-23. doi:10.1016/j.scienta.2017.08.024.

Sayyari M., M. Babalar, S. Kalantari, D. Martinez-Romero, F. Guillén, M. Serrano and D. Valero, 2011. Vapour treatments with methyl salicylate or methyljasmonate alleviated chilling injury and enhanced antioxidant potential during postharvest storage of pomegranates. Food Chemistry, 124: 964-970.

Snedecor, G.W. and W. G. Cochran, 1989. Statistical Methods, 8th edition. Iowa State University Press, Iowa, USA.

Singh, Z., and A.S. Khan, 2010. Physiology of plum fruit ripening. Stewart Postharvest Review, 2: 3.

Smith, F., 1956. Colorimetric method for determination of sugar and related substance. Analytical Chemistry, 28: 350-356.

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

Valero, D., Martinez-Romero, A.D., Valverde, J.M., Guillen, F., and Serrano, M. (2003). Quality improvement and extension of shelf life by 1-methylcyclopropene in plum as affected by ripening stage at harvest. Innovative Food Science Emerging Technologies, 4: 339-348.

Wang, L., S. Chen, W. Kong, S. Li and D.D. Archbold, 2006. Salicylic acid pretreatment alleviates chilling injury and affects the antioxidant system and heat shock proteins of peaches during cold storage. Postharvest Biology and Technology, 41, 244-251.

Wensttein, D.V., 1957. Chlorophyll Letal and Der supunikroskapisenej or winneck sec Der. Plastiden. Experimental Cell Research 12, 427.

Wintermans, J.F.G.M. and D.E. Mats, 1965. Spectrophotometric characteristics of chlorophylls and their pheophytins in ethanol. Biochem. Biophys. Acta., 448-453.

Zayan, M. A., G. B., Mikhael, and S.K. Okba, 2016. Treatments for improving tree growth, yield and fruit quality and for reducing double fruit and deep suture incidence in “Desert red” peach trees. International Journal of Horticultural Science, 22 (3-4), 7-19.
تحسين التلوين والجودة والقدرة التخزينية لثمار البرقوق صنف "الكلزى" برش بعض المعاملات قبل الحصاد

يعتبر البرقوق الكلزى واحد من الأصناف متاخرة النضج في مصر، لكن تحت الظروف المصرية يعاني من ضعف التلوين مسببًا خسائر اقتصادية. أجريت هذه الدراسة خلال موسمين متتاليين (2018، 2019) على اشجار برقوق صنف الكلزى عمرها خمس سنوات مطعومة على أصل نيماجرد بمنطقة النوبارية – محافظة البحيرة، لدراسة تأثير الرش قبل الحصاد بكل من البروتون (50، 100 جزء في المليون)، الجاسمونيك أسيد (1000، 2000 جزء في المليون) والكنترول على تحسين التلوين والجودة والقدرة التخزينية لثمار البرقوق صنف "الكلزى". تم تخزين الثمار لمدة 30 يوم على درجة حرارة +1 °C ورطوبة نسبية 90–95%. تم تقييم صفات الثمار عند صفر، 10، 20، 30 يوم لتحديد التغيرات في خصائص جودة الثمار خلال التخزين المبرد. أوضحت النتائج أنه عند الحصاد فإن معالمة الجاسمونيك أسيد (2000 جزء في المليون) كانت الأفضل في تحسين بعض خصائص الجودة من حيث وزن الثمار، حجم الثمار، وزن اللحم ونسبة اللحم إلى البذرة. علاوة على ذلك، خلال ظروف تخزين البرقوق المبرد، فإن معالمة الجاسمونيك أسيد قد زادت من محتوى الثمار من صبغة الأنتوسينيان، السكريات الكلية ونسبة المواد الصلبة الذائبة الكلية إلى الحموضة. إضافة إلى ذلك فإنها قلت من النسبة المئوية للفقد في وزن الثمار وكذلك نسبة الأصابة بالأمراض الفطرية والفيسيولوجية مع أعطاء قيم متوسطة لصلابة الثمار.