



Influence of Cultivars, Calcium Chloride and Periods on Fruit Storage Behavior of Pomegranate (*Punica granatum L.*)

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Abstract

Fruits of two local pomegranate cultivars (Sharmny and Hablary) were harvested during 2011 season; harvested fruits were dipped in 0, 2 and 4% CaCl₂ for 4 minutes and stored at ambient temperature for four storage periods (1, 2, 3 and 4) months. Results revealed that Hablary cultivar was significantly maintained titratable acidity (%), reduced fruit weight loss and fruit decay compared to Sharmny cultivar. Moreover, Fruit dipped in 4 % CaCl₂ had a significant decrease in fruit weight loss and recorded the highest TSS, TSS/TA ratio and vitamin C. compared to other treatments. Furthermore, TSS, TSS/TA ratio and fruit weight loss were significantly increased, while TA and vitamin C significantly reduced with the prolonging of storage periods.

Introduction

Pomegranate (*Punica granatum L.*) belongs to the Punicaceae family and is one of the oldest known edible fruits. It is an important fruit crop of many subtropical and tropical regions of the world. Pomegranate is classified as a non-climacteric fruit with no detectable levels of ethylene produced during storage and the fruit are generally harvested fully ripe [1]. Pomegranate is consumed as fresh fruit and fruit juice. It's juice is rich in many nutrients such as sugars, organic acids, vitamins (A, C, E and Folic acid), polyphenols and essential minerals [2]. The economic importance's of pomegranates appear during a long duration that displays in the markets [3]. During postharvest, pomegranate exhibits important quality loss due to several physiological and enzymatic disorders, the major problems related to advanced pomegranates storage are weight loss, shrinkage, decay development and appearance blemishes on skin [4].

Postharvest application of calcium may delay senescence in fruits with no detrimental effect on consumer acceptance [5]. Hussein *et al.*, (2003) [6] immersed Anna and Dorest Golden apples in 2 or 4% CaCl₂ solutions and stored at room temperature. Results founded that TSS and TSS/acid ratio gradually increased, but acidity content decreased with advanced storage period. Ramezani and Rahemi (2007) [7] evaluated that pomegranate fruits were dipped in 2% CaCl₂ and stored at 2°C for 4.5 months significantly reduced water loss and maintained fruit quality for up to 13 weeks. Kazemi *et al.*, (2011) [8] dipped

kiwifruits cv. Hayward in three CaCl_2 concentration (0, 2 and 4%) and kept at 1°C for 60 days. The results appeared that fruit treated with CaCl_2 had no significantly influenced on fruit decay and vitamin C as compared to control. Abd-Elghany *et al.*, (2012) [9] showed that fruits of 'Wonderful' pomegranate dipped in 2% or 3% calcium chloride solution for 4 min. and stored at $5\pm 1^\circ\text{C}$ with $85\pm 5\%$ RH, had significantly reduced fruit weight loss, but led to maintained vitamin C in comparison with non treated fruits during storage periods. Hamad (2012) [10] revealed that spraying Salakhani pomegranate tress with 2% CaCl_2 and stored fruits at $2\pm 1^\circ\text{C}$ with 84-86% RH for two months resulted to no significant effect on TSS and titratable acidity at the end of storage period compared to fruits of untreated trees.

In Iraq and Kurdistan region, there are deficient of studies about postharvest treatments and storage method especially for pomegranate fruits. Therefore, our study was aimed to evaluate the effectiveness of calcium chloride (CaCl_2) on physical and chemical characteristics of two pomegranate cultivars locally named (Sharmny and Hablary) during storage periods and to prolong storability of pomegranate fruit.

Materials and Methods

A. Fruits

Fully mature pomegranate fruits when TSS 15-17% and (240-260g) weight were picked randomly from different trees of 14-year old for two locally cultivars named Sharmny (sour- sweet) and Hablary (sour) in October 2011 from a private orchard of pomegranate in Kandy village, Duhok, Iraq KRG. Picked fruits were directly brought to the central laboratory/ Faculty of Agriculture and Forestry, where those Diseased, bruised and injured fruits were discarded and sound fruits were preserved in the cold room to remove field heat (Pre-cooling).

B. Treatments

Uniform size and healthy fruits of each cultivar were randomized and divided into three groups (each group contained 108 fruits), in addition of that three replicates for each treatment were placed for weight loss and physiological disorders (each replicate include 12 fruits), solutions of calcium chloride $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ (36% Ca) were prepared and fruits of each group were dipped in 0, 2 and 4% CaCl_2 solutions for 4 minutes [11]. After dipping, fruits were air-dried and stored at ambient temperature for four storage periods (1,2,3,4 months) in the laboratory of handling and storage/ Horticulture department. The experiment was laid out in factorial experiment, Randomized Complete Block Design [12].

C. Measurement Methods

- Total Soluble Solid (TSS %) was determined by Hand Refractometer as described in [13].
- Titratable Acidity (TA %) was determined by the method of [14].
- TSS/TA ratio was calculated by dividing TSS to TA [15].
- Vitamin C (mg. 100 ml^{-1} juice) was measured according to [16].
- Fruit Weight Loss (%) was calculated according to [17].
- Fruit Decay (%) was calculated on the bases used by [11].

D. Statistical analysis

Data were tabulated and statistically analyzed with a computer using SAS program [18]. The variation between various treatment means were tested with Duncan Multiple Range test at the $P < 0.05$ level [19].

Results and Discussion

Total Soluble Solid (TSS %): Results in table (1) showed that Sharmny cv. was exceeding significantly on Hablary cv. in TSS (%) of fruit. The same table (1) appeared that there was no significant influence of 2 and 4% CaCl_2 dip on fruit TSS (%) as compared with untreated fruit. On the other hand, the data in table (1) revealed that fruit TSS (%) significantly increased with prolonged storage period from 1 month to 4 months, the highest TSS (18.82%) record when fruit stored for 4 months, which was differ significantly as compared

to other periods. The interaction among the three studied factors was significantly affected on fruit TSS (%). The interaction among Sharmny cv. with 0 or 4% CaCl₂ and 4 months storage period was the surpassed treatment as it gave the highest fruit TSS (19.50 %), but the lowest value (16.00 %) was recorded at Hablary cv. that immersed in 2% CaCl₂ and stored for 1 month storage period (Table 1). These results were in agreement with those gained by [6] on Anna and Dorest Golden apples, and [10] on Salakhani pomegranate. The reason of a significant increase in fruit TSS (%) with prolonged of storage periods, could be due to the alteration in cell wall structure and increasing the breakdown of complex carbohydrates into simple sugars, or might be due to increased juice concentration as a result of water loss (dehydration) from the fruit through transpiration or evaporation which occurred in fruit during storage period [6].

Table- 1: Effect of cultivar, CaCl₂ (%) dip, storage period and their interactions on total soluble solid (%) of pomegranate fruit stored at ambient temperature.

| Cultivars | CaCl ₂ (%) | Storage Periods (Months) | | | | Cultivar × CaCl ₂ | Cultivar Mean |
|------------------------------------|-----------------------|--------------------------|-------|-------|-------|------------------------------|---------------|
| | | 1 | 2 | 3 | 4 | | |
| Sharmny | 0 | 17.83 | 18.33 | 18.83 | 19.50 | 18.62 | 18.36 |
| | | d-g | c-e | a-c | a | a | |
| | 2 | 17.17 | 17.67 | 18.33 | 19.33 | 18.13 | |
| | | f-h | e-g | c-e | ab | ab | |
| | 4 | 17.17 | 18.00 | 18.67 | 19.50 | 18.34 | |
| | | f-h | c-f | b-d | a | a | |
| Hablary | 0 | 16.17 | 16.67 | 17.33 | 17.60 | 16.94 | 17.25 |
| | | i | hi | f-h | e-g | c | |
| | 2 | 16.00 | 17.00 | 18.00 | 18.33 | 17.33 | |
| | | i | gh | c-f | c-e | bc | |
| | 4 | 16.17 | 17.00 | 18.00 | 18.67 | 17.46 | |
| | | i | gh | c-f | b-d | bc | |
| Storage Period Mean | | 16.75 | 17.45 | 18.19 | 18.82 | CaCl ₂ Mean | |
| | | d | c | b | a | | |
| CaCl ₂ × Storage Period | 0 | 17.00 | 17.50 | 18.08 | 18.55 | 17.78 | |
| | | c | bc | ab | a | a | |
| | 2 | 16.59 | 17.34 | 18.17 | 18.83 | 17.73 | |
| | | c | bc | ab | a | a | |
| | 4 | 16.67 | 17.50 | 18.34 | 19.09 | 17.90 | |
| | | c | bc | ab | a | a | |
| Cultivar × Storage Period | Sharmny | 17.39 | 18.00 | 18.61 | 19.44 | | |
| | | d | c | b | a | | |
| | Hablary | 16.11 | 16.89 | 17.78 | 18.20 | | |
| | | f | e | cd | bc | | |

Means of each factor and their interactions followed by the same letter's are not different significantly from each other, according to Duncan's multiple ranges test at 5% level.

TSS % at harvest in Sharmny cv. fruit=16.33 %, Hablary cv. fruit= 15.33 %

Titrateable Acidity (TA %): Data presented in table (2) showed that the difference between two cultivars was significant on TA (%) in fruit, Hablary cv. fruit was significantly superior over Sharmny cv. in fruit TA (%). With respect to the specific effect of CaCl₂, it was noticed from table (2) that the highest TA (1.58%) of fruit appeared in fruit dipped in 2% CaCl₂ which was significantly higher than TA (%) of those dipped in 4% CaCl₂. On the other hand, TA (%) was significantly decreased as the storage period prolonged, the highest TA (1.70 %) was obtained when fruit stored for 1 month, while the lowest TA (1.37%) was acquired from storage fruits for 4 months. Regarding the interaction among cultivars, CaCl₂ and storage period was significantly influenced on fruit TA (%). The combinations among Hablary cv., 2% CaCl₂ and 1 month

storage period was the best treatment as it gave significantly the maximum TA (%) in fruit (2.46 %) as compared with the minimum value (0.72 %) at the treatment of Sharmny, 4 % CaCl₂ and 4 month storage period (Table 2). Similar results were obtained by [6] on Anna and Dorest Golden apples, and [10] on pomegranate fruits cv. Salakhani. Fruit dipped in 2% CaCl₂ was recorded the highest titratable acidity compared to other treatments, this effect of calcium could be due to decreasing the activity of citric acid glyoxylase enzyme which responsible for the degradation of citric acid and converted into sugars and their further utilization in metabolic processes in the fruit [20].

Table- 2: Effect of cultivar, CaCl₂ (%) dip, storage period and their interactions on titratable acidity (%) of pomegranate fruit stored at ambient temperature.

| Cultivars | CaCl ₂ (%) | Storage Periods (Months) | | | | Cultivar × CaCl ₂ | Cultivar Mean |
|------------------------------------|-----------------------|--------------------------|------|------|------|------------------------------|---------------|
| | | 1 | 2 | 3 | 4 | | |
| Sharmny | 0 | 0.94 | 0.91 | 0.85 | 0.73 | 0.86 | |
| | | gh | gh | g-i | i | b | |
| | | 0.99 | 0.94 | 0.86 | 0.75 | 0.89 | 0.87 |
| | 2 | g | gh | g-i | i | b | b |
| | | 0.97 | 0.94 | 0.83 | 0.72 | 0.87 | |
| | | gh | gh | hi | i | b | |
| Hablary | 0 | 2.44 | 2.33 | 2.23 | 2.02 | 2.26 | |
| | | a | a-c | cd | ef | a | |
| | | 2.46 | 2.33 | 2.25 | 2.05 | 2.27 | 2.24 |
| | 2 | a | a-c | cd | ef | a | a |
| | | 2.40 | 2.29 | 2.15 | 1.95 | 2.20 | |
| | | ab | bc | de | f | a | |
| Storage Period Mean | | 1.70 | 1.62 | 1.53 | 1.37 | | |
| | | a | b | c | d | | |
| CaCl ₂ × Storage Period | 0 | 1.69 | 1.62 | 1.54 | 1.38 | 1.56 | |
| | | a | a | a | a | ab | |
| | | 1.73 | 1.64 | 1.56 | 1.40 | 1.58 | |
| | 2 | a | a | a | a | a | |
| | | 1.69 | 1.62 | 1.49 | 1.34 | 1.53 | |
| | | a | a | a | a | b | |
| Cultivar × Storage Period | Sharmny | 0.97 | 0.93 | 0.85 | 0.73 | | |
| | | e | e | f | g | | |
| | | 2.43 | 2.32 | 2.21 | 2.01 | | |
| | Hablary | a | b | c | d | | |

Means of each factor and their interactions followed by the same letter's are not significantly different from each other, according to Duncan's multiple range test at 5% level.

TA % at harvest in Sharmny cv. fruit=1.15 %, Hablary cv. fruit= 2.57 %

TSS/TA ratio: Results recorded in table (3) demonstrated that Sharmny cv. significantly dominated Hablary cv. in TSS/TA ratio of fruit. The same table (3) showed that there was no significant effect of dipping fruit in 2 and 4% CaCl₂ on fruit TSS/TA ratio in comparison with untreated fruit. Moreover, fruit TSS/TA ratio was significantly increased with prolonged the storage period. Fruit stored for 4 months proved to be the most effective treatment for obtained significantly the highest (17.91) fruit TSS/TA ratio compared to other storage periods. Result indicated that the interaction between cv., CaCl₂ and storage periods significantly effected on fruit TSS/TA ratio. Where the interaction among Sharmny cv., 4% CaCl₂ and 4 months storage period was the most influential treatment which gave the highest TSS/TA ratio in fruit (27.29), but the lowest value (6.51) was observed in the interaction of Hablary cv., 2% CaCl₂ and 1 month storage period (Table 3).

These results are in accordance with those obtained by Hussein *et al.*, (2003) [6] on apple fruits cultivars Anna and Dorest Golden.

The increasing in the TSS/TA ratio in fruit immersed at 4% CaCl₂ compared to the other treatments were returned to increasing fruit TSS (%) in (Table 1) and decreasing acid contents in the same fruits (Table 2).

Table- 3: Effect of cultivar, CaCl₂ (%) dip, storage period and their interactions on TSS/TA ratio of pomegranate fruit stored at ambient temperature.

| Cultivars | CaCl ₂ (%) | Storage Periods (Months) | | | | Cultivar × CaCl ₂ | Cultivar Mean |
|---------------------------------------|-----------------------|--------------------------|-------------|-------------|-------------|---------------------------------|------------------|
| | | 1 | 2 | 3 | 4 | | |
| Sharmny | 0 | 19.06 de | 20.19 cd | 22.17 bc | 26.91 a | 22.08 a | 21.56 a |
| | 2 | 17.36 e | 18.85 de | 21.42 bc | 25.99 a | 20.91 a | |
| | 4 | 17.74 e | 19.22 de | 22.55 b | 27.29 a | 21.70 a | |
| Hablary | 0 | 6.63 h | 7.14 gh | 7.78 f-h | 8.73 f-h | 7.57 b | 7.77 b |
| | 2 | 6.51 h | 7.31 f-h | 8.02 f-h | 8.97 fg | 7.70 b | |
| | 4 | 6.75 gh | 7.44 f-h | 8.39 f-h | 9.57 f | 8.04 b | |
| Storage Period Mean | | 12.34 d | 13.36 c | 15.06 b | 17.91 a | CaCl ₂ Mean | |
| CaCl ₂ × Storage Period | 0 | 12.85 a | 13.67 a | 14.98 a | 17.82 a | 14.83 a | |
| | 2 | 11.94 a | 13.08 a | 14.72 a | 17.48 a | 14.30 a | |
| | 4 | 12.25 a | 13.33 a | 15.47 a | 18.43 a | 14.87 a | |
| Cultivar × Storage Period | Sharmny | 18.05 d | 19.42 c | 22.05 b | 26.73 a | | |
| | Hablary | 6.63 g | 7.30 fg | 8.06 ef | 9.09 e | | |

Means of each factor and their interactions followed by the same letter's are not significantly different from each other, according to Duncan's multiple range test at 5% level.

Vitamin C (mg. 100 ml⁻¹ juice): Data reported in table (4) illustrated that there were no significant difference between the both cultivar in fruit vitamin C. Also, the results showed that there was no significant difference between CaCl₂ concentrations on fruit vitamin C, however the highest fruit vitamin C content was registered by dipping fruit in 4% CaCl₂, while the lowest vitamin C appeared in untreated fruit. The obtained data in table (4) revealed that prolonging storage period resulted in a significant decrease in fruit vitamin C. The highest vitamin C (4.05 mg. 100 ml⁻¹ juice) obtained when fruit stored for 1 month, which was differ significantly compared to other periods, but the lowest vitamin C (1.16 mg. 100 ml⁻¹ juice) content recorded when fruit stored for 4 months. The results of cv., CaCl₂ and storage period interactions exposed that the best interaction for fruit vitamin C was among Hablary cv., 2% CaCl₂ and 1 month storage period (4.75 mg. 100 ml⁻¹ juice), which was significantly differed from the most other interactions, whereas the lowest fruit vitamin C (0.93 mg. 100 ml⁻¹ juice) was gained in Sharmny cv. fruit that dipped in 0 % CaCl₂ for 4 month storage period (Table 4). The gained results are in line with those obtained by [8] on kiwi fruits cv. Hayward, and [9] on the fruits of 'Wonderful' pomegranate.

Ascorbic acid is an important nutrient quality parameter and is very sensitive to degradation due to its oxidation as compared to other nutrients during storage [21]. Higher concentrations of CaCl₂ delayed the rapid oxidation of fruit ascorbic acid by the inhibition of ascorbate oxidase activity [22].

Table- 4: Effect of cultivar, CaCl₂ (%) dip, storage period and their interactions on vitamin C (mg.100ml⁻¹juice) of pomegranate fruit stored at ambient temperature.

| Cultivars | CaCl ₂ (%) | Storage Periods (Months) | | | | Cultivar × CaCl ₂ | Cultivar Mean |
|---------------------------------------|-----------------------|--------------------------|------|------|------|---------------------------------|------------------|
| | | 1 | 2 | 3 | 4 | | |
| Sharmny | 0 | 4.32 | 3.70 | 2.02 | 0.93 | 2.74 | 2.70 |
| | | ab | b-d | g-i | j | a | |
| | 2 | 4.04 | 3.24 | 2.02 | 1.08 | 2.60 | |
| | | a-c | c-e | g-i | ij | a | |
| | 4 | 4.17 | 3.67 | 2.16 | 1.08 | 2.77 | |
| | | a-c | b-d | f-h | ij | a | |
| Hablary | 0 | 3.27 | 2.66 | 2.16 | 1.19 | 2.32 | 2.66 |
| | | c-e | e-g | f-h | h-j | a | |
| | 2 | 4.75 | 2.95 | 2.59 | 1.23 | 2.88 | |
| | | a | d-g | e-g | h-j | a | |
| | 4 | 3.72 | 3.02 | 2.88 | 1.44 | 2.77 | |
| | | b-d | d-f | d-g | h-j | a | |
| Storage Period Mean | | 4.05 | 3.21 | 2.31 | 1.16 | CaCl ₂ Mean | |
| | | a | b | c | d | | |
| CaCl ₂ × Storage Period | 0 | 3.80 | 3.18 | 2.09 | 1.06 | 2.53 | |
| | | a-c | cd | e | f | a | |
| | 2 | 4.40 | 3.10 | 2.31 | 1.16 | 2.74 | |
| | | a | cd | e | f | a | |
| | 4 | 3.95 | 3.35 | 2.52 | 1.26 | 2.77 | |
| | | ab | bc | de | f | a | |
| Cultivar × Storage Period | Sharmny | 4.18 | 3.54 | 2.07 | 1.03 | | |
| | | a | b | d | e | | |
| | Hablary | 3.91 | 2.88 | 2.54 | 1.29 | | |
| | | ab | c | cd | e | | |

Means of each factor and their interactions followed by the same letter's are not significantly different from each other, according to Duncan's multiple range test at 5% level.

Vitamin C at harvest in Sharmny cv. fruit= (6.48 mg. 100 ml⁻¹ juice), Hablary cv. fruit= (7.25 mg. 100 ml⁻¹ juice)

Fruit Weight Loss (%): Results in table (5) showed that Hablary cv. significantly had lowest fruit weight loss (%) than Sharmny cv. Data founded in table (5) realized that fruit dipped in 4% CaCl₂ significantly reduced fruit weight loss (%), and it proved to be the most efficient treatment in reducing fruit weight loss (%). Fruit weight loss (%) appeared to be significantly increased as the storage period prolonged. Fruit stored for 4 month obtained the highest fruit weight loss (25.55%) which was significantly differ when compared to other periods. Concerning the interaction among the three studied factors, there were a significant impact on fruit weight loss (%).Hablary fruit immersed in 4% CaCl₂ and stored for 1 month was the most influential treatment that gave the lowest fruit weight loss (13.55%), while the maximum fruit weight loss (28.68%) appear from the interaction of Sharmny cv., 2% CaCl₂ and 4 months storage period (Table 5). Similar results were obtained by [7] on pomegranate fruits and [9] on the fruits of 'Wonderful' pomegranate.

Fruit dipped in 4% CaCl₂ has significantly decreased fruit weight loss (%) compared to other treatments, thus might be interpreted that calcium applications have known to be effective in membrane functionality and integrity maintenance [23]. On the other hand, the use of appropriate CaCl₂ those used in

the present study might delay the removal of epicuticular waxes, which play an important role in water exchange through the skin [24].

Table-5: Effect of cultivar, CaCl₂ (%) dip, storage period and their interactions on weight loss (%) of pomegranate fruit stored at ambient temperature.

| Cultivars | CaCl ₂ (%) | Storage Periods (Months) | | | | Cultivar × CaCl ₂ | Cultivar Mean | | |
|------------------------------------|---------------------------|--------------------------|--------------|--------------|-------------|------------------------------|---------------|------------------------|--|
| | | 1 | 2 | 3 | 4 | | | | |
| Sharmny | 0 | 15.67 i | 21.01 e-h | 23.58 cd | 26.62 b | 21.72 ab | 22.33 a | | |
| | 2 | 19.01 h | 25.06 bc | 25.28 bc | 28.68 a | 24.51 a | | | |
| | 4 | 15.01 ij | 21.10 e-h | 21.82 d-f | 25.17 bc | 20.78 b | | | |
| | 0 | 14.54 ij | 19.86 f-h | 22.05 de | 24.89 bc | 20.34 b | | | |
| Hablary | 2 | 14.65 ij | 19.68 f-h | 21.27 e-g | 24.18 c | 19.95 b | 19.86 b | | |
| | 4 | 13.55 j | 19.15 gh | 20.77 e-h | 23.74 cd | 19.30 b | | | |
| | Storage Period Mean | | 15.41 d | 20.98 c | 22.46 b | 25.55 a | | CaCl ₂ Mean | |
| | 0 | 15.11 fg | 20.44 de | 22.82 b-d | 25.76 a | 21.03 b | | | |
| CaCl ₂ × Storage Period | 2 | 16.83 f | 22.37 b-e | 23.28 bc | 26.43 a | 22.23 a | | | |
| | 4 | 14.28 g | 20.13 e | 21.30 c-e | 24.46 ab | 20.04 c | | | |
| | Cultivar × Storage Period | Sharmny | 16.56 f | 22.39 cd | 23.56 bc | 26.82 a | | | |
| Hablary | | 14.25 g | 19.56 e | 21.36 d | 24.27 b | | | | |

Means of each factor and their interactions followed by the same letter's are not significantly different from each other, according to Duncan's multiple range test at 5% level

Fruit Decay (%): The gained results in table (6) revealed that Hablary cv. fruit has significantly reduced fruit decay (1.16%) when compared to the fruit decay (6.79%) in Sharmny cv. The same table (6) appeared that there were no significant influence of 2, and 4% CaCl₂ dip on fruit decay (%) as compared with untreated fruit, however treated fruit with 2% CaCl₂ (2.78%) recorded the lowest decay (%) in fruit. Fruit decay (%) was decreased as the storage period advanced. The highest value (14.35%) recorded when fruit stored for 1 month, which was differ significantly when compared to the other periods. Furthermore, the interaction the three factors were significantly affected on fruit decay (%), and the combination between Sharmny cv., 0 % CaCl₂ and 1 month storage period showed a highest fruit decay (%), which was (27.78%). Also should be noted that the decay (%) in fruit appeared only in the interaction between Sharmny cv. or Hablary cv. dipped in 0, 2, 4% CaCl₂ and 1 month storage as well as in the interaction between Sharmny cv., 0 or 4% CaCl₂ and 2 month storage (Table 6). These results were in agreement with those obtained by [8] on kiwi fruits cv. Hayward.

Fruit immersed in 2 and 4% CaCl₂ decreased fruit decay (%) compared to untreated fruits, this might be due to increased Calcium ions in the cell wall. The stability of the cell wall may be related to the cooperative binding of polygalacturonate chains with Ca ions, making the cell wall of the fruit less accessible to enzymes that cause softening or to cell wall degrading enzymes produced by fungal pathogens. Calcium can also reduce pathogen germination, sporulation and growth. This ultimately reduces the storage decay of fruits [25]. Furthermore, fruit decay (%) decreased this might be interpreted that pomegranates peel were hardened with a long of storage periods, so insects and Fungi could not easily attacked, also peel hardened

could be decrease gas exchanging between fruit and external atmosphere which finally decrease respiration and ripening metabolism.

Table- 6: Effect of cultivar, CaCl₂ (%) dip, storage period and their interactions on fruit decay (%) of pomegranate fruit stored at ambient temperature.

| Cultivars | CaCl ₂ (%) | Storage Periods (Months) | | | | Cultivar × CaCl ₂ | Cultivar Mean | | |
|---------------------------------------|------------------------------|--------------------------|------------|------------|-----------|---------------------------------|------------------|------------------------|--|
| | | 1 | 2 | 3 | 4 | | | | |
| Sharmny | 0 | 27.78 a | 5.56 c | 0.00 c | 0.00 c | 8.34 a | 6.79 a | | |
| | 2 | 19.44 b | 0.00 c | 0.00 c | 0.00 c | 4.86 a | | | |
| | 4 | 25.00 ab | 3.70 c | 0.00 c | 0.00 c | 7.18 a | | | |
| | 0 | 5.55 c | 0.00 c | 0.00 c | 0.00 c | 1.39 a | | | |
| Hablary | 2 | 2.78 c | 0.00 c | 0.00 c | 0.00 c | 0.70 a | 1.16 b | | |
| | 4 | 5.56 c | 0.00 c | 0.00 c | 0.00 c | 1.39 a | | | |
| | Storage Period Mean | | 14.35 a | 1.54 b | 0.00 b | 0.00 b | | CaCl ₂ Mean | |
| | 0 | 16.67 a | 2.78 b | 0.00 b | 0.00 b | 4.86 a | | | |
| CaCl ₂ × Storage Period | 2 | 11.11 a | 0.00 b | 0.00 b | 0.00 b | 2.78 a | | | |
| | 4 | 15.28 a | 1.85 b | 0.00 b | 0.00 b | 4.28 a | | | |
| | Cultivar × Storage Period | | 24.07 a | 3.09 bc | 0.00 c | 0.00 c | | | |
| | Hablary | 4.63 b | 0.00 c | 0.00 c | 0.00 c | | | | |

Means of each factor and their interactions followed by the same letter's are not significantly different from each other, according to Duncan's multiple range test at 5% level.

Conclusions

From the present study we could concluded that fruits of both cultivars showed different behavior in measured parameters through the storage periods. Moreover, Dipped pomegranate fruit in 4% CaCl₂ was superior over the other treatment in most studied parameters.

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